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*Review Article*

# A Skill Gap study of LMV Drivers in and around Hyderabad

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***Abstract*** *- In the interest of passengers, drivers, local government, quality & standards of living of families of drivers, societal issues, literacy level problems, involvement CPW/NHAI in the identification of own traffic badges and society, it is the need of the hour to know and document problems faced by various sectors related to traffic awareness and its impact on the profession, banking, insurance, government, society and family members.*
*It is the right choice to study a city like Hyderabad due to its travel demand with three dimensions: design, density, and diversity. Town Planning, GHMC, HMDA, RTA, Traffic engineers, Architects, and urban planners have been paying more attention to explore the correlation between education and experience of drivers of LMVs/Taxis in light of their attitude, behavior, role, and responsibility in addition to their knowledge of MV Act rules and regulations. In the recent past, the involvement of technology with reference to driver/passengers personalized information and also with regards to OEM-MIS models regarding technical maintenance of vehicles. In the olden days, we checked the wear and tear of various components and accessories of any vehicle manually. Today, the situation is not like that very high-end models came into the market through IT/ITES/AI development intervention. The study conducted within Hyderabad City, covering all four corners of the city, covered the ORR range of HMDA. The main focus is on studying the quality of living standards of drivers of LMVs/Taxis and their revenue generation capabilities, socio-economic back-ground, problems, issues, and challenges in their profession. Further, the study tries to dig out future education and training possibilities for needy people based on their attitudes and interests. The study started with an assumption that many of the LMV/Taxi drivers do not have the proper attitude, educational qualifications, experience to understand the MV Act, Traffic rules, regulations, and traffic awareness & responsibility for being a citizen of the country.*

***Keywords*** *- Drivers, RTA, MV Act rules & regulations, technical maintenance of vehicles, quality of living standards, socio-economic back-ground, traffic awareness*

## I. INTRODUCTION

In the interest of passengers, drivers, local government, quality & standards of living of families of drivers, societal issues, literacy level problems, involvement CPW/NHAI in the identification of own traffic badges and society, it is the need of the hour to know and document problems faced by various sectors related to traffic awareness and its impact on the profession, banking, insurance, government, society and family members.

It is the right choice to study a city like Hyderabad due to its travel demand with three dimensions: design, density, and diversity. Town Planning, GHMC, HMDA, RTA, Traffic engineers, Architects, and urban planners have been paying more attention to explore the correlation between education and experience of drivers of LMVs/Taxis in light of their attitude, behavior, role, and responsibility in addition to their knowledge of MV Act rules and regulations. One of the important modes is taxis and plays a key role in the urban passenger transportation market. It provides convenient and comfortable service to the passengers; in recent past, technology involvement with reference to driver/passengers personalized information regarding OEM-MIS models regarding technical maintenance of vehicles. In the olden days, we checked the wear and tear of various components and accessories of any vehicle manually. Today, the situation is not like that very high-end models came into the market through IT/ITES/AI development intervention. Both owner/Driver and Manufacturer/Dealer/service organization get electronic SMS/mail alerts regarding vehicle and driver behavior maintenance. Very surprisingly, today, there was a system if the driver is tired the vehicle alerts and went off to the road and immediately stops the vehicle and technology behave, human slave, as rightly pointed out by Morris Garages. Bioinformatics is also into the automobile-field by way of VGT/VTVT technology. It is a constant feed of accelerator also found by feather touch of fingers on the pedal and inform or alert pilot in cock-pit immediately by buzz

warning. As SKODA Motors rightly pointed intelligent engines with cruise control and auto-pilot. Auto-pilot mechanism is still not in Indian markets; once that is introduced, we has to feed the machine about the concepts rather than individual in the cockpit. In the future, there may not be any requirement for a chauffeur for your vehicle. However, this is the story of the future after a couple of decades. But today, there is a lot of need to educate and train drivers in the interest of the nation, society, and their career.

### *A. Scope of the Study*

The study conducted within Hyderabad City, covering all four corners of the city, covered the ORR range of HMDA. The main focus is studying the quality of living standards of drivers of LMVs and their revenue generation capabilities, socio-economic back-ground, problems, issues, and challenges faced in their profession. Further, the study tries to dig out possibilities of further education and training to the needy people based on the respondents' attitude and interest. However, this study compels, in general, the drivers of various categories, and in particular, the government departments, educational institutes, and societal partners, to build the career of drivers by way of providing a suitable platform to further educate and train towards building the career and excel in the profession.

### *B. Problem Statement*

The study started with an assumption that many of the LMV/Taxi drivers do not have the proper attitude, educational qualifications, experience to understand the MV Act, Traffic rules, regulations, and traffic awareness & responsibility for being a citizen of the country. This study helps the government and private agencies set down some skill cum technology up- gradation programmes for betterment of driver’s families and provide further education and training to respondents' interest-specific segment. Skillset assessment, providing necessary training, TNA, attitude, and LMV drivers behavior in both organized and unorganized sectors. However, the sample size is less to the city's population, having 1.50 crores of them not less than one million vehicles fleet on the road. But there is a lot of scope to the government, RTA department, Law & Order Department, MHRD, Academic Partners, NGOs, and Society to chalk-out suitable programs. But the issue is, what should be the size of the institution, size of trainers, trainees, resources, revenue generation, time and cost constraints in addition to the interests policymakers and trainees towards new frontiers of the training system to provide certificates, diplomas, and even degrees after recognition of RPL criteria.

### *C. Objectives of the Study:*

- To understand behavior, attitude, interests, responsibilities of LMV/Taxi Drivers
- To analyze the problems, challenges, issues of LMV/Taxi drivers in organized and unorganized sectors
- To observe technical issues related to their profession
- To forecast career prospects & growth
- To assess the driver's ambitions towards further education & training
- To predict the possibility of offering a certificate/diploma course by CE/DE
- To establish Skill Development /Facilitation /Study/Training/ Simulators at different locations of Hyderabad
- To identify the possibility of involvement of academic /government /RT/Law & Order/Unions/NGOs

### *D. Hypotheses*

- There is no significant difference between literacy and traffic awareness
- There is no significant difference between experience and traffic awareness
- There is no significant difference between literacy and observing MV Act rules & regulations
- There is no significant difference between experience and observing MV Act rules & regulations
- There is no significant difference between literacy and attitude & the responsibility of drivers
- There is no significant difference between experience and attitude & the responsibility of drivers
- There is no significant difference between literacy and safety precautions of drivers
- There is no significant difference between the experience and safety precautions of drivers
- There is no significant difference between literacy and technical knowledge & maintenance of vehicles
- There is no significant difference between experience and technical knowledge & maintenance of vehicles

### *E. Research design, sampling, and data collection methods:*

It is initially started to collect a sample of 600 from LMV/taxi drivers. Still, due to the severity of COVID-19 and the difficulty of personal contact and interviews, the numbers were reduced only to interview through a schedule canvassed to around 400 drivers due to state and central government restrictions and because of the convenience of respondents. The data collection is from the primary source point to point contact by maintaining necessary personal distance and with necessary PP kits by the people who collected data under the government's directives. It is planned to collect in four ways, i.e., questionnaire, schedule, personal interaction, and video with timestamps by our representative teams. It is decided to cover all four corners of Hyderabad Metro Limits. Data collection is based on convenient and purposive sampling in identifying the location and with reference to the respondents at random. The entire data is primary data with its general and specific limitations of both respondents and persons involved in collecting data.

## II. LITERATURE SURVEY

At present, much literature is not collected from secondary sources. Many of us know the primary, secondary, socio-cultural, psychological, and behavioral issues of drivers in general and their issues and challenges in particular because of the risk involved in their profession. However, the study mainly focuses on attitude, behavior, responsibility, safety, maintenance, and technical knowledge concerning their educational background and experience. However, there were some studies found suitable in light of the present study across the globe.

Researchers usually use virtual customer origin-destination demand patterns to analyze the taxi service model, which can refer to Arnott (1996) R. Arnott, "Taxi travel should be subsidized," Journal of Urban Economics, vol. 40, no. 3, pp. 316–333; H. Yang and S. C. Wong, "A network model of urban taxi services," Transportation Research Part B: Methodological, vol. 32, no. 4, pp. 235–246, 1998; and K. I. Wong, S. C. Wong, and H. Yang, "Modeling urban taxi services in congested road networks with elastic demand," Transportation Research Part B: Methodological, vol. 35, no. 9, pp. 819–842, 2001.

D. Luo, Urban Mixed Traffic Network Equilibrium Analysis under the Influence of Taxi Services, Dissertation of Central South University, Changsha, China, 2009 For the taxi driver's characteristics (driving experience, road network familiarity, etc.) and randomness of the passenger's arriving, the driver's searching for the next passenger can be seen as a random variable. Luo (2009) had expressed taxi driver's searching for the next passenger as a double exponential (Gumbel) distribution.

L. Liu, C. Andris, and C. Ratti, "Uncovering cabdrivers' behavior patterns from their digital traces," Computers, Environment and Urban Systems, vol. 34, no. 6, pp. 541–548, 2010. Liu et al. (2010) described the taxi driver's operation patterns and the difference between top drivers and ordinary drivers' behavior in Shenzhen and discussed taxi drivers' behavior based on the taxi daily GPS traces data; they analyzed the drivers' spatial selection behavior, operation behavior, and route choice behavior. But in the research of Liu et al. (2010), they did not mention drivers' searching space behavior pattern. This paper attempts to bridge these gaps between theoretical research and practical development, based on Shenzhen's taxi GPS trajectories data to explore urban land use and taxi drivers' operation behavior. This paper focuses on the time series distribution dynamic characteristic of passengers' temporal variation in certain land-use types and taxi drivers' searching behavior connection between different activity spaces for different observation periods. This paper focused on the following topics (1) Exploring the taxi driver operation behavior by the measurements of activity space and the connection between different activity spaces for different time duration; (2) Mainly focusing on eight TAZs of Shenzhen and exploring the customer's real-time origin and destination demand on spatial-temporal distribution on weekdays and weekends; and (3) Taxi station optimization based on the passenger demand and expected customer waiting time distribution.

Giraudo and Peruch (1988) had divided the taxi operation into two phases, "the transport phase" and "the approach phase," which also can be used to represent the taxi with passenger and without passenger operation, respectively. The taxi drivers searching passenger behavior happens in "the approach phase." When the driver has dropped off the prior passenger, then he/she drives around the area or region searching for the next passenger after a short time. M.-D. Giraudo and P. Peruch, "Spatio-temporal aspects of the mental representation of urban space," Journal of Environmental Psychology, vol. 8, no. 1, pp. 9–17, 1988.

R. Cervero and K. Kockelman, "Travel demand and the 3Ds: density, diversity, and design," Transportation Research Part D: Transport and Environment, vol. 2, no. 3, pp. 199–219, 1997. mit.edu. the built environment is thought to influence travel demand and three principal dimensions density, diversity, and design. This paper tests this proposition by examining how the '3Ds' affect residents' trip rates and mode choice in the San Francisco Bay Area. Using 1990 travel diary data and land-use records obtained from the US census, regional inventories, and field surveys, models are estimated that relate features of the built environment to variations in vehicle miles traveled per household and mode choice.

R. Arnott, "Taxi travel should be subsidized," *Journal of Urban Economics*, vol. 40, no. 3, pp. 316–333, 1996. In a first-best environment, taxi travel should be subsidized. The result derives from economies of density—doubling trips and taxis reduces waiting time. The subsidy should cover the shadow cost of taxis' idle time, evaluated at the optimum. The paper provides proof of the result for dispatch taxis and then discusses its implementation's practicality.

C. Kang, X. Ma, D. Tong, and Y. Liu, "Intra-urban human mobility patterns: an urban morphology perspective," Physica A: Statistical Mechanics and its Applications, vol. 391, no. 4, pp. 1702–1717, 2012. This paper provides a new perspective on human motion with an investiGATIon in determining how human mobility patterns inside cities are affected by two urban morphological characteristics: compactness and size. Mobile phone data have been collected in eight cities in Northeast China and used to extract individuals' movement trajectories. The massive mobile phone data provides wide coverage and a detailed depiction of individuals'.

Y. Zheng, Y. Liu, J. Yuan, and X. Xie, "Urban computing with taxicabs," in Proceedings of the 13th International Conference on Ubiquitous Computing

(UbiComp '11), pp. 89–98, ACM, Beijing, China, September 2011. Urban computing for city planning is one of the most significant applications in Ubiquitous computing. This paper detects flawed urban planning using taxi cabs' GPS trajectories traveling in urban areas. The detected results consist of (1) pairs of regions with salient traffic problems and (2) the linking structure and correlation. These results can evaluate the effectiveness of the carried out planning, such as a newly built road and subway lines in a city, and remind city planners.

K. I. Wong, S. C. Wong, and H. Yang, "Modeling urban taxi services in congested road networks with elastic demand," Transportation Research Part B: Methodological, vol. 35, no. 9, pp. 819–842, 2001. This paper extends Yang and Wong's urban taxi services (Yang, H., Wong, SC, 1998. Transportation Research B 32, 235–246). The extensions include incorporating congestion effects, customer demand elasticity, reformulation of the model, and developing a new solution algorithm. Instead of the previous characterization of pure taxi movements in a network by a nonlinear system, a two-level model formulation is proposed for taxi movements in congested road networks.

N. Sathaye, "The optimal design and cost implications of electric vehicle taxi systems," Transportation Research Part B: Methodological, vol. 67, pp. 264–283, 2014. In recent years, taxis in multiple cities and metropolitan areas worldwide have shifted to utilizing alternative fuel options. Such change has significant potential to reduce environmental externalities and can contribute to alleviating energy policy concerns. However, little work has been conducted to assess the tradeoffs between selecting various taxi fuels or designing alternative fuel taxi systems. These tradeoffs exist due to the differing costs associated with fleet replacement, infrastructure deployment, and operations**.**

### *A. Limitations of the study*

As usual for any research study, here also there are many limitations to our study. Some of them are listed as Personal bias, Geographical issues, Time & cost constraints, Technique bias, Forced choice of drivers, Unable to gauge the behavior based on experience, issues, and challenges as they do not fit into scale, Socio-economic issues, and some legal issues regarding environment protection.

### *B. Future scope*

At present study involved only LMV/Taxi drivers in and around Hyderabad only. Similar studies can be conducted in every city/ town /suburban/ villages /hamlets. Moreover, the study took all ages without special focus on their income levels, assets, number of dependents, technical issues regarding training, issuing licenses, renewals, permits and dexterity tests, and other specific problems they faced in the city and outskirts. There is a lot of scope for further dichotomy, attribute-based study, organization-based study, formal and informal studies, and so on. One can conduct in different provincial cities and conduct F-Tests, issues of mileage, and other problems the drivers/passengers face for their timely reach to office/destination, traffic, mileage, and any other related issues.

## II. DATA COLLECTION & PRESENTATION ON SKILL GAP STUDY LIGHT MOTOR VEHICLE DRIVERS

The following is the category of various respondents with reference to the LMV survey of 180 individuals during September 2020 in different locations of Hyderabad Metro and its surrounds and all four corners covered by the research team such as Siddipet, Medchal, BHEL, Uppal, and Dilsukhnagar they covered within and around ORR of Hyderabad.

**Table 1**

| ***Description*** | ***No S*** | ***%*** |
|---|---|---|
| AUTO | 21 | 12% |
| DCM/TRUCK | 51 | 28% |
| HEAVY | 23 | 13% |
| MINI/MICRO | 77 | 43% |
| OWNERS | 8 | 4% |
| TOTAL | 180 | 100% |

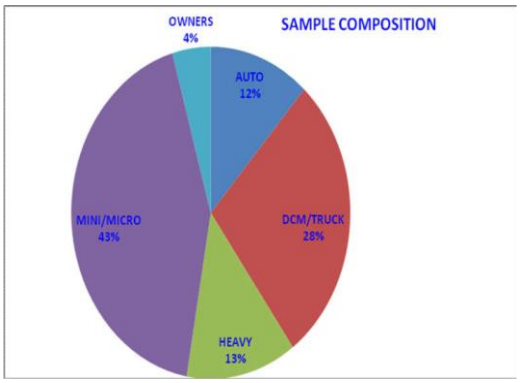



**Fig. 1 Sample Composition**

### *A. Scoring Pattern of Respondents:*

The following is the pattern of successful responses by way of choice of correct answer out of available options given to them to understand their literacy levels, experience in occupation and technical knowledge related to their profession at present they are in and expectations of government especially regarding traffic rules, regulations and general/specific awareness after getting a driving license and continuing the profession as on the date of the survey. It is quite noticeable that only 22/180 respondents (12%) scored less than 10 points by correct responses, followed by 94/180 respondents(52%) who marked correct answers by 11-16 points, and the rest scored above 17 points up to 21 questions; which alarms to retrain people towards their profession for better performance. Around 64% of

respondents scored 15 points where their Job expects 100% performance, unlike other professions where there is a cushion in targets and performance. Poor or Underperformance leads to many accidents, poor maintenance of vehicles without proper understanding and causes damage to the organization, insurance companies, family members of victimized and including own family members that tax the economy to invest more by way quality of living standards. The overview gives a lot of scope to the government to identify the need for flexible multi-functional-training complexes in many cities/towns/villages to provide proper education & training to rescue the economy from sudden fall down financial/social strength of dependents of the deceased. This sector can't be addressed online/off-job training. The government should identify the necessary tailor-made skill/orientation/training programs suitably through RTA/NGO/Govt/Private Agencies and provide the scope of efficient professional, social and economical up-lift the weaker sections of the economy. They are the economy's backbone through logistics arrangements in any economy; hence the economy became handicapped if they are not up to the mark.

**Table 2**

| Points Scored | 10 Points | 11-16 Points | 17-21 Points |
|---|---|---|---|
| No | 22 | 94 | 64 |
| % | 12.22 | 52.22 | 35.56 |

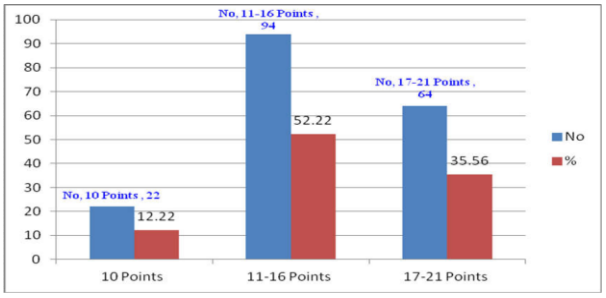



**Fig. 2 Scoring Pattern of Respondents**

### *B. Age-wise distribution:*

A lion share of respondents are below the age of 50 years, i.e., 66% of count which gave researchers a better scope for improvement by training and upgrading of respondents even after 50 years of their age, and they can be in the profession for another decade by two times renewal of five years each as per Motor Vehicles Act. Hence the study is fruitful and provides light on need-based training programs at different locations of Hyderabad. This study provides a different angle under RPL. Many of the respondents are having general education. Now we can bring them into the ring under the NSQF-UGC scheme and provide vocational education, especially in the field of automobile engineering, and upgrade them in their own chosen career from unskilled to semi-skilled/skilled employees in any formal organization, sometimes even they can erode as front line managers in operations wing of any private sector organization.

**Table 3.**

| Age---> | 20-29 | 30-39 | 40-49 | >50 |
|---|---|---|---|---|
| No. of Respondents | 47 | 57 | 31 | 45 |
| % | 12.22 % | 52.22 % | 35.56 % | 35.56 % |

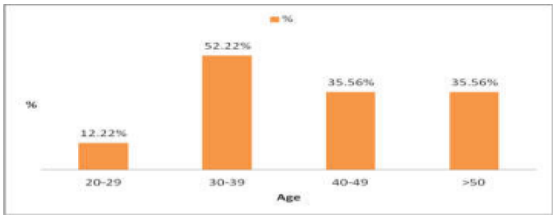



**Fig. 3 No of Respondents AgeWise**

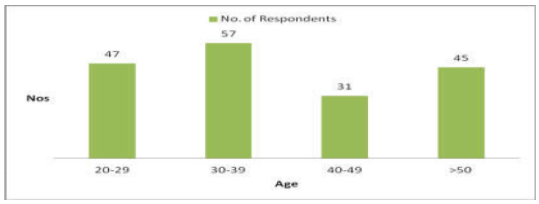



**Fig. 4 % of Respondents Age Wise**

### *C. Qualification Index:*

The respondents' education pattern is really useful and serves the purpose of the survey, and provides ample scope to uplift them toward better professional advancement and career development. As many of them are up to higher secondary education, this point triggers RPL and reorient them under NSQF of UGC and Central Government Kaushal Schemes. It provides better scope for Certificate/Diploma/UG/PG courses. Especially in this field if they can have any diploma that helps them grow up in their present career and provide scope to turnout from blue-collar to white-collar i.e., middle level technical advisors in big logistic firms/enterprise. On one side, they can improve their educational qualification. On another side, they can build their career, as the central government is behind them to support in all respects and increase their quality of work-life and living standards.

**Table 4**

| Qualifications | Illiterates | ELE/P/UP | SSC/HSC | UG/PG |
|---|---|---|---|---|
| No. of Respondents | 27 | 35 | 109 | 9 |
| % | 15.00% | 19.44% | 60.56% | 5.00 % |

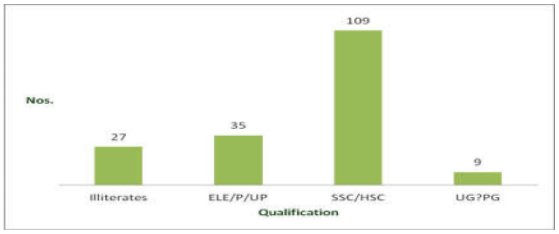



**Fig. 5 No of Respondents Qualification Wise**

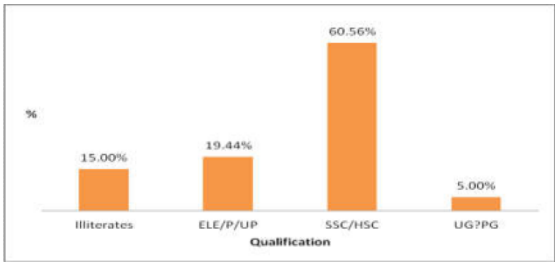



**Fig. 6 % of Respondents Qualification Wise**

### *D. Experience Index:*

The diversity of experience gave another angle to the study. It helped us understand the tune and length of the training program, the number of programs, ad-hoc programs, and the benefit that respondents get after the program. Simply it provides a list & gist of revenue that can be generated for the benefit of their family members and job satisfaction levels in the rest of life by way of surplus life, income, and revenue generated by the beneficiaries. It gives scope to the government agencies for specific/ad-hoc full/part-time programs and their timings. Authorized government agencies can partner with academic institutions, industry, tradeunions,RTAagencies/franchises,sellers/dealers/principal manufacturers, and state and the central government in this program. The government may even extend the study by considering the trainer's competence by 'train-a-trainer' programs.

**Table 5**

| Experience | <5 Years | 10 to 19 Years | 20 to 29 Years | 30 to 39 Years | 30 & Above Years |
|---|---|---|---|---|---|
| No. of Respondents | 28 | 64 | 54 | 26 | 8 |
| % | 15.56 % | 35.56% | 30.00% | 14.44% | 4.44% |

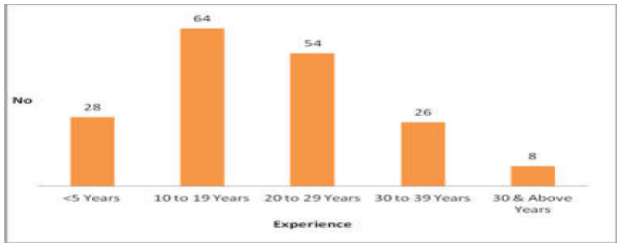



**Fig .7**

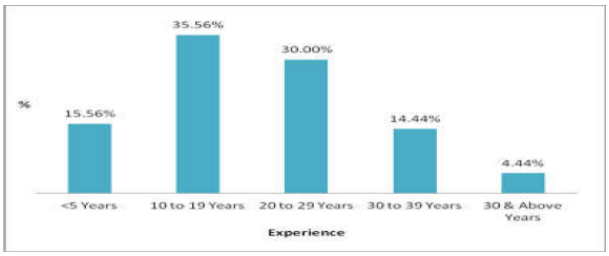
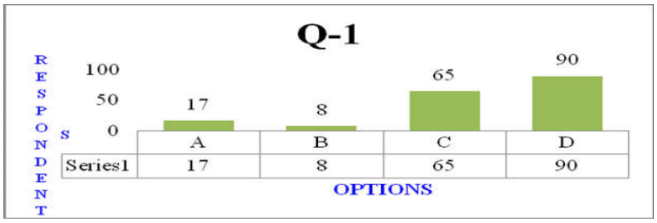



**Fig. 8**

## ANALYSIS OF RESPONSES

1) By what percentage do the seatbelts reduce the risk of death for a person sitting in the front seat?
(a) 40 Percent (b) None of these (c) 60 percent (d)50 Percent

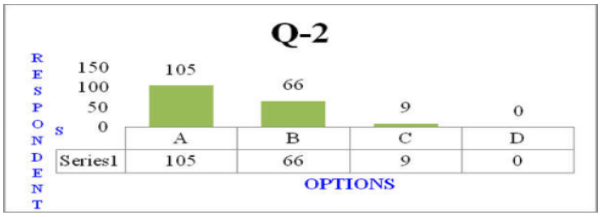



Interpretation of Q1: Exactly 50% of respondents opted for the correct answer for the enquired question of the 29%(26/90) have literacy below primary and have experienced below five years. The rest of the sample though literates and having a good amount of experience in the profession, couldn't answer the question properly. Hence, there is a lot of scope ab-initio to start with technical and general skill up-gradation programs to the respondents. It is found in the general observation that many of them are ready to learn about their profession but found a dearth of the right platform/arena to retrain/retreat them. This situation determines the need for training for all categories of respondents appropriately, and some ad-hoc programs can be chalked-out with the involvement of the local community, trade-unions, RTA, Police Department & State/Central Government.

A Chi-Square test was conducted at one degree of freedom at different levels of significance among respondents to test the impact of literacy and experience on the safety attitude. The reported critical values(as per statistical tables at different levels of significance, i.e., at 1% level 6.63, at 5% level it is 3.84, and finally at 10% level it is

2.70. These values are compared with calculated values, and finally, inferences are drawn in general for all questions. After thorough analysis, it is observed that there is no significant difference between and amongst respondents with reference to educational qualification; but there is a significant difference with regards to the experience of respondents. Hence, nobody can be brought experience all of sudden, but the government and partnering organizations can provide simulator training wherever possible through IT/AI tools and techniques in addition to Expert/Intelligent Decision Support Systems. Corresponding chi-test cross-table data annexed at the end of the report.

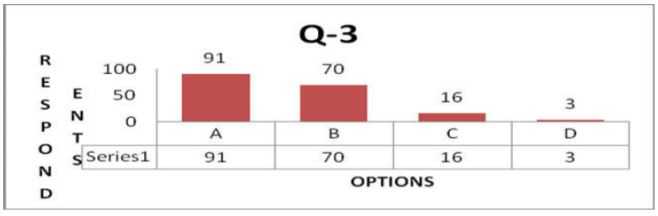
2) Hand Brake is used to control a skid
(a)True (b) False (c) Maybe both (d)None of the above




Interpretation of Q2: 63% (114/180) of respondents beat on this question and are unable to answer the purpose of the lever in the cockpit. Of the 73% (83/114) are having more than five years of experience in the profession. 60% (50/83) of respondents opt for the wrong answer and have a better education. Hence, this situation demands the need for some or other sort of technical training and orientation towards their profession, especially literates; which reveals the fact that the literacy and experience do not have any influence on profession towards technical- excellence.

A Chi-Square test was conducted at one degree of freedom at different levels of significance among respondents to test the impact of literacy and experience on the safety attitude. After thorough analysis, it is observed that there is no significant difference between and amongst respondents with reference to educational qualification; but there is a significant difference with regards to the experience of respondents. This means and includes some sort of technical training is to be adopted for all respondents and also suggested to all drivers irrespective of the study.

3)Helpers springs are usually used
(a)In heavy Vehicles in the suspension system to obtain a two-stage spring rate (b) In vehicles to improve the load capacity of suspension systems (c) To provide anti-rolling effect (d) To stiff the suspension

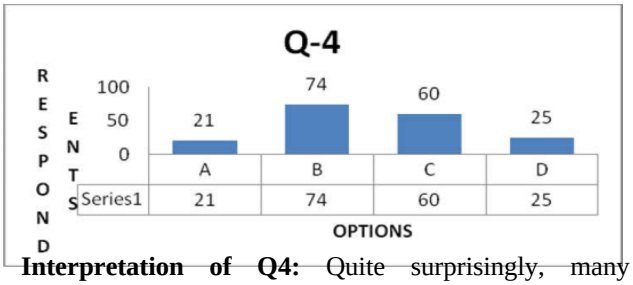



**Interpretation of Q3:** 50%(91/180) gave a correct answer; of them, illiterates are 37%(10/27). 76%(69/91) of them are having more than five years of experience and having a literacy level at higher education are 51%(35/69). This scenario provides scope for the adaption of training programs of different tenures to a different category of respondents. Some of the experienced respondents alternatively answered that it is even being used to load management. This would alarm us to provide necessary skill up-gradation programs.

A Chi-Square test was conducted at one degree of freedom at different levels of significance among respondents to test the impact of literacy and experience on the safety attitude. After thorough analysis, it is observed that there is no significant difference between and amongst respondents with reference to educational qualification at 1% level only, and there is a significant difference at 5% & 10% LOS indicates that there is a need for re-education and technical configuration awareness. Further, there is no significant difference at all levels with regard to the experience of respondents. There is a curiosity attribute found significant among illiterates and support the urge for retraining and reorientation.

4)How should you clean the sulphation on battery terminals?

(a)With cold water (b)With warm water (c) With Distilled water (d) With tap water

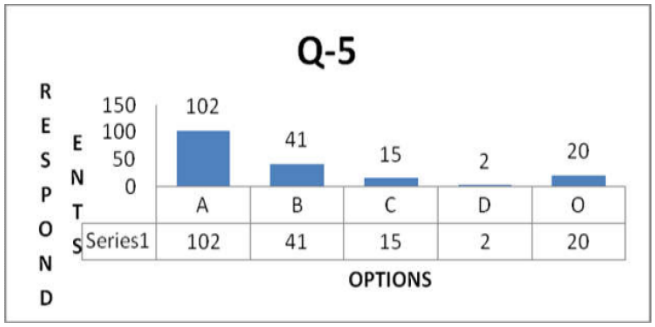



**Interpretation of Q4:** Quite surprisingly, many respondents don't know how to clean/maintain the battery-terminals and stated that nowadays, they are getting maintenance-free batteries. One should appreciate at least they know that part of the vehicle. 59%(106/180) of respondents did not give correct answers of the respondents having experience more than five years in the profession are 69%(73/106). Out of them, respondents having a good literacy level are 60%(44/73).

A Chi-Square test was conducted at one degree of freedom at different levels of significance among respondents to test the impact of literacy and experience on the maintenance of electrical items in the vehicles and their attitude & responsibility. After a thorough observation, it is found that there is no significant difference between and amongst respondents with reference to educational qualification and experience.

5)The backward tilt of the centerline of the ball joints from the vertical is called

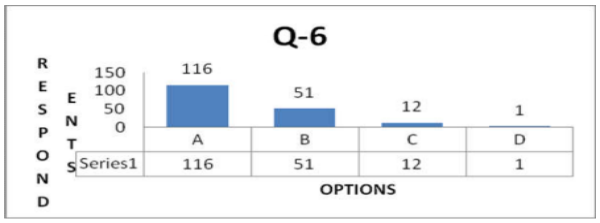
(a)Positive caster (b) Negative Caster (c) Positive Camber (d) Negative Camber




**Interpretation of Q5:** Though the majority of the respondents are answered correctly, they do not have technical knowledge of several terms used in the response sheet. Only at the time of wheel alignment and balancing they come across these terms, but they go by the advice of the technical advisor whether to replace damper/suspension/ partial replacement/repair of LH/RH joints/shafts/cross-joints separately. Even today, they are using local/vernacular language to change components/ consumables/accessories, etc. This shows the importance of technical education and training with reference to their profession.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the impact of literacy and experience on the technical knowledge and maintenance of their vehicles. It is understood that there is no significant difference between and amongst respondents with reference to educational qualification and but experience matters, especially technical knowledge though respondents have primary education.

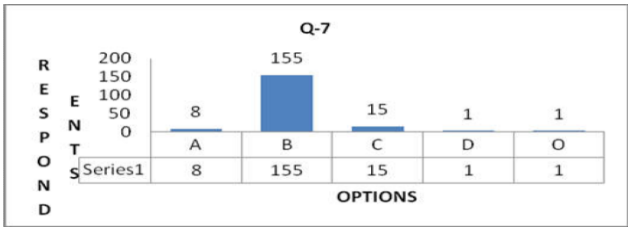
6)The trip meter can be reset
(a)True (b) False (c) Maybe both (d) None of the above




**Interpretation of Q6:**

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the DIS(Driver Information System) impact of literacy and experience on the basic knowledge and reporting on their vehicle's performance of both vehicle and driver technically. It is understood that there is no significant difference between and amongst respondents with regards to reporting mechanism by education and experience. In view of the about information, it is suggested to provide necessary re-orientation programs on the interpretation of technical values and corresponding remedial actions of drivers in the cockpit.

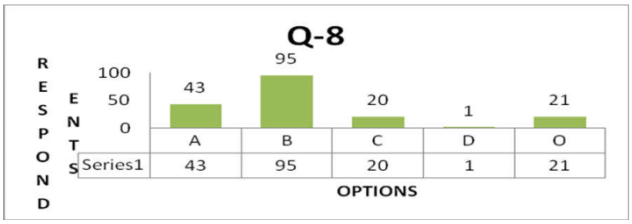
7)What does the temperature gauge indicate?
(a)Outside Temperature (b) Engine Temperature (c) Oil Temperature (d) None of the above




**Interpretation of Q7:** Out of 56%(14/25), wrong answers gave by the respondents having SSC to Degree level literacy and of which 93%(13/14) are having more than 5 years experience surprisingly. This situation provides the scope for technical training to respondents. Many technical failures of vehicles are only because of improper maintenance of vehicle lead and underutilization of resources by the way failure of warranty and guarantee from manufactured components.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the TDIS(Technical Driver Information System) impact of literacy and experience on the basic knowledge and to report on their vehicle performance of both vehicle and driver technically. It is understood that there is no significant difference between and amongst respondents with regards to reporting mechanism by education and experience. Somehow or other all respondents know about temperature gauge and its effect on both engine performance and their side effects.

8) What is called SFC with respect to controls
(a)Specific fuel consumption (b) Semi forward control (c) Super forward cabin (d) all of the above

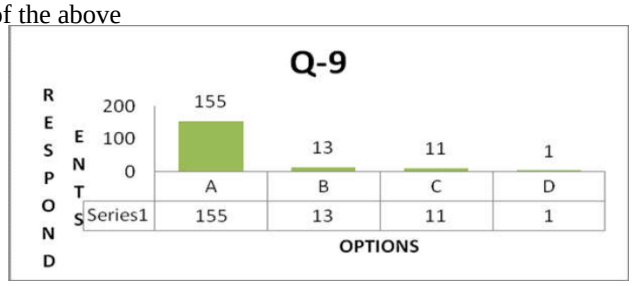



**Interpretation of Q8:** 48%(85/180) of the having poor understanding about control of the vehicle showing a negative impact on fleet control, without knowing anything they are running vehicles alarms for technical training to drivers of all categories. Surprisingly 17.64%(15/85) only count illiterates, and the balance is literates. 60%(51/85) are having SSC and above the literacy level. Surprisingly there were 12%(21/180) blank responses of which literates count was 81%(17/21) balance are illiterates. The given situation

alarms us to provide necessary training to them, whether offline or online, by establishing some multi-functional complexes in every town/city/suburban area with the help of the government. It is noticeable that 10 out of 17 respondents who gave blank answers are SSC, which reveals the seriousness of the situation and the severity of action to be taken up by the concerned departments responsible.

A Chi-Square test was executed at one degree of freedom at different levels of significance between and amongst respondents to understand the engine-related TDIS(Technical Driver Information System) impact of literacy and experience on the basic knowledge of reporting on their vehicle's performance technically. It is understood that there is no significant difference between and amongst respondents with regards to reporting mechanism by education and experience. Many of the respondents exhibited the knowledge, but raw statistics show the significant difference, which means and includes that some more investigations are necessary for this direction.

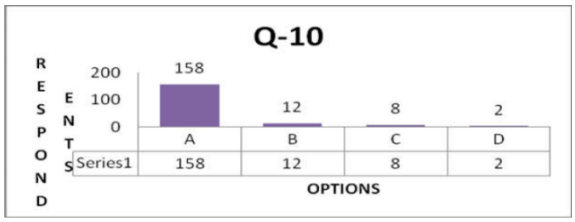
9) What is the purpose of the Rear view mirror?
(a)For viewing the traffic from the behind (b) For checking the passengers (c) A hazard as it causes distraction, d) None of the above




**Interpretation of Q9:** 21/25 was surprisingly literates don't know the purpose of the rearview mirror, and out of 21, 19 are above SSC level. This situation provides a lot of scope for training and educating the respondents with reference to their occupation and make them perfect. There are some cunning drivers who answered that it is to observe passengers probably they are in the riding of cab/auto at a prior level before taking up this Job. However, it is another question that makes an attempt to understand the attitude of the driver and provide relevant education.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the GIS(General Information System) impact of literacy and experience on the basic knowledge and terrific attitude shown that there is no significant difference between and amongst respondents with regards to the general knowledge on education and experience.

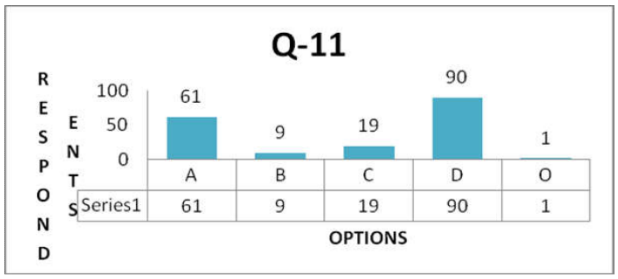
10)What is the safety device for the passengers & Drivers in the car?
(a)Seat belts (b) Door handle (c) Instrumental Panel (d) None of the above




**Interpretation of Q10:** 82%(18/22) of literates don't know the safety equipment in the vehicle itself, and no surprise, it repeats with another part of the survey. Hence, there is significant scope to provide education and training regarding traffic rules, safety devices, and rules either of Job or on Job. Many respondents felt that they start learning many things after they got a driving license and on entry into the profession. Issuance of the driving license itself is in question in India. They expressed if somebody can demonstrate the handling of the vehicle in exigencies and emergencies, that is quite helpful to them.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the safety equipment or components in the vehicle to rescue persons inside the vehicle. Assessment of the impact of literacy and experience on the basic safety knowledge and alert attitude cum awareness; it is found that there is no significant difference between and amongst respondents with regards to the educational qualification and experience.

11)You wish to park facing downhill. Which of the following should you do?
(a)Turn the steering wheel towards the kerb and put the hand brake on firmly (b) Park close to the bumper of another car (c) Park with two wheels on the kerb (d) Turn the steering wheel away from the kerb.

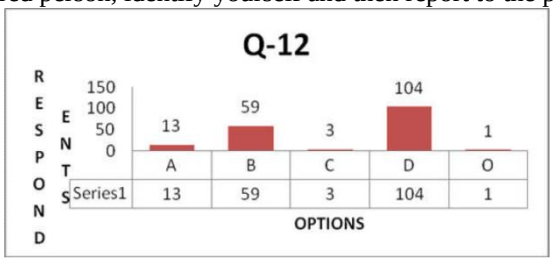



**Interpretation of Q11:** 50%(90/180) of respondents don't know about the technicalities of driving skill, and around 30%(33/90) are literates. Here, there is an opportunity to provide proper training to identified respondents based on the educational level and background. Corporate drivers little bit know about technical terms because of the training from the end of the organization. Where in other cases, they

never bother to know the technicalities involved in the profession.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the safety equipment or components in the vehicle to rescue persons inside the vehicle in general to assess the impact of literacy and experience on the basic safety knowledge and alert attitude and awareness; it is found that there is no significant difference between and amongst respondents with regards to the educational qualification at 1% LOS only, but it is significant at 5% & 10% levels of LOS educational qualification matters. With reference to the respondent's experience for the same question that there is no significant difference at all levels of LOS. Hence, there is a scope for providing technical training to all the respondents irrespective of education & experience.

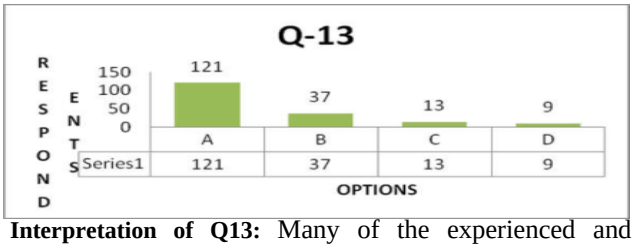
12)If your vehicle hits a pedestrian, you should:
(a)Identify yourself and leave (b) Help the person and call an ambulance (c) Avoid been seen by the public (d) Help the injured person, identify yourself and then report to the police




**Interpretation of Q12:** 57.77%(104/180) respondents gave the correct option, but some of the respondents raised calling ambulance rather than finding police is better in a critical situation. Once upon a time, it is not allowed. Now medico-legal cases are also allowed without the interference of police to save the life of the injured is still justifiable, and one should appreciate their attitude to save people at critical times. 17 respondents couldn't give any correct answer, and it is noticeable that they are having more than 10 years of experience and educated.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the traffic rules awareness and its impact on literacy and experience on the basic knowledge of their prevailing MV Act and general rules. It is understood that there is a significant difference between and amongst respondents with regard to their educational qualifications. The experience of the drivers didn't fetch any right answer; hence the null hypothesis was rejected and indicated us to provide some programs to understand the responsibilities of drivers, especially when accidents took place.

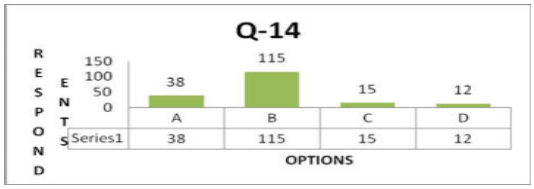
13)When should you switch on your hazard warning lights? When you cannot avoid causing an obstruction (b) When you are driving slowly due to bad weather (c) When you are towing a broken down vehicle (d) When your vehicle is parked on double yellow lines.




**Interpretation of Q13:** Many of the experienced and literate drivers answered it could be even for bad weather condition, towing, and sudden stop of the vehicles due to technical failures on double yellow lines; many of the respondents tried to defend themselves with other answers showing their curiosity about learning new things and questioning facts pose scope for further education and training for them. 47.45%(28/59) are having 10 years of experience and good education, which indicates that there is no impact on education and experience on the attitude of the driver

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general attitude, behavior and responsibility and impact of education and experience reveals that at 1% & 5% levels of significance as calculated value is lower than table value with regards to educational qualification Ho Accepted, but at 10% level of significance, the same is rejected. With reference to experience is concerned that there is no significant difference in experience between and amongst respondents. This means one should educate drivers irrespective of education and experience on the right platform.

14)You are traveling at the legal speed limit. A vehicle comes up quickly behind, flashing its headlights. You should (a)Accelerate to make a gap behind you (b) Depress the brakes sharply to show your brake lights (c)Move to the right to prevent the vehicle from overtaking (d) Allow the vehicle to overtake.




**Interpretation of Q14:** Many respondents answered correctly but raised a doubt that as per their experience, nobody follows traffic rules and overtake without blowing the horn and flashing headlights even night time also. We thought we know the rule many of us desperate ly

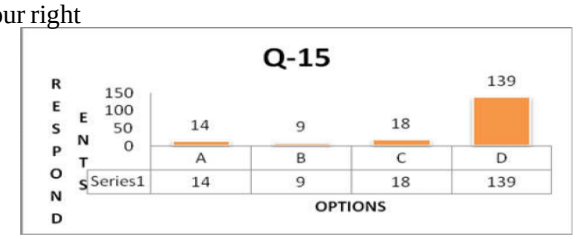
accelerate the vehicle to maintain a gap and later give way to them to overtake. As per their experience, young drivers don't give way to overtake.

61.50%(40/65) of respondents having very good literacy, but their experience is less than 5 years they couldn't understand the value of life because of accidents. This particular question shows the need for training of young drivers.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general attitude, behavior and responsibility and impact of education and experience reveals that at all levels of significance, the calculated value is lower than table value with regards to educational qualification Ho rejected at all level of significance. With reference to experience is concerned that there is no significant difference between and amongst respondents. This point provides scope for educating the respondents further.

15)You want to turn right from the main road into a side road. Just before turning, you should

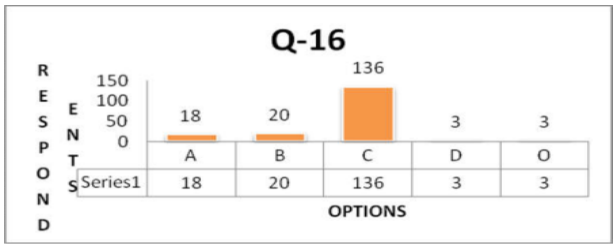
(a)Select First Gear (b) Cancel your right turn signal (c) Stop and set the hand brake (d) Check for traffic overtaking on your right




**Interpretation of Q15:** Many respondents at first instance couldn't understand the question later answered correctly. However, 22.77%(41/180) of respondents couldn't answer the question properly though they have better literacy and experience again warn literacy and experience does not impact the behavior of drivers. 63.41%(26/41) are having more than 10 years of experience, and out of them, 69.23%(18/26) are having higher education but not understood the importance of traffic awareness and behavior A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general attitude, behavior, and responsibility, and impact of education and experience reveals that at all levels of significance that the educational qualification has no impact and not associated. But when it comes to experience, it matters. Suppose the experience of the driver has increased the behavior and attitude of drivers subjected to some change in answering questions rightly. However, we can't increase experience, but we can educate people in this profession by simulator experience.

16) You wish to overtake a long, Slow-moving vehicle on a busy road where traffic is moving in both directions. You should

(a)Follow it closely and keep moving out to see the road ahead (b) Flash your headlights to warn traffic coming from the opposite direction to stop (c) Keep well behind until you see the road ahead is clear and then overtake (d) None of the above

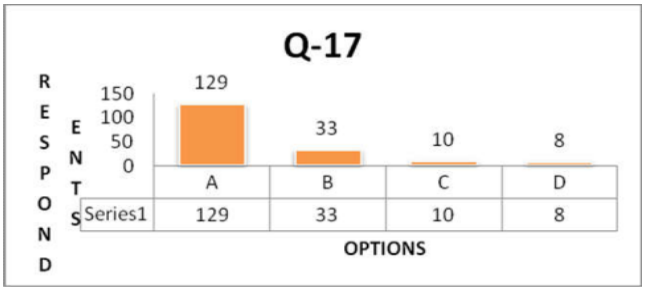



**Interpretation of Q16:** Good response to this question by lion part of the respondents. However, there were around 24.44%(44/180) of respondents who wrongly answered the question, defend all are correct in their perspective, and we use all simultaneously. 27.27% (12/44) are well educated & experienced who answered the question differently alarm the researchers to provide some sort of reorientation may be required. Here also age, experience & education does not affect the traffic behavior of drivers, and sometimes it is quite surprising that there is no empathy in drivers and they are willing to ride as they like rather understanding the fact that the probability of driving-skill of us arrest accidents to the extent of only 50%.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general attitude, behavior, self-responsibility, impact of education, and experience reveals that at all levels of significance that there is no significant impact of educational qualification and experience when it comes to the self-responsibility regarding traffic rules, general awareness and safety, that all the respondents exhibit the similar experience.

17) Following documents are required along with the Driver during duty

(a)RC, Insurance, Permit, DL & Pollution (b) RC, Pollution, DL & Insurance (c) None of the above (d) Only DL

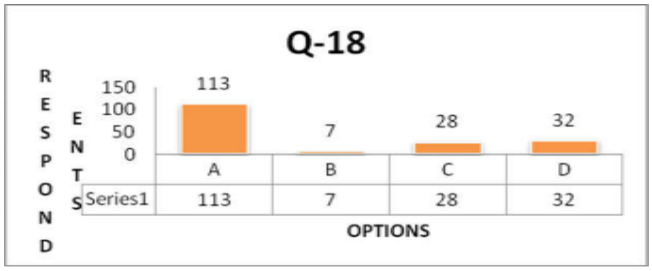


**Interpretation of Q17:** Good response for this question by lion segment of the respondents 71.66%(129/180) of respondents rightly answered the question, Around 18.33%(33/180)Some of the respondents chose the alternative answer that is also equally correct but raised doubt that nowadays we are all having smart mobiles and the department allowing online data through RTA wallet in city surrounds, and more to that Euro-IV vehicles are hybrid engines and non-pollutants. However, 51/180 respondents not correctly answered, which alarm us to educate them on what papers are to be carried while on duty.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general MV Act and self-responsibility. It found that there is a significant difference between education & experience in understanding the traffic rules and prevailing systems of verification and documents to be carried while driving in vehicles. However, one should create awareness about documents that are physically supposed to be carried and digital awareness. These are not only limited documents, so many other related documents need to be carried in the case of LMV vehicle drivers.

18)The following signs represent?

(a) Traffic Island Ahead (b)Hospital Ahead (c) Give Way (d)None of these

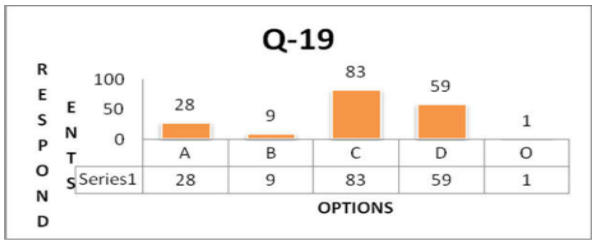



**Interpretation of Q18:** Out of all, 37.22 % of respondents do not understand the signboards used at various cross-sections road, and moreover they answered nobody could remember that many symbols and argued that the visibility level of symbol and size of the signboard is in question. And they said while going at 50KMPH speed, it is impossible to read signboard in English/Telugu/Vernacular Language. Hence, it is hereby suggested the respective authorities increase the size and display of the boards in the right places. Some of the experienced drivers pointed out that the signboard is exactly where the right/left compulsory turn is there it is impossible to follow, especially in Hyderabad. Even on ORR, also they pointed out some of these problems. Some drivers with better literacy levels advised instead of charging no parking challans, better stop, and ask the meaning of many symbols and create awareness. Many of the respondents who gave wrong answers are having more than 10 years of experience and better education levels. This reveals that education and experience together don't have any impact on traffic sense.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the general MV Act signs and driver's responsibility. It is found that there is no significant difference between and amongst respondents based on their education. But experience matters in understanding the traffic signs, symbols, and traffic rules. This point should be noted that there is a scope for retraining the respondents, especially with reference to acquiring knowledge of traffic signs, symbols, and rules across India; this is because now-a-day vehicles are under national permits than route permits. It is further noticed drivers who are in the ambition of going abroad must have sign-board knowledge primarily in addition to minimum educational qualification in many countries. Hence, a good number of programs to be scheduled in this direction.

19)When fuel is filled into a vehicle?

(a)None of these (b) Shall check air pressure (c) Shall not smoke (d) Shall not use any light of the vehicle

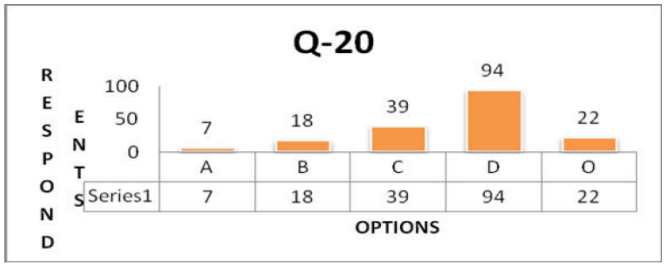



**Interpretation of Q19:** Only 46.11% of respondents gave the correct answer as per the questionnaire; this is quite a pathetic situation, but some parts good they know somehow about dos and don'ts fairly. In many of the petrol filling stations/pumps expressly exhibit at all conspicuous places both visuals and placards, many drivers do not understand the behavior that they should exhibit while filling fuel into their vehicles. Many of them answered both C and D, and in general, all the answers are correct, but in a particular context, it is D. 34.44%(62/180) of respondents having 10 years of experience with better literacy levels. This notice us literacy and experience together don't have any significant impact on the behavior of drivers. One respondent even not answered anything, give scope to us to provide proper training in this regard.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the driver's responsibility, especially at the time filling fuel into their vehicle. It is found that there is no significant difference between and amongst respondents based on their education and experience. It is

good to see that all the respondents are based on the test. But raw data reveals that there is a slight difference because of the fact that all answers are more or less correct, and there is no option for all of the above. The options put them in a dilemma about the correctness and perfectness of the driver.

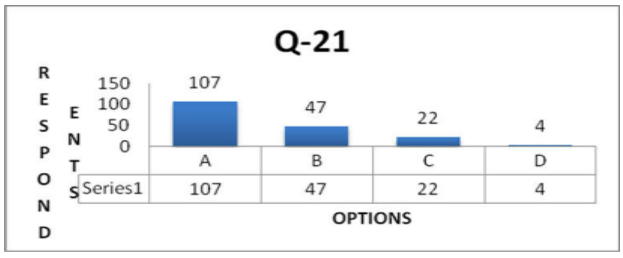
20)A person crosses 600 m long street in 5 minutes, what is his speed in Km/hr? (a)10 km/hr (b) 3.6 km/hr (c) 8.4 km/hr (d) 7.2 km/hr




**Interpretation of Q20:** It is the quite puzzling lion share of the respondents don't have basic mathematical knowledge of time, distance, and speed. It is again surprised the researchers that 88.37%(76/86) are having 5 years of experience and 75%(57/76) respondents having above upper primary education levels, questioning our existing education, research, and training system. Promoting students based on attendance alone gives rise to this type of problem. All of us know that at the SSC level, its people talk about probability, interpolation, extrapolation & LPP, etc. now, these people count 63 questions literary standards of the region itself.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the driver's numerical ability with reference to speeds and feeds of their own vehicle and other vehicles approximations. The test reveals that there is no significant difference among respondents regarding experience and education. But data reveal a lot of insights into the ability of drivers in approximations about opposite or vehicles in the same lane really matters when it comes to reality. Sometimes statistics mislead us on one side, and it is so puzzling many of them are well educated and experienced but still couldn't choose the right option in the questionnaire.

21)What is the maximum speed limit for the motorcycle?
a)50 km (b) 55 kmph (c) 40 kmph (d) None of these

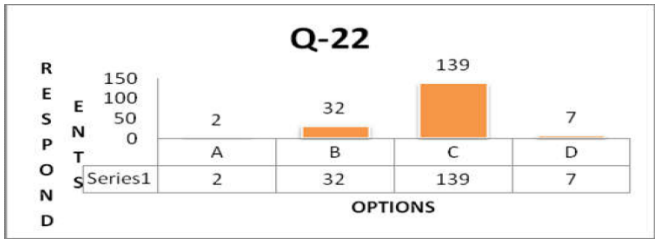



**Interpretation of Q 21:** It is quite noticeable that 40.65%(73/180) respondents don't know the speed limits of other vehicles in general, and people having more than five years of experience are 91.78%(67/73) members out of which 73.13%(49/67) having better educational levels that alarms to create more traffic awareness programs to all categories of respondents. Moreover, they understood maximum speed in a sense upper limit of the vehicle rather than mentioned in the MV Act.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the driver's ability with reference to speed limits of various vehicles, which reveals that there is a significant difference with regards to education and experience. This situation demands further training & education.

22)The best way of avoiding an accident is by

(a)Doing work in an accident way (b) Using safety equipment (c) Observing safety rules related to Job (d) Doing work in one's own way

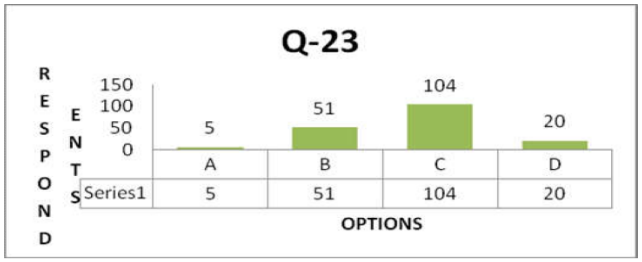



**Interpretation of Q 22:** 77.22%(139/180) of respondents positively observe traffic rules properly, which avoids frequent accidents, and some of them answered that Euro-IV vehicles have continuous low beam day-light also helped them to avoid an accident; one must hats-off their knowledge in profession. Around 92.68%(38/41) respondents having more than five years of experience gave the wrong answer very surprisingly. Out of 38 respondents, 89.47%(34/38) of them having high literacy levels. We can interpret that literacy has no impact on traffic awareness. Surprisingly 30 respondents who gave correct answers are from low literacy levels, which alarms that the government should put effort into training both categories of respondents.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the driver's responsibility, attitude, and understanding ability with reference to speeds and feeds of their own vehicle and other vehicles approximations. The test reveals that there is no significant difference among respondents regarding experience and education. It is a good indication that all the respondents, more or less, have an understanding of accidents and how to avoid them in a better manner.

23) An oily floor should be cleaned by

(a)Putting water (b) Clean with cotton waste (c) Putting Sawdust (d) Spraying CO2 or Sand




**Interpretation of Q23:** It is observed that even literates also unable to answer the question properly. Some illiterates orally said that fire-extinguisher might be used as they have seen in organized cab services. We should appreciate their curiosity to understand whether it is used for arrest fire or oily floor and moreover they asked very innocently how we get sawdust all of sudden where vehicle got break- down. They further answered. Generally, they use roadside sand/robosand dust as a primary activity to stop the skid of other vehicles. 89.47%(68/76) respondents are having more than 5 years of experience, and out of them, 77.84%(53/68) respondents having better education to understand minimal things.

A Chi-Square test executed at one degree of freedom at different levels of significance between and amongst respondents to understand the driver's responsibility, attitude, and understanding ability with reference to road safety attitude of their own/other vehicles. The test reveals that there is no significant difference among respondents regarding experience and education. It is a good indication that all the respondents, more or less, have an understanding of accidents and how to avoid them in a better manner. However, the statistics rang dangerous bells about many of the respondents don't have a basic minimum understanding of what they have to do; here, there is a need to run some programs to make them aware of certain maintenance things related to their vehicles when they repaired on-road or break-down maintenance procedures.

## III. RESEARCH FINDINGS/OBSERVATIONS

- Exactly 50% of respondents opted for the correct answer for the enquired question of the 29%(26/90) are having literacy below primary and having experience below five years. The rest of the sample though literates and having a good amount of experience in the profession, couldn't answer the question properly. Hence, there is a lot of scope ab-initio to start with some sort of technical and general skill up-gradation programs to the respondents. It is found in the general observation that many of them are ready to learn about their profession but found a dearth of the right platform/arena to retrain/retreat them. This situation determines the need for training for all categories of respondents appropriately, and some ad-hoc programs can be chalked-out with the involvement of the local community, trade-unions, RTA, Police Department & State/Central Government.
- 63%(114/180) of respondents beat on this question and are unable to answer the purpose of the lever in the cockpit. Of them, 73%(83/114) are having more than five years of experience in the profession. 60%(50/83) of respondents opt for the wrong answer and have a better education. Hence, this situation demands the need for some or other sort of technical training and orientation towards their profession, especially literates; which reveals the fact that the literacy and experience do not have any influence on profession towards technical-excellence.
- 50%(91/180) gave the correct answer; of them, illiterates are 37%(10/27). 76%(69/91) of them are having more than five years of experience and having a literacy level at higher education are 51%(35/69). This scenario provides scope for the adaption of training programs of different tenures to a different category of respondents. Some of the experienced respondents alternatively answered that it is even being used to load management. This would alarm us to provide necessary skill up-gradation programs.
- Quite surprisingly, many respondents don't know how to clean/maintain the battery-terminals and stated that nowadays, they are getting maintenance-free batteries. One should appreciate at least they know that part of the vehicle. 59%(106/180) of respondents did not give correct answers of the respondents having experience more than five years in the profession are 69%(73/106). Out of them, respondents having a good literacy level are 60 %( 44/73).
- Though the majority of the respondents are answered correctly, they do not have technical knowledge of several terms used in the response sheet. Only at the time of wheel alignment and balancing they come across these terms, but they go by the advice of the technical advisor whether to replace damper/suspension/ partial replacement/repair of LH/RH joints/shafts/cross-joints separately. Even today, they are using local/vernacular language to change components/ consumables/accessories, etc. This shows the importance of technical education and training with reference to their profession.
- Very surprisingly, 81%(52/64) are literates of them, 71%(37/52) are having higher education and above qualifications. The bare minimum things also respondents don't know. It provides scope to bring them into the ring and provide necessary re-skilling.

Even literates are having good experience also not aware of instrument panel devices and Drive Information System, EMC, and their indications because reading and interpreting technical information is prima- facie in this profession.

- Out of 56%(14/25), wrong answers gave by the respondents having SSC to Degree level literacy and of which 93%(13/14) are having more than 5 years experience surprisingly. This situation provides the scope for technical training to respondents. Many technical failures of vehicles are only because improper maintenance of vehicles leads to unwanted wear and tear that taxes owners in a different manner and underutilization of resources by the way failure of warranty and guarantee from manufactured components.

- 48%(85/180) of the respondents having a poor understanding of the control of the vehicle showing a negative impact on fleet control. Without knowing anything, they are running vehicle alarms for technical training to drivers of all categories. Surprisingly 17.64 % (15/85) only count illiterates, and the balance is literates. 60%(51/85) are having SSC and above the literacy level. Surprisingly there were 12%(21/180) blank responses, of which the literates count was 81%(17/21) balance are illiterates. The given situation alarms us to provide necessary training to them, whether offline or online, by establishing some multi-functional complexes in every town/city/suburban area with the help of the government. It is noticeable that 10 out of 17 respondents who gave blank answers are SSC, which reveals the seriousness of the situation and the severity of action to be taken up by the concerned departments responsible.

- 21/25 was surprisingly literates don't know the purpose of the rearview mirror, and out of 21, 19 are above SSC level. This situation provides a lot of scope for training and educating the respondents with reference to their occupation and make them perfect. There are some cunning drivers who answered that it is to observe passengers probably they are in the riding of cab/auto at a prior level before taking up this Job. However, it is another question that makes an attempt to understand the attitude of the driver and provide relevant education.

- 82% (18/22) of literates don't know the safety equipment in the vehicle itself, and no surprise, it repeats with another part of the survey. Hence, there is significant scope to provide education and training regarding traffic rules, safety devices, and rules either of Job or on Job. Many respondents felt that they start learning many things after they got a driving license and on entry into the profession. Issuance of the driving license itself is in question in India. They expressed if somebody can demonstrate the handling of the vehicle in exigencies and emergencies, that is quite helpful to them.

- 50%(90/180) of respondents don't know about the technicalities of driving skill, and around 30%(33/90) are literates. Here, there is an opportunity to provide proper training to identified respondents based on the educational level and background. Corporate drivers little bit know about technical terms because of the training from the end of the organization. Where in other cases, they never bother to know the technicalities involved in the profession.

- 57.77% (104/180) respondents gave the correct option, but some of the respondents raised calling an ambulance rather than finding police is better in a critical situation. Once upon a time, it is not allowed; now, medico-legal cases are also allowed without the interference of police to save the life of the injured is still justifiable, and one should appreciate their attitude to save people at critical times. 17 respondents couldn't give any correct answer, and it is noticeable that they are having more than 10 years of experience and educated.

- Many of the experienced and literate drivers answered it could be even for bad weather condition, towing, and sudden stop of the vehicles due to technical failures on double yellow lines; many of the respondents tried to defend themselves with other answers showing their curiosity about learning new things and questioning facts pose scope for further education and training for them. 47.45%(28/59) are having 10 years of experience and good education, which indicates that there is no impact on education and experience on the attitude of the driver.

- Many respondents answered correctly but raised a doubt that as per their experience, nobody follows traffic rules and overtakes without blowing the horn and flashing headlights even night time also. We thought we know the rule many of us desperately accelerate the vehicle to maintain a gap and later give way to them to overtake. As per their experience, young drivers don't give way to overtake. 61.50%(40/65) of respondents having very good literacy, but their experience is less than 5 years they couldn't understand the value of life because of accidents. This particular question shows the need for training of young drivers.

- Many respondents, at first instance, couldn't understand the question later answered it correctly. However, 22.77%(41/180) of respondents couldn't answer the question properly though they have better literacy and experience again warn literacy and experience does not impact the behavior of drivers. 63.41%(26/41) are having more than 10 years of experience, and out of them, 69.23%(18/26) are having higher education but not

understood the importance of traffic awareness and behavior.

- Good response to this question by lion part of the respondents. However, there were around 24.44%(44/180) of respondents who wrongly answered the question, defend all are correct in their perspective, and we use all simultaneously. 27.27% (12/44) are well educated & experienced who answered the question differently alarm the researchers to provide some sort of reorientation may be required. Here also age, experience & education does not affect the traffic behavior of drivers, and sometimes it is quite surprising that there is no empathy in drivers and they are willing to ride as they like rather understanding the fact that the probability of driving-skill of us arrest accidents to the extent of only 50%.

- Good response for this question by lion segment of the respondents 71.66%(129/180) of respondents rightly answered the question, Around 18.33%(33/180)Some of the respondents chose the alternative answer that is also equally correct but raised doubt that nowadays we are all having smart mobiles and the department allowing online data through RTA wallet in city surrounds, and more to that Euro-IV vehicles are hybrid engines and nonpollutants. However, 51/180 respondents not correctly answered, which alarms us to educate them on what papers are to be carried while on duty.

- Out of all, 37.22 % of respondents do not understand the signboards used at various cross-sections road, and moreover, they answered nobody can remember that many symbols and argued that the visibility level of symbol and size of the signboard is in question. And they said while going at 50KMPH speed, it is impossible to read signboard in English/Telugu/Vernacular Language. Hence, it is hereby suggested the respective authorities increase the size and display of the boards in the right places. Some of the experienced drivers pointed out that the signboard is exactly where the right/left compulsory turn is there it is impossible to follow, especially in Hyderabad. Even on ORR, also they pointed out some of these problems. Some drivers with better literacy levels advised instead of charging no parking challans, better stop, and ask the meaning of many symbols and create awareness. Many of the respondents who gave wrong answers are having more than 10 years of experience and better education levels. This reveals that education and experience together don't have any impact on traffic sense.

- Only 46.11% of respondents gave the correct answer as per the questionnaire, this is quite a pathetic situation, but some part good they know somehow about dos and don'ts fairly. In many of the petrol filling stations/pumps expressly exhibit at all conspicuous places both visuals and placards, many drivers do not understand the behavior that they should exhibit while filling fuel into their vehicles. Many of them answered both C and D, and in general, all the answers are correct, but in a particular context, it is D. 34.44%(62/180) of respondents having 10 years of experience with better literacy levels. This notice us literacy and experience together don't have any significant impact on the behavior of drivers. One respondent even not answered anything, give scope to us to provide proper training in this regard.

- It is the quite puzzling lion share of the respondents don't have basic mathematical knowledge of time, distance, and speed. It is again surprised the researchers that 88.37 % (76/86) are having 5 years of experience, and 75%(57/76) respondents having above upper primary education levels, questioning our existing education, research, and training system. Promoting students based on attendance alone gives rise to this type of problem. All of us know that at the SSC level, its people talk about probability, interpolation, extrapolation & LPP, etc. now, these people count 63 questions literary standards of the region itself.

- It is quite noticeable that 40.65%(73/180) respondents don't know the speed limits of other vehicles in general, and people are having more than five years of experience are 91.78%(67/73) members out of which 73.13%(49/67) having better educational levels that alarms to create more traffic awareness programs to all categories of respondents. Moreover, they understood maximum speed in a sense upper limit of the vehicle rather than mentioned in the MV Act.

- 77.22%(139/180) of respondents positively observe traffic rules properly, which avoids frequent accidents, and some of them answered that Euro-IV vehicles have continuous low beam day-light also helped them to avoid an accident; one must hats-off their knowledge in profession. Around 92.68%(38/41) respondents having more than five years of experience gave the wrong answer very surprisingly. Out of 38 respondents, 89.47%(34/38) of them having high literacy levels. We can interpret that literacy has no impact on traffic awareness. Surprisingly 30 respondents who gave correct answers are from low literacy levels, which alarms that the government should put effort into training both categories of respondents.

- It is observed that even literates also unable to answer the question properly. Some illiterates orally said that fire-extinguisher might be used as they have seen in organized cab services. We should appreciate their curiosity to understand whether it is used for arrest fire or oily floor and moreover they asked very innocently how

we get sawdust all of sudden where vehicle got break-down. They further answered. Generally, they use roadside sand/robosand dust as a primary activity to stop the skid of other vehicles. 89.47%(68/76) respondents are having more than 5 years of experience, and out of them, 77.84%(53/68) respondents having better education to understand minimal things.

## IV. ABSTRACT OF CHI-SQUARE TESTS APPLIED TO LMV DRIVERS

Abstract of Attributes which are used for Chi-Square Test is Experience and Literacy with reference to safety, attitude, behavior, responsibility, understanding of rules & regulations, technicalities involved in maintenance and traffic awareness of the questionnaire and responses of interviewees:

If time permits following Q/Chi-Square Tests are employed for various questions:

**Table 6.**

| No | Category | Questions Covered | Attributes | Hypotheses |
|---|---|---|---|---|
| 1 | Safety | 1,2,3,5, 7,8,10,11,18,19 & 23 | Impact of Literacy & Experience | $H_0$: There is no significant impact of literacy on safety practices of drivers of the vehicle under observation<br>$H_1$: There is no significant impact on the experience of vehicle drives on different factors under observation |
| 2 | Maintenance | 4,6 & 17 | Impact of Literacy & Experience | $H_0$: There is no significant impact of literacy on maintenance practices of drivers of the vehicle under observation<br>$H_1$: There is no significant impact of experience on vehicle maintenance by drivers |
| 3 | Attitude | 1,9,12,13,14,15, 16,19,22 & 23 | Impact of Literacy & Experience | $H_0$: There is no significant impact of literacy on the attitude of drivers under different situations<br>$H_0$: There is no significant impact of experience on the attitude of drivers under different situations |
| 4 | DIS | 20 & 21 | Impact of Literacy & Experience | $H_0$: There is no significant impact of literacy on providing or using DIS<br>$H_0$: There is no significant impact of experience on providing or using DIS |

## V. SUMMARY, CONCLUSION AND RECOMMENDATIONS

In general, there is no significant difference between and amongst various drivers from various locations, income, qualifications, and socio-economic background. Most of them are in the same direction with reference to attitude, behavior, responsibilities, awareness of MV Act rules & regulations, and traffic awareness. Many respondents with better educational qualifications opted for alternative answers due to the reason some of the other options gave in the questionnaire are very proximate to the correct answer. As their education demanded, alternative answers exhibit their curiosity towards hunting for a turnaround. This behavior helps us to provide further training and education and setup some ad-hoc/tailor-made/specific programs suitable to the respondents at different places in and around Hyderabad Metro Surrounds.

Respondents have shown good interest in answering the questions and allowed our team to take a video clip about their experiences. The study revealed that there is a huge need for setting-up up facilitation/study centers in and around Hyderabad to provide suitable education towards reorientation/re-skilling/retraining through various certificates, diplomas, and UG courses. Many respondents have shown interest if time is flexible to them; they are ready to undergo training, but their main dilemma is how this program helps them in their present career. The following are some of their queries with regards to their existing level to that of future ambient level; (1) Where are the opportunities to take swift & shift in their career; (2) What efforts are required from their end; (3) What is the tenure of their efforts towards the end-outcomes by way of shifting themselves towards by setting up own house with few own vehicles; and (4) shift from unorganized sector to organized sector.

Some of the respondents, though they are well educated, face the main-stream problem in communication and soft-skills, especially people, drove towards destinations such as airport, Hi-Tech city, Gachibowli, and Secunderabad Railway stations. The drivers are more or fewer localities know vernacular languages only with less GPS, IT, Digital Knowledge, which makes them, get afraid of to connect with people in the organized sector and put their vehicles in the franchise with UBER/OLA/PRYDO/MEERU/SkyCab so on. The main problem of drivers is communication/conversation/contact, which most of the time run in English alone between and amongst passengers

traveling in the cab. Due to this reason, drivers are unable to understand the intentions of passengers and approach them in a client-friendly manner. It makes them distant from justifying their profession and excels them in providing better services. In view of this, drivers stand departed from customers, owners, and franchising agencies, which created a big gap in the total transport chain of services.

Drivers' community is ready to upgrade themselves irrespective of experience and an educational qualification not only with English but also in many other languages because of their profession/situation demands. Many of the passengers are from North & South Indian towns/cities. In the case of Hindi/Marathi/Gujarathi, somehow they are able to manage because of the situational advantage that the Hyderabadi-Drivers have informal knowledge of speak and understand Hindi. Hence, our local drivers are able to deal with & address North and Westside passengers in a fair manner. But at the same time, they are unable to address people, especially from Tamil Nadu, Karnataka, and Kerala. This point makes them ambient to focus on the learning of some or at least one another South-Indian language. This really helps them in career development because of the reason that many of the franchising organizations are from Bangalore & Chennai, and passengers are from Karnataka & Kerala. More to this, many of them felt that they are lack of technical knowledge of the vehicle they drove and being in the dilemma that whether a particular component is really to be changed or can be repaired. There are many unorganized repairers ready to repair the vehicle instantly, but the problem is the reliability of components and owners. In the case of the unorganized sector, most of them go by local repairers as a cost-cutting measure; but which is not acceptable in the case of organized formal franchisers as they believe in reliability rather cost-cutting. Moreover, in the organized sector, it is a B2B concept, and that they are forced to service their vehicles in branded/authorized/principal-dealers outlets only. In this case, as queues are very long, they are unable to get serviced the vehicles in one or two days.

Many branded outlets are closed on Saturday and Sunday, and very few outlets offer express and round the clock service. However, Saturday and Sunday vehicle service stations are also sluggish in a moment of service. This situation may be right from the end of drivers, but the problem is from the end of franchise/hiring organization they are on off only for two days in a week, i.e., Saturday and Sunday. Hiring organizations are not ready to take the risk of reliability with local service providers though they serve on weekends. Any mishap, the loss from drivers-commitment of the hiring organizations is mind-blowing by way of financial commitments both to their employees and client organizations. The penalties they come across in millions of dollars for failures of their employee's commitments. In view of the above, it is advisable to start multi-branded outlets in connecting with franchise organization which works round the clock and also week-ends on one side and partner Driver STOP programs to mitigate the risk of non-commitments, unforeseen, unwanted, untoward and awkward situations either with the driver, employee, contractors, and client. This study is really useful but should not confine only to Hyderabad, but should extend similar studies in all towns/cities/metros with large volumes of respondents from drivers, employees, client-organizations, government, RTA, law & order departments, manufacturers, bankers, Insurers, local-multi branded-service stations, mechanics in unorganized sector and principal-dealers. In cities like Hyderabad, lakhs of drivers are looking for a right-break in their career. This is possible only when companies & government come forward with proper planning and commitment towards society.

Every question is provided with specific recommendations & suggestions wherever possible. Hence, this part of the study is meant for suggestions to the government, hiring companies, RTA, MHRD, academic institutions, NGOs, and societal representatives to chalk-out most appropriate time schedules for learning and reorientation to up-lift the quality of standards of living of drivers & their families at the earliest possible. This study does not focus on infrastructure requirements, accessibility, flexibility, mobility of trainers/trainees, and facilitation centers. One suggestion in this direction when drivers are on duty round the clock; what is the problem of providers to work on the same basis. As everybody of us knows very well, that Saturday and Sunday are weekly-off to many taxi drivers and then facilitators can focus on these two days. When it comes to LMV drivers, Sunday is the only- option for going to truck parking yards, sub-urban villages to create awareness about their career and modules of present programs, which benefits them to re-build their own career.

It is the responsibility of research-organizations to send the survey reports about costs/benefits to the government, insurance companies, bankers, hiring organizations, dealers, manufacturers, RTA, Law & Order, and DEA about monetary commitments of the government/hiring organizations/manufacturers/insurers/funding-agencies by way of compensation to passengers, drivers, and clients in addition to loss/damage of vehicles/passengers. The opportunity cost is not more than the pay off of any company on one side and on the other side government that declares an ex-gratia of not less than Rs. 1 lakhs to Rs.5.00 lakhs to each and every person injured in such cases, in addition to the insurance company, owners and hiring organization.

But still, we may not recover the life of the insured either partially or fully, i.e., catastrophic losses. Motor Unions are also working on it, but they couldn't come to any conclusion. Beyond all this, what are the terminal benefits at the end of their career such as retirement from occupation

technically is a question to government/society and whether government pay any old-age pension or leave them to their fate. All these issues, challenges, and responsibilities alert all the stakeholders to invest in training and education rather than paying compensation to drivers. Even insurance companies and manufacturers of the vehicles should also be made partners in the program. One better suggestion should be the insurance must be provided by the manufacturer only rather third party agencies/organizations. Then automatically cost of maintenance, reliability, and safety come into the picture and rescues the nation from huge costs/taxes.

This skill cum technology up-gradation program turnout some drivers as owners by the involvement of funding agencies and facilitation centers should work as a single-window system to provide bank loans once they got certified from these STUP centers.

Locational/Organizational specific studies give better results than macro-level studies like this. More socio-economic factors are to be included to get a better understanding of driver's issues and challenges. One of the most important factors is all the drivers, irrespective of their education and experience, must be technically trained towards repairs and maintenance of their vehicles, which will help them to drive vehicles in the most economic/fair/reasonable manner.

Around 66% of drivers expressed the study is very excellent, and they ever come across this type of study in the interest of drivers especially, and they said the government should conduct more number of specific surveys in this direction. Some of them expressed some sort of social/professional security measures such as job loss, no demand, no service, etc., which are offered to software employees and, for that matter, all categories of employees/business and entertainment houses.

Some of them questioned that an agriculturalist is rescued when there is a draught/no rain situation; why can't we be considered on similar grounds by the government is a thought-provoking question to be answered by the policymakers and hiring organization in addition to society.

Our Telangana State Honourable Chief-Minister Shri K. Chandra Sekhar Rao announced much flexibility to auto/cab drivers in the unorganized sector, and he recognized the need for rehabilitation to drivers. All of us know many autos/cabs/LCVs in Hyderabad are outdated and crossed their operational age. Still, our CM gave a better offer to owners of such vehicles to exchange with Taxis at most-subsidized rates of interest & the DIR Scheme in light of Euro-Norms. One should hats-off to the guts of CM to take such a bold decision, which was nowhere legally found implemented except in the state of Telangana.

By this, we conclude the study, which gave a rich experience to our team members to have bright insight into the driver's issues and challenges in addition to passengers and owners. There should be a separate study to be taken-up to understand the issues and challenges of owners, service providers, banking agencies, insurers, manufacturers, and passengers.

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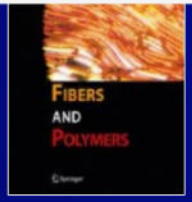
# A MULTI-DIMENSIONAL STUDY ON STRESS & CONFLICT OF IT SECTOR EMPLOYEES IN AND AROUND HYDERABAD

Anoosha, Dr. Kiran Kumar Thoti • Published 2021 • Business, Computer Science, Psychology

The research try to attempt the test of various facts, variables, attributes with all possible qualitative and quantitative models in a hypothetical organization such as manufacturing, IT, and ITES sectors at different levels i.e., top level, middle level and front line. In general it is the assumption that stress levels are very high when employee start climbs up to the ladder with various positions and promotion. Every position makes employee more and more responsible and decisive. Every decision has bearing on his employment and existence in the company. Every conflict leads to stress make employ to bet his career along with his dependent family member. In other words, every dependent family member cause compromise in career development, risky decisions, make employee quite submissive in character and surrender whole and sole to organization without any bargain of any nature, may be financial or non financial. Simply give-up himself in all respects, a day never the later he quit organization sometime quit from life even. Collapse

# Extraction and Effects of Mechanical Characterization and Thermal Attributes of Jute, Prosopis Juliflora Bark and Kenaf Fibers Reinforced Bio Composites Used for Engineering Applications

Regular Articles | Published: 26 April 2021 | **22**, 2018–2026 (2021)

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R. Muthalagu, V. Srinivasan, S. Sathees Kumar & V. Murali Krishna

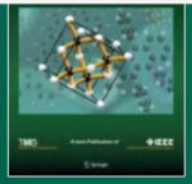


## Abstract

In the present work tensile, flexural, impact and hardness properties of Prosopis juliflora bark (PJb), jute fiber (JF) and kenaf fiber (KF) reinforced polyester composites are expressed for the first time. The challenge in working with natural fiber composites (NFC) is the large variation in properties and characteristics. The properties of NFC to an enormous degree are impacted by the sort of fibers, a natural condition where the plant

# Effect of Ceramic Fillers on the Dielectric, Ferroelectric and Magnetic Properties of Polymer Nanocomposites for Flexible Electronics

Original Research Article | Published: 14 April 2021 | 50, 3652–3667 (2021)



Journal of Electronic Materials

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R. Anlin Golda, A. Marikani & E. John Alex



## Abstract

Polymer nanocomposites have been investigated for their flexibility, light weight, low production cost and conformability to different shapes. In this paper, the functional properties of the polymer nanocomposites are studied by varying the ceramic fillers with bismuth ferrite, dysprosium (Dy) doped bismuth ferrite and gadolinium (Gd) doped bismuth ferrite. The developed polymer nanocomposites are seen to possess excellent magneto-dielectric behaviour, a property well-suited for developing high-frequency

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*Research Article*

# Thermal and Residual Stress Distributions in Inconel 625 Butt-Welded Plates: Simulation and Experimental Validation

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Thermal and residual stress distributions induced by the gas tungsten arc welding (GTAW) process on Inconel 625 were studied using numerical simulation and experiments. A multi-pass welding model was developed that uses a volumetric heat source. Thermomechanical analysis is carried out to assess the Thermal and residual stress distributions. Experiments were carried out with 5 mm thick Inconel 625 plates. X-ray diffraction techniques were used to measure residual stresses, and IR thermometry was employed to capture the temperature values on the welded joints. Simulations were performed with ANSYS numerical code, and a close agreement was found between the predicted and experimentally measured residual stress. Thermal measurements were collected pass by pass from the analysis, and the agreement was 9.08%. The agreement between the measured and analysed residual stress was 11%.

## 1. Introduction

Fusion welding is one of the major joining techniques employed in industrial applications. In particular, gas tungsten arc welding (GTAW) allows yielding sound welds with different alloys. The selection of welding process parameters is one of the major challenging tasks to control welding residual stresses and distortions. Further, these welding process parameters will affect structural integrity. Experimental tests can be performed to estimate the improvement in parameters, but they are expensive and also quite time-consuming; in this scenario, welding numerical simulation may help avoid such drawbacks. Kermanpur et al. [1] developed an FEA model for multi-pass GTAW process of Incoloy 800 pipes. Temperature results obtained by using volumetric heat source were in good agreement with those obtained employing thermocouples located at the heat-affected zone of the joints. However, the authors did not focus on residual stresses caused by the joining process. In another recent work, Balram and Rajalakshmi [2] reported the experimental results regarding thermal stresses and thermal fields developed in the GTAW process applied to similar and dissimilar welded joints. The ERNiCrMo-3 alloy was used as filler wire. Tensile tests showed that the failure occurred within the parent metal, proving the high quality and strength of the welded joints obtained. Korrapati et al. [3] investigated the weldability and metallurgical and mechanical properties of the PCGTA welded Inconel 625 alloy employing ERNiCrMo-3 filler wire. In this case, despite the fact that defect-free welded joints were obtained, failures occurred at the weld region and the average tensile strength of the weldments was found to be 852.4 MPa.

In order to decrease the computational time without losing accuracy, Perić et al. [4] proposed a T-joint numerical model conducted by combining the shell and 3D finite elements. Results of thermal and displacement distributions were found in good agreement with those measured in real joints. Finally, the influence of the 3D model size on the temperature, residual stress, and displacement distributions was investigated. Vemanaboina et al. [5] studied the residual stress evolutions in multi-pass dissimilar joints (IN 625-AISI 316L). The $L_4$ orthogonal array was chosen for the tests. Two levels of each welding factor, filler wire and root gap parameters, were chosen for the experiments. It was concluded that the pulsed current-induced low residual stresses in the weld region were within the factor of safety of parent materials. In subsequent work [6], they deepened the weldability of such similar and dissimilar welded joints. Weldments free from defects and stresses within the yield limits of the base materials were obtained. In computational weld mechanics (CWM) [7, 8], the thermal load is obtained by using power density distribution functions that calibrate parameters using experimental results. This approach allows reducing the computational time required to calculate the residual stresses and distortions compared to that needed by models based on fluid dynamic analyses.

Nine different welding sequences [9] were used to find the best conditions that minimized distortions and residual stresses in a T-weldment. The simulation was carried out by using ABAQUS numerical code. As expected, the best conditions were achieved when joining both sides in the same direction and at the same time. Kamble and Rao [10] developed a three-dimensional sequentially coupled thermomechanical model of 10 mm thick plate. The GMAW process was used for joining two 3Cr12 stainless steel plates. The thermal study was carried out at different time intervals. Thermally induced residual stress was predicted using ANSYS numerical code. In that work, the authors described the effect of process parameters on thermal and structural behaviour of the welded joints. Attarha and Sattari-Far described a thermal study of similar and dissimilar single-pass butt-welded joints [11]. A 3D numerical model was developed with ABAQUS®, and the Goldak heat source was used to simulate the thermal input of the process (GTAW). Excellent agreement was observed between numerical and experimental temperature values measured with k-type thermocouples located in the heat-affected zone (HAZ). Capriccioli and Frosi [12] carried out a computational analysis of the multi-pass welding process for dissimilar materials. The 316L stainless steel to IN625 welding simulation was carried out for both TIG and laser welding using ASNSYS®. The mechanical results were found very sensitive to the mesh shape, which had to be very fine and regular close to the fusion zones. In that work, an effort was made to reduce the CPU time that is the major objective to achieve when simulating a multi-pass welding process. Lostado et al. [13, 14] used finite element models to better understand heat behaviour and its impact on angular distortion and bead shape in GMAW butt weldments. The study employed genetic algorithms with multi-objective functions. The influence of heat input reveals growing angular distortion and weldment bead shape. The FEA models and experimental findings correlate well. Another work reported that the tensile residual is maximum at the fusion zone and also stated that the findings of the FEA were in agreement with the experimental results [15].

Weld beads and related regions undergo plastic deformation during the welding process as a result of heating and cooling cycles, resulting in residual stress. Thermal and lattice spacing impact residual stresses in weldments, resulting in microstructure changes and thermomechanical stresses. With the help of FEA, it is possible to forecast the degree of heat effect in the weldment. Since no work has been published on the in situ thermal behaviour study during GTAW for Inconel 625 material, the authors believe that there is a lack of confirmation on simulations for the estimate of temperature profiles and residual stresses. Multipass welding of Inconel 625 with GTAW process conditions is the major focus in the present planned study. Welded components are analysed in 3D to determine their thermal and residual stresses. With the ANSYS® package, APDL code is used to do thermomechanical analysis. Infrared thermography is used to measure welding temperatures. X-ray diffraction is used to evaluate residual stresses in a weldment after it has cooled to ambient temperature for verification.

## 2. Finite Element Analysis

Figure 1 shows an overview of the present numerical model. ANSYS package was used to develop the welding simulation. The plate has a square butt groove with no gaps between the two parts. According to the real butt-welded joint thickness, the FZ height was increased by 1.7 mm at each run, taking advantage of the activation-deactivation function of elements implemented in ANSYS code (Figure 2), roughly equal to that of weld bead measured by experiment. The thermal analysis was computed with the 8-node thermal element [16] SOLID70 and then switched to the 8-node finite element SOLID45 for the subsequent structural calculation. The two types of mesh options are used for the simulation models. The finer mesh is applied at fusion zone with a mesh size of 1.5 mm, and coarse mesh is applied to the rest of the plate with a mesh size of 3 mm, as shown in Figure 3. In this study, an equal time interval is assumed for every pass as heating time. The temperature-dependent [12] thermal and mechanical properties considered for Inconel 625 for the present study have been depicted in Figure 4.

Goldak et al. proposed double ellipsoidal heat source model for the arc welding process [17]. For present weld simulations, the moving heat source model is treated as volumetric heat flux with constant heat input throughout the length. For each weld pass the bead size, initial boundary conditions are defined along with volumetric heat flux. The constant heat input loads are calculated as per the welding process parameters shown in Table 1.

The volumetric heat flux [18, 19] of each weld pass is determined using the following equation:

$$Q = \frac{\eta UI}{V}, \tag{1}$$

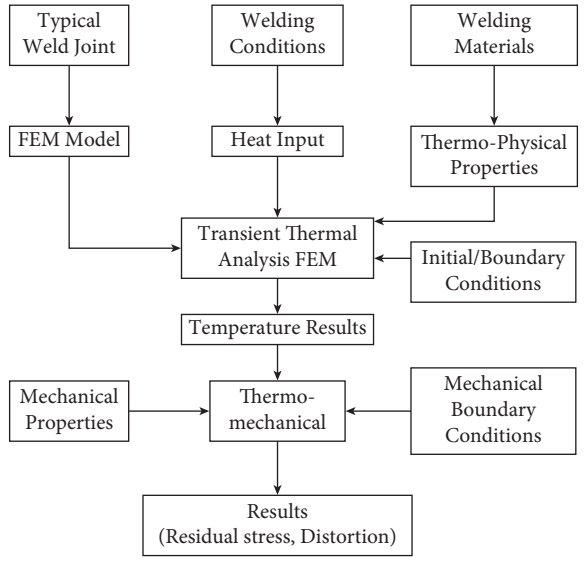



Figure 1: Overview of the thermo-elastic-plastic FEM analysis procedure.

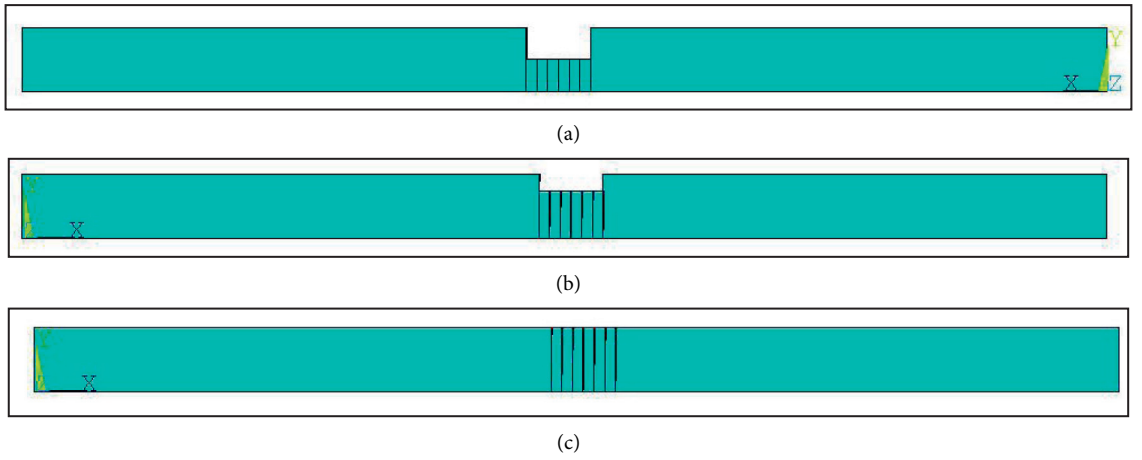



Figure 2: Simulation models for each pass. (a) Model for pass-1. (b) Model for pass-2. (c) Model for pass-3.

where $\eta$ is the arc welding efficiency, $U$ is the voltage, $I$ is the welding current, and $V$ is the volume of weld pass. The volume of the bead is added for each as shown in Figure 2. The value of arc efficiency is assumed to be 0.65 for the GTAW welding process. The heat conduction equation for welding simulation is given by

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right)+Q=-\rho C_p\frac{\partial T}{\partial t}, \tag{2}$$

where $\rho$ is the density, $C_p$ is the specific heat under constant pressure, and $k$ is the parent material conductivity. The coefficient of heat transfer rate was calculated for the weldment (equation (3)). Heat loss by convection was applied at the top and side faces of the weldment, while heat loss by both convection and radiation (equation (4)) was taken into account over the surface of the third weld bead obtained during the last welding run. In equations (4) and (5), $T_0$ is the ambient temperature, $\varepsilon$is the emissivity of the parent material, $\sigma$ is the Stefan–Boltzmann constant, and $h$ is the convective heat coefficient.

$$H = 24.1 * 10^{-4}\,\varepsilon T^{1.61}, \tag{3}$$

$$q_c = h\left(T - T_0\right), \tag{4}$$

$$q_r = \varepsilon\sigma\left(T^4 - {T_0}^4\right). \tag{5}$$

Boundary conditions were applied in order to simulate the thermal behaviour induced by the three passes.

(1) For pass-1, initial temperature was ambient temperature.

(2) Convention was applied at the root opening of the plates for pass-1 and pass-2.

(3) In pass-3, both convection and radiation were specified only on the top surface of the weld plate.

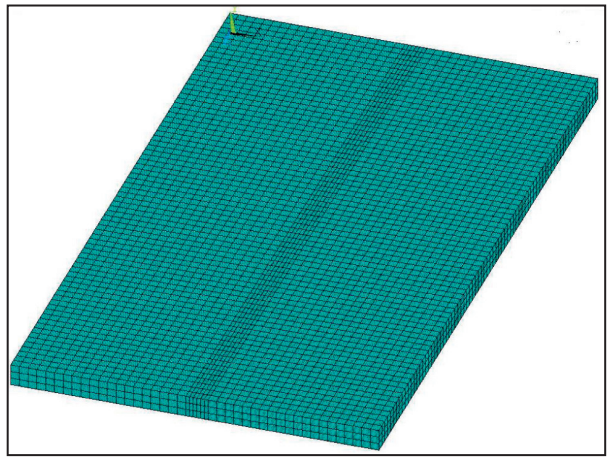


Figure 3: Meshing of the model.

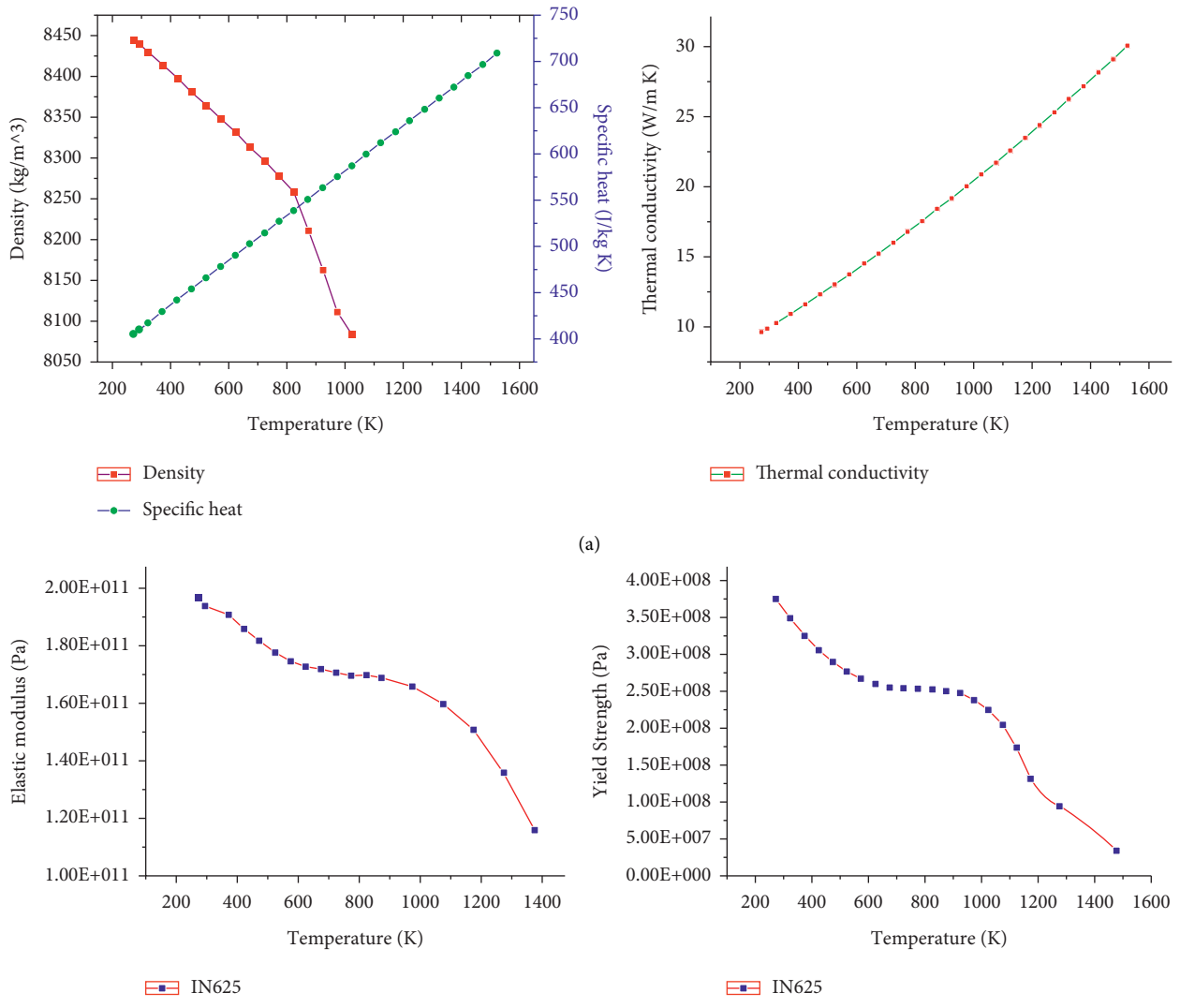



Figure 4: Temperature-dependent material properties.

Table 1: Multi-pass welding process parameter.

| Pass no. | Welding current ($I$) A | Root gap mm | Argon gas flow rate LPM | Time for each pass s |
|---|---|---|---|---|
| Pass-1 | 145 | | | 36 |
| Pass-2 | 145 | 2 | 12 | 27 |
| Pass-3 | 145 | | | 31 |

(4) The inter-pass [20] temperature is considered for pass-2 and pass-3 to avoid hot cracking. The initial temperature for pass-I is ambient, i.e., 30°C, and for pass-2 and pass-3, it was maintained at about 200–250°C.

## 3. Experimentation Procedure

The real butt-welded joint was produced by the GTAW technique. The dimensions of the plates were100 mm length × 60 mm width × 5 mm thickness, as shown in Figure 5. The single V-groove angle of 60° was used. The gap between the plates was filled with three passes: pass-1 (root pass), pass-2 (filler pass), and pass-3 (cap pass). ERNiCrMo-3 was used as filler wire. Base material and filler wire chemical composition are given in Table 2. The base material mechanical properties are listed in Table 3. The process parameters chosen for experimentation are welding current (I), root gap (RG), and shielding gas flow rate ($G$) and are summarized in Table 1.

Welding current, root gap, and Argon flow rate were set to 145 A, 2 mm, and 15LPM, respectively. The same parameters are used for all passes. To avoid the hot cracking in the weld, an inter-pass temperature [21] (~150–250$^0$C) is maintained between the runs. Sound welded joints were obtained, and surface cracks and defects are verified by visual inspection and X-ray radiography.

### 3.1. Measuring Techniques

*3.1.1. Infrared Thermography.* Infrared thermography and X-ray diffraction techniques are employed to measure thermal and residual stresses in the welded joints. The weld pool temperatures are recorded during each pass of the welding process with infrared thermography. The temperatures were measured using the FLIR infrared thermography, with an accuracy of ±0.1 C. The thermal imager measures the amount of heat emitted by the surface. The infrared thermography is used for measuring the temperature in the weldment. The base material surface-emission efficiency is necessary for measuring the surface temperature of the joint. In this work, the emissivity was taken equal to $\varepsilon = 0.9$. Figure 6 shows how the infrared thermography works.

*3.1.2. X-Ray Diffraction.* The weld area undergoes a heating and cooling cycle during the welding process. The thermal expansion and contraction of the parent material affect residual stresses and distortions. Figure 7 displays the Bruker D8-Discover$^{TM}$ diffractometer for measuring residual stresses. Figure 8 shows the Vantec$^{TM}$ area locator, and goniometer head is used for microfocus with laser tracking. Table 4 summarizes the measuring parameters.

The residual stresses were calculated by using Bragg's law(equation (6)):

$$n\lambda = 2d \sin\theta, \tag{6}$$

where $n$ refers to the order of reflection beam, $d$ is the interplanar lattice spacing, $\lambda$ is the wavelength of the incident wave, and $\theta$ is the scattering angle. In the transverse direction, the residual stresses are measured on the top surface and calculation [22] of the residual stress is carried out by using the following equation:

$$\sigma_\phi = \frac{m}{d_0}\left(\frac{E}{1+\nu}\right), \tag{7}$$

where $E$ is Young's modulus, $\nu$ is Poisson's coefficient, $d_0$ is the stress-free lattice spacing, and $m$ is the slope of the curve drawn between $d$ (spacing) and $\sin^2\Psi$.

## 4. Result and Discussion

ANSYS (APDL) was used for modelling, meshing, and transient thermal and static structural analysis. The computational welding mechanics technique was applied to reduce the CPU time by solving in a consecutive manner the thermal and the mechanical analysis for each welding pass. Temperatures and residual stresses at nodes were analysed in the transverse direction of the weldments. The details are illustrated in further sections given below.

*4.1. Thermal Distribution.* The welding cycle time was 40 s for all the passes. The cooling cycle was maintained for about 1000 s after the last welding run. Between a welding pass and the other one, an inter-pass temperature of about 250°C was maintained to avoid hot cracking. Figure 9 illustrates the numerically assessed temperature map. During the first welding pass, a maximum temperature of 2080°C was observed, whereas the second pass induced a maximum temperature equal to 2158°C and a minimum temperature of 250°C (imposed inter-pass temperature). Finally, the pass-3 produced a maximum temperature of 1707°C. The maximum temperature was experimentally seen at the weld zone of the real joints. The heat is collected at the weld zone of the joint and extends in the transverse direction, which leads to form the HAZ. A narrow FZ was observed due to the low thermal conductivity of the analysed alloy.

*4.2. Thermal Analysis Using Infrared Thermography.* Thermal distribution during the welding is displayed in Figures 10(a)–10(c). Line-1 represents the longitudinal and

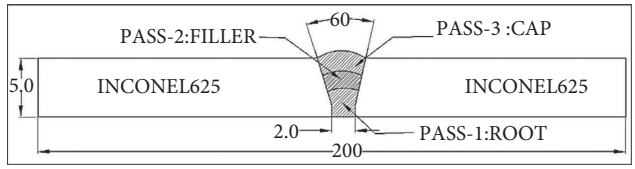



Figure 5: Multi-pass welding process.

Table 2: Base plate and filler material chemical properties (wt %).

| Samples | Ni | C | Mn | S | Cu | Si | Cr | P | Fe | Al | Mo | Ti | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inconel 625 | 58 | 0.1 | 0.5 | 0.015 | 0.5 | 0.5 | 20–23 | 0.015 | 5 | 0.40 | 8–10 | 0.1 | — |
| Filler wire ERNiCrMo-3 | 64 | 0.1 | 0.5 | 0.015 | 0.50 | 0.5 | 22–23 | 0.015 | 1 | 0.40 | 0.015 | 0.40 | Nb 3.6–4.5, |

Table 3: Parent material mechanical properties.

| Material | Yield strength (YS) (MPa) | Poisson's ratio | Coefficient of thermal expansion |
|---|---|---|---|
| Inconel 625 | 254 | 0.28 | $12.3e^{-6}$ |

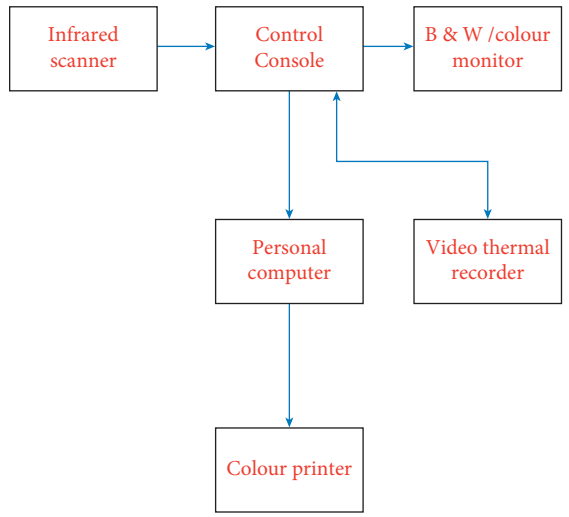



Figure 6: Illustration of thermography system.

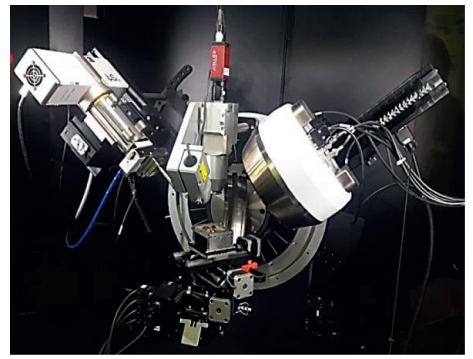


Figure 7: Bruker X-ray diffraction.

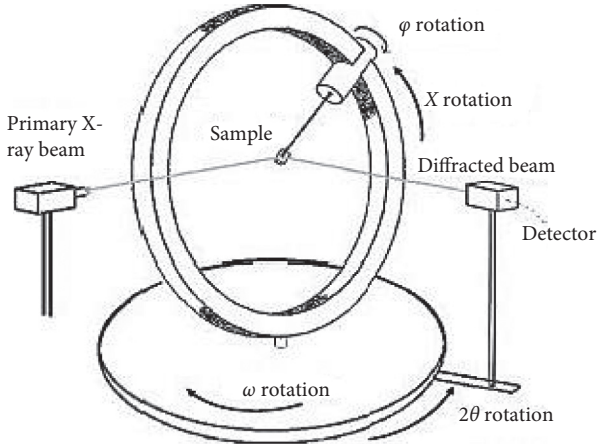



Figure 8: Goniometer head with a detector.

Table 4: XRD measuring parameters.

| Measurement | Transverse direction |
|---|---|
| Tube | Mn_K-Alpha |
| Bragg angle | 155.0° |
| Peak location | Gaussian-80% |
| D-spacing (Angstroms) | 1.0771016 |
| Wavelength | 2.103 |

line-2 for the transverse direction of the weld plate, respectively, as shown in Figure 10(a). The temperatures can be recorded at any point of time, and the current thermography results are reported at the welding zone in the longitudinal and transverse directions at the instance of time. Figure 10(a) shows the temperature distribution ranges from 500°C to 1779.5°C in the transverse direction and from 500°C to 1580°C in the longitudinal direction. During the second welding pass, the measured maximum temperatures were 1838°C and 1867°C in the transverse and longitudinal directions, respectively (Figure 10(b)). The temperature distribution as shown in Figure 10(b) was waving up and down because the material was filled in the root gap, filler, and cap (Figure 5). The maximum interpass temperature 250°C was maintained in between the passes. Figure 10(c) shows the final welding pass; the maximum temperatures were reported to be 1325°C and 1878°C for the longitudinal and transverse directions, respectively. The measured torch temperature value was1000°C.

The experimental and numerical peak temperature values at each welding pass are compared in Figure 11. It is observed that the thermal results of FEA simulation slightly differ from experimental ones. This phenomenon is due to the fixed time assumption for all the welding passes, i.e., 40 s.

The FZ geometry and dimensions are shown in the macrograph of Figure 12. It was wide, with 11.38 mm on the top of the weld, 5.69 mm in the midsection (2.5 mm thick), and 6.7 mm on the bottom of the plate. Metallographic examinations revealed a sound weld without defect and a fully penetrated bead. The filler wire is mixed well with parent material, and homogeneous joint was formed.

*4.3. Residual Stresses.* The residual stress developed across the welding direction of various weldments using simulation is reported here. The residual stress distribution is shown in Figure 13. After pass-1, the weldment experiences compressive stress of −200 MPa at fusion zone and −120 MPa at the end of the plate as shown in Figures 13(a). Figure 13(b) shows the residual stresses induced by pass-2. They range from −110 MPa in fusion zone to 120 MPa close to the HAZ. The parent metal is stress free. After pass-3, the total plate experiences tensile stresses, with a value of 178 MPa in the FZ and 18 MPa far from it (at the end of the plate) (Figure 13(c)).

The measured tensile residual stress distribution was observed at weld zone and compressive stress in remaining zones. This is due to the expansion of the material during welding and high temperatures at the fusion zone; however, this expansion is retarded by the neighbouring base metal region. The material experiences contraction while cooling to maintain the plate's original dimension, which generates plastic deformation. At HAZ, it undergoes high-stress concentration to maintain the equilibrium between shrinkage action of the base plate and the solidification of the molten weld pool. It is determined that balanced stress distribution in the weldment is due to uniform thermal conductivity along the plates. Figure 14 shows the comparison between experimentally measured and numerically predicted residual stresses analysed for a welded joint. It is observed that the material experiences tensile stresses near the weld bead. The maximum experimental and numerical tensile stress was observed to be 200 MPa and 178 MPa, respectively. Further, it was verified that the stresses were not

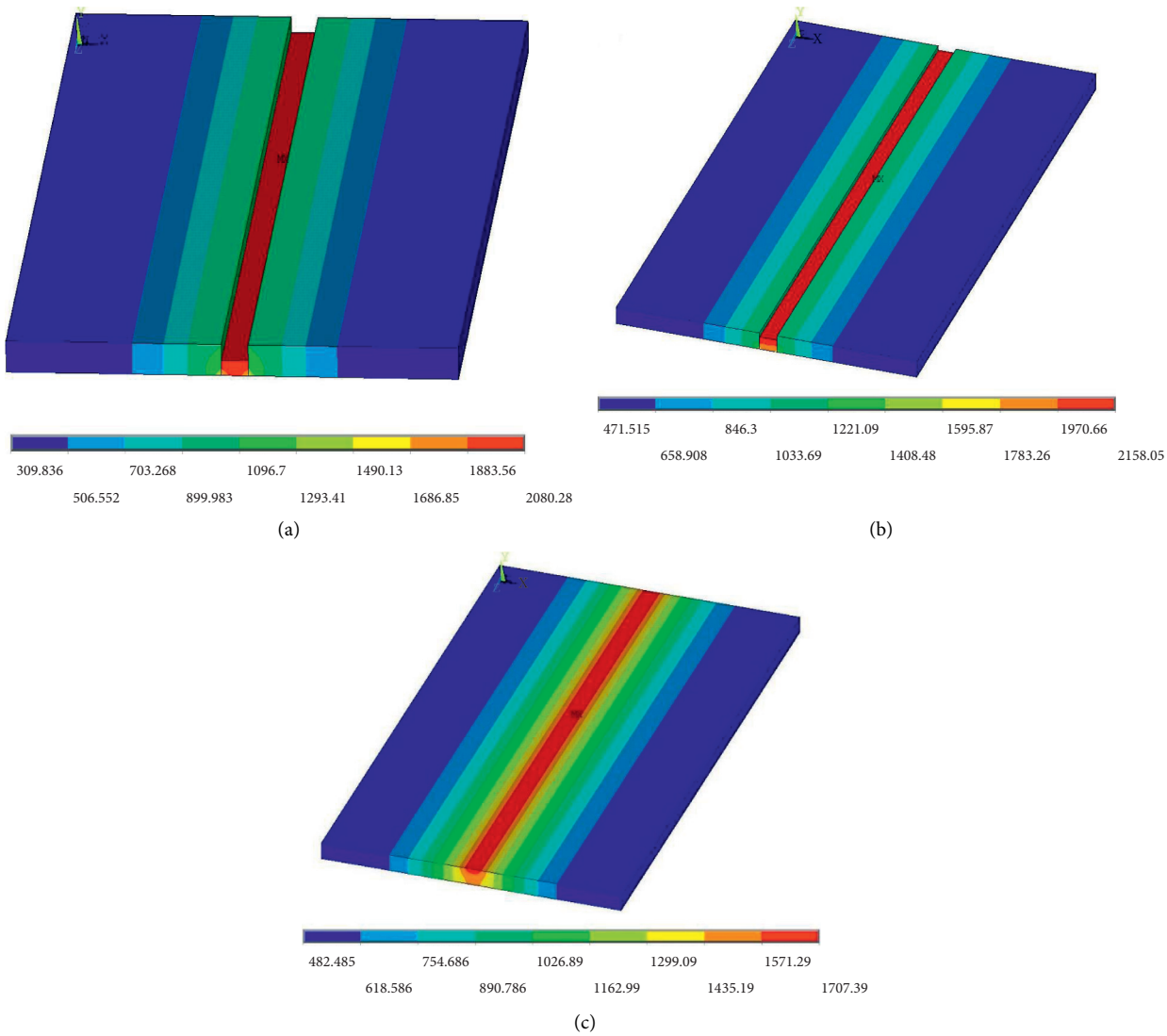
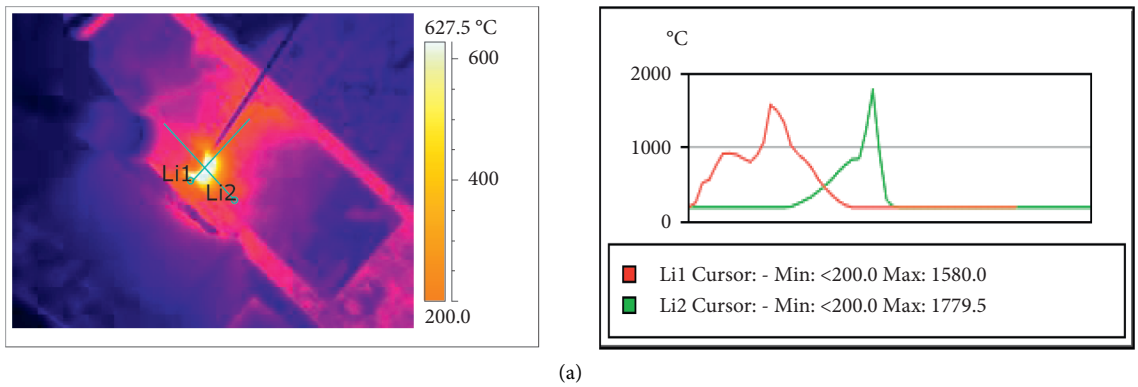



Figure 9: Distribution of temperatures in the weldment. (a) Weld pass-1. (b) Weld pass-2. (c) Weld pass-3.




(a)

Figure 10: Continued.

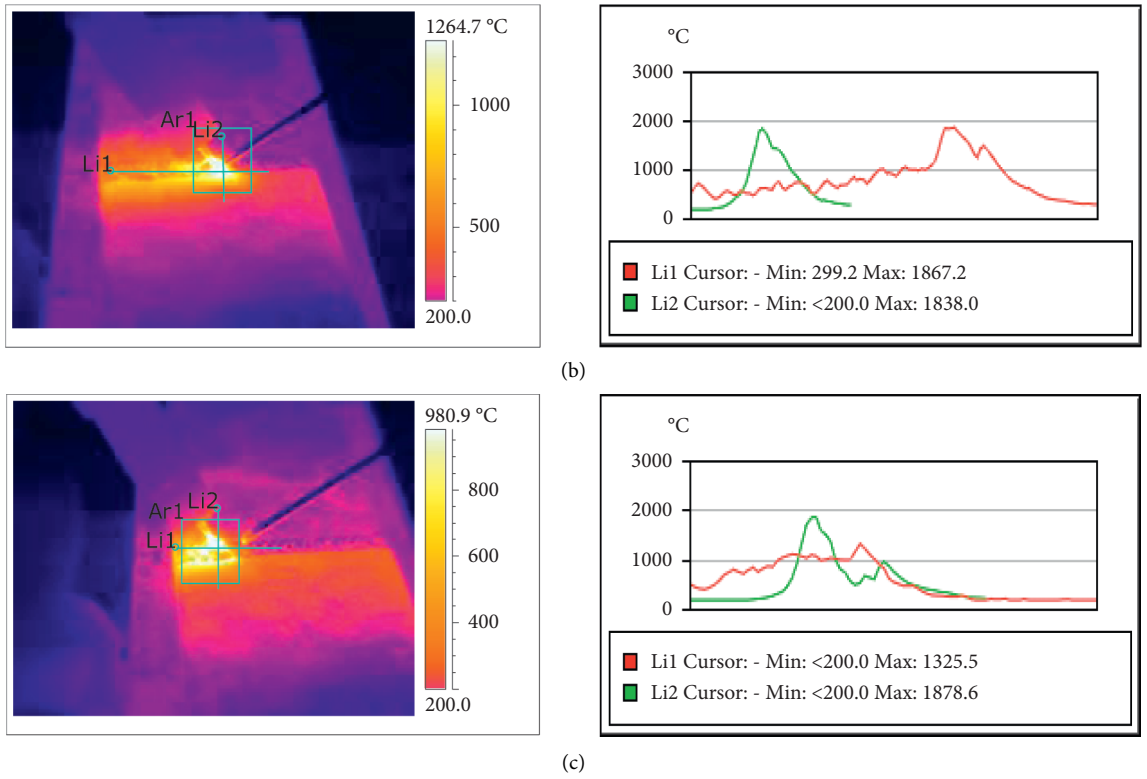



Figure 10: Infrared thermography pass-wise analysis during the process. (a) Pass-1 IN625 to IN625. (b) Pass-2 IN625 to IN625. (c) Pass-3 IN625 to IN625.

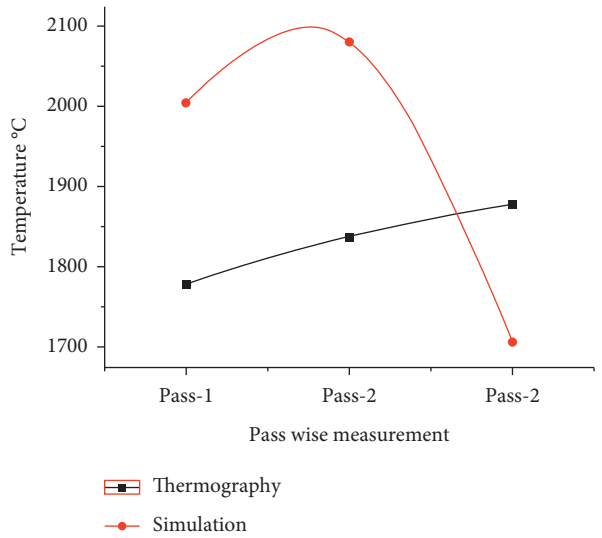



Figure 11: Comparison of thermal distribution.

self-balanced in the structure. Temperature measurements were collected pass by pass from the analysis, and the agreement was 9.08%. The agreement between the measured and analysed residual stress was 11%. Due to the influence of heat input in small areas during establishing the weld joint, the regions next to the weld line undergo severe thermal cycles, resulting in an increase in residual stresses. The result will be a reduction in the structure's life. The same was seen in the current investigation for welding simulation results, with an increase in the error percent of residual stresses. Studies have shown that the maximum residual stress occurs due to the assumption of a constant welding duration in the simulation. In the experiment, the welding duration is changed depending on the weld machine's duty cycle and

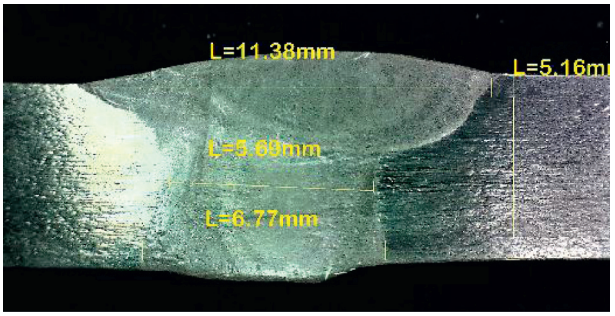



Figure 12: Weld bead geometry of the final weldment.

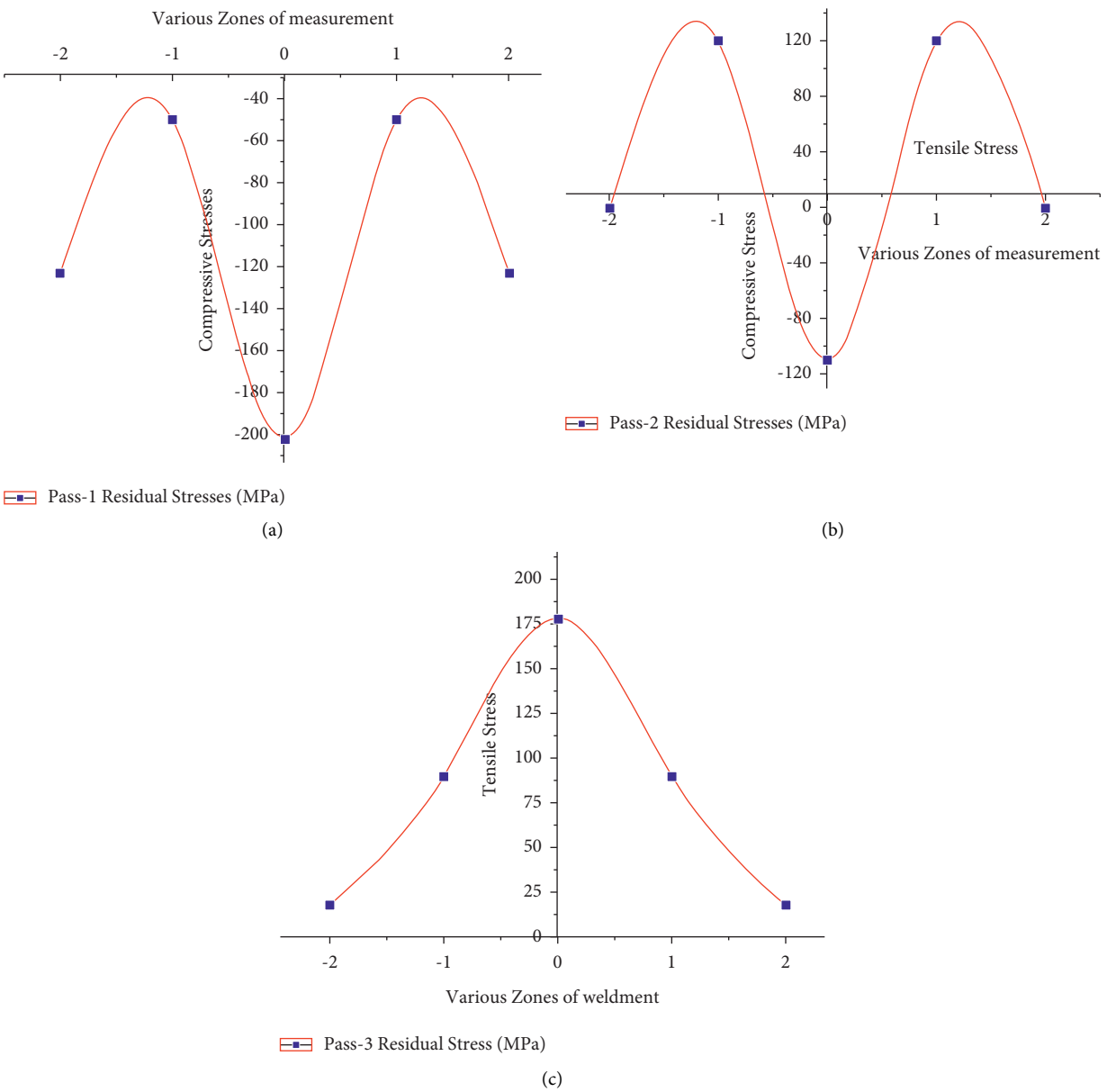



Figure 13: Distribution of residual stress using FEA. (a) Weld pass-1. (b) Weld pass-2. (c) Weld pass-3.

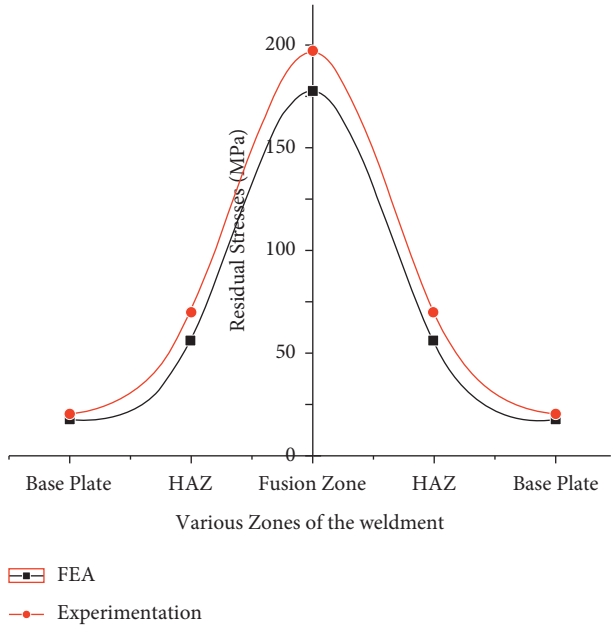



Figure 14: Comparison of residual stresses.

when the filler wire melts and solidifies. Additionally, in Lostado et al.'s research [15], they noted that the welded joints can be expanded greatly if nonlinearities are present. This influence results in the dropping of structural integrity.

## 5. Conclusions

Computational welding mechanics used ANSYS to predict residual stresses and temperature distribution arising from the Inconel 625 multi-pass GTAW process. A double ellipsoidal volumetric heat source model with boundary conditions was used for the thermal analysis.

(i) The multi-pass welding process was established successfully for Inconel 625 by the GTAW process for 5 mm thick plate free from flaws and defects.

(ii) The hot cracking flaws were eliminated by including inter-pass temperatures between the second and third passes. The results are in good agreement with the predicted thermal and mechanical boundary conditions.

(iii) The residual stresses generated were within the yield limits of the parent material.

(iv) The factor of safety was 1.27 for experimentation and 1.42 for simulation of the Inconel 625 welding process.

(v) Temperature measurements were collected pass by pass from the analysis, and the agreement was 9.08%. The agreement between the measured and analysed residual stress was 11%.

## Data Availability

The data used to support the findings of this study are included within the article.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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# Influence of the multi-resolution technique on tomographic reconstruction in ultrasound tomography

Luong Thi Theu, Quang-Huy Tran, Vijender Kumar Solanki, Tatiana R. Shemeleva & Duc-Tan Tran

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## Abstract

The greatest advantage of scattering theory-based ultrasound tomography (UT) is its ability to investigate small structures. DBIM is the Distorted Born Iterative Method. The nearest neighbour interpolation method is used to enhance the reconstruction performance and reduce the reconstruction time. The raw ($N_1 \times N_1$) and dense ($N_2 \times N_2$) meshed integration areas are reconstructed in $N_{N1}$ and $N_{N2}$ iterations, respectively. However, choosing the best value of $N_{N1}$ to get the highest performance was not mentioned in previous works. If it is not well chosen, the reconstruction quality is even worse than that when using no interpolation. This study proposes a method to enhance the UT reconstruction by using the nearest neighbour interpolation (MR-DBIM). The corresponding algorithms are specified by the graphical concurrent programming language of Sleptsov nets. Some significant results are (1) the MR-DBIM is only meaningful when $\boldsymbol{r} < 1$ (i.e. sparse scattering domain); (2) the best performance is obtained in the DBIM when $N_t = N_r$, but in the MR-DBIM when $N_r = 2N_t$; (3) the well-investigated value of $N_{N1}$ is 2 when $0.5 < \boldsymbol{r} < 1$ and is 3 when $0.2 < \boldsymbol{r} < 0.5$.

# A Study on Material Removal Rate and Surface Roughness of Abrasive Water Jet Machining Process on Hybrid Metal Matrix Composites using Response Surface Methodology

June 2021 · International Journal of Vehicle Structures and Systems 13(2):200-205
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Abstract

Hybrid metal matrix composite (HMMC) plays a crucial role in the development of better and advanced materials and in their automotive and aeronautical applications. In this investigation also HMMC is prepared using aluminium alloy, as matrix of material and boron nitrate and silicon carbide are chosen for reinforcing material and stir casting

# Effect of Tin Oxide Coatings by Spray Pyrolysis Process on Mechanical Properties of Aluminium, Brass and Mild Steel

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Abstract and Figures

Mechanical properties of materials are enhanced by different methods to increase the usage of the materials. In this research spray pyrolysis method is employed to increase the mechanical characteristics of three different materials. The tin oxide is chosen as coated material and aluminium, brass, mild steel are selected as substrate materials. The 500nm thin film is developed over the substrate materials by spray pyrolysis. The

**Object categorisation and flame apprehension**

by B. Santhosh Kumar; S. Velliangiri; J. Ajayan

*International Journal of Intelligent Enterprise (IJIE), Vol. 8, No. 2/3, 2021*

***Abstract:*** Object categorisation is a customary errand of PC observation which includes deciding if a picture contains some particular class of question. The thought is firmly related with acknowledgment, arrangement, and misgiving. The several techniques are used in this categorisation and to speak to a division of articles, from shape investigation, or neighbourhood inscriptions, like SIFT, and several methods used. The possible point is to extricate semantics from video to be utilised in a larger amount action examination undertakings. Arranging the uncovered video question is a significant advance in accomplishing this objective. Nonetheless, late research has demonstrated that question groups and their areas in pictures are found in a freely way too. Our contemporary question arrangement calculation influences utilisation of the closer view pixel delineating to every individual associated area to make a blueprint for the protest. Customarily fire sensors which sense the nearness of specific particles created by smoke and fire by photometry were utilised to recognise fire. Normal sensors mean to detect particles, accordingly, an essential shortcoming of point locators is separate limited and decay in open spaces. We depict the computational models utilised to deal with achieve the objectives indicated previously.

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Research Article

# Predicting Election Results from Twitter Using Machine Learning Algorithms

**Author(s):** Yadala Sucharitha*, Yellasiri Vijayalata and Valurouthu K. Prasad

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## Abstract

Introduction: In the present scenario, the social media network plays a significant role in sharing information between individuals. This incorporates information about news and events that are presently occurring in the worldwide. Anticipating election results is presently turning into a fascinating research topic through social media. In this article, we proposed a strategy to anticipate election results by consolidating sub-event discovery and sentimental analysis in micro-blogs to break down as well as imagine political inclinations uncovered by those social media users.

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*Research Article*

# Optimization of Reinforced Aluminium Scraps from the Automobile Bumpers with Nickel and Magnesium Oxide in Stir Casting

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Here, the investigation is spotlighted on the aluminium alloy from the waste materials of the automobile bumpers which is a reinforced metal matrix composite created with 5 percentage of nickel and 5 percentage of magnesium oxide through the stir casting method. The stir casting process inputs parameters such as pressure of squeezing, time of squeezing, and speed of stirrer which were optimized based on the two mechanical properties' outcome such as the tensile strength (TS) and Rockwell hardness. There are nine different experiments which were conducted based on the L9 array. The Taguchi method is used to identify the optimum input values for the greatest result of the processing condition by Minitab software. The responses-based parameters were ordered based on the rank identified through the investigational effects. Finally, the optimized input consideration values and the linear equations are recommended for both the considered outputs as conclusions.

## 1. Introduction

Around the world, scraps of the automobiles are increased day by day, so the effective utilization of the wastes of automobiles, such as accidental bodies, damaged bodies, and replaced bodies, can be reusable after recycling. Here, especially the automobile bumpers which are made up of aluminium were chosen for this investigation. Christy et al. [1] completely explained about optimization techniques used for the input parameters of the squeeze and stir casting with the help of the Taguchi technique. They also explained with the various microstructure diagrams and comparison plots. They used the four input parameters for the four output responses. The basic things of the optimization techniques for the various machining processes of composites such as various proportions of aluminium with zirconium carbide composite [2], several combinations of aluminium with silicon carbide [3], and numerous combinations of aluminium with nanomaterials [4] in the same way machining such as parameters of the laser welding

process [5], electrochemical machining process [6], A-GTAW welding [7], diffusion bonding process [8], turning process on the Lathe machine [9]. Krishnan et al. [10] discussed fully about the metal matrix composites which are produced from the aluminium scrap and materials from the wastes. They give the justification and implementation idea about the various techniques used for the production from those wastes and the scraps. They also defended based on the microstructures and also with characteristics of the composite material with the preliminary materials. Gesing et al. [11] clearly discussed regarding the light metals recycling through the used vehicles and life-ended vehicles' parts and scraps. These recommendations provide confidence to create this type of the research work. Similarly, Gupta et al. [12] reviewed through various research articles and explained about the process of solidification of metal matrix composites. In this investigation mainly focused with the used or damaged or scraped aluminium automobile bumpers recycling with the reinforcement then the optimization undergo with the basic mechanical properties like tensile strength and hardness based input parameters. Alaneme et al. [13] successfully explained regarding the creation in addition age-hardening accomplishment of aluminium composite through silicon carbide for the formation of composite through stir casting method.

Mohan et al. [14] explained the mechanical properties-based optimization of the parameters on the aluminium composites. Pawar et al. [15] professionally investigated about spur gear-based composite of aluminium reinforcement with silicon carbide. They fully expressed the different application with perfect experimental discussion with different figures. Evangelia Georgantzia et al. [16] exclusively clarified concerning AA6XXX series numerous applications with regard to more than a few sizes of physical components in dissimilar forms, process of welding, and equipment through bolted places of equipment. Weiwei et al. [17] investigated about the wheel hub of aluminium alloy failure-based analysis with various simulations. They mentioned the importance of the bumpers as follows: it is accomplished of enduring influences at 2 mph through complete breadth and 1 mph on bends. The bumper must be adept of tolerating influences to prevent 5 mph crashes of the automobiles. Vousden [18] mentioned about the Ferrari about its bumper shape made up of aluminium which is stress-free fiber of carbon composites with neglectable weight. Zhang et al. [19] investigated about the aluminium alloy of 7003 based on the stress corrosion with respect to the automobile vehicles. They also focused on the bumpers made up of aluminium with merits and demerits. These aluminium bumpers were less in weight and more strong when compared to steel. Weiwei et al. [17] discussed about automobile parts-based examination such as breakage of the wheel made up of the aluminium alloy with the various simulations and recommendations of the recycling of the used and damaged automobile parts. Vijay Kumar et al. [20] entirely examined various magnesium-based research articles and they provided the maximum information about the composites of biodegradable magnesium . They also gave the importance for the attention with properties and their availability, usages on the environment. The biodegradable magnesium composites had the advanced strength to wear ratio in addition to furthermore articulated microstructure of the composite by means of various SEM pictures.

Abhijit et al. [21] completely reviewed by means of more than sixty research articles regarding the composite of the magnesium with various combinations of alloys. They concluded that the magnesium is used to strengthen the engineering materials with numerous fabrication methods and also they gave details about the reinforcement influence on the magnesium with additional materials such as silicon carbide, aluminium oxide, boron carbide, titanium carbide, fibers, and carbon nanotubes. This investigation predominantly focused to find the appropriate parameters used to produce the recycling of the scraps or wastes from the automobile bumpers by the way of composite formation with nickel and magnesium oxide in stir casting process. The suitable parameters were considered based on the experimental consequence of furthermost desirable mechanical properties such as tensile strength and hardness of the composite produced by the way of stir casting process.

*1.1. Experimental Setup.* The waste aluminium bumpers were collected from various mechanic shops and different automobile service centers. Then, some pieces of the entire waste bumper were taken for this investigation and were cleaned and converted into small pieces which are also converted into powder form by pulverizing. It contains 1.1 to 1.7 percentage of silicon, 0.7 to 1.3 percentage of magnesium, 0.8 to 1.18 percentage of copper, 0.7 to 1.2 percentage of manganese, and 0.5 percentage of chromium in the total composition. Then, the cleaned aluminium majorly used then the five percentage of nickel and five percentage of magnesium oxide reinforce in the total volume of the composite metal.

The stir casting setup used for this experimental trail is bottom pouring method. It contains the control panel, electrical furnace, runway preheater, die, reinforcement preheating chamber, and hydraulic sequence pressure ram. Initially, the pieces of the automobile bumpers and the nickel and magnesium were placed in the stir casting place, as shown in Figure 1. As shown in Table 1, there are nine experimental trails which created hydraulic squeeze pressures considered as 80 MPa, 100 MPa, and 120 MPa. The sintering speed varies from 400 rpm, 500 rpm, and 600 rpm. The time of the squeeze varied as 20 sec, 40 sec, and 60 sec. The holding pressure was maintained as 300ºC throughout all experiments.

As shown in Table 1, the specimens were formed as per the size of 30 mm × 30 mm × 120 mm as width, length, and height by bottom pouring on the mold. There are nine specimens prepared with pressure, time, and speed variations for the specimens. Then, the specimens were used to take the tensile strength as per the traditional method in the universal testing machine as per the standards. Then, the tensile strength was noted for each specimen. Similarly, the Rockwell hardness machine with the diamond intender cone is used to identify the hardness of each specimen and the corresponding values were noted.

Figure 1: The friction stir machine setup used.

Table 1: Experimental trails of design.

| Experimental trail No. | Pressure ($P$) (MPa) | Time ($t$) (s) | Speed ($N$) (rpm) |
|---|---|---|---|
| ET 1 | 80 | 20 | 400 |
| ET 2 | 80 | 40 | 500 |
| ET 3 | 80 | 60 | 600 |
| ET 4 | 100 | 20 | 500 |
| ET 5 | 100 | 40 | 600 |
| ET 6 | 100 | 60 | 400 |
| ET 7 | 120 | 20 | 600 |
| ET 8 | 120 | 40 | 400 |
| ET 9 | 120 | 60 | 500 |

## 2. Results and Discussion

The measured values of the tensile strength and the hardness values are clearly mentioned in Table 2 for all the experimental trails. Here, the Taguchi technique was implemented for both tensile strength and hardness separately and jointly. For all these three conditions, larger is better condition which is used for the processing in the Minitab-18 software. Individual plots and combination plots were utilized to identify the real impact on the experimental results.

Figure 2 shows the tensile strength foremost result diagram for ratio of SN and Figure 3 shows the tensile strength foremost result diagram for ratio of means clearly. From these two diagrams, the maximum output is obtained in the range for pressure of squeezing is 120 MPa, time of squeezing is 60 sec, and speed of stirrer is 400 rpm. Table 3

Table 2: Results of the experiments.

| Experimental trail No. | Pressure ($P$) (MPa) | Time ($t$) (s) | Speed ($N$) (rpm) | Tensile strength (MPa) | Hardness (HRB) |
|---|---|---|---|---|---|
| ET 1 | 80 | 20 | 400 | 128.48 | 49.82 |
| ET 2 | 80 | 40 | 500 | 133.98 | 51.26 |
| ET 3 | 80 | 60 | 600 | 139.48 | 52.7 |
| ET 4 | 100 | 20 | 500 | 121.2 | 46.1 |
| ET 5 | 100 | 40 | 600 | 126.7 | 47.54 |
| ET 6 | 100 | 60 | 400 | 169.7 | 62.66 |
| ET 7 | 120 | 20 | 600 | 113.92 | 42.38 |
| ET 8 | 120 | 40 | 400 | 156.92 | 57.5 |
| ET 9 | 120 | 60 | 500 | 162.42 | 58.94 |

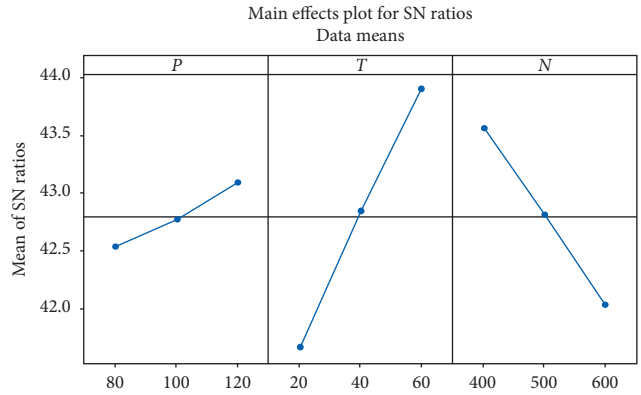


Figure 2: Tensile strength: foremost result diagram for ratio of SN (in $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

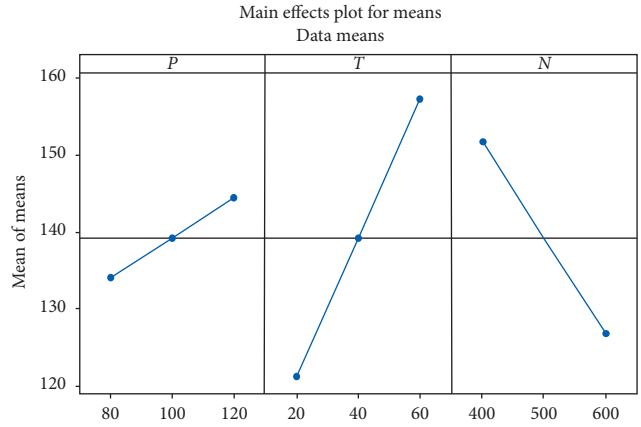


Figure 3: Tensile strength: foremost result diagram for ratio of means (in $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

details about the responses for SN ratio and means for the tensile strength; from that response table, the most impact crated factor is time of squeezing; secondly, it is speed of stirrer, and the last parameter is pressure of squeezing. Table 4 shows variance analysis provided that the minimum "$P$" values which express the reliability of the experiments and parameters are considered.

Figure 4 shows the three different plots of contour diagram in a single plot. It contains the contour diagrams of the time verses pressure, speed verses pressure, and then speed verses time. The variations were represented as the color variations which are clearly represented in the right side of the diagram; each range has a different color for the representations. Figure 5 represents the histogram diagram for the tensile strength with respect to the frequencies which have the mean as 139.2 MPa and standard deviation of 19.51.

The probability plot is shown in Figure 6 with respect to the tensile strength which is represented in $X$ axis and percent is mentioned in the $Y$ axis. In this diagram, entire values were near to the mean line of the plot nearly four to

Table 3: Tensile strength response table.

| Level | Response for SN ratio | | | Response for means | | |
|---|---|---|---|---|---|---|
| | $P$ (MPa) | $t$ (s) | $N$ (rpm) | $P$ (MPa) | $t$ (s) | $N$ (rpm) |
| 1 | 42.54 | 41.66 | 43.56 | 134.0 | 121.2 | 151.7 |
| 2 | 42.77 | 42.84 | 42.81 | 139.2 | 139.2 | 139.2 |
| 3 | 43.09 | 43.90 | 42.03 | 144.4 | 157.2 | 126.7 |
| Delta | 0.55 | 2.24 | 1.54 | 10.4 | 36.0 | 25.0 |
| Rank | 3 | 1 | 2 | 3 | 1 | 2 |

Table 4: Tensile strength variance analysis for SN ratios.

| Source | DF | Seq SS | Adj SS | Adj MS | $F$ | $P$ value |
|---|---|---|---|---|---|---|
| $P$ (MPa) | 2 | 0.4570 | 0.45696 | 0.22848 | 54.29 | 0.018 |
| $t$ (s) | 2 | 7.5283 | 7.52829 | 3.76415 | 894.43 | 0.001 |
| $N$ (rpm) | 2 | 3.5365 | 3.53650 | 1.76825 | 420.17 | 0.002 |
| Residual error | 2 | 0.0084 | 0.00842 | 0.00421 | | |
| Total | 8 | 11.5302 | | | | |

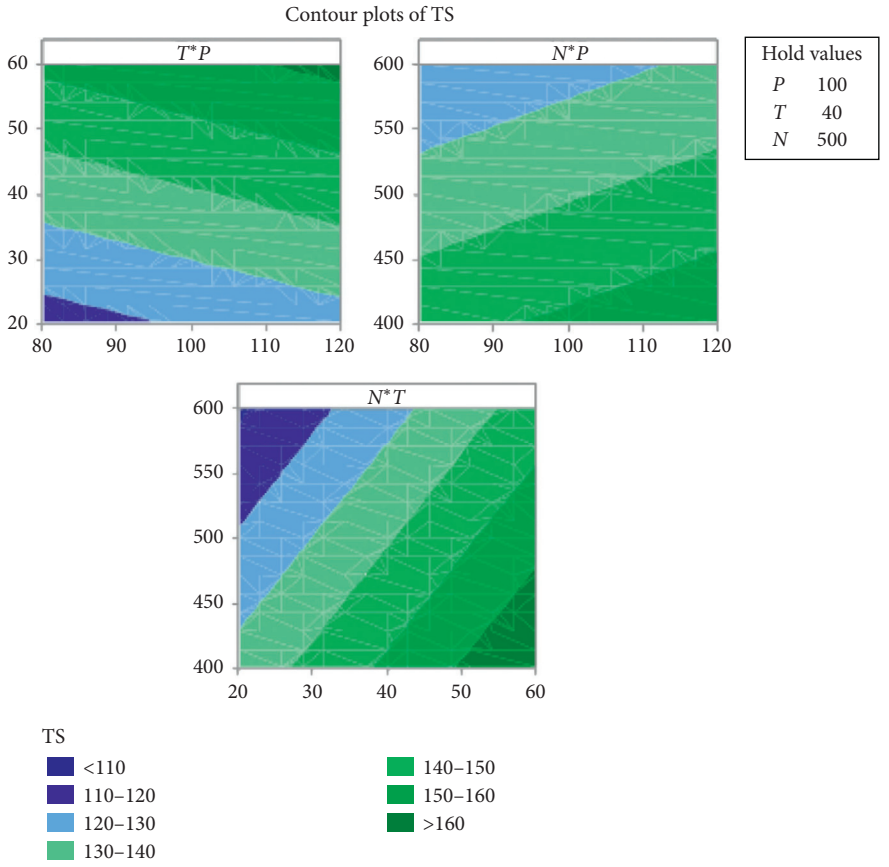


Figure 4: Contour diagrams for tensile strength ($P$, pressure in MPa; $T$, time in s; $N$, speed in rpm).

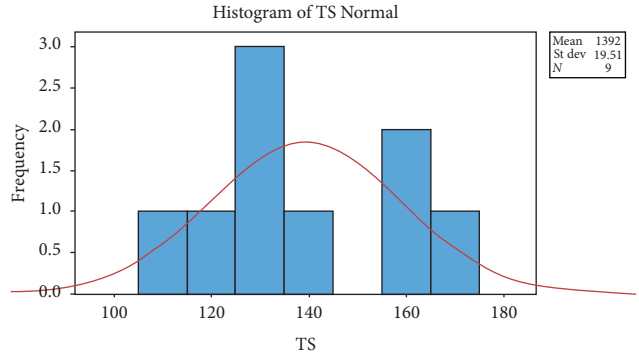


Figure 5: Tensile strength responses as histogram ($X$ axis: TS in MPa and $Y$ axis: frequency in Hz).

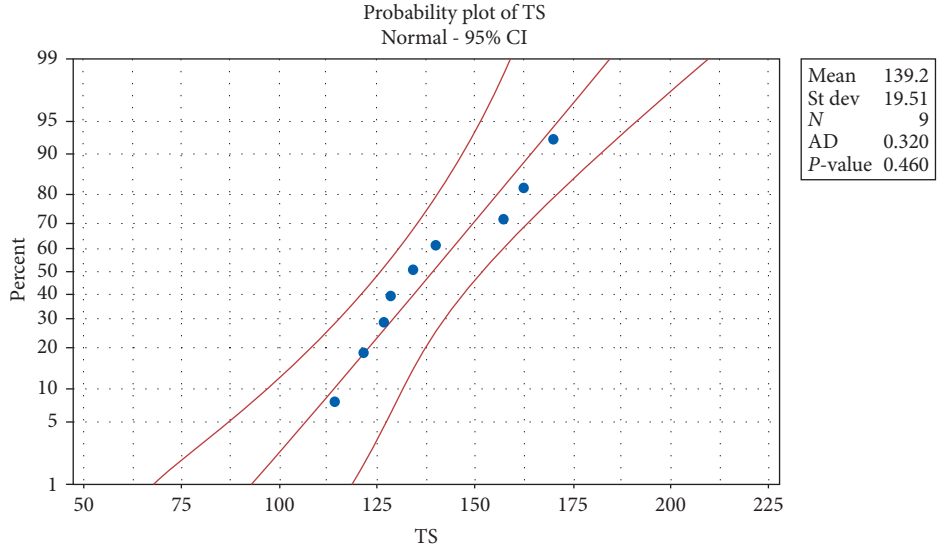


Figure 6: Tensile strength responses as probability plot ($X$ axis: TS in MPa and $Y$ axis: %).

five points' lies on the mean line. By using the regression, the following equation is formed for the tensile strength with respect to the contribution considerations:

$$\text{regression equation for tensile strength} = \text{TS} = 139.6 + 0.2610P + 0.9000T - 0.1250N. \quad (1)$$

The experimental results of the hardness-based foremost result diagram for ratio of SN and means of date are plotted in Figures 7 and 8, respectively; in the same order, these experiments analysed based on the condition of larger is better. The optimum input parameters for the upper most results of the harness were 120 MPa of the pressure of squeezing, 60 sec time of squeezing, and 400 rpm speed of stirrer. These values were also confirmed by both the SN ratio-based diagram and means-based diagram.

The corresponding response table based on the SN ratio and means is shown as Table 5 with the condition of larger is better. For both the conditions, time reached the rank one, speed of stir reached the second rank, and the holding pressure reached the last rank among these three parameters based on the experimental results of the hardness. Similarly, Table 6 lists the variation of the analysis for the hardness results based on the SN ratio. The $P$ value is less than 0.2 for all the parameters, especially time and speed have very low value of the $P$ value in Table 6.

$$\text{Regression equation for hardness (HRB)} = 58.70 + 0.04200P + 0.3000T - 0.04560N. \quad (2)$$

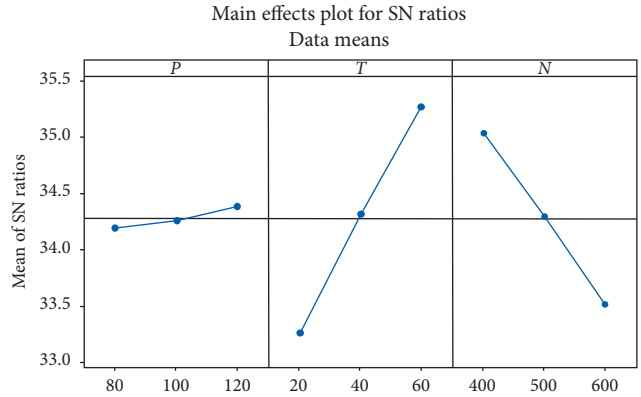


Figure 7: Hardness: foremost result diagram for ratio of SN (in $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

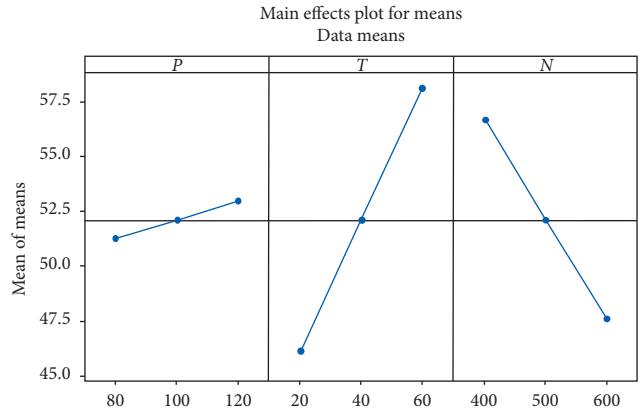


Figure 8: Hardness: foremost result diagram for means (in $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

Table 5: Hardness response table with ranks.

| Level | Response for SN ratio | | | Response for means | | |
|---|---|---|---|---|---|---|
| | $P$ (MPa) | $t$ (s) | $N$ (rpm) | $P$ (MPa) | $t$ (s) | $N$ (rpm) |
| 1 | 34.19 | 33.26 | 35.03 | 51.26 | 46.10 | 56.66 |
| 2 | 34.25 | 34.31 | 34.29 | 52.10 | 52.10 | 52.10 |
| 3 | 34.38 | 35.26 | 33.51 | 52.94 | 58.10 | 47.54 |
| Delta | 0.19 | 2.01 | 1.52 | 1.68 | 12.00 | 9.12 |
| Rank | 3 | 1 | 2 | 3 | 1 | 2 |

Table 6: Analysis of variance of hardness for ratios of SN.

| Source | DF | Seq SS | Adj SS | Adj MS | $F$ | $P$ value |
|---|---|---|---|---|---|---|
| $P$ (MPa) | 2 | 0.05575 | 0.05575 | 0.02787 | 5.09 | 0.164 |
| $t$ (s) | 2 | 6.04324 | 6.04324 | 3.02162 | 551.85 | 0.002 |
| $N$ (rpm) | 2 | 3.46786 | 3.46786 | 1.73393 | 316.67 | 0.003 |
| Residual error | 2 | 0.01095 | 0.01095 | 0.00548 | | |
| Total | 8 | 9.57780 | | | | |

Figure 9 provides the details of the experimental results of the hardness as the contour plot depends on the parameter variations in a single diagram with the color variations for the identification of the range variation on the results. Similarly, the histogram view of the experimental outcomes of the hardness values is clearly plotted in Figure 10 with linear relation curve. There is no gab in between the columns available on the histogram diagram. The probability chart for the harness results is plotted in Figure 11. All the experimental values nearly closer the median line on the chat. Nearly six to seven points were nearly close to the median line.

In Table 7, the confirmation test is created with the combination of the both tensile and harness strength based foremost result diagram for ratio of SN is shown in Figure 12, and the foremost result diagram for data means is shown in Figure 13; similarly, response table with ranks based on SN ratios is shown as Table 6. As shown in Figures 12 and 13, the maximum output of both the mechanical properties reached higher values at the pressure of squeezing 120 MPa, time of squeezing 60 sec, and speed of stirrer

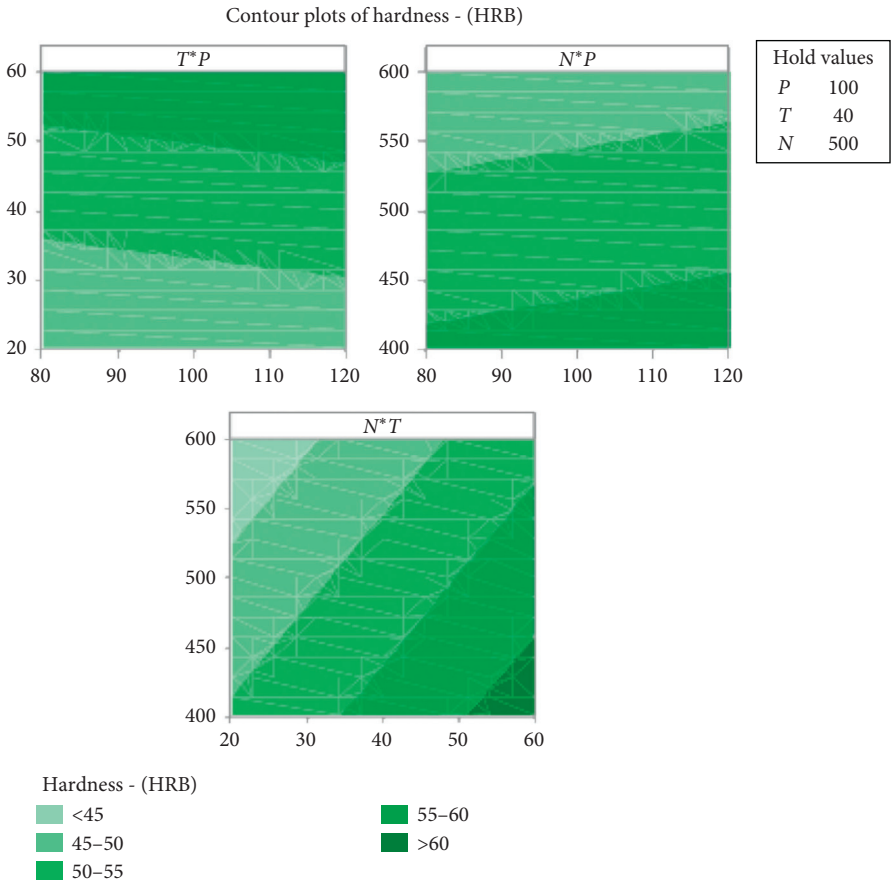


Figure 9: Hardness-contour plot depends on the parameters variations ($P$, pressure in MPa; $T$, time in s; $N$, speed in rpm).

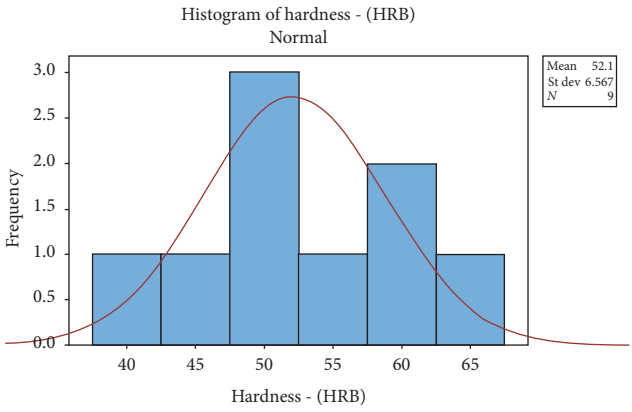


Figure 10: Hardness: histogram diagram ($X$ axis: TS in MPa and $Y$ axis: frequency in Hz).

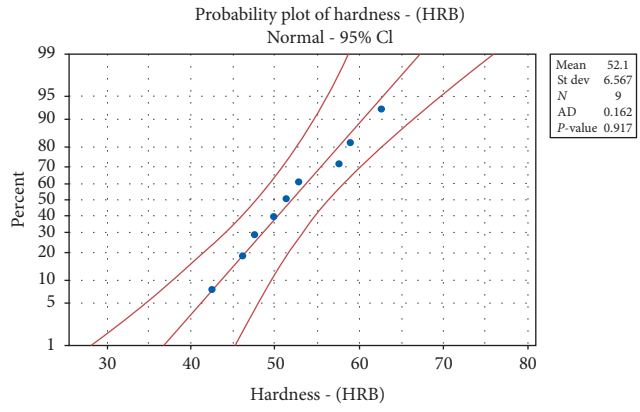


Figure 11: Hardness: probability plot ($X$ axis: TS in MPa and $Y$ axis: %).

Table 7: Tensile strength and harness-based response table with ranks based on SN ratios.

| Level | $P$ (MPa) | $t$ (s) | $N$ (rpm) |
|---|---|---|---|
| 1 | 36.61 | 35.68 | 37.47 |
| 2 | 36.69 | 36.75 | 36.73 |
| 3 | 36.84 | 37.71 | 35.95 |
| Delta | 0.23 | 2.04 | 1.52 |
| Rank | 3 | 1 | 2 |

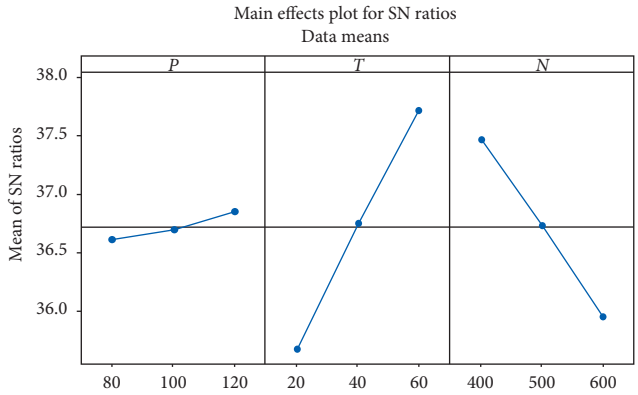


Figure 12: Both tensile strength and harness-based foremost result diagram for ratio of SN (In $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

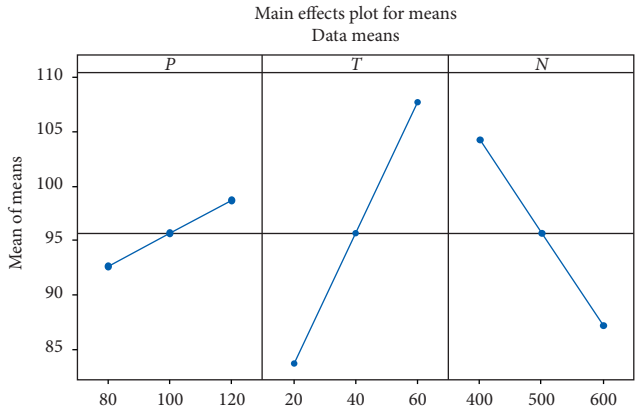


Figure 13: Both tensile strength and harness-based foremost result diagram for data means (In $X$ axis, $P$ is the pressure in MPa, $T$ is the time in s, and $N$ is the speed in rpm).

400 rpm. The corresponding ranking is obtained in the order of time, speed, and pressure as first, second, and third.

## 3. Conclusions

This optimization study of reinforced aluminium scraps from the automobile bumpers with nickel and magnesium oxide in stir casting gave the following results as conclusions:

(i) The recycling of the aluminium automobile bumpers into the reinforced composite is possible.

(ii) For the experimental results of the tensile strength, hardness and both combination conditions response table gave the first rank for time of squeezing, the second rank for speed of stirrer, and the third rank for holding pressure.

(iii) The regression equations (1) and (2) were created for tensile strength and hardness with respect to the same conditions, respectively.

(iv) Both the enhanced mechanical properties were obtained at the input parameters such as pressure of squeezing 120 MPa, time of squeezing 60 sec, and speed of stirrer 400 rpm.

(v) The optimized contribution concern values and the linear equations are recommended for tensile strength and hardness.

(vi) Further scope of this work was extended to conduct the impact test for the same material with increase of the reinforcement for preventing the impact of accident to the vehicle.

## Data Availability

The data used to support the findings of this study are included within the article. Further data or information is available from the corresponding author upon request.

## Disclosure

This study was performed as part of employment in Hawassa University, Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

## Acknowledgments

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*Review Article*

# Strength Enhancement Study on Composites of AA6066 Aluminium Alloy with Magnesium Oxide and Coal Ash

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Aluminium alloy is the most favourable material based on the various properties and economic factors. Always there are so many researches going on based on the enhancement of the material properties with various combinations and the various materials mixing rate depending upon the availability. These researches were focused on the augmentations of the properties, and then the corresponding properties can be used in the various applications depending upon the results. In this study, the AA6066 aluminium alloy composites were created with the magnesium oxide and coal ash with a variety of grouping. The specimens were named as AAMgOCA 1 to AAMgOCA 6 with respect to the volume concentration composition. Then, the composites were tested to identify the impact on various strengths such as yield strength, ultimate tensile strength, shear strength, and flexural strength. These strengths were compared with the two conditions of the composites such as annealed and heat-treated conditions. AAMgOCA 3 has the greatest results in heat-treated condition when compared with the annealed condition.

## 1. Introduction

There are number of researchers who were encouraged to conduct research to identify the new things and alteration of the existing things which are applicable for engineering materials especially in aluminium alloy due to its wide usage among all the places. Georgantzia et al. [1] explained the various uses of aluminium alloys in different structure-based applications with various recognizable buildings in UK, USA, UAE, Russia, etc. They also reviewed various researchers' point of view and gave idea about the different grades of aluminium alloys. Davis JR [2] provided the outline of fundamental values and explanations for produced alloys and the equivalent subdivisions. He gave the method of annealed conditions for ductility, toughness, etc.

Zhu et al. [3] discussed the heat treatment conditions and methods of the various aluminium alloys with eight tests. They also followed the design code standards for preparation of the specimens. The various methods can be identified with the basic methods. Mukhopadhyay [4] individually reviewed the aluminium alloy 6XXX series with respect to designing and handing out through nearly

seventy-five references. He completely gave a variety of specifications, heat treatment methods, characteristics, and also the application point of view for the 6XXX series. AA6066 alloy has the percentage composition of 1.3% of magnesium, 1.6% of silicon, 1.15% of copper, 0.38% of chromium, and 1.05% of manganese, and the remaining is aluminium alloy in the total composition [4].

Tiryakioğlu et al. [5] talked about the harness strength in the aluminium alloy with some mathematical relations as well as the various SEM images in the different approaches. The considered material's pulverized powders are shown in Figure 1. Palani et al. [6] mentioned that the annealed casting specimens have higher dimensional stability and ductility when compared with the tempered specimens and similarly explained the hardened products which also have obtainable ductility in front of the elevated temperatures.

Imran et al. [7] investigated the composite specimen of Al7075 aluminium alloy with various combinations of the graphite and bagasse ash for testing of mechanical properties such as the ultimate tensile strength, hardness, percentage of elongation, and yield strength comparison. They also individually plotted and compared the various percentage variations with optimization technique. They concluded that the hybrid composites provided the greatest enhancement in their properties when compared with the individual alloy specimen.

Kumar et al. [8] focused only about the wear and tensile strength of the aluminium-based composite with silicon and titanium. From this investigation, microstructures were clearly identified and porosity can be controlled by the design parameters of the mold. Uthayakumar et al. [9] explained the hybrid composites of boron carbide- and silicon carbide-used aluminium alloy with various sliding circumstance for performance of the wear rate. Kumar and Dhiman [10] investigated and explained the response surface methodology-based hybrid and normal alloy of Al7075 aluminium alloy.

Senapati et al. [11] clearly explained the fly ash participation in tehe production of matrix composite of the aluminium alloy in the successive way. Mohammed Razzaq et al. [12] explained the reinforcement of the aluminium alloy with the fly ash composites. They clearly explained the basic properties and microstructure with XRD images and SEM images. The bulk density, porosity formation, impact strength, hardness, and brittleness of the reinforced composites were directly proportional to the fly ash content in the total proportions.

Sivaprasad et al. [13] studied the aluminium composite with titanium diboride reinforcement and studied the mechanical properties and mentioned the various applications. Wang et al. [14] investigated the reinforcement of aluminium alloy with the metallic glass fiber with the help of the microstructures and various characteristics. They concluded that the adhesive strength is the prior quality for the composites of the metal matrix. Efzan et al. [15] clearly explained fly ash-based aluminium composites along with applications with respect to the mechanical and physical behaviours.

Singh and Chauhan [16] reviewed the hybrid composites of the aluminium alloy with a number of research articles and they concluded that the properties of the composites were increased with increasing the percentage concentration on the composites. Sun et al. [17] clearly explained the aluminium alloy, titanium oxide, and magnesium oxide-based composite in heat treatment condition with the help of SEM images and XRD images. Tong et al. [18] also investigated the alumina and magnesium oxide composite-based mechanical properties enhancement by heat treatment.

Manikandan et al. [19] discussed magnesium oxide with aluminium alloy composite by reinforcement. The mechanical properties like compression strength, hardness, and wear behaviour were analysed with various SEM images. They concluded that the wear rate can be increased with the increase of the percentage of the magnesium oxide in total volume percentage. Kheder et al. [20] discussed and compared the composite combination of the aluminium alloy with various percentages of aluminium oxide, silicon carbide, and magnesium oxide separately. Increase of these metals in aluminium alloy provides enhancement in the mechanical properties; also, they mentioned that the magnesium oxide with aluminium alloy composite can be used in the structural components in the construction field related applications with high strength. The combined effect of the aluminium alloy at any series with the hard reinforced particles induced the high strength of the composites even at any type of composite preparation process [21, 22]. The mechanical properties also increased gradually by addition of reinforcement particles into the aluminium alloy [23].

In this study, the aluminium alloy composite reinforcement is involved with magnesium oxide and the coal ash with various percentage. Then the composites were forced for annealed and heat-treated conditions. The corresponding mechanical properties for these composites with two conditions were compared to identify the greater results among the composites.

## 2. Experimental Procedure

For this approach, aluminium alloy AA6066 composites are created using magnesium oxide and coal ash as per the combination of volume percentage variation in the complete volume in Table 1. All the materials were available in the market which are collected and used for the experiments. The coal ash is collected from the thermal power stations outcome which is cleaned and filtered from the various dust particles. The entire composite contains eighty percent of aluminium alloy AA6066 as a major component. The remaining twenty percent of the composite is filled with magnesium oxide and coal ash. Magnesium oxide proportion decreased from twenty percent to zero percent with four percent decrement for each specimen.

Similarly, coal ash percentage is increased from zero contribution to twenty percent with decrement of four percent. There are six combinations of the specimens prepared. The name of composite created was as per the mixing material's notations AAMgOCA (AA means aluminium alloy, MgO means magnesium oxide, and CA means coal

(a) (b) (c)

Figure 1: Powdered form of the materials. (a) AA6066. (b) MgO. (c) Coal ash.

Table 1: Percentage details of the composites for the experimental purpose.

| Composite name | Volume percentage of the total composite (%) | | |
|---|---|---|---|
| | AA6066 | MgO | Coal ash |
| AAMgOCA 1 | 80 | 20 | 0 |
| AAMgOCA 2 | | 16 | 4 |
| AAMgOCA 3 | | 12 | 8 |
| AAMgOCA 4 | | 8 | 12 |
| AAMgOCA 5 | | 4 | 16 |
| AAMgOCA 6 | | 0 | 20 |

ash) with number from 1 to 6 for the various combinations of metals.

The individual specimens were prepared by the sand molding method. Sand molding process was created by tightly packing of sand with the addition of clay binder and correct level of water in the molding boxes. The mold cavity was formed by the way of pattern. The metal pattern was used for this experimental work; it formed the required shape of the samples after casting. The molten metal was poured into the mold cavity through the gate way; after filling the mold cavity, the molten material was allowed to cool. After solidification process, the casting part was removed from the sand mold; finally, the unwanted projection was removed by the fettling process. The metals used for this investigation were taken in the form of powder with the dimension from 30 microns to 70 microns. Here, the specimen was prepared with the dimension of 40 mm diameter and 200 mm length in three numbers for each combination. Then, the prepared rod specimens were carried for the two conditions such as annealed (900 K) condition and the heat-treated (1100 K) condition and then cooled artificially. Each specimen should maintain these two conditions.

In this place, there are four different mechanical strength tests conducted for the strength comparison on each combination in two conditions. The strengths considered for this experimental investigation were followed such as yield strength (YS), ultimate tensile strength (UTS), shear strength (SS), and flexural strength (FS). All these tests were conducted with the help of the universal testing machine mentioned in Figure 2. ASI brand universal testing machine was used to conduct the tensile test; the universal testing machine had a capacity of 60 tones. The model of the UTM was named UTE-60; this machine was functioning hydraulically. The bending test was also termed flexural test; it was conducted by universal testing machine with three-point bend fixture; normally, 3-point bend fixture was used. Then the created specimens were prepared as per the testing standards of the individual testing conditions with respect to the universal testing machine. In this experimental work ASTM E8 standard procedure was used to conduct the tensile test.

Figure 2: UTM for the testing.

Ultimate tensile strength and the yield strength can be measured in single specimen with the single attempt of the testing. But the shear strength and flexural strength need separate specimens and separate arrangement change in the UTM. Then the corresponding arrangements were created with respect to the testing and Figure 3 shows the arrangement and testing method for the flexural strength. Finally, the experimental results from the individual tests were taken for both annealed condition and heat treatment conditions.

## 3. Result and Discussion

The complete experimental results of yield strength (YS), ultimate tensile strength (UTS), shear strength (SS), and

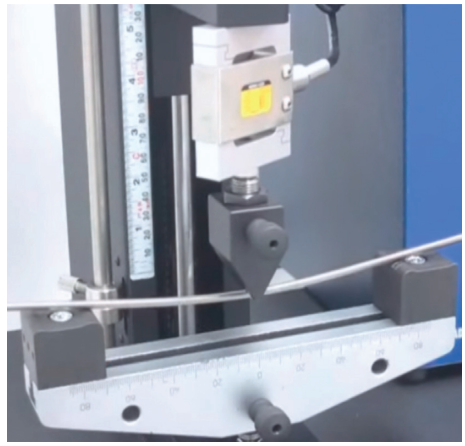

Figure 3: Flexural testing.

flexural strength (FS) obtained from the various testing conducted with annealed conditions and heat-treated conditions for the each specimens are clearly pointed out in Tables 2 and 3 correspondingly in the unit of MPa for all the strengths.

Figure 3 represents the yield strength comparison in the form of three-dimensional surface plot for both annealed and heat-treated specimens. Annealed specimens have less yield strength when compared with heat-treated specimens' results. For heat-treated condition, the maximum yield strength (415 MPa) is reached for the specimen AAMgOCA 3 and the minimum yield strength (395.59 MPa) is achieved for the specimen AAMgOCA 1. For the greatest result the annealed specimens were very low when compared with lowest heat-treated specimen.

The experimental outcomes of the ultimate tensile strength comparison for the annealed and heat-treated conditions are explained in Figure 4 as a three-dimensional surface plot. From this plot, ultimate tensile strength of heat-treated specimens' results was greater than the annealed specimens with higher difference. The supreme ultimate tensile strength of 452.76 MPa has been obtained for the specimen AAMgOCA 3 for heat-treated specimens. Similarly, the greatest ultimate tensile strength value for annealed condition can be achieved for the same specimen as 172.98 MPa which is very low.

The measured experimental results of shear strength for heat-treated specimens and annealed specimens were clearly mentioned as the three-dimensional surface plot in Figure 5. The highest and lowest shear strength for the annealed specimens were 109.12 MPa (AAMgOCA 3) and 103.87 MPa (AAMgOCA 1), respectively. Similarly, the greatest and smallest shear strength values for the heat-treated specimens were 265.85 MPa (AAMgOCA 3) and 253.04 MPa (AAMgOCA 1). Among these values, the lowest values of the heat-treated specimen were also higher than the highest shear strength value of the annealed specimens.

In Figure 6, the three-dimensional surface plot was plotted for the comparison on the flexural strength results from the experiments for heat-treated specimens comparison with the annealed specimens. The maximum and minimum flexural strength for the heat-treated specimens were 136.99 MPa (AAMgOCA 3) and 130.89 MPa (AAMgOCA 1), respectively. Similarly, the supreme and least flexural strength values for the annealed specimens were 82.42 MPa (AAMgOCA 3) and 78.45 MPa (AAMgOCA 1). Among these values, the lowest flexural strength (136.99 MPa) of the heat-treated specimen was also higher than the highest flexural strength (82.42 MPa) of the annealed specimens.

The comparisons of the all experimental results based on the strength for the specimens in both heat-treated and annealed condition were clearly mentioned as a bar chart in Figure 7. These composites have the highest ultimate tensile strength and lower flexural strength among these strengths. The annealed specimens have the lower results when compared with heat-treated specimens for all specimens'

Table 2: Experimental outcome of the specimens in annealed conditions.

| Specimen name | Annealed specimens (MPa) | | | |
|---|---|---|---|---|
| | YS | UTS | SS | FS |
| AAMgOCA 1 | 91.2 | 164.645 | 103.87 | 78.455 |
| AAMgOCA 2 | 93.48 | 168.761 | 106.466 | 80.416 |
| AAMgOCA 3 | 95.817 | 172.98 | 109.128 | 82.426 |
| AAMgOCA 4 | 94.619 | 170.817 | 107.764 | 81.396 |
| AAMgOCA 5 | 93.436 | 168.682 | 106.417 | 80.378 |
| AAMgOCA 6 | 92.268 | 166.574 | 105.087 | 79.374 |

Table 3: Experimental outcome of the specimens in heat-treated conditions.

| Specimen name | Heat-treated specimens (MPa) | | | |
|---|---|---|---|---|
| | YS | UTS | SS | FS |
| AAMgOCA 1 | 395.59 | 430.95 | 253.045 | 130.39 |
| AAMgOCA 2 | 405.479 | 441.723 | 259.371 | 133.649 |
| AAMgOCA 3 | 415.616 | 452.766 | 265.855 | 136.99 |
| AAMgOCA 4 | 410.421 | 447.107 | 262.532 | 135.278 |
| AAMgOCA 5 | 405.291 | 441.518 | 259.250 | 133.587 |
| AAMgOCA 6 | 400.225 | 435.999 | 256.009 | 131.917 |

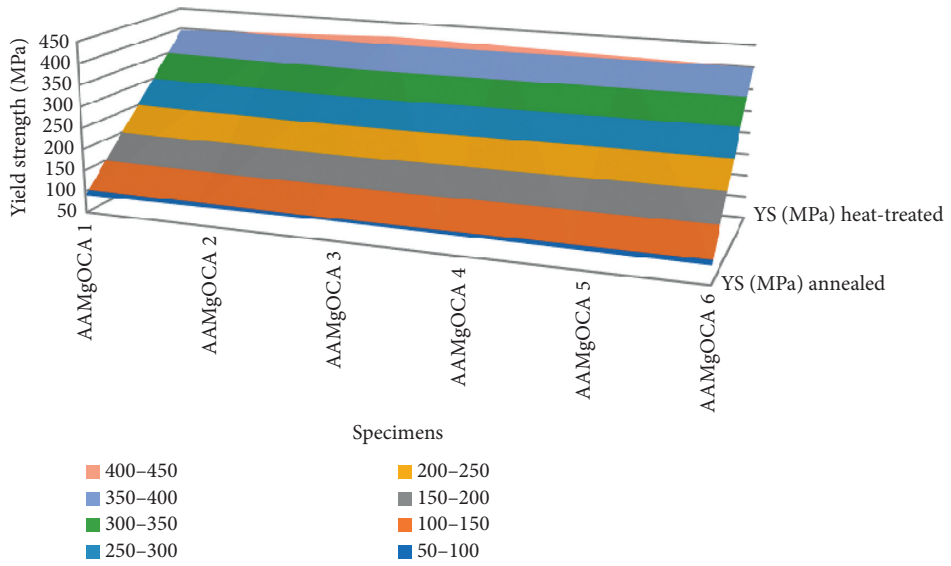


Figure 4: Three-dimensional surface plot comparison on yield strength.

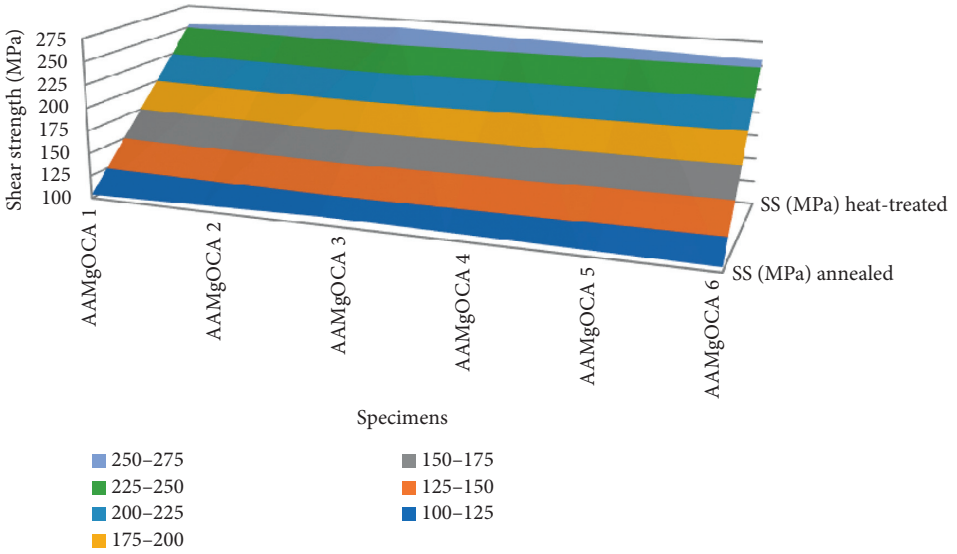


Figure 5: Three-dimensional surface plot comparison on shear strength.

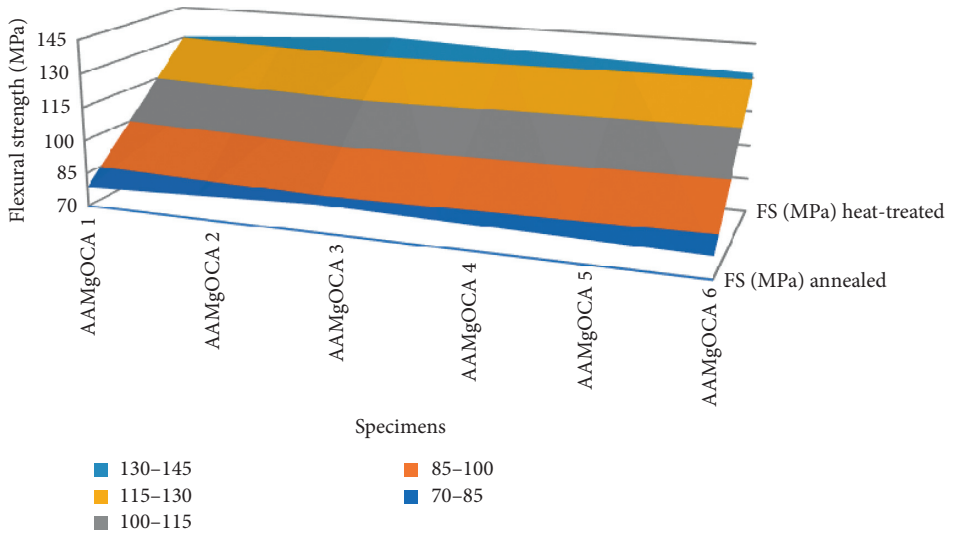


Figure 6: Three-dimensional surface plot comparison on flexural strength.

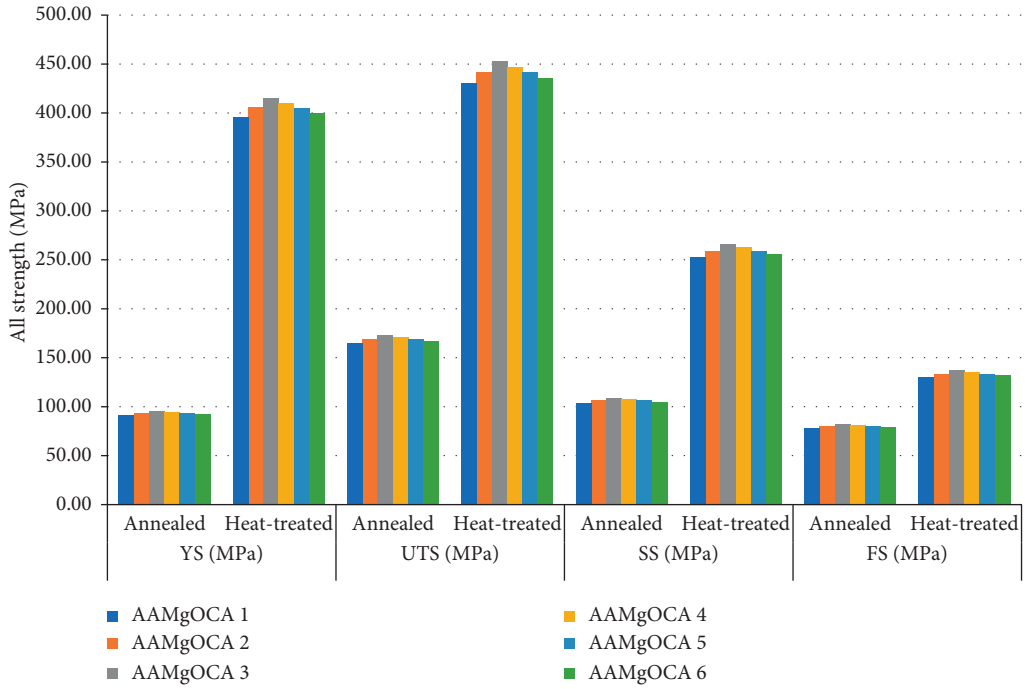


Figure 7: Comparison of all specimen results based on strength.

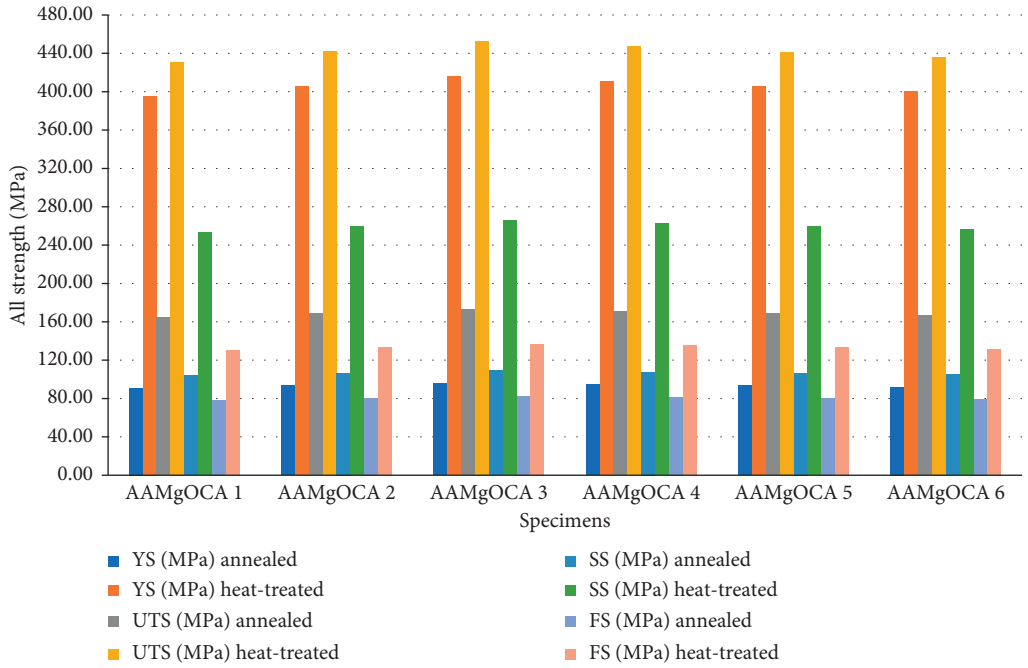


Figure 8: Comparison of all experimental results based on specimens.

yield strength (YS), ultimate tensile strength (UTS), shear strength (SS), and flexural strength (FS). The values of all strengths were increased up to the AAMgOCA 3, and then, the strengths were decreased up to AAMgOCA 6.

Similarly, Figure 8 gives the details of experimental results of all strengths for both heat-treated and annealed condition with respect to the individual specimens. Among these six specimens AAMgOCA 3 had the greatest results of

Table 4: Maximum experimental results.

| Specimen name | YS (MPa) | | UTS (MPa) | | SS (MPa) | | FS (MPa) | |
|---|---|---|---|---|---|---|---|---|
| | Annealed | Heat-treated | Annealed | Heat-treated | Annealed | Heat-treated | Annealed | Heat-treated |
| AAMgOCA 3 | 95.82 | 415.62 | 172.98 | 452.77 | 109.13 | 265.86 | 82.43 | 136.99 |

all strengths when compared with other specimens for both heat-treated and annealed condition. Similarly, AAMgOCA 1 specimen had the minimum values of all tested results in the investigation for both annealing and heat-treated condition. The maximum strength values are mentioned in Table 4 for specimen AAMgOCA 3.

## 4. Conclusion

The mechanical strength enhancement study on composite of AA6066 aluminium alloy with magnesium oxide and coal ash through various experimental results produced the following as conclusions:

(i) The composite of the AA6066 aluminium alloy with magnesium oxide and coal ash with different combinations based on Table 1 is possible.

(ii) In all the experimental results, annealed specimens have the lower results in strength value

(iii) Similarly, for all the experimental results, heat-treated specimens have the higher results in strength value

(iv) From the comparison, the specimen "AAMgOCA 3" has reached the highest experimental results for both conditions (Table 4)

(v) The strength values get increased up to the specimen AAMgOCA 3, and then the results start to decrease simultaneously

(vi) So, the coal ash participation less than MgO produced the good result when compared with the higher coal ash concentration specimens' results

(vii) Therefore minimizing the coal ash content and maximizing the MgO participations provide the greatest result in strength

(viii) At last, 80% of AA6066 aluminium alloy with 12% of MgO and 8% of coal ash reached the maximum yield strength, ultimate tensile strength, shear strength, and flexural strength when compared with the remaining composite specimens

## Data Availability

The data used to support the findings of this study are included in the article. Further data or information are available from the corresponding author upon request.

## Disclosure

This work was performed as a part of the Employment of College of Engineering and Technology, Hawassa University, Hawassa, Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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*Research Article*

# Improving the Mechanical Properties of Natural Fiber Composites of Hemp Fiber with Ramie and Banana Fiber through Compression Molding Method

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Natural fiber composite is the most preferable research area in the modern situation due to its availability, applications, and ecofriendly quality. This paper deals with the influence of hemp fiber with the various compositions of the ramie fiber and some basic mechanical properties of banana fiber composites. The hemp fiber is maintained as 20 percentage of total volume. Then, the remaining volume percentage is shared with the ramie fiber and banana fiber with various combinations. Eleven specimens were prepared to identify the some basic mechanical properties. The chemical compositions were mentioned as a pie chart, and then experimental results were plotted as graphical representations like line diagram and radar diagram for clear identification that the composite with higher ramie fiber concentration provided the greater results in the mechanical behaviors. The suitable composite combinations were recommended based on their superior properties as conclusions.

## 1. Introduction

Composite materials created the revolution of the materials in the world especially the natural fiber composite has the most influence on it based on their physical properties, availability, and economic supports when compared with the metals. This investigation is based on sources of the fiber plant and is shown in Figure 1. Dipen Kumar et al. [1] clearly reviewed about the fiber reinforcement composites with various industrialized methods, and they identified the characteristics with usage. They also discussed about the synthetic and natural fibers with the help of various images and evidences from the research articles. Asim [2] clearly discussed regarding physical properties and mechanical properties of the hemp fiber with the help of different articles. He also proved the SEM images of bundle fiber and loose fiber also. The hemp fiber chemical compositions are clearly shown in Figure 2.

Seena et al. [4] clearly explained about the glass and banana fibers reinforcement with phenol formaldehyde, and they compared the characteristics individually with the help of various testing methods. They also provided various details and history of the banana fiber from the beginning. Sreekumar et al. [5] focused on the banana fiber reinforced composite with polyester which can be created through RTM, and they gave more attention to the mechanical properties and the water sorption investigations in a clear way. The chemical compositions of the banana are clearly mentioned in Figure 3.

Thonangi et al. [6] explained fully about the natural fiber reinforcement techniques with reliable diagrams, and they also compared the natural fiber with the glass fiber. They mentioned that the availability of the ramie fiber among the world with the help of the various articles and pointed out the chemical compositions and various mechanical properties of the ramie fiber with some list of fibers. The chemical compositions of the ramie fiber are clearly shown in Figure 4.

Layth et al. [3] reviewed with more than hundred research papers regarding the application of the reinforced natural fiber composites. They concluded that the main appreciable properties of the natural fibers when compared with synthetic fibers are less density, low solidity, and good economic characteristics. Mainly these natural fiber composites were used in the construction field, industries of automobiles, decoration field, and so on. They also mentioned that the reinforcement produced the greatest results in characteristics of the composites.

Sathish et al. [7] discussed about the basic properties of the hemp fiber based on the spectroscopy and microscopy. They mentioned that the most important factor of the reinforced natural fiber composite is bonding strength. Michael et al. [8] investigated about the hemp fiber compositions and arrangements with different chemical methods. They treated the hemp fiber with various chemicals such as sodium hydroxide, calcium chloride, calcium hydroxide, and various acids and tested with various thermal methods.

Le Troedec et al. [9] mentioned that the hemp fiber has higher brittleness property than jute fiber composites. Paul et al. [10] mentioned the applications of the hemp fiber as electrical components, products of building, cloths, wrapping materials, and pipes manufacturing. Tara and Reddy [11] discussed about the ramie fiber and modification based on different reaction of hydroxyl groups with isocyanate used chemical treatments. He et al. [12] mentioned the applications of kitchen and home-based furniture, fisher web, screen cloths, and so on.

Chandramohan et al. [13] explained about the ramie fiber. They concluded that the volume fraction of the fiber concentration leads to the augmentation of the properties of the composites but thirty percentage of volume fraction of ramie fiber has the supreme storage modulus amongst the comparison of the other volume fractions. In the same way, Mwaikambo [14] and Zulkifli et al. [15, 16] recommended the thirty percentage volume fraction of the ramie fiber for the greatest results in the mechanical characteristics.

Eko et al. [17] obviously investigated about the epoxy resin used banana composite with surface treatment influence on the characteristics. They clearly mentioned the basic properties and compositions of the banana fibers. They used the different concentrations of the sodium hydroxide alkali treatment with the banana composite. They concluded that the one percentage of the sodium hydroxide used treatment reaches the greater consequences in the characteristics of the composites when associated with supplementary percentage of concentrations.

Eko et al. [18] completely explained about the reinforced banana fiber composite with different methods especially volume fraction has the most important influence in the mechanical behaviors. Venkateshwaran et al. [19] focused the thermal and mechanical characteristics natural fiber composites of the banana. They are provided the significant improvement and recommendations for the natural fibers which can be executed with the intention of augmentation of the characteristics. Ramesh et al. [20] explained about the banana fiber and pandanus reinforcement composites. They concluded that composites of woven banana fibers have the lesser water absorption when compared with the composite of woven pandanus [21]. From all these investigations, following research gabs are identified.

The hemp, banana, and ramie fibers were separated; combination of these two or other fibers based composites was only studied. However, this investigational research article is noticeably focused on natural fiber composites of constant twenty percentage of hemp fiber with banana and ramie fiber in different combinations of volume fractions and on the basic mechanical behavior (tensile strength, Young's modulus, percentage of elongation and density) based appropriable volume fraction of fiber composites [22].

## 2. Experimental Procedure

This experiment is conducted with fibers of hemp, banana, and ramie with the resin of polylactic acid by the compression molding method. This experiment is done with the compression molding machine with capacity of five tones, 50 kW powers [23]. It contains upper part of die and lower part of the die with guide pins. Lower part of the die has the heating and cooling facilities with molding cavity. The fiber combinations (as per Table 1) and resin were taken into the mold cavity of specimen size of 250 mm length, 200 mm width, and 12 mm thickness [24]. Then, the upper and lower parts of the die are closed. Then, the pressure of 150 kg/cm$^2$ to 600 kg/cm$^2$ was applied, and the heat is also applied to the mold place in the range of 70°C to 80°C for the preheating purpose. After curing, the specimens were collected with the help of the extraction pin.

Eleven specimens were prepared as per the variations mentioned in Table 1. All the specimens have 20 percentage of the hemp fiber due to its higher mechanical properties. Then, the banana fiber and the ramie fiber have the remaining 80 percentage with the various combinations to produce the specimens for the testing [25]. The specimens were named $P1$ which means piece number 1; similarly, others also named as $P2$, $P3$,. . ., $P11$. The concentration of the banana fiber of volume percentage in the total volume percentage get reduced from eighty percentage to zero

(a) (b) (c)

Figure 1: Natural fiber plants of (a) hemp; (b) banana; (c) ramie.

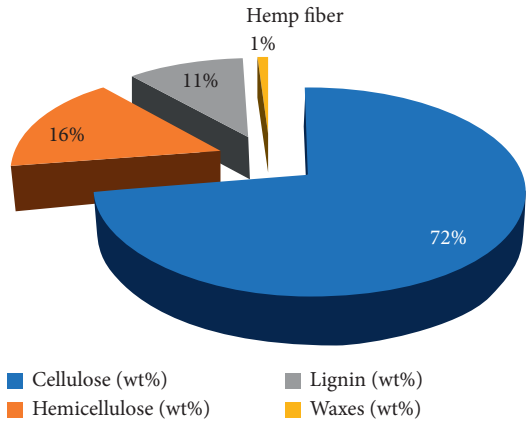


Figure 2: Chemical compositions of the hemp fiber [3].

percentage with the decrement of eight percentage of the volume fraction in each specimen from $P1$ to $P11$.

Similarly, ramie fiber volume percentage increased from zero percentage to eighty percentage with eight percentage of volume concentration in the specimens from $P1$ to $P11$, respectively. Then, the individual specimens were prepared as per the ASTM E8 standard methods for the universal testing machine [26]. Here, tensile strength and percentage of elongation were identified with the same testing machine mentioned in Figure 5. However, Young's modulus of the samples can be found based on Hook's law relation such as stress strain relations. The density values of the specimens were measured with the help of the weighing machine. Then, the density is calculated with the ratio of mass to the unit volume calculations.

## 3. Results and Discussion

The radar diagram really helps to identify the separation of the results with one or more in the sequence level and the interaction between the outcomes of the experimental results. So, in this investigation, radar diagrams especially filled radar diagrams (created by Microsoft Excel software) were used to realize the results in the clear identification. The experimental results of the tensile strength are plotted in Figure 6(a) as a radar diagram and Figure 6(b) as a line diagram. The tensile strength has enhancement from lower to higher with respect to increasing ramie fiber contribution among the composites. The highest tensile strength is achieved at specimen $P11$; similarly, the lowest tensile strength is achieved at $P1$. From the radar diagram, it is mentioned that $P8$ to $P11$ specimens have the greatest value region from 650 MPa to 740 MPa as experimental results when compared with others.

Similarly, experimental results of Young's modulus in GPa are plotted as radar diagram and line diagram in Figures 7(a) and 7(b), respectively. Hear, also Young's modulus gets increased in each specimen with increase in ramie fiber contribution in the specimens. The maximum Young's modulus is reached at the $P11$ composite specimen, and the minimum Young's modulus is reached at specimen $P1$. From the radar diagram, maximum Young's modulus range is identified between 50 GPa and 55 GPa, and among all specimens, $P7$ to $P11$ have reached the maximum values as per the radar diagram.

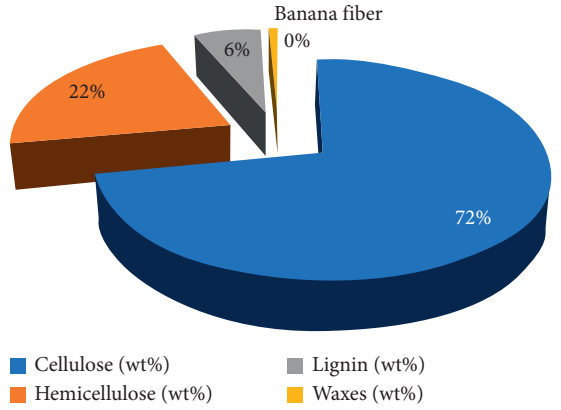


Figure 3: Chemical compositions of the banana fiber [3].

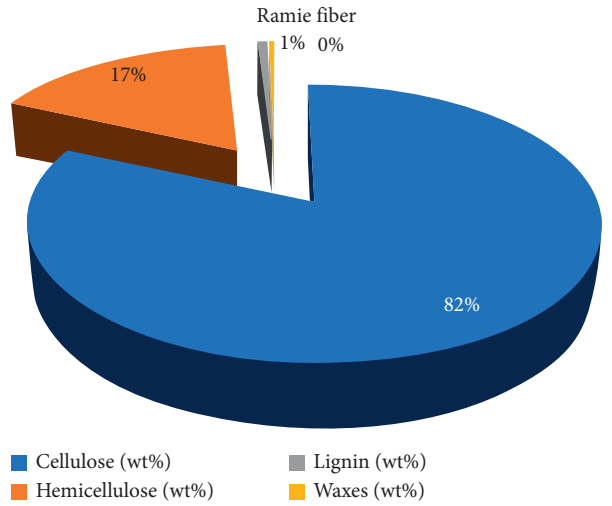


Figure 4: Chemical compositions of the ramie fiber [3].

Table 1: Natural fiber contribution details in composite specimens.

| Specimen piece name | Percentage of fiber used in total volume | | |
|---|---|---|---|
| | Hemp | Banana | Ramie |
| *P*1 | | 80 | 0 |
| *P*2 | | 72 | 8 |
| *P*3 | | 64 | 16 |
| *P*4 | | 56 | 24 |
| *P*5 | | 48 | 32 |
| *P*6 | 20 | 40 | 40 |
| *P*7 | | 32 | 48 |
| *P*8 | | 24 | 56 |
| *P*9 | | 16 | 64 |
| *P*10 | | 8 | 72 |
| *P*11 | | 0 | 80 |

Figures 8(a) and 8(b) point out the radar diagram and line diagram correspondingly for the experimental outcome of the percentage of elongation which will get decremented with respect to the decrement of the banana fiber composite concentrations. Maximum percentage elongation reached for specimen *P*1 is 48%, and the lowest percentage elongation is obtained at specimen *P*11. From the radar diagram, the maximum percentage of elongation range is between 38% and 48% for the specimens from *P*1 to *P*3; similarly, the lowest percentage elongation region is 3% to 12% for

Figure 5: Testing machine for the investigation.

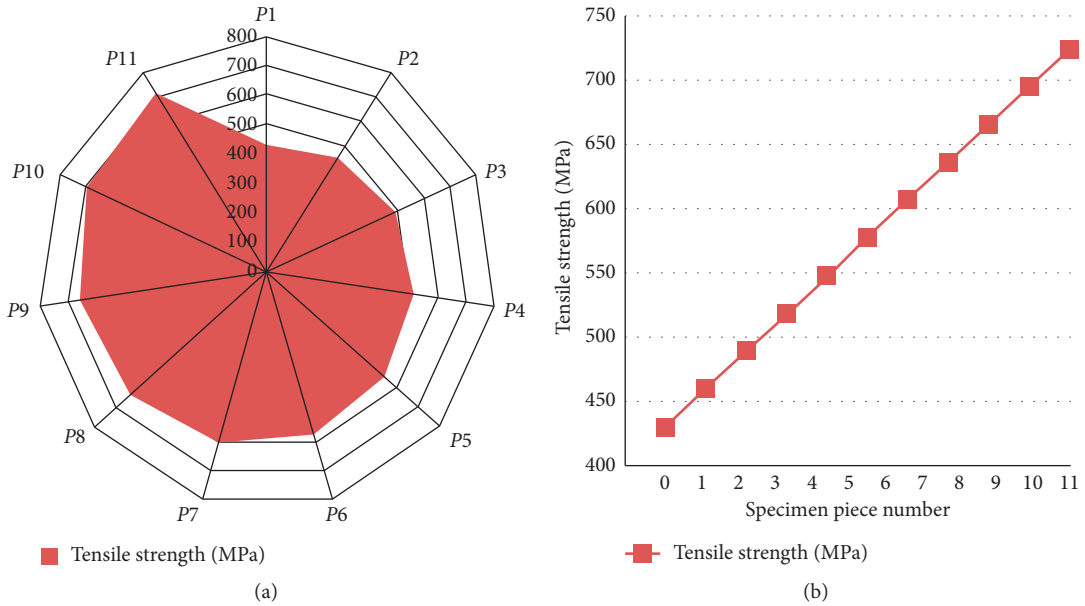


Figure 6: Experimental results of the tensile strength in MPa: (a) radar diagram; (b) line diagram.

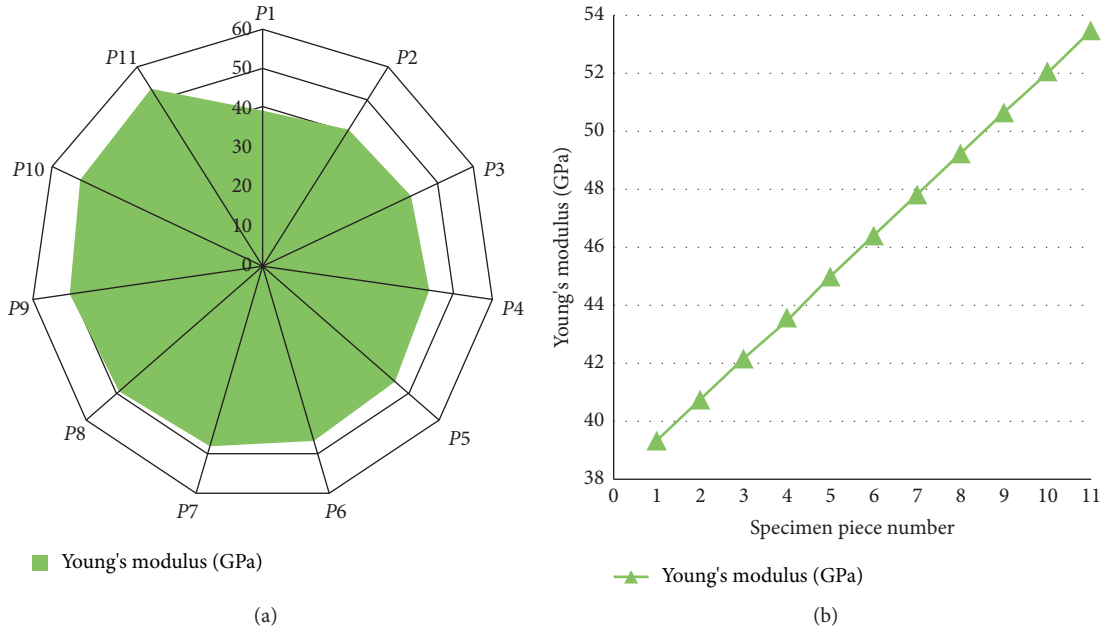


Figure 7: Experimental results of Young's modulus in GPa: (a) radar diagram; (b) line diagram.

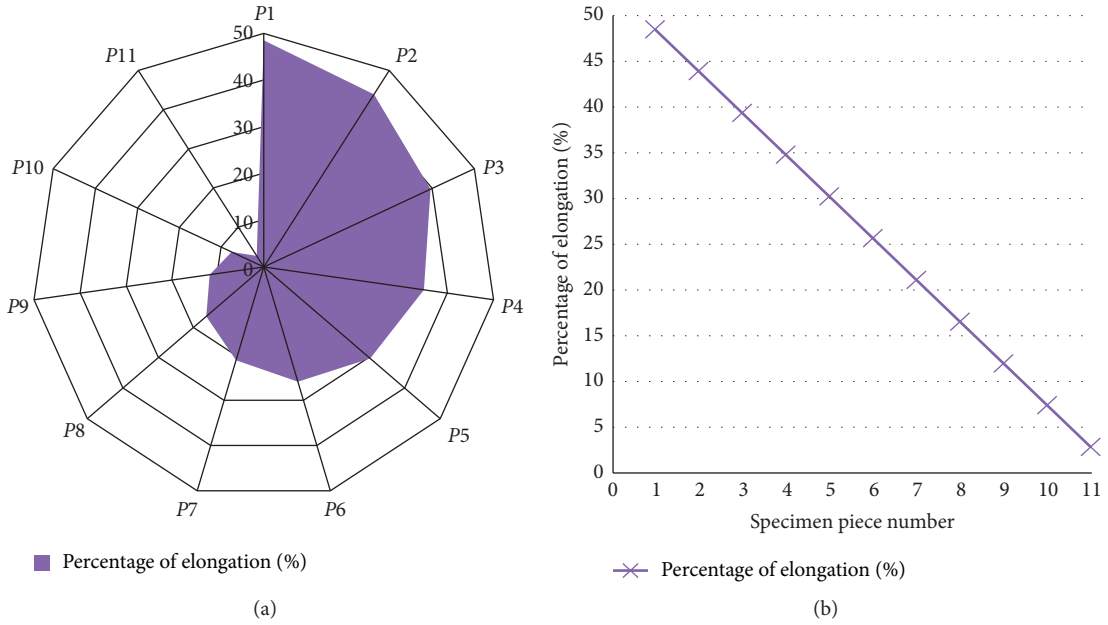


Figure 8: Experimental results of the percentage of elongation: (a) radar diagram; (b) line diagram.

specimens $P9$, $P10$, and $P11$. $P11$ specimens have the maximum contribution of the ramie fiber, so they have the lowest elongation.

In the same way, Figures 9(a) and 9(b) show the radar diagram and line diagram of the experimental results of the density which get augmented results relating to increase in the concentration of the ramie fiber. From the line diagram, the maximum density of 1.49 g/cm$^3$ is obtained for specimen $P11$ and the minimum density of 1.41 g/cm$^3$ is reached for specimen $P1$. From the radar diagram, maximum density range is between 1.47 g/cm$^3$ and 1.49 g/cm$^3$ of specimens $P9$ to $P11$.

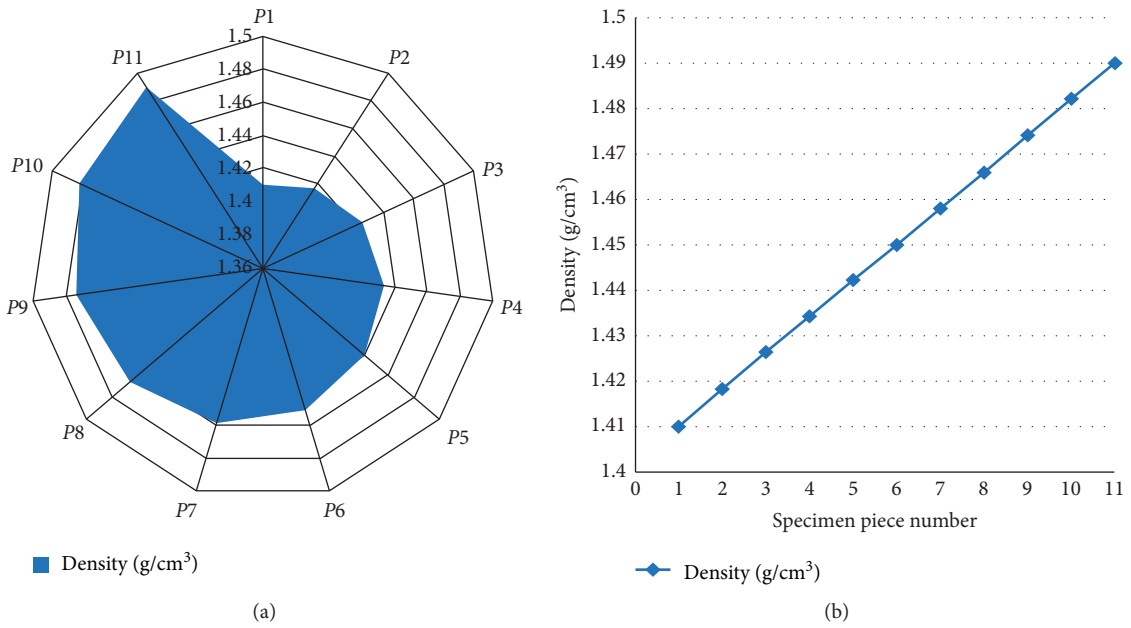


Figure 9: Experimental results of the density in g/cm$^3$: (a) radar diagram; (b) line diagram.

## 4. Conclusions

In this experimental study, based on the influence of hemp fiber in the basic mechanical properties of ramie and banana fiber composites, the following results are produced as conclusions:

(i) Hemp fiber produced the enhancement in each property with respect to the 20 percentage involvement in the total volume percentage in composite fiber

(ii) With the increment of the ramie fiber, volume percentage produced the incremental values in tensile strength, Young's modulus, and density

(iii) However, the percentages of elongation get decreased with the influence of ramie fiber concentration

(iv) Composite specimens *P*8 to *P*11 were suitable for greatest tensile strength

(v) Composite specimens *P*7 to *P*11 were suitable for furthermost Young's modulus

(vi) Composite specimens *P*1 to *P*3 were suitable for maximum percentage elongation

(vii) Composite specimens *P*9 to *P*11 were suitable for supreme density.

(viii) So, specimens *P*9 to *P*11 reached the highest tensile strength, Young's modulus, and density with lower percentage of elongation

## Data Availability

The data used to support the findings of this study are included within the article. Additional data or information is available from the corresponding author upon request.

## Disclosure

It was performed as a part of the Employment of College of Engineering and Technology, Hawassa University, Hawassa, Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

## Acknowledgments

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Research Article

# Threshold Detection Scheme Based on Parametric Distribution Fitting for Optical Fiber Channels

**Author(s):** Mohammed Usman*, Mohd Wajid, Muhammad Z. Shamim, Mohd D. Ansari and Vinit K. Gunjan

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## Abstract

Background: When data is transmitted by encoding it in the amplitude of the transmitted signal, such as in Amplitude Shift Keying, the receiver makes a decision on the transmitted data by observing the amplitude of the received signal.

Objective: Depending on the level of the received signal, the receiver has to decode the received data, with

Article preview



# On the optimization of temperature and cooling rate to maximize strength and ductility of near α titanium alloy IMI 834

T. Mahender [a], M.R. Anantha Padmanaban [b], I. Balasundar [c], T. Raghu [c]



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## Abstract

Microstructural features that vary in morphology, topology and size affect the static and dynamic mechanical properties of titanium alloys both individually and synergistically. These microstructural features are in turn influenced by the post deformation heat treatment parameters such as temperature and cooling rate. In the current study, near alpha titanium alloy IMI 834 was subjected to solution treatment followed by cooling in seven different media. Apart from conventional cooling media viz., water, oil, air and furnace, three other cooling medium were identified and used to bridge the large cooling rate gap that exists between air and conventional furnace cooling. The effect of solution treatment temperature and cooling rate on the microstructure and room temperature tensile properties of the alloy has been evaluated and reported here. An attempt has been made here to establish the correlation between the heat treatment parameters and all the resulting tensile properties such as yield strength, ultimate tensile strength

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*Research Article*

# Effect of Heat Input on Distortions and Residual Stresses Induced by Gas Tungsten Arc Welding in SS 316L to INCONEL625 Multipass Dissimilar Welded Joints

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In the present study, distortion and residual stresses in the multipass welded joint were analyzed with respect to heat input. The welded joint was produced using the gas tungsten arc welding (GTAW) process with dissimilar Ni-based filler of ERNiCrMo-3. This dissimilar joint is essential in power generating nuclear and thermal plants operating at elevated temperatures. The distortion and residual stress measurements were taken using the Vernier height gauge and XRD method. To evaluate the mechanical properties, tensile testing was carried out at room temperature. The welded joint qualified the tensile test with an average value of 593 MPa. In the weld metal, a significant variation of residual stresses is measured on the top surface of the weldment along with the thickness with peak magnitude of 145 MPa to 180 MPa at the fusion zone.

## 1. Introduction

Dissimilar materials combinations such as stainless steels and nickel-based alloys are extensively used in high temperatures and corrosion-resistant applications such as power plants, chemical industries, aerospace, and nuclear applications. In general, the joining of such alloys is obtained by fusion welding that, for its nature, involves localized heating and cooling in the joining zone of the workpieces; the heat produced during welding leads to metallurgical and structural changes such as distortion and residual stress which shorten (or negatively affect) the life of the welded structure. Kumar and Shahi [1] reported the effect of heat input in microstructure and mechanical properties of weldments made out of AISI 304, 6 mm thick plates with double V-grooved edge preparation. Three heat inputs have been used for comparison, while the interpass temperature has been maintained equal to about 150°C. It was found that the lower the heat input, the higher the ultimate tensile strength. Adamczuk et al. [2] studied the angular distortion induced by the solidification of fusion zones (FZs) in multipass weldments; 16 mm and 19 mm thick plates were used in the experiments with a variable heat input of 0.06 kJ/mm to 2.5 kJ/mm. Distortions were measured with a linear variable differential transformer technique. An analytical model was developed to predict the welding induced distortion as a function of process parameters. Deng and Murakawa [3] developed a 3-dimensional finite element model to investigate the distortion mechanism arising in 1 mm, but welded joints were produced by the GMAW process using ABAQUS package.

Ramkumar [4, 5] reported a structural characterization and mechanical properties of dissimilar multipass welds of stainless steel to INCONEL (AISI316L/IN625 and AISI304/

IN625) joints. A single V-groove joint was used for the GTAW process of constant and pulsed mode power with ER2209, ERNiCr-3, and ERNiCrMo-3 as filler rods. Conventional (optical) and advanced (SEM/EDAX) microscopy was carried out to characterize the joints. In both cases, the fracture was always observed to occur at stainless steel parent metal. The detailed study of microstructure and mechanical properties are reported for dissimilar materials in [6–10]; the examination is carried out for stainless steels and nickel-based alloys and its combination using the arc (GTAW and SMAW), friction, and electron beam welding processes. Arc welding processes are carried out with suitable fillers wires of various diameters to improve the joints' structure and strength properties. Laser, electron beam, and friction welding processes are carried out without using filler materials. The effect of the filler wire was also reported for solid solubility with the welds' base material and micro- and mechanical properties. The metallurgical study was reported at various zones of the weldment. The effect of filler metal chemical composition was analyzed. It was found that sound welds, less susceptible to hot cracking, are obtained with the filler metal.

Juang and Tarng [11] were interested in finding process parameters inducing optimal weld pool geometry in stainless steels' TIG welding. To reach that goal, they used $L_{16}$ ($4^5$) orthogonal array and the modified Taguchi method. Process parameters' optimization was the focus of Manikandan's research work [12], as well. The design of experiments (DOE) and Taguchi method with $L_9$ orthogonal array are used to find the better penetration depth induced by the pulsed-current gas tungsten arc welding (PCGTAW) process. It was observed that the pulsed current was the most influencing parameter on the penetration depth. Kumar and Sundarrajan [13] investigated the influence of peak and base current, weld torch velocity, and frequency on the structural and mechanical properties of AA5456 aluminium alloy welded joints. They were optimized using the two-level parameters with $L_8$ orthogonal array for the pulsed TIG welding process. They also observed an improvement in mechanical properties due to the planishing effect.

A welding numerical model was developed by Vemanaboina et al. [14, 15] to study the temperature distribution during the process and residual stresses in the weldments produced by GTAW [14] and in multipass dissimilar welding (IN625/SS316L) [15]. In this last work, both constant and pulsed current GTAW processes along with ERNiCrMo-3 and ERNiCr-3 filler rods were used. It was observed that residual stresses were lower in the pulsed current GTAW process with ERNiCrMo-3 with a 95% confidence level. Finally, it was highlighted that the root gap was the most critical parameter. Hashemzadeh et al. [16] reported the variations of residual stresses for 4 mm and 6 mm plates joined with single- and multipass welding process, respectively. In their study, temperature distribution and residual stresses were measured on the external surface of the weld. The FE model was developed using the commercial numerical code ANSYS® and validated with experimental results.

To the best of the authors' knowledge, no research has been carried out on the impact of heat input in multipass dissimilar weldments in the present literature. In this work, the study was focused on understanding the effect of heat input on residual stress and distortion in multipass dissimilar weldments. The joining process was carried out with a gas tungsten arc welding process between SS316L and INCONEL625, using ERNiCrMo-3 filler rod. Distortion and residual stress are measured using the Vernier height gauge and X-ray diffraction technique, respectively.

## 2. Materials and Experimental Procedure

Dissimilar SS316L-INCONEL625 welded joints were obtained using gas tungsten arc welding process using the ERNiCrMo-3 filler wire, suitable for Inconel alloys of various grades. During the process, the 60°V groove was filled by the filler metal in three passes. The plates measured 100 mm × 60 mm × 5 mm, while the filler wire diameter was 2.4 mm. The chemical composition of parent materials and filler wire used in this study is collected in Table 1. The thermal conductivity of SS316L and INCONEL 625 is 21.26 W/m K and 16.78 W/m K, respectively. The welding parameters' values used in the experiments are summarized in Table 2. The root gap was about 2.0 mm (Table 2), while the voltage was maintained at a constant value of 12 volt for all the trials. The interpass temperature was about 200–250°C [15, 17] to avoid hot cracking during the welding process.

*2.1. Heat Input.* The heat input is quantified by Equation (1) [15], where $I$ is the current (ampere), V is the voltage (volts), and $S$ is the welding speed (mm/min). The heat input is increased according to the changes in the process parameters used (Table 2). The heat input is calculated for each pass and the average heat input used in each trial is reported in Figure 1:

$$H_i = \left(\frac{I^* V^* 0.06}{S}\right). \quad (1)$$

*2.2. Distortion.* Any unwanted geometrical change or departure from specifications in a fabricated structure or component, as a consequence of welding, is called welding distortion. Nonuniform expansion and contraction of the weld metal and the surrounding base metal create weld distortion during the welding process, which occurs throughout the heating and cooling cycles. In a dissimilar weld, there is also an effect induced by both the nonuniform heat flux resulting from different values of alloys thermal conductivity and different thermal expansions coefficients of the coupled alloys. The calculation of the weldment's angular distortion [17–20], expressed in degrees, is carried with

$$\alpha = \sin^{-1}\left[\frac{h_1 - h_2}{b}\right], \quad (2)$$

where $h_1$ is the total height at Vernier height, $h_2$ is the total height of the workpiece from the surface, and $b$ is the length of the plate. Figure 2(a) shows the types of distortion caused

Table 1: Parent materials and filler wire chemical composition.

| | Element (wt%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ni | C | Mn | S | Cu | Si | Cr | P | Others |
| INCONEL 625 | 58 | 0.1 | 0.5 | 0.015 | 0.5 | 0.5 | 20–23 | 0.015 | Fe 5, Al 0.40, Mo 8–10, Ti 0.1 |
| SS 316L | 12–18 | 0.03 | 2.00 | 0.030 | — | 1.00 | 16–18 | 0.045 | Mo 2–3 |
| ErNiCrMo-3 | 64 | 0.1 | 0.5 | 0.015 | 0.50 | 0.50 | 22–23 | 0.015 | Fe 1.0, Al 0.40, Nb 3.6–4.5, Mo 0.015, Ti 0.40 |

Table 2: Process parameters and their levels.

| Process parameters/trial no/units | Welding current Amp | Argon flow rate LPM | Welding speed mm/min | Root gap mm |
|---|---|---|---|---|
| 1 | 135 | 12 | 125 | 2.0 |
| 2 | 145 | 12 | 113 | 2.0 |
| 3 | 155 | 12 | 129 | 2.0 |

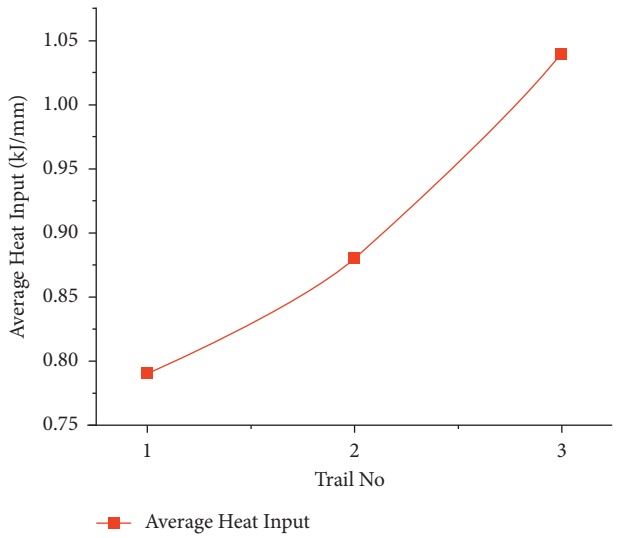



Figure 1: Heat input for various trials.

by welding in both the longitudinal and transverse direction of weldments, arising as soon as they are unclamped. The distortion measurement principle using the Vernier height gauge in butt-welded joints is shown in Figure 2.

*2.3. Residual Stress.* In this work, RS is measured in a transverse direction (perpendicular to the weld line) at various distances from the weld line on both the top and bottom surfaces of the weldment. Before measuring, the sample surface was cleaned with emery sheets. The arc welding process is linked to the underlying local heating and cooling cycles. The combined effects of thermal stress and strain would leave the welds with residual stresses. The measurement of residual stresses is carried out using the X-ray diffraction method as

$$n\lambda = 2\ d\ \sin\ \theta, \tag{3}$$

where $n$ refers to the order of the reflected beam, $d$ is the interplanar lattice spacing, $\lambda$ the wavelength of the incident wave, and $\theta$ is the scattering angle. Residual stress was calculated on the upper surface of the weld in the transverse direction by using the following equation:

$$\sigma_\phi = \frac{m}{d_0}\left(\frac{E}{1+\nu}\right). \tag{4}$$

Young's modulus is $E$, $\nu$ is the Poisson coefficient, and $d_0$ is the stress-free lattice spacing. Figure 3 shows the equipment used in the present work for measuring welding residual stress. Bragg's angle of 155° and the wavelength of 2.103 [Å] were used for the measurements. The measuring parameters are given in Table 3.

## 3. Results and Discussion

*3.1. Nondestructive Tests for Weld Quality Analysis.* The radiographic test is a nondestructive technique used for detecting defects such as flaws, cracks, or porosity in the weldment. The test piece is placed between the X-ray source and the film throughout the imaging process (or detector). Variations in the density and thickness of the test material will reduce the penetrating radiation's intensity via interaction processes such as scattering and/or absorption. It is possible to capture the variations in absorption on film or electronically. ASME SEC IX-2017 standard was used for the quality testing of the weldments. It was observed that all weldments had straight white lines indicating acceptable weldments. The obtained results, shown in Figure 4, confirmed the soundness of the welds under investigation; the weldments were free from defects.

*3.2. Distortion.* Temperature gradients induced by welding cause dimensional changes in the weldments that adversely affect the structure assembly. The weld distortions were measured after the last welding pass and the joints reached the ambient temperature. Heating and cooling cycles during multipass welding cause local nonhomogeneous plastic deformation that result in distortion of the weld parts at the macroscale. This change will affect the design of critical parts such as turbine blades, heat exchangers, and pressurizer surge nozzles that need to fit during the assembly operations exactly. Lower the quality characteristics chosen for the weld distortion is, better the characteristics is. The lowest was observed in trail-1 with 0.72° at 0.79 kJ/mm, in trail-2 with 1.2° at 0.88 kJ/mm, and in trail-3 with 1.43° with a heat input of 1.04 kJ/mm. With

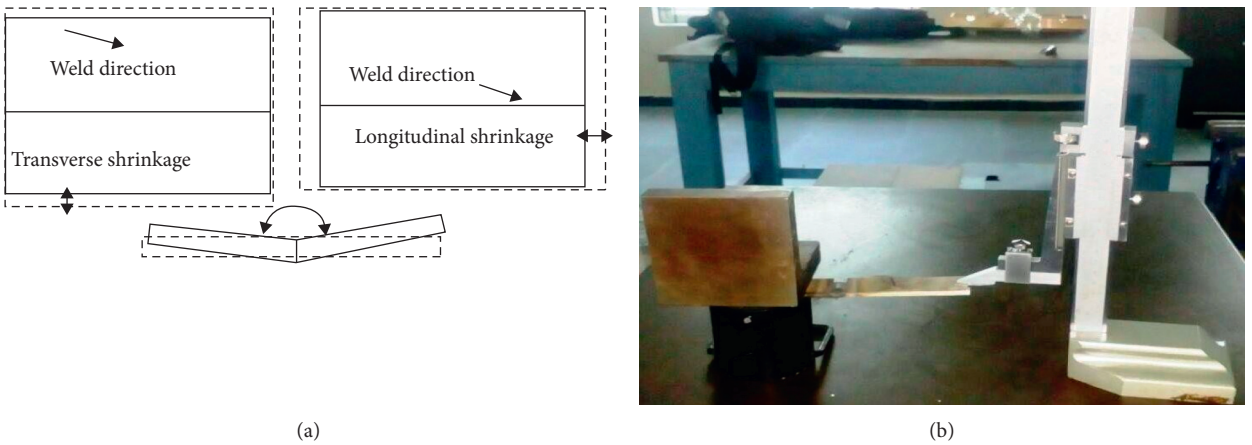



Figure 2: (a) Different types of weld distortions and shrinkages. (b) Measurement of weld distortion using Vernier height gauge.

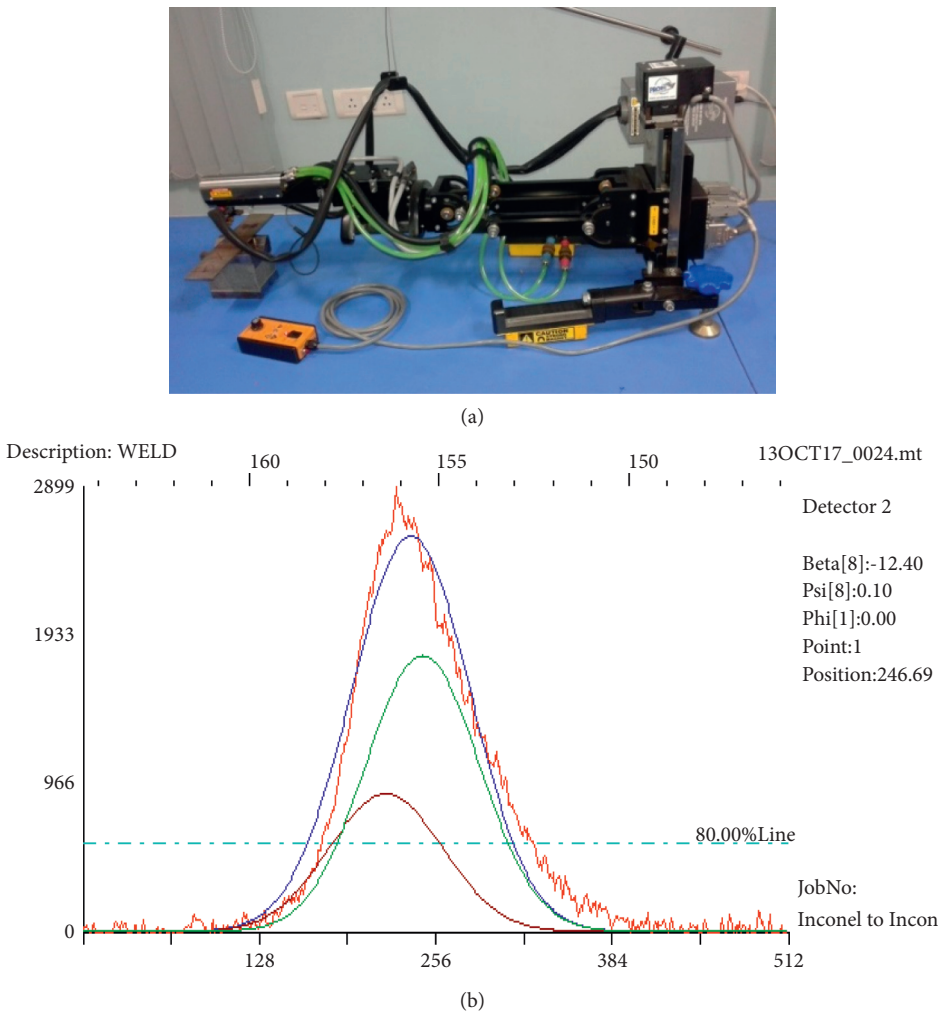



Figure 3: Residual stress measuring instrument.

the increase of 0.09 kJ/mm heat input, the distortion in the weldment raised to 0.48° which was found in trail-1 to trail-2. In trail-2 to trail-3, it was about 0.16 kJ/mm difference in heat input, but the distortion was raised to 0.23°. In all the joints, distortion was lower at the Inconel side than the stainless steel side; this is due to higher thermal conductivity and lower thermal expansion coefficient of the SS alloy [18]. The weld distortion increases with the increase of the total heat input (Figure 5). However, its value resulted always below 2°, which is the recommended limit to assure the assembly [19].

Table 3: Tensile strength properties of dissimilar weldments of INCONEL625 and SS316l.

| Property | Units | Trial-1 | Trial-2 | Trial-3 |
|---|---|---|---|---|
| Maximum load | kN | 36.72 | 36.52 | 36.04 |
| Ultimate tensile strength | MPa | 594.65 | 595.75 | 590.72 |
| 0.2% proof strength | MPa | 340.80 | 344.31 | 360.07 |
| Elongation | % | 31.04 | 33.20 | 32.20 |
| Fracture zone | — | | Fracture at SS side | |

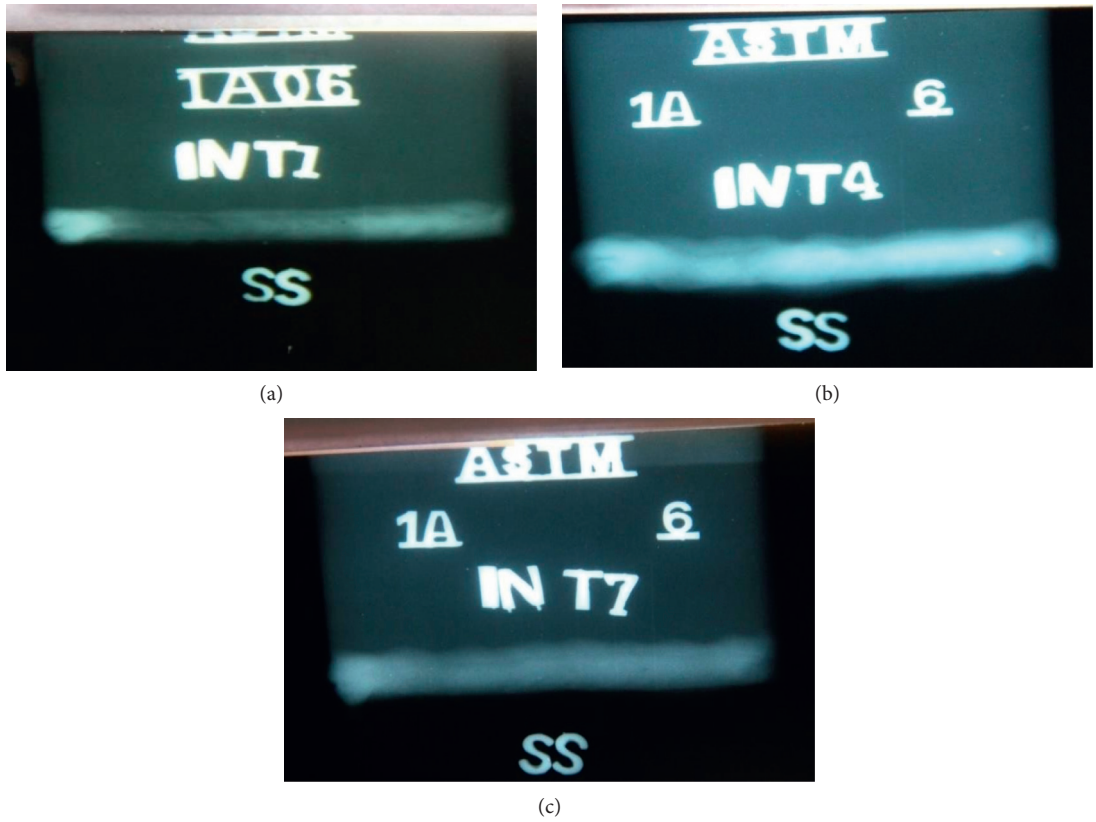



Figure 4: Radiography test of the weldments.

*3.3. Residual Stresses.* It is one of the most commonly used destructive methods for the measurement of the residual stresses. The stress measurement was carried out at the fusion zone for all the trials after completing the third pass and cooling to ambient temperature. The peak longitudinal and transverse residual stress magnitude was at the weld zone. Tensile residual stresses were found throughout the plate with peak magnitude of the longitudinal stress which was the top surface of the weld plate at the fusion zone. The observed residual stress value for tail-1 is 145 MPa, trail-2 is 158 MPa, and trail-3 is 180 MPa. The measured value on the welded joints was obtained with the heat input equal to 0.79 kJ/mm, 0.88 kJ/mm, and 1.04 kJ/mm, respectively. Tensile stresses were observed in the fusion zone. The increasing trend with heat input is shown in Figure 6. Even though the thermal conductivity of the SS316L is 1.3 times greater than that of the Inconel material, the residual stresses show a better factor of safety at the joint when compared to yield strength of parent materials. Thermal and mechanical properties such as thermal conductivity, the coefficient of thermal expansion, and the yield strength of the base materials will play a vital role in residual stresses distribution in the dissimilar joints. The joint obtained in trial-1 is characterized by a factor of safety of the base material equal to 1.58, second one by a value of 1.45, and the last by a value of 1.27. The almost linear increase of the residual stresses with the heat input (Figure 6) induces a decrease of the safety factor, which suggests a life reduction of the joint. With the increase of 0.09 kJ/mm heat input, the stresses in increasing trend of 9 MPa were found in trail-1 to trail-2. Whereas from trail-2 to trail-3, it was about 0.16 kJ/mm difference in heat input, but the residual stresses are increased in tensile of about 22 MPa [21–24]. Based on authors' experience, in order to minimize the increasing linear trend of welding residual stresses, it is recommended that first pass be carried out with a higher weld current compared to that used for the remaining passes.

*3.4. Weld Bead Geometry.* Weld bead shapes are shown in Figure 6. A good aspect ratio was observed for all the weldments. The bead geometry was measured at a vertical and

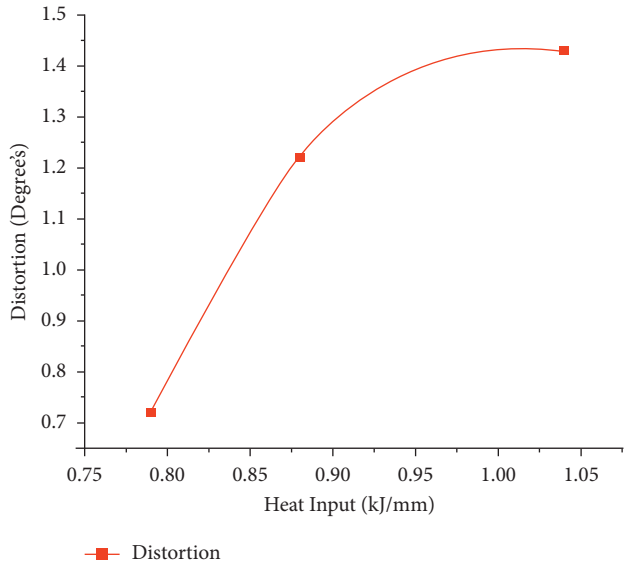



Figure 5: Weld distortion as a function of total heat input.

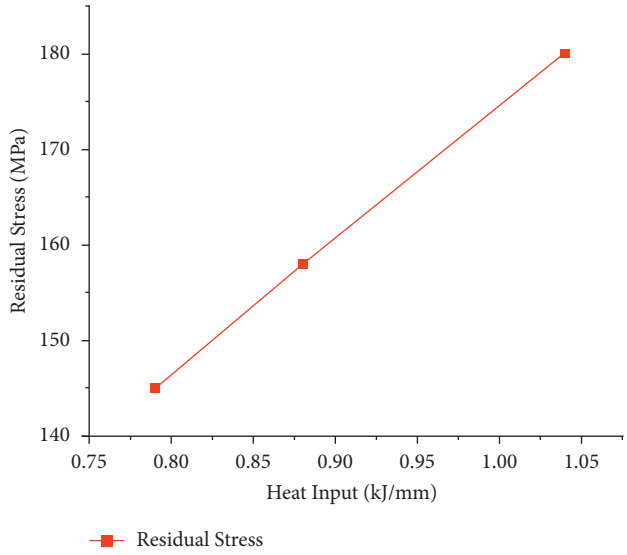
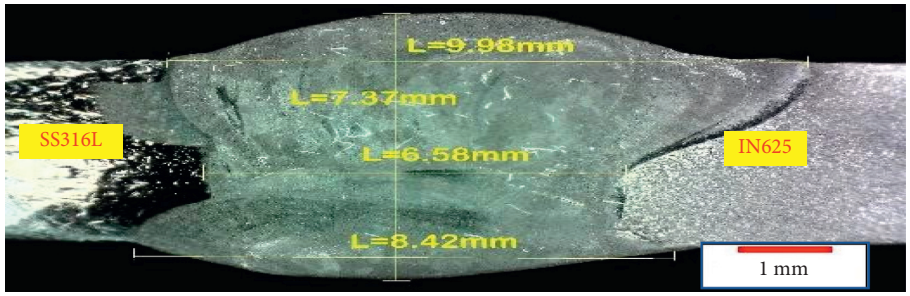


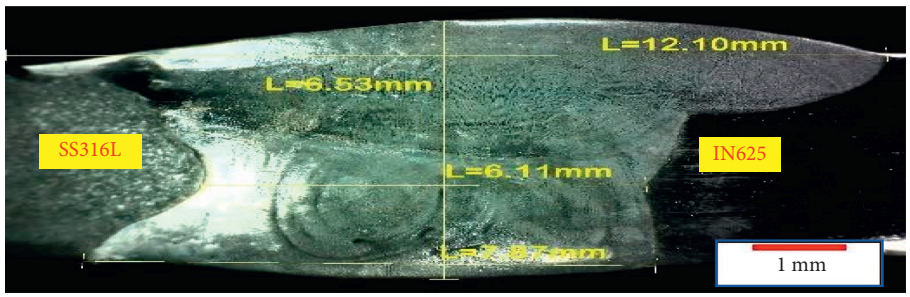

Figure 6: Residual stresses as a function of heat input.

horizontal position at the fusion zone. In Figure 7(a), for Trial-1, the root pass width is 8.42 mm, the filler pass width is 6.58 mm, and the final bead height is 7.37 mm with a total bead width of 9.98 mm. In Figure 7(b), for Trial-2, at the weld root, the width is 7.37 mm, at the midpass, the bead width is 6.11 mm, and, at the cap pass, the total width is 12.10 mm with a total bead height of 6.53 mm. Finally, in Figure 7(c), for trial-3, the root pass width is 10.82 mm, at the midpass, width is 6.03 mm, while, at the cap pass, it is 9.80 mm with a total FZ height of 7.30 mm. In Figure 7(c), the excess of penetration observed compared to the other two trials is due to the higher welding current used. It was observed that a uniform distribution of filler metal characterizes all welded joints.

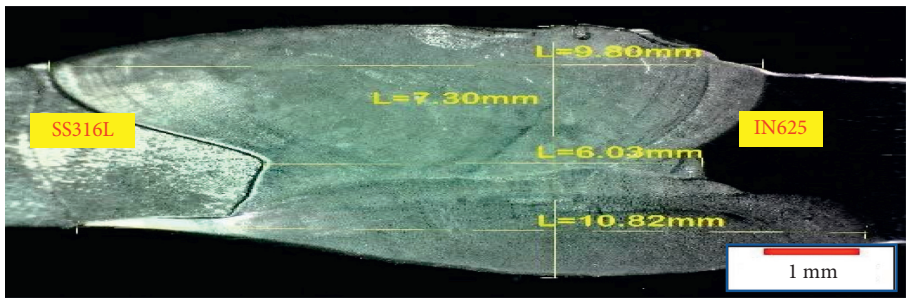
*3.5. Tensile Strength.* The multipass dissimilar welds of 5 mm thick plates were tested for tensile properties. The tensile testing was carried out for all specimens in the transverse direction (across the welds) as per the ASTM A 370 : 2012. Plastic deformation was observed before samples' fracture. All the multipass dissimilar welds failed at parent material, stainless steel (SS) side (Figure 8). The average tensile strength and 0.2%




(a)



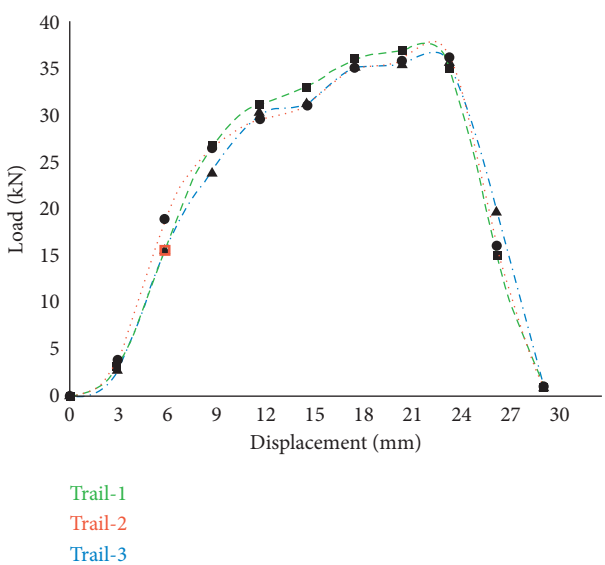

(b)




(c)

Figure 7: Weld bead geometry: (a) trial-1, (b) trial-2, and (c) trial-3.


(a)




(b)

Figure 8: Specimens after machining prepared for tensile strength. (a) Fracture occurred at the parent metal of SS316L. (b) Load vs. displacement.

proof strength were found to be 593 MPa and 348.4 MPa, as reported in Table 3. Compared with the base materials, all the weldments showed higher tensile strength.

## 4. Conclusions

Dissimilar welding between Inconel 625 and stainless steel 316L was carried out using the GTAW process with various heat inputs. All the weldments were verified to be free from cracks and flaws via radiography tests. The distortion and residual stresses were found to vary with heat input. The main results can be summarized as follows:

(i) With the incorporation of interpass temperatures between the second and third pass, the hot cracking defects had overcome

(ii) The peak magnitude of the longitudinal stress and transverse stress was measured with a minimum of 145 MPa and maximum of 180 MPa, respectively, under the weld condition

(iii) The average tensile strength was measured 593 MPa for with joint efficiency of higher than 100%

(iv) The heat input increased, resulting in higher distortion and tensile residual stresses in weldments

(v) The peak magnitude of the longitudinal stress and transverse stress was measured 145 MPa to 180 MPa, respectively, in the weldment

(vi) Furthermore, to decrease the distortion and residual stresses peaks, authors recommend welding with high heat input for the first pass for proper mixing of base and filler materials, and further, there are decreases in heat input for second and third passes by maintaining interpass temperatures

## Data Availability

The data used to support the findings of the study are available within the article.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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*Research Article*

# Parameters of Porosity and Compressive Strength-Based Optimization on Reinforced Aluminium from the Recycled Waste Automobile Frames

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Automobile industries were ready to recycle the waste old parts as well as the damaged parts of the old vehicles as much as possible. This study mainly focused on the recycling of the waste and damaged aluminium frames of the automobile bodies. These aluminium-based frames only collected the metal matrix composite created by reinforcement of 3% silicon carbide (SiC) and 3% high carbon steel. The stir casting method is chosen to make the composites. Optimization is done by Taguchi ANOVA technique. Three input parameters such as stir speed, time of squeeze, and the temperature of the preheating were considered. The outputs such as compressive strength and porosity were experimentally measured with the combination of nine (L9) experimental trails. The measured experimental results were analyzed and optimized with the help of Taguchi technique with different plots for clear identification. The optimized parameters based on low porosity and high compressive strength were recommended for conclusion.

## 1. Introduction

Nowadays, recycling the wastes is considered as the new production in the industrial world. In automobile industry, arrival of the new vehicles leads to increasing old vehicle scraps. Krishnan et al. [1] entirely studied about scrap of aluminium-used composites' metal matrix. The source aluminium is clearly collected and used from the wastes. They provide explanation and accomplishment suggestion concerning different methods bringing into play for creation through those wastes as well as scraps. Furthermore, they explained the various composite material microstructure behavior and composite material mechanical properties with various experiment results.

Similarly, Gupta and Satyanarayana [2] completely discussed the solidification procedure on metal matrix composites of aluminium with the help of various researchers point of view. There are different methods, processes, combination of composite materials and corresponding parameters considered, and optimization

methods used for the metal matrix. They also mentioned individually in a clear manner. Gesing and Wolanski [3], without a doubt, argued on the subject of recycling the light metals from the used vehicles and spare parts of the automobiles and scraps. These suggestions afford assurance to generate research work related to this method.

Christy et al. [4] discussed the stir and squeeze casting input parameters optimization by using the technique of Taguchi with four different input and outputs for the experiments. They express the microstructures to identify the relation of the experimental result outcomes. They used the aluminium alloy wheel scrap for the formation of the composites by the method of stir casting. They optimized with help of the Taguchi method based on the preferable mechanical properties' outcomes and also explained them with optical microscopic images, scanning electron microscopic images, and diffraction of X-ray and X-ray spectroscopy. Importance of the porosity was explained.

The fundamental belongings to the optimization method for different reinforced composites such as Al reinforced to nanomaterials [5], Al reinforced to ZiC [6], and Al reinforced to silicon carbide [7] were discussed clearly. In the same way, various operations such as turning process [8], diffusion bonding [9], laser welding process [10], electrochemical machining [11], and A-GTAW welding [12] were experimentally tried in each article with different parameters and responses.

Mazahery and Shabani [13] undoubtedly investigated the composites of sintered Al matrix regarding the abrasive wear behavior and microstructure property with various experiments and clear comparison on results. Dai et al. [14] explained about the aluminium scrap details and aluminium content based on recycling and also expressed about the fibers of carbon materials. They also mentioned that the scrap of the aluminium material-based car parts was increased day by day due to the need of the increasing vehicles with different articles' reference.

Cullen and Allwood [15] explained about liquid aluminium-based product conversion into global usages. They created the recycled secondary products of aluminium by using the ancient scraps of aluminium collected from different places of the customers. They used recycling in the closed loop method. Oliveux et al. [16] reviewed various articles regarding the reinforcement of composites with various methods. They mentioned about the reuse and recycling of different composites.

Mishra and Srivastava [17] explained about the wear behavior of the composite of aluminium alloy with silicon carbide with the number of SEM images with respect to the load variation. They clearly mentioned the microstructures of the composites. Almadhoni and Khan [18] reviewed the metal matric composite research article with different combinations and different compositions of various metals. They mainly focused the stir casting process with three major parameters such as temperature of the die and speed of the stirrer. They also conclude that the speed of the stirrer is directly proportional to the homogenous collaboration on the reinforcement matrix of aluminium alloys.

Chandla et al. [19] reviewed the stir casting process with the aluminium alloy-based composites. They mainly listed the various combinations of materials such as alumina, silicon carbide, barium carbide, red mud, iron oxide, aluminium oxide, frit, graphite, carbon nano tube, zirconium oxide titanium carbide, and other materials in different percentage volumes with aluminium alloy-based composites. They compared the considered parameter variations and mentioned the corresponding properties augmentations for single metal matrix composites and hybrid composite metal matrix. Silicon carbide-based stir casting parameters are also compared with their consequences.

Arulraj et al. [20], Manivannan and Sasikumar [21], M. K. Sahu and R. K. Sahu [22], and Aravindan et al. [23] clearly explained the following. Stir casting method retains numerous benefits over further conventional techniques such as less handling cost, high homogeneity between the particulates, absorption of moisture is low, and suitable for huge manufacture. It is also preferable for different sizes with various shapes and dimensions. Due to its simple method for the production, it is the most preferable one for the production industry. This can be used to reduce the cost of the production from 10% to 35% of the other methods used for production.

In this paper, reinforced composite was created from the waste automobile frames by recycling along with reinforcement materials such as silicon carbide and high carbon steel. These composite specimens were prepared by the stir casting method. The suitable stir casting parameters will be selected based on properties such as porosity and compressive strength by the optimization method.

*1.1. Experimental Procedure.* From the automobile industries, automobile service centres, and mechanic workshops, the samples of the aluminium frames were collected and converted into small scrap pieces. The scarps of aluminium having composition such as 0.95% of magnesium, 0.7% of silicon, 0.68% of iron, 0.39% of copper, 0.31% of zinc, 0.16% of manganese, 0.2% of titanium, and 0.4% of chromium, and then, the remaining have aluminium content in the percentage of weight basis. There is 92% of scrap particles reinforcement with two materials for the remaining percentage of volume concentrations.

There is 3% of silicon carbide, and the remaining 3% is utilized with the high carbon steel. All these materials were in the form of powder. The scrap aluminium material is powered by using the ball bearing pulveriser. Then, these materials were placed into the stir casting machine. This stir casting has the pouring method in the bottom side. The machine shown in Figure 1 has the electrical furnace, reinforcement preheating chamber, runway preheater, hydraulic sequence pressure ram, and electrical control panel.

In this optimization-based investigation, L9 ANOVA table is used as per Table 1. It contains variations in holding temperature which were 300°C, 400°C, and 500°C. The squeezing time considered were 20 sec deviation from the 20 sec to 60 sec. Then, the stir speed is maintained with 100 rpm variation starting with 400 rpm to 600 rpm. The holding pressure is

Figure 1: Stir casting machine.

Table 1: Details of experimental parameters (L9).

| Trail of experiment no. | Holding temperature as temp (°C) | Time as $t$ in sec | Stir speed as $N$ in rpm |
|---|---|---|---|
| TE 1 | 300 | 20 | 400 |
| TE 2 | 300 | 40 | 500 |
| TE 3 | 300 | 60 | 600 |
| TE 4 | 400 | 20 | 500 |
| TE 5 | 400 | 40 | 600 |
| TE 6 | 400 | 60 | 400 |
| TE 7 | 500 | 20 | 600 |
| TE 8 | 500 | 40 | 400 |
| TE 9 | 500 | 60 | 500 |

maintained as 120 MPa throughout the process. The specimens were prepared for both desired properties such as porosity and compressive strength with the dimensions of 40 mm diameter and 30 mm height in small cylinders.

The porosity of the specimens was calculated with the traditional formula that if the ratio of the experimental and theoretical density values was multiplied by 100, then the total value is subtracted from the number one. By Archimedes principle, the experimental density of the individual sample specimen is obtained. Similarly, the theoretical density is obtained from the rule of the mixture on the specimen. Then, the compressive strength is measured by the traditional method in a universal testing machine with compressive strength analyzed as per the ASTM standards such as ASTM E9. Porosity and compressive strength of the individual specimen was tested as per Table 1.

## 2. Results and Discussion

*2.1. Porosity.* The experimentally measured values of porosity and the compressive strength are mentioned in Table 2

Table 2: Experimental results for the trails of experiments.

| Trail of experiment no. | Porosity in % | Compressive strength CS in MPa |
|---|---|---|
| TE 1 | 12.328 | 319.44 |
| TE 2 | 18.215 | 345.58 |
| TE 3 | 24.102 | 371.72 |
| TE 4 | 12.155 | 306.34 |
| TE 5 | 18.042 | 332.48 |
| TE 6 | 22.948 | 360.72 |
| TE 7 | 11.982 | 293.24 |
| TE 8 | 16.888 | 321.48 |
| TE 9 | 22.775 | 347.62 |

in detail. There are nine trials which were conducted as per Table 1. Initially, porosity-based results were examined with minimum being the desirable condition. Then, the compressive strength was examined with maximum being the desirable condition. Then, both porosity and compressive strength values were examined with nominal being the suitable condition. All these three examinations were conducted with the help of the Taguchi analysis by using the Minitab 18 software.

Significant consequence diagram based on the SN ratio for experimental results of porosity is clearly mentioned in Figure 2. In this place, minimum porosity in needed condition is used. Significantly minimum results of porosity can be obtained at 500°C of the holding temperature with 20 sec of the holding time and 400 rpm speed of the stir in the stir casting process. Likewise, the significant consequence diagram based on the means of porosity is shown in Figure 3. The maximum porosity is obtained at the input parameters such as 300°C of the holding temperature with 60 sec of the holding time and 600 rpm speed of the stir. From these two diagrams, minimum and maximum porosity obtaining parameters were clearly obtained.

Comparison of porosity responses using contour plots is shown in Figure 4. There are three different contour plots such as time in competition with temperature, speed contrasted with temperature, and speed versus time available based on the porosity results. The variations on the contour plot were expressed in the form of the colour variation with the various ranges for the individual colours based on the intensity of the experimental results achieved from the experiments. Similarly, Figure 5 shows the surface plots comparison for porosity as the three-in-one diagram. In this diagram, porosity in the vertical direction and the remaining two directions in each diagram are time-contrasted with temperature, speed as opposed to temperature, and speed in competition with time, respectively.

Significant consequence table for porosity is clearly mentioned in Table 3 for both SN ratio and means response. The highest priority of the parameters reached as rank of one, two and three for the holding time, stir speed, and holding temperature in the same order. So, the holding time has the superior contribution when compared to other similar speed of the stir which has the least significant contribution based on the minimum porosity outcomes. The corresponding regression equation is given as follows for the considered parameter-based experimental results:

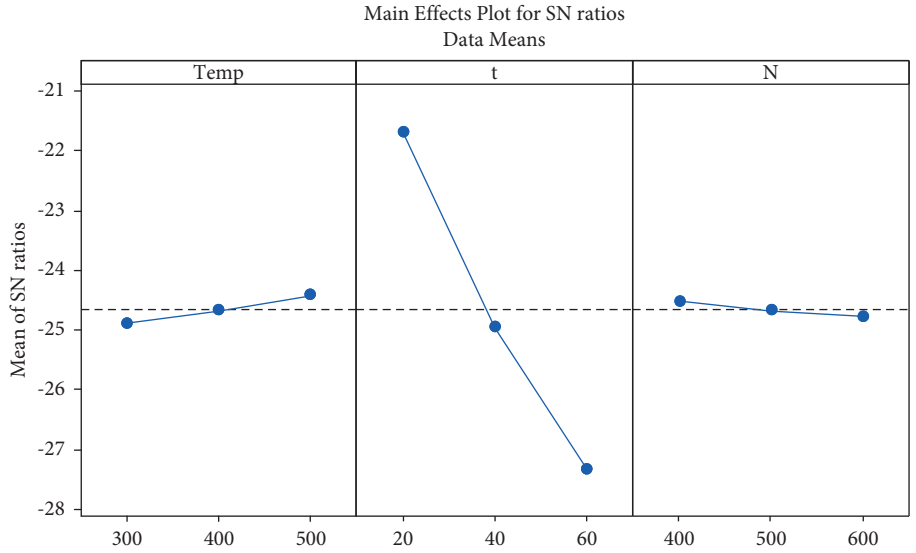


Figure 2: Significant consequence diagram based on the SN ratio for porosity (temp: temperature in ˚C; *t*: time in sec; and *N*: stir speed in rpm).

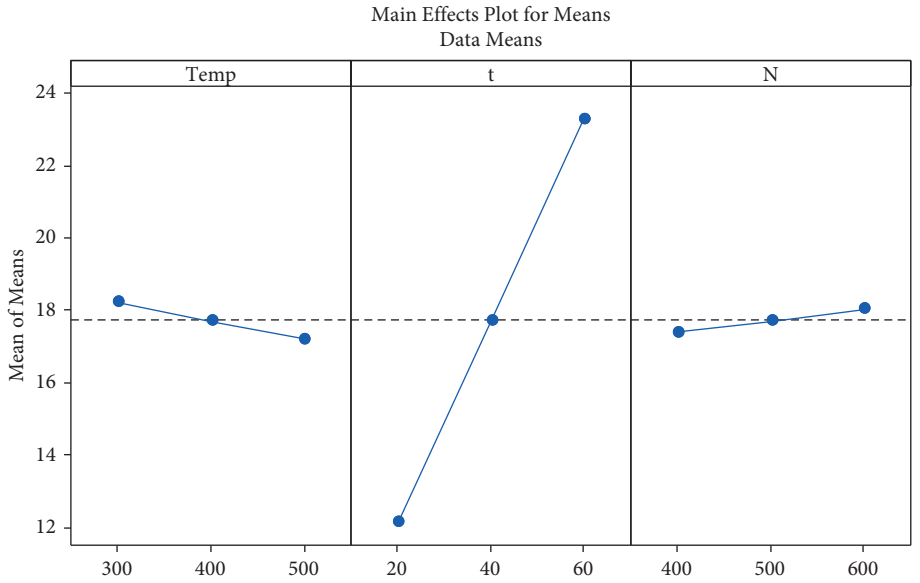


Figure 3: Significant consequence diagram based on means for porosity (temp: temperature in ˚C; *t*: time in sec; *N*: stir speed in rpm).

$$\text{regression equation for porosity} = 6.960 - 0.005000\,\text{temp} + 0.2780\,t + 0.003270\,N. \quad (1)$$

*2.2. Compressive Strength.* Significant consequence diagram based on the SN ratio for compressive strength is evidently pointed out in Figure 5. Similarly, Figure 6 explains about the significant consequence diagram based on means for compressive strength. These two figures were supported each other with the same condition such that the greatest compressive strength is preferable. These two figures based on the experimental outcomes of the compressive strength results obviously point out that the uppermost compressive strength is obtained for the input parameters such as 300˚C of the holding temperature with 60 sec of the holding time and 400 rpm speed. Likewise, the lowest compressive strength is obtained for the input parameters such as 500˚C of the holding temperature with 20 sec of the holding time and 600 rpm of stir speed of the stir in the friction stir operation.

Figure 7 unmistakably shows the contour plots comparison such as speed with respect to temperature, time with respect to temperature, and speed with respect to time for the compressive strength results with different colour intensities for different range of results in Figure 8. Similarly, Figure 9 demonstrates the surface plots comparison such as compressive strength in vertical axis and horizontal axis which were mentioned with speed versus temperature, time versus temperature, and speed versus time. Table 3 provides

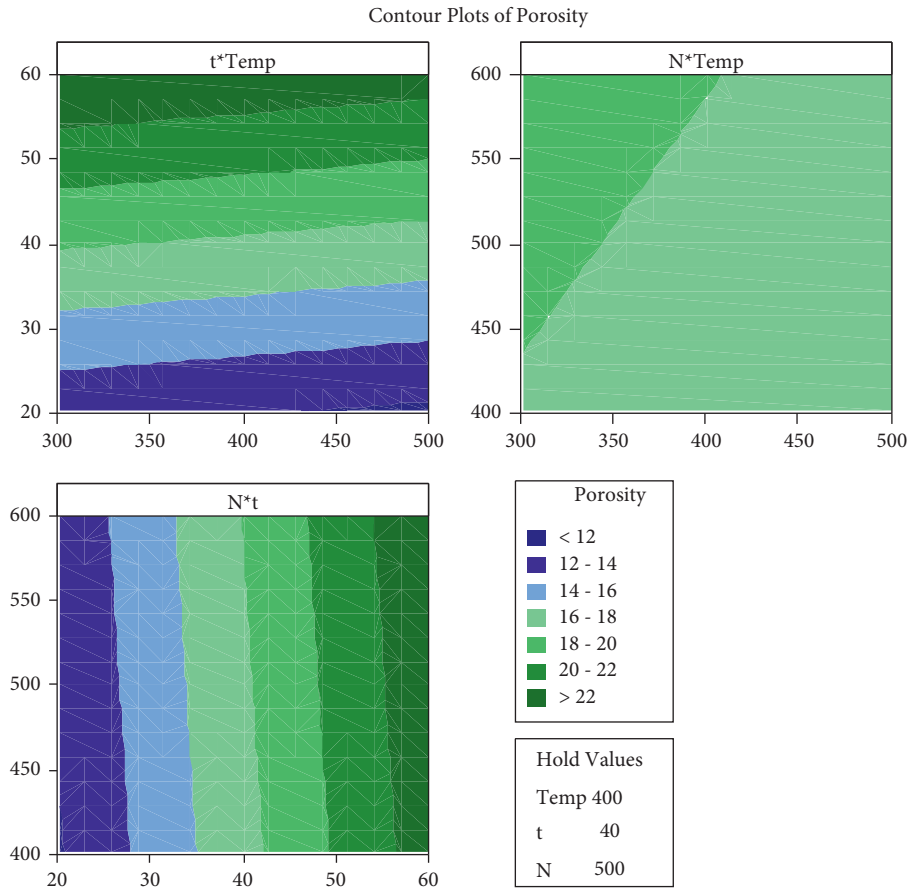


Figure 4: Contour plots comparison for porosity (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

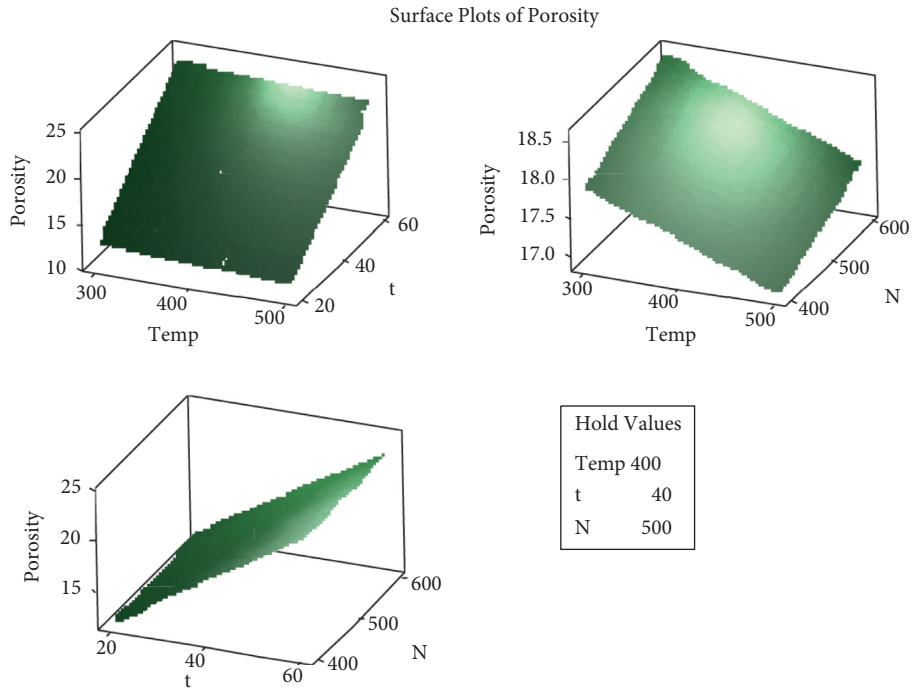


Figure 5: Comparison of surface plots for porosity (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

Table 3: Significant consequence for porosity.

| Level | Response for SN ratio | | | Response for means | | |
|---|---|---|---|---|---|---|
| | Temperature (°C) | Time (sec) | Stir speed (rpm) | Temperature (°C) | Time (sec) | Stir speed (rpm) |
| 1 | −24.89 | −21.69 | −24.53 | 18.22 | 12.15 | 17.39 |
| 2 | −24.68 | −24.96 | −24.68 | 17.72 | 17.72 | 17.72 |
| 3 | −24.42 | −27.34 | −24.78 | 17.22 | 23.28 | 18.04 |
| Delta | 0.47 | 5.64 | 0.25 | 1.00 | 11.12 | 0.65 |
| Rank | 2 | 1 | 3 | 2 | 1 | 3 |

Temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm

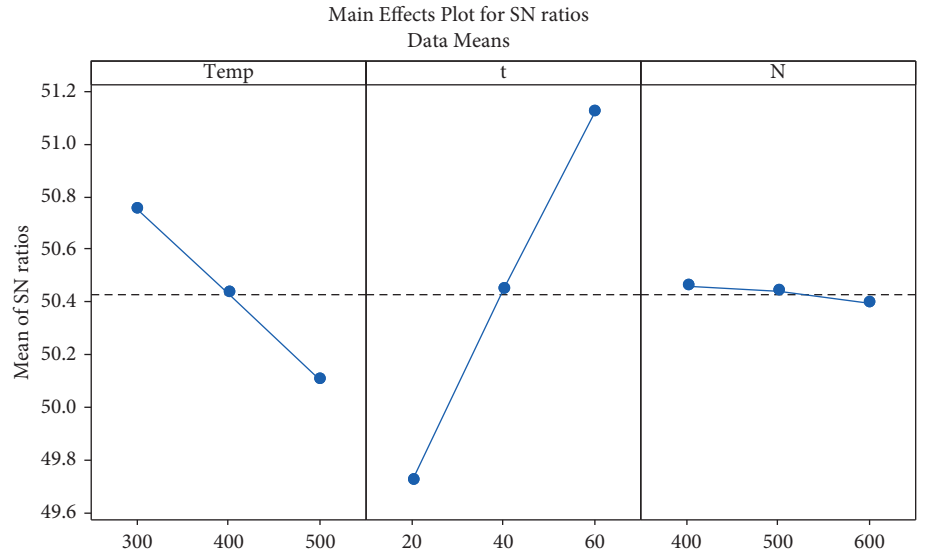


Figure 6: Significant consequence diagram based on the SN ratio for compressive strength (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

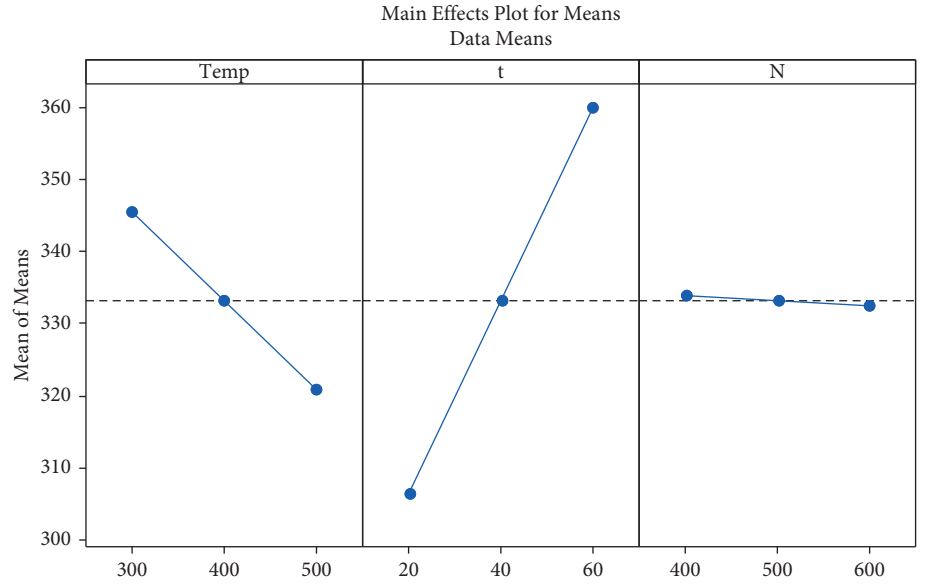


Figure 7: Significant consequence diagram based on means for compressive strength (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

the response of the compressive strength based on SN ratio and means. Here, larger is better condition is used. The first, second, and third ranks are provided for time, holding temperature, and stir speed, respectively and the corresponding regression equation is mentioned as follows for the compressive strength based on the input parameters used:

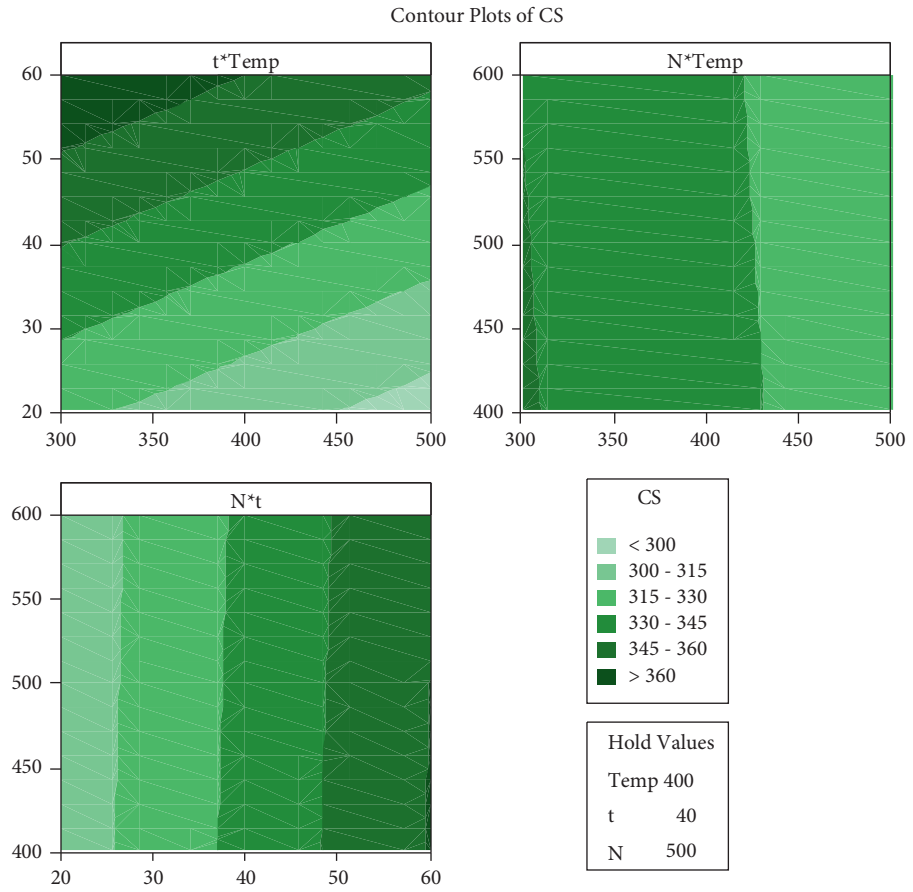


Figure 8: Comparison of the compressive strength using contour plots (temp: temperature in ˚C; *t*: time in sec; *N*: stir speed in rpm).

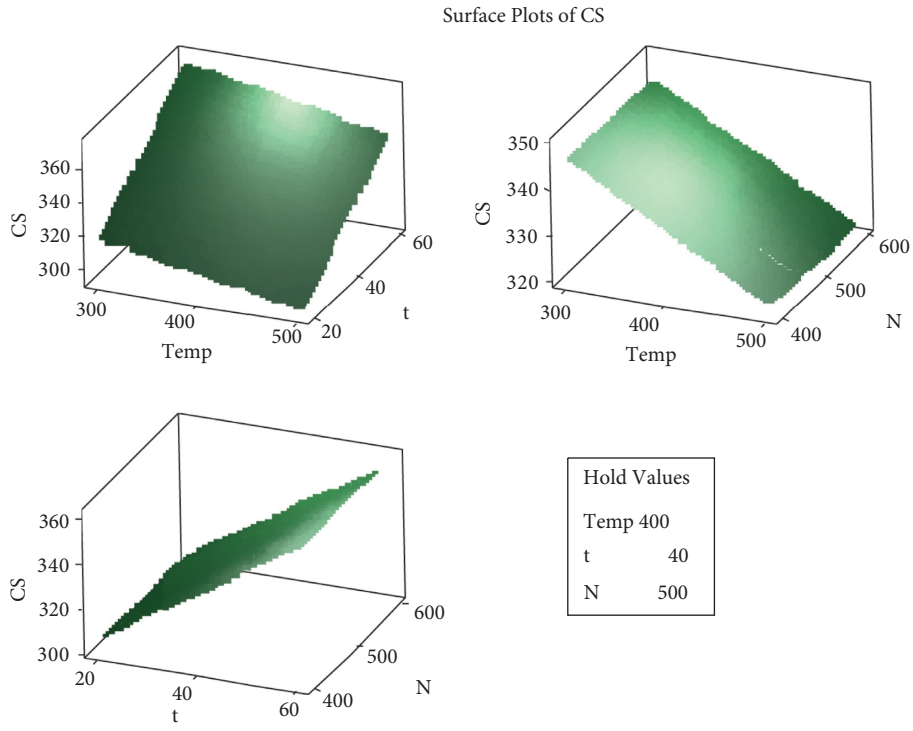


Figure 9: Comparison of the compressive strength using surface plots (temp: temperature in ˚C; *t*: time in sec; *N*: stir speed in rpm).

Table 4: Porosity and compressive strength-based responses.

| Level | Temperature (°C) | Time (sec) | Stir speed (rpm) |
|---|---|---|---|
| 1 | −47.28 | −46.36 | −46.99 |
| 2 | −46.95 | −46.96 | −46.96 |
| 3 | −46.62 | −47.53 | −46.91 |
| Delta | 0.66 | 1.18 | 0.08 |
| Rank | 2 | 1 | 3 |

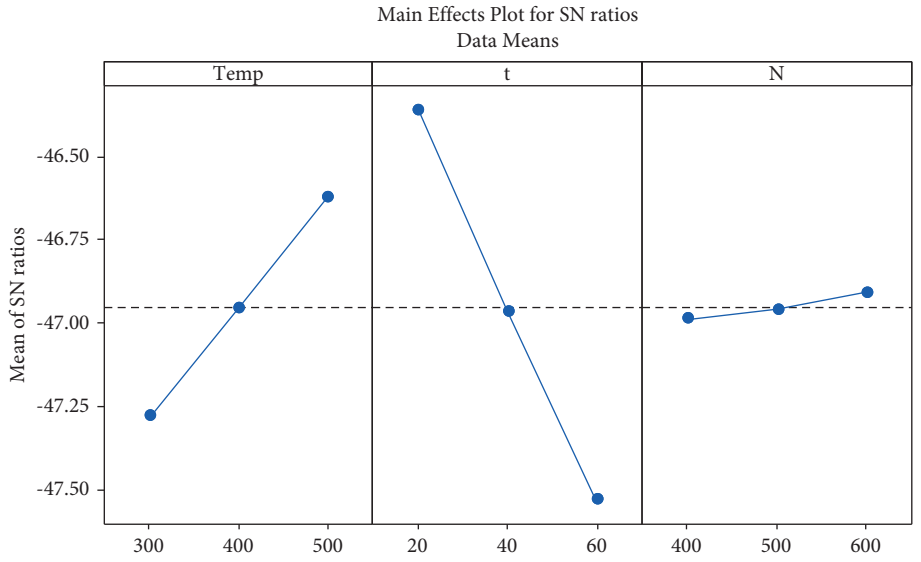


Figure 10: Significant consequence diagram based on the SN ratio for porosity and compressive strength (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

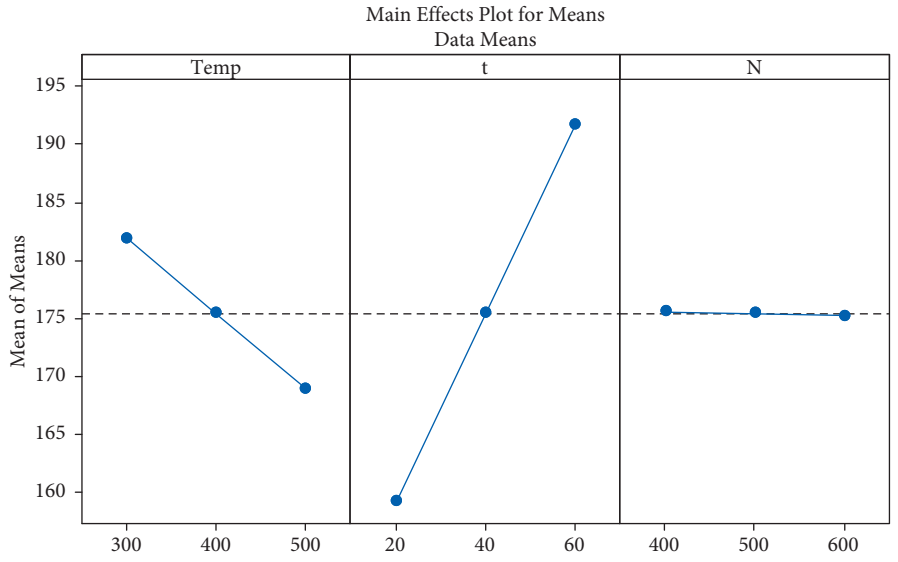


Figure 11: Significant consequence diagram based on means for porosity and compressive strength (temp: temperature in °C; *t*: time in sec; *N*: stir speed in rpm).

regression equation for compressive strength

$$= \text{CS} = 332.6 - 0.1240\,\text{temp} + 1.342\,t - 0.007000\,N. \quad (2)$$

*2.3. Porosity and Compressive Strength.* After completing the individual optimization based on porosity and compressive strength values, the combination of these two was considered with nominal being the best condition in Table 4.

Table 5: Compressive strength response table.

| Level | Response for SN ratio | | | Response for means | | |
|---|---|---|---|---|---|---|
| | Temperature (°C) | Time (sec) | Stir speed (rpm) | Temperature (°C) | Time (sec) | Stir speed (rpm) |
| 1 | 50.75 | 49.72 | 50.46 | 345.6 | 306.3 | 333.9 |
| 2 | 50.43 | 50.45 | 50.44 | 333.2 | 333.2 | 333.2 |
| 3 | 50.10 | 51.12 | 50.39 | 320.8 | 360.0 | 332.5 |
| Delta | 0.65 | 1.40 | 0.06 | 24.8 | 53.7 | 1.4 |
| Rank | 2 | 1 | 3 | 2 | 1 | 3 |

Figure 10 shows the significant consequence diagram based on the SN ratio for porosity and compressive strength. Similarly, Figure 11 shows the significant consequence diagram based on means for porosity and compressive strength. From Figures 10 and 11, the nominal results can be achieved for the input parameters such as 500°C of the holding temperature with 20 sec of the holding time and 600 rpm speed of the stir. Table 5 provides the porosity and compressive strength-based responses with the ranks such as first rank for time, second rank for holding temperature, and last rank for stir speed. Time is superior and most important parameter for porosity and compressive strength. Among these three cases, speed of stir obtained the very low preference for the responses.

## 3. Conclusion

This study on parameters of porosity and compressive strength-based optimization on reinforced aluminium from the recycled waste automobile frames can be possible, and the corresponding conclusions are as follows:

(i) The lowest porosity-based optimum parameters were 500°C of holding temperature with 20 sec of holding time and 400 rpm speed of the stir

(ii) The maximum compressive strength-based optimum parameters were 300°C of holding temperature with 60 sec of holding time and 400 rpm speed of the stir

(iii) The porosity and compressive strength-based optimum parameters were 500°C of holding temperature with 20 sec of holding time and 600 rpm speed of the stir

(iv) In future, the work was extended to conduct the impact test for checking the impact strength of the frame in the vehicle and also planned to conduct the corrosion test of the reinforced composites

## Data Availability

The data used to support the findings of this study are included in the article. Further data or information which are required are available from the corresponding author upon request.

## Disclosure

This work was performed as a part of the Employment Hawassa University, Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

## Acknowledgments

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# MECHANICAL AND MICROSTRUCTURAL STUDIES OF OPTIMIZED TAGUCHI GREY RELATIONAL ANALYSIS OF PCGTAW PROCESS PARAMETERS FOR JOINING MONEL 400 AND AISI 316

Balram YELAMASETTI[1*], G. RAJYALAKSHMI[2], K. SRAVAN KUMAR[3]

*In the present paper an approach for producing sound weld quality characteristics using pulsed current gas tungsten arc welding process to join base metal combination of Monel 400 and AISI 316 with ERNiCrMo-3 as filler while employing Taguchi method to design experiments and analyze the experimental data is presented. For optimizing the size of HAZ and tensile properties of weldments, an L9 array has been used. The grey relational analysis was performed for optimizing process parameters with multi-objective responses. Analysis of variance was performed to find the significance in effect of the welding parameters on dissimilar weldments. The analysis results of 8th trail were obtained as best performance set of values with main current at 180 A, background current at 90 A and frequency at 4 Hz. Further, mechanical and metallurgical properties have been evaluated for optimum process parameter experiment. Improved mechanical properties and fine grain structure in the weld zone were observed from the best performance set of parameters.*

**Keywords**: PCGTAW, Taguchi Methods, Grey Relational Analysis, ANOVA, Mechanical Properties, Microstructural Studies

## 1. Introduction

One of the chosen base metals, i.e., Monel 400, has applications in petrochemical and marine industries, exhibit its toughness and high strength at high temperatures with good corrosion resistance [1]. Similarly, AISI 316 shows better properties when subjected to cryogenic temperatures, especially in pitting and crevice corrosion. Addition of 2% of Molybdenum to a standard AISI 304 has shown an increase of 40% in tensile strength at 760 $^{o}$C temperature [2]. Balram et al. [3] reported that the bimetallic combination of austenitic steels and Monel 400 has various applications in nuclear industries, petrochemical and food processing equipment. Choosing a proper filler wire is a critical step in joining of heterogeneous metals which significantly affect mechanical and metallurgical properties. Venukumar et al. [4] studied on joints of austenitic steel 416 and Ni-Cr based super alloy Inconel 718 developed with Pulsed Current Gas Tungsten Arc

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Welding (PCGTAW) process and results have revealed that the Ni-Cr based fillers are most suitable for improving toughness of combination joints of AISI 416 and Inconel 718. The addition of other elements, such as Molybdenum, Niobium, will help to pass the formation of carbides after solidification. This is an effective method to increase resistance to ductility dip cracking in Ni-based filler wires [5].

In Constant Current Gas Tungsten Arc Welding (CCGTAW) technique, due to continuous heat input, high amount of heat energy is produced and consequently results in weld zones containing coarse grain structures. Ramkumar et al. [6] discussed results on weldments of Monel 400 and stainless steel 304 weldments developed by CCGTAW and PCGTAW process. The metallurgical results revealed that the segregation of filler elements like Cu and Cr occur at the interface of weld zone when CCGTAW technique was employed. Continuous heat inputs in the CCGTAW technique has caused the development of new phases and micro-segregation and thus causing an overall reduction in quality of weldments [7]. From the literature review on pulsed current welding process, it was stated to have advantages over continuous welding process and hence it is suggested for various applications requiring fusion welding. By using PCGTAW process, some of the microstructural improvements, like grain refinement, lower segregation effect can be achieved and thus an improvement in mechanical properties of welded joints [8]. Devendranath et al. [9] developed the dissimilar weldments between AISI 416 and Inconel 718 by employing PCGTAW process to study the metallurgical properties. From the results it is revealed that the lower segregation effect of alloying elements with reduced coarse grain weldments were obtained in PCGTAW process. Reddy et al. [10] developed the aluminum-lithium alloy weldments by using PCGTAW process at different pulse frequencies. The results indicating that the strength of weldments has improved at low pulse frequency due to the formation of fine grains structures around the fusion zone.

Taguchi's method is a systematic method to model and analyze the experimental values for enhancing the desired outcome like quality etc. Srirangan et al. [11] applied Taguchi Grey Relational Analysis (GRA) to design the factors like, welding speed, arc voltage and welding current to optimize the breaking strength and yield properties at the temperature about 27 $^{o}$C and at 750 $^{o}$C. From the GRA analysis, a combination of welding current ($I_A$) of 110 A with voltage (V) of 12 V and weld speed (s) of 1.5 mm/s were found as optimum parameters. Magudeeswaran et al. [12] used Taguchi technique in their experiments for optimizing parameters of CCGTAW technique that included weld current, voltage drop, electrode gap and travel speed for the development duplex stainless steels weldments. The optimum parameters to obtain best weld quality were reported as 140 A for welding current, 1 mm electrode gap with a weld speed of 130 mm/min and arc voltage at 12 V. Kumar et al. [13] developed the regression model for

improving the tensile properties of PCGTAW of aluminum alloys. Esme et al. [14] optimized geometry of weld pool of CCGTAW weldments by using GRA and Taguchi method wherein an L-16 array is used for optimizing bead height, width, depth of penetration and penetration area. Reports suggested that GRA is the best statistical multi-objective optimization tool with the combination of Taguchi method. Choudhury et al. [15] used L-16 array for welding parameters that included main current, flow rate and diameter of filler using Taguchi technique. The statistical tools Analysis of Variance (ANOVA) and S/N (Signal to Noise ratio) methods have been employed to study the effect input factors on output response i.e., Ultimate Tensile Strength (UTS). The optimal welds geometry was also reported that would produce sound welds. Agrawal et al. [16] examined the effect of welding speed, pulsed current and frequency on SS 304 thin sheets in the PCGTAW technique. It is reported that the tension and hardness properties were enhanced about 12% at high welding speed and higher mean current.

In this research, multi-objective optimization using Taguchi based GRA was used to optimize the PCGTAW input parameters which includes main and background currents and frequency. The output responses were yield strength, UTS and Heat Affected Zone (HAZ) width of Monel 400 and AISI 316. ANOVA method was adopted to understand the effect of individual parameters on weld characteristics. Further, the low grey grade obtained from the experiments were validated by conducting confirmation test. Also, the present research work studies the effect of PGCTAW parameters on mechanical behavior and metallurgical changes on weldments of Monel 400 and AISI 316 for optimum condition weldment.

## 2. Experimentation

The chosen base metals were EDM cut to a size of 120 x 80 x 5 mm. The filler wire ERNiCrMo-3 was used to join base plates of Monel 400 to AISI 316 by employing PCGTAW machine. The chemical composition of base materials and filler are given in Table 1. For edge preparation V-grooves configuration is chosen while maintaining prescribed root gap (1.5 mm). Taguchi L9 array was used for conduction experiments and the process parameter of PCGTAW technique and their experimental levels are given in Table 2.

*Table 1*

**Chemical composition (in wt.%) of base materials and filler wire**

| Base and filler metal | Ni | Cr | Mo | Fe | Cu | C | Mn | C | Si | Others |
|---|---|---|---|---|---|---|---|---|---|---|
| Monel 400 | Rem | - | - | 2.5 | 31.5 | 0.12 | 1.6 | 0.12 | 0.4 | - |
| AISI 316 | 10.4 | 17.9 | 2.1 | Rem | - | 0.08 | 2.0 | 0.08 | 0.4 | P- 0.002 |
| ERNiCrMo-3 | Rem | 21.5 | 9.0 | 5.0 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | Nb-3, Co-9.0 and Ti-0.4 |

*Table 2*

**Process parameters of PCGTAW technique and their levels**

| Parameters | Unit | Level-1 | Level-2 | Level-3 |
|---|---|---|---|---|
| Main current ($I_m$) | A | 160 | 170 | 180 |
| Background current ($I_b$) | A | 80 | 90 | 100 |
| Pulse frequency (f) | Hz | 4 | 6 | 8 |

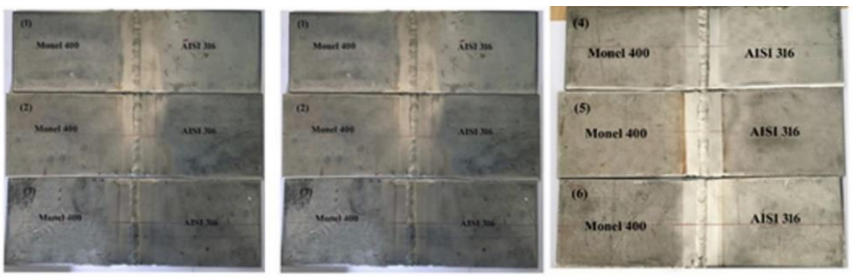


Fig. 1. Dissimilar joints developed by PCGTAW process

The output responses were considered to be YS, UTS and HAZ width of Monel 400 and AISI 316. The fabricated weldments of base plates are shown in Fig. 1.

## 3. Taguchi GRA

The Taguchi's GRA is a quantitative analysis used to optimize the multiple responses simultaneously. It combines all the responses considered (multi-objectives) into a single response which can be used to solve the single response (objective) optimization problem. To apply this method, input characteristics (objective function) need to be normalized. This way of optimizing the responses is called grey relational analysis. The experimental results of tension test and HAZ width of base metals considered for output responses are given in Table 3.

### 3.1 Signal to noise ratio

The conversion of S/N ratio value was computed for the investigational response values by using Eqs. 1 and 2. For "the larger the better" criteria equation (1) is used whereas for "the larger the better" criteria equation (2) is used. In the present study, the quality characteristics "the larger the better" is selected for optimizing the tensile properties and "the smaller the better" for HAZ width of AISI 316 and Monel 400. The S/N ratio of each level of response were calculated using Eqs.1 and 2 and are tabulated in Table 4. In GRA, the normalized data are used for evaluating the grey relation coefficient.

$$\frac{S}{N} = -10 * log_{10}(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y^2}) \quad (1)$$

$$\frac{S}{N} = -10 * log_{10}(\frac{1}{n}\sum_{i=1}^{n} Y^2) \quad (2)$$

Where, n= number of runs and Y=performance results.

### 3.2 Grey relation generation

The preferred characteristics for YS and UTS is "the larger the better" criterion. The "larger the better" characteristics can be normalized by using the following Eq. 3.

$$Y^*(k) = \frac{Y_i(k) - Min(Y_i(k))}{Max(Y_i(k)) - Min(Y_i(k))} \quad (3)$$

Where, i= number of runs 1, 2, 3……9, $Y_i(k)$ = response factor, $Y^*(k)$= Grey relation generation.

The preferred characteristics for HAZ width is "the smaller the better" criterion and this characteristic can be normalized by using following Eq. 4.

$$Y^*(k) = \frac{Min(Y_i(k)) - Y_i(k)}{Max(Y_i(k)) - Min(Y_i(k))} \quad (4)$$

Similarly, for remaining experiments the calculated is repeated for all the sequences after preprocessing data using Eqs. 3 and 4. The Grey Relational Generation (GRG) values are listed in Table 5.

*Table 3*

**Experimental results of tensile properties and HAZ width**

| Exp. No | UTS, MPa | YS, MPa | HAZ Width of SS 316, mm | HAZ width of Monel 400, mm |
|---|---|---|---|---|
| 1 | 518 | 281 | 2.82 | 2.53 |
| 2 | 543 | 303 | 3.05 | 2.62 |
| 3 | 514 | 301 | 3.14 | 2.68 |
| 4 | 504 | 319 | 2.92 | 2.59 |
| 5 | 502 | 309 | 3.18 | 2.75 |
| 6 | 526 | 324 | 3.14 | 2.65 |
| 7 | 544 | 310 | 3.25 | 2.80 |
| 8 | 546 | 363 | 3.04 | 2.59 |
| 9 | 539 | 320 | 3.34 | 2.91 |

### 3.3. Grey relation coefficient and grade

After normalization of sub-sequence data, a Grey Relation Coefficient (GRC) can be evaluated with deviation sequence and GRG. The GRC relation is defined in Eq. 5.

$$\xi_i(k) = \frac{\Delta min + (\zeta * \Delta max)}{\Delta_{oi}(k) + (\zeta * \Delta max)} \quad (5)$$

where, $\Delta_{oi}(k)$= deviation sequence among $Y_i^*(k)$ and $Y_o^*(k)$; $\xi_i(k)$ =Grey relation coefficient, $\zeta$= identification coefficient, ($\zeta$= 0.5, since equal consideration is given to all the weldment responses).

Similarly, the GRC of each experiment is calculated by the Eq. 6. After computing GRC, the grades of each experiment are determined by considering the average of GRC for every inspection as represented in Eq. 6.

$$\gamma_i = \frac{1}{n}\sum_{i=1}^{Q} \xi_i(k) \tag{6}$$

*Table 4*

**S/N ratio of response parameters**

| Exp. No | S/N ratio of UTS | S/N ratio of YS | S/N ratio of HAZ of SS 316 | S/N ration of HAZ of Monel 400 |
|---|---|---|---|---|
| 1 | 54.2911 | 48.9979 | -9.0050 | -8.0624 |
| 2 | 54.7115 | 49.6309 | -9.6860 | -8.3660 |
| 3 | 54.2201 | 49.5924 | -9.9386 | -8.5627 |
| 4 | 54.0608 | 50.0951 | -9.3077 | -8.2660 |
| 5 | 54.0215 | 49.8000 | -10.0485 | -8.7867 |
| 6 | 54.4332 | 50.2088 | -9.9386 | -8.4649 |
| 7 | 54.7169 | 49.8124 | -10.2377 | -8.9432 |
| 8 | 54.7542 | 51.2165 | -9.6575 | -8.2660 |
| 9 | 54.6466 | 50.1011 | -10.4749 | -9.2779 |

*Table 5*

**Taguchi grey relational generation**

| Exp. No | UTS | YS | HAZ of SS 316 | HAZ of Monel 400 |
|---|---|---|---|---|
| 1 | 0.3680 | 0.0000 | 1.0000 | 1.0000 |
| 2 | 0.9417 | 0.2853 | 0.5367 | 0.7502 |
| 3 | 0.2711 | 0.2679 | 0.3649 | 0.5884 |
| 4 | 0.0537 | 0.4945 | 0.7941 | 0.8325 |
| 5 | 0.0000 | 0.3615 | 0.2901 | 0.4041 |
| 6 | 0.5620 | 0.5458 | 0.3649 | 0.6688 |
| 7 | 0.9491 | 0.3671 | 0.1614 | 0.2754 |
| 8 | 1.0000 | 1.0000 | 0.5561 | 0.8325 |
| 9 | 0.8531 | 0.4972 | 0.0000 | 0.0000 |

## 4. Results and discussions

From the Taguchi GRA, the maximum grey relational grade (81.97%) has been observed in the 8$^{th}$ experiment of orthogonal array which has better multi-response characteristics. A rank is assigned to each experiment based on GRG value. The optimized parameters of PCGTAW from Taguchi GRA with main current as 180 A, base current of 90 A with pulse frequency of 4 Hz were taken for welding chosen base materials. Since L9 array was used, it would be easy to estimate the effect of individual process parameter on GRG by separating values at all the levels. As an example for instance, the mean of GRG for the pulse frequency at levels 1, 2 and 3 can be computed by taking the average of GRG of (Exp. No.1, 6 and 8), (Exp. No. 2, 4 and 9) and (Exp. No. 3, 5 and 7) as listed in Table. 6. Similarly, the mean values of peak current and background current are computed. The maximum values of average GRG are highlighted in Table 7. From the experimentation, the order of effecting parameters are 1) pulse frequency, 2) base current and 3) peak current. The means of mean effect on GRG are shown in Fig. 2.

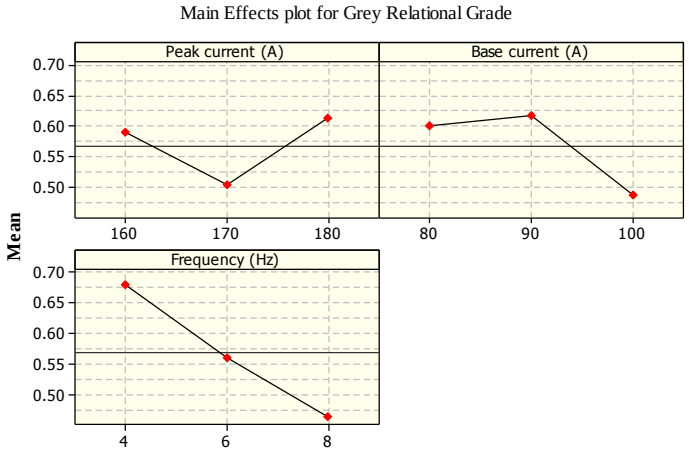


Fig. 2. Main effect plot of GRG

Basically, the higher GRG gives the product quality closer to the best and hence it is desirable for best performance. Therefore, the optimal process parameters setting for better pulse frequency and lesser peak current and background current.

### 4.1 Analysis of means for GRG

Analysis of mean indicates the optimal combination of parameters. ANOVA was calculated by taking the average of responses of that particular level. The GRG values of welding parameters are given in Table 7. From the analysis of means, the optimal parameters obtained are main current ($I_m$) at Level-

3 (180 A), background current ($I_b$) at Level-2 (90 A) and frequency at Level-1 (4 Hz).

*Table* 6

**Grey relational co-efficient and grade**

| Exp. No | UTS | YS | HAZ of SS 316 | HAZ of Monel 400 | GRG | Rank |
|---|---|---|---|---|---|---|
| 1 | 0.4417 | 0.3333 | 1.0000 | 1.0000 | 0.6938 | 2 |
| 2 | 0.8956 | 0.4116 | 0.5191 | 0.6668 | 0.6233 | 3 |
| 3 | 0.4069 | 0.4058 | 0.4405 | 0.5485 | 0.4504 | 8 |
| 4 | 0.3457 | 0.4973 | 0.7083 | 0.7491 | 0.5751 | 4 |
| 5 | 0.3333 | 0.4392 | 0.4132 | 0.4563 | 0.4105 | 9 |
| 6 | 0.5330 | 0.5240 | 0.4405 | 0.6016 | 0.5248 | 6 |
| 7 | 0.9077 | 0.4413 | 0.3735 | 0.4083 | 0.5327 | 5 |
| 8 | **1.0000** | **1.0000** | **0.5297** | **0.7491** | **0.8197** | **1** |
| 9 | 0.7730 | 0.4986 | 0.3333 | 0.3333 | 0.4846 | 7 |

*Table 7*

**Mean values of GRG**

| Parameters | Level-1 | Level-2 | Level-3 | Main effect (max-min) | Rank |
|---|---|---|---|---|---|
| $I_m$ | 0.5892 | 0.5035 | **0.6123** | 0.0232 | 2 |
| $I_b$ | 0.6005 | **0.6178** | 0.4866 | 0.0173 | 3 |
| $f$ | **0.6794** | 0.561 | 0.4645 | 0.1184 | 1 |

### 4.2 Analysis of variance for S/N ratios

ANOVA is an approach that extensively considers the involvement of each factor variation made by the overall variance of output response variation. It indicates the % of contribution of each factor towards the output responses. The influence of process parameters background current, main current and pulse frequency on output response to grey relational grade has been determined with statistical tool Minitab 16.0. This could be calculated by separating the total variability of the GRG value as mean square deviation of GRG and its error.

Table 8 shows the analysis of variance of GRG. From the ANOVA results, it is clear that the pulse frequency (53%) influence on the quality of welded joint and subsequently with lower percentage from background current and main current with 23% and 15% respectively.

### 4.3 Confirmation experiment

For verifying the optimal process parameters obtained from the GRA, a confirmation test has been performed by choosing optimal parameters. The weldments of the chosen combination were developed with optimum parameters and the output responses were measured. The GRA and confirmation test outcomes are listed in Table 9. From this test, it was confirmed that the optimum values of test results are very close to the results obtained from GRA.

*Table 8*

**ANOVA results for GRG**

| Source | DF | Seq. SS | Adj. SS | Adj. MS | P | F | % of contribution |
|---|---|---|---|---|---|---|---|
| $I_p$ | 2 | 0.020 | 0.020 | 0.010 | 0.363 | 1.750 | 15.06% |
| $I_b$ | 2 | 0.031 | 0.031 | 0.015 | 0.269 | 2.710 | 23.30% |
| Hz | 2 | 0.070 | 0.070 | 0.035 | 0.139 | 6.180 | 53.08% |
| Error | 2 | 0.011 | 0.011 | 0.006 | | | 8.56% |
| Total | 8 | 0.131 | | | | | |

*Table 9*

**Confirmation test and optimal GRA values**

| Optimal parameters | Ultimate tensile strength, (MPa) | Yield strength, (MPa) | HAZ of AISI 316 (mm) | HAZ width of Monel 400 (mm) |
|---|---|---|---|---|
| 8$^{th}$ trial of array | 546 | 363 | 3.04 | 2.59 |
| Confirmation experiment | 548 | 359 | 3.02 | 2.62 |

### 4.4 Hardness studies

The microhardness of dissimilar welded joint was obtained from Vickers hardness tester and its distribution is shown in Fig. 3.

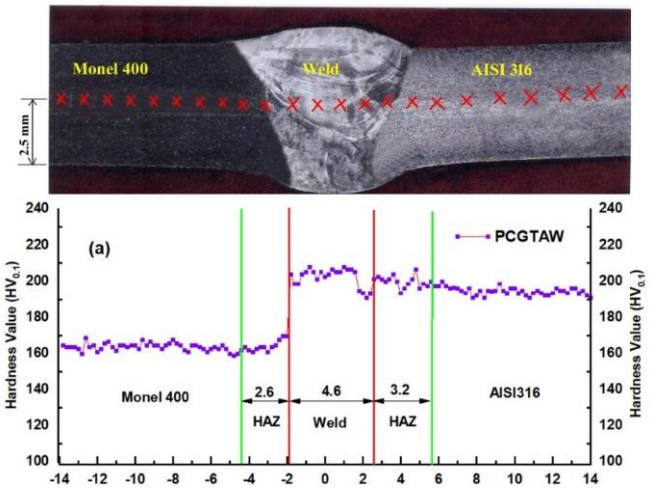


Fig. 3. The Vickers microhardness distribution along fusion zone of Monel 400 and AISI 316

The maximum hardness number was seen at the weld zone than the base materials. It can be seen from the hardness plot, the surface hardness value decreased at the HAZ of AISI 316 as compared to its base materials, whereas the surface hardness number increased at the interface of Monel 400 than that of its base materials. It is also evident from the microstructures, that the grain refinement has been observed at the Monel 400 interface which is the cause of improvement in the hardness value. The width of HAZ is more at the AISI 316 side as compared to Monel 400 side because of its thermal properties.

### 4.5 Microstructural investigation

For the optimal test experiment, the microstructure of various zones has been evaluated. The OM and SEM structures of the weld interfaces are shown in the Fig. 4.

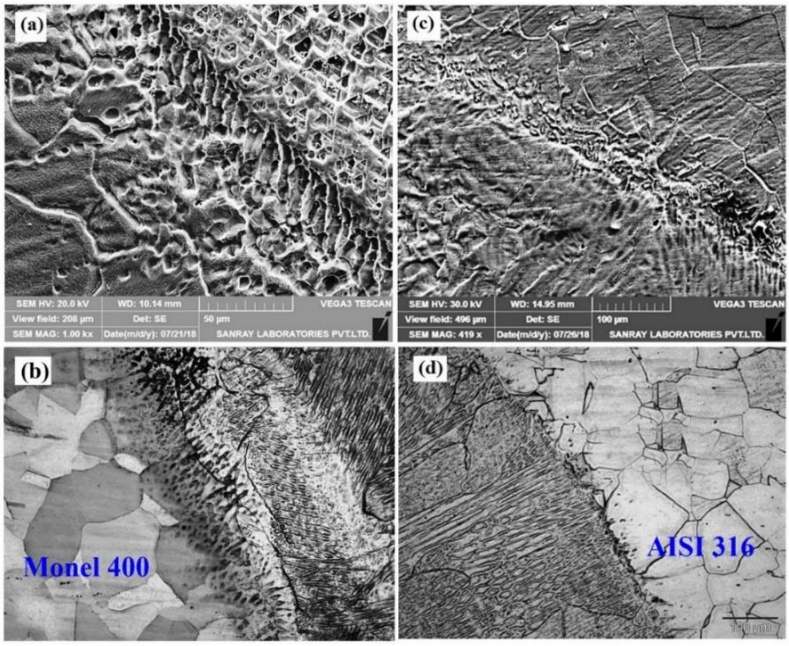


Fig. 4. OM images and SEM micrographs of (a, b) Monel 400 and (c, d) AISI 316 weld joint

No grain coarsening was identified near the HAZ of Monel 400 from Fig. 4a & b, which could be attributed to the controlled total heat input and low frequency. The long dendritic and columnar like structures were seen on the HAZ of Monel 400 weld and fine grain structures near the interface of AISI 316 from Fig. 4c & d. Also, complete austenitic phases were seen on weld region from Fig. 5. Due to Ni-Cu enrich phases at the weld zone the maximum hardness values have been observed. Secondary phase formation and isolation of alloying elements are greatly minimized in this welding technique. SEM micrographs of weld interfaces are presented in Fig. 6. Enrich of Ni, Mo and Cr and also peaks of Cu and Fe were observed. Results of EDS point analysis i.e., the chemical compositions of HAZ and weld zone of dissimilar weldments are listed in Table 10.

*Table 10*

**Point analysis (% weight) on dissimilar weldments**

| Zone | Ni | Cr | Fe | Cu | Mo | Mn | Si | Others |
|---|---|---|---|---|---|---|---|---|
| Monel 400 HAZ | 61.93 | -- | 4.17 | 32.17 | -- | 1.37 | 0.34 | --- |
| Fusion zone | 46.07 | 19.71 | 18.4 | 9.4 | 3.2 | 1.98 | 0.4 | Nb-0.79 |
| AISI 316 HAZ | 9.31 | 18.74 | 68.69 | -- | 1.24 | 1.96 | - | - |

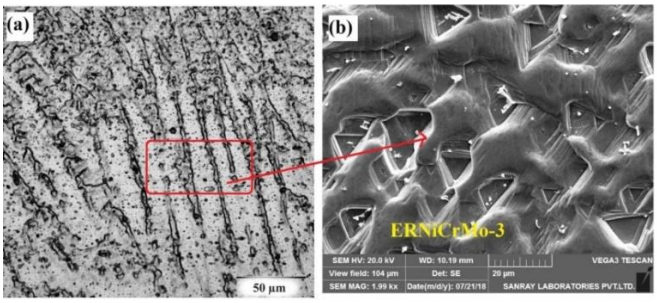


Fig. 5. Weld zone of dissimilar PCGTAW weldments: (a) OM and (b) SEM micrographs

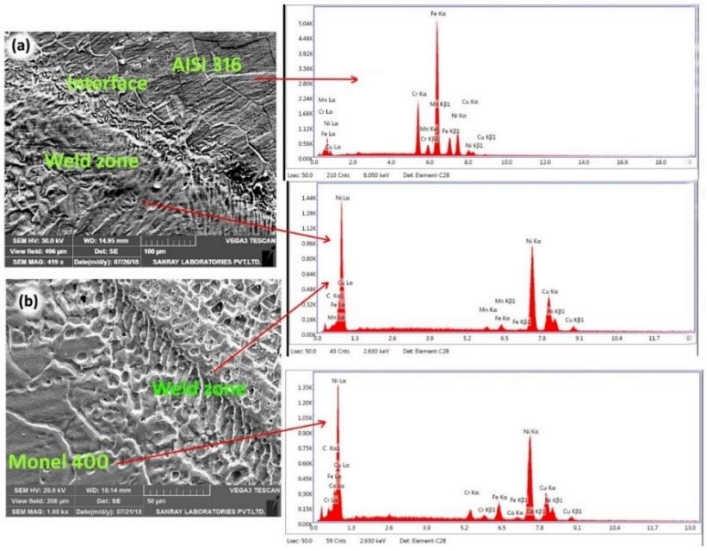


Fig. 6. EDS X-ray point analysis of dissimilar weldments: (a) AISI 316 and (b) Monel 400

## 5. Conclusions

The dissimilar combination of Monel 400 and AISI 316 are joined by PCGTAW technique successfully with ERNiCrMo-3 filler wire. The conclusions drawn from Taguchi analysis are given below;

- The best performance set of parameters from Taguchi's GRA are obtained as main current at 180 A, low current at 90 A and pulse frequency at 4 Hz.
- From the ANOVA grey relational analysis, it is seen that the order of effecting parameters are pulse frequency (53%) followed by background (23%) and main currents (15%) on output factors.
- The HAZ of both sides of base metals has been minimized and a small grain coarsening was identified at the boundary of stainless-steel side because of its thermal properties.
- The microstructure of weld zone has shown complete austenitic structures and grain refinement at the interface of Monel 400 and AISI 316 by maintaining low pulse frequency (4 Hz).

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# INNOVATIVE METHODS AND TOOLS IN ENGLISH LANGUAGE TEACHING



December 2021

**Authors:**

**Deepa B.**
Gokaraju Rangaraju Institute of Engineer…



Citations (2) References (6)

## Abstract

No doubt technology is an offshoot of science. Education has been revolutionized, so too the teaching methods have changed radically particularly, the English language teaching methods. Millennials are digital natives (people born with digital devices in their hands) and are easily stressed out with the abundance of information available on different websites which may likely to distract them. So, it is the responsibility of English teachers or instructors, to create a beautiful learning environment. To sustain interest in students and motivate them, digital platforms must be chosen wisely and effectively. Besides technical skills, communication skills, analytical skills, and writing skills also play a significant role in the holistic development of English language learners. This paper Explores how the process of English language learning in this digital era can be promoted with the ICT (Information and Communication Technologies). Teachers may feel that a special language learning tool is effective, however it is necessary to understand the advantages and the time it takes for students to learn to use the tools. Incorporating technology into teaching pedagogy simultaneously cultivate students their digital literacy skills along with the English language. So, it is the responsibility of instructors or teachers make the learning environment more congenial for learner"s

Article PDF Available

# EARLY INDIAN WOMEN ENGLISH NOVELISTS: A STUDY.

February 2021

**Authors:**

**Deepa B.**
Gokaraju Rangaraju Institute of Engineer…

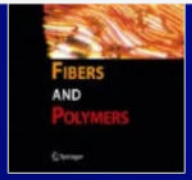


Abstract

The Indian English novel is a late development. The earliest writing of Indians in English is considered as prose letters, translations, and religious, social, political and cultural tracks. Some of the important factors for the late development of novels in Indian literature were the absence of novels as an important genre of imaginative literature, which gives artistic expression to the relationship of man and society. The novel as an art form came to India with the British. It was a new genre in Indian literature. Novels are vivid and gendered imaginings of selves and subjects. Reform is crucial in these enterprising undertakings-reform of self and society, including patriarchy and racism. The novels of Toru Dutt, Krupabai Satthianadhan, Rokeya Sakhawat Hossain and Swarna Kumari Devi Ghosal and their themes are discussed in this paper. The focus of reform in these novels concerns romance, livelihood, and women's education claims to spaces in the public sphere.

# Influence of Mechanical Attributes, Water Absorption, Heat Deflection Features and Characterization of Natural Fibers Reinforced Epoxy Hybrid Composites for an Engineering Application

Published: 21 July 2021 | **22**, 3444–3455 (2021)

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A. K. Arun Raja, K. Arun Vasantha Geethan, S. Sathees Kumar & P. Sabarish Kumar



## Abstract

Natural fiber composites (NFC) are getting more attention and importance over synthetic fibers in terms of their various advantages and applications. Nonetheless, the applications are restricted because of their poor mechanical properties and high moisture absorption, contrasted with synthetic fiber composites. To overcome the previously mentioned issues and to extend the potential applications, an endeavor has been made in the current study to investigate and describe the hybrid natural fibers/epoxy matrix composites. In the present

# Influence of Mechanical Attributes, Water Absorption, Heat Deflection Features and Characterization of Natural Fibers Reinforced Epoxy Hybrid Composites for an Engineering Application

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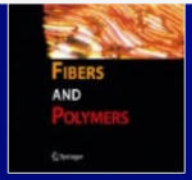


Fibers and Polymers

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## Abstract

Natural fiber composites (NFC) are getting more attention and importance over synthetic fibers in terms of their various advantages and applications. Nonetheless, the applications are restricted because of their poor mechanical properties and high moisture absorption, contrasted with synthetic fiber composites. To overcome the previously mentioned issues and to extend the potential applications, an endeavor has been made in the current study to investigate and describe the hybrid natural fibers/epoxy matrix composites. In the present

# Hybrid Model Using Scrum Methodology for Softwar Development System

September 2021 · Journal of Nuclear Energy Science & Power Generation Technology 10(9):1-6

**Authors:**

**Pundru Chandra**

**Shaker Reddy**

**P Chandrashaker Reddy**
CMR College of Engineering & Technology

**S Nachiyappan**

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Citations (13) References (26) Figures (5)

Abstract and Figures

Because since the mid-1990s, traditional project management techniques have been progressively being phased out and replaced with lightning experimental tools. This issue is mostly caused by the inadequacies of traditional techniques, which include a sluggish response time to positively influence business needs as well as a proclivity to

# Implementing an Effective and Secure Resource Architecture for vlsi Block Encryption

September 2021 · Journal of Nuclear Energy Science & Power Generation Technology 10(9):1-6



**Authors:**

**Sucharitha Yadala**
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**T S Karthik**

**Dhiraj Kapila**
Lovely Professional University

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Citations (2) References (12)

Abstract

Portable encryption plays a key role in the emergence of computer applications in resource-controlled settings based on identification. In this document, we displayed higher resource-efficient VLSI configurations for both 80-bit and 128-bit PRESENT cryptosystem Algorithms, called PRESET-80 and PRESET-128. These designs' FPGA

# Facial Recognition Based Upon the Domestic Security System Using IOT

September 2021 · Journal of Nuclear Energy Science & Power Generation Technology
10(9):1 - 4

**Authors:**

**Vijendra Babu D**
Vellore Institute of Technology

**V Lokeswara Reddy**

**G Naga Rama Devi**

**A Prakash**

Show all 6 authors

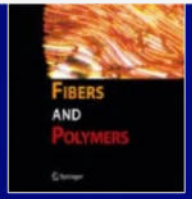


Abstract

The Internet of Things is developing, which will be significantly evolving in all fields such as industry, medical, enterprises, domestic appliances, intelligent gadgets, etc. In a little more Information applications, its mixed development in the areas of image processing has begun to spread. The successful complexity of IoT devices and intelligent sensors helps to restructure a human personality for better outcomes and safety. Designers identify the person's images in our investigation and examine the individual's mind in many processes. Computing versions is essentially regarded to be one of the most

# Exploration of Mechanical Attributes, Thermal Behaviors and Atomic Force Analysis of Alkali Treated Hybrid Polyester Composites for an Engineering Application

Published: 19 May 2021 | **22**, 2535–2542 (2021)




Fibers and Polymers

Aims and scope →

Submit manuscript →

V. Mugesh Raja & S. Sathees Kumar



## Abstract

This work exposes the mechanical attributes, characterization and thermal behaviors of alkali treated banana fiber (BF), coir fiber (CF) and palm fiber (PF) of Asian palmyra reinforced with polyester composites are expressed. Due to the high tensile attributes of banana fiber, in this experimental work banana fiber has considered as a base material, palm and coir fibers are utilized as fillers. The natural fiber composite specimens were fabricated through injection moulding method by varying the weight percentages of fibers.

# Hybrid spatio-frequency domain global thresholding filter (HSFGTF) model for SAR image enhancement

S. Iwin Thanakumar Joseph [a], J. Sasikala [b], D. Sujitha Juliet [a], S. Velliangiri [c]
Show more



https://doi.org/10.1016/j.patrec.2021.02.023


## Abstract

Synthetic Aperture Radar (SAR) deploys single antenna for both transmitting and receiving radar signals since it comes under mono static category. Major research work based on airborne and orbital focused on moving vehicle capturing, base penetration, greenery or vegetation penetration, methodologies to improve the quality of the captured images etc. In general, synthetic aperture radar imaging provides high level resolution images of vast regions under coverage. The pixel intensity of images in synthetic aperture radar is measured based on roughness, dimensional orientation and dielectric constant of plane captured. Processing of SAR images is mapping of signal data received by the radar in to a spatial image. Synthetic Aperture Radar images are easily vulnerable to speckle noises. These kinds of noises disrupt the image elucidation. This research article proposed the hybrid spatio-frequency domain global thresholding filter

Edited by Antonio Fernández-Caballero, Yong Shi, Paval Lafta, P. Karrupusamy

# Hybrid Crypto Techniques for Secured Multimedia Big Data Content Protection System (SMBDCPS)

April 2021 · International Journal of e-Collaboration 17(2):1-21
DOI:10.4018/IJeC.2021040101



**Authors:**

**Velliangiri Sarveshwaran**
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**Naga Rama Devi G.**



Abstract

Most of the existing work does not ensure the optimal and secured storage maintenance of big data. This is resolved in the proposed research method name called secured multimedia big data content protection system (SMBDCPS). The proposed scheme has using AES and SHA-256 hybrid mechanism for securing the keys of encryption and decryption. This method has integrated the key value of AES and SHA-256 together to generate the new key value for increasing the security level. The main advantage of the proposed scheme has required only small storage which is computation efficient. The overall performance of the proposed scheme has carried out on MATLAB simulation environment over the medical health care datasets. The performance proves the proposed scheme has yield better results than the existing scheme.

# Cation distribution in Ni substituted $Ba_{0.5}Sr_{1.5}Co_2Fe_{12}O_{22}$ Y-type hexagonal ferrites

M. Manendar [a], S. Shravan Kumar Reddy [b], J. Ramesh [c], M. Sreenath Reddy [a], M. Manivel Raja [d], Ch. Gopal Reddy [a], P. Yadagiri Reddy [a], V. Raghavendra Reddy [e]

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Received 14 November 2020, Revised 9 December 2020, Accepted 10 December 2020, Available online 16 December 2020, Version of Record 25 February 2021.

Review Article, J Nucl Ene Sci Power Generat Technol Vol: 10 Issue: 9

# Wireless Communication Without the Need for Pre-Shared Secrets is Consummate Via the Use of Spread Spectrum Technology

**Y Sucharitha[1*], S Vinothkumar[2], Vikas Rao Vadi[3], Shafiqul Abidin[4], Naveen Kumar[5], and G Shobana[6]**

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**Received date:**August 31, 2021 **Accepted date:** September 15, 2021 **Published date:** September 22, 2021

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## Abstract

Researchers describe the utilization of wideband chirp signals in domestic environments for frequency hopping technologies. Chirp transmission and pulse compressing are used in the system principles described. Varied modulating systems for chirp impulses leading to different application performance and complexities are evaluated for AWGN and frequency-dependent inside radio stations, in terms of their bit accuracies. We show similar calculations and measuring findings for the production of the chirp signals using demonstration systems that employ Superficial Auditory Waves (SSAW) sensors. The proposed system is equipped with 2.5 GHz, 358.8 MHa, and 85 MHz of RF and IF frequencies and communication bandwidth. The technology is not susceptible to selected frequency fading, CW interfering and sound owing to a processor increase of 16dB–enabling its use of SAW devices-as well as the broad communication bandwidth.

**Keywords:** Wireless communication; Chirp transmission

# Analysing the User Actions and Location for Identifying Online Scam in Internet Banking on Cloud

May 2021 · Wireless Personal Communications 127(1)
DOI:10.1007/s11277-021-08585-y

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Abstract and Figures

Although money laundering does seem to be a new problem, the financial crisis generally occurs during an economic recession compared with standard economic development periods. Due to user fraud transactions and tolerance, they encountered numerous issues, particularly with internet banking fraud. Modernization and an

# Experimental investigation on temperature profiles and residual stresses in GTAW dissimilar weldments of AA5052 and AA7075

Balram Yelamasetti, Deepak Kumar, Kuldeep K Saxena & Rajyalakshmi G

Pages 352-365 | Accepted 03 May 2021, Published online: 28 May 2021

Cite this article https://doi.org/10.1080/2374068X.2021.1927641 Check for updates





## 2 ABSTRACT

In this research, the dissimilar metals of AA5052 and AA7075 were joined by employing gas tungsten arc welding process using ER4043 as filler metal. During welding, the temperature distribution over the weld surface was measured using Infrared thermography. Using X-ray diffraction technique, residual stresses were measured in each welding pass on different weld zones. From thermography results, the peak temperature of 712, 789 and 816 °C was recorded in pass-1, pass-2 and pass-3, respectively. Higher temperature values were recorded at the HAZ of AA5052 than at the HAZ of AA7075. Peak residual stress of 66, 28 and 45 MPa was observed in pass-1, 2 and 3, respectively. Minimum residual stresses were observed at the HAZ of AA5052 than HAZ of AA7075.

KEYWORDS: Gas tungsten arc welding | AA5052 | AA7075 | infrared thermography | x-ray diffraction

July 2022
e12899

# Fetal health classification from cardiotocographic data using machine learning

Abolfazl Mehbodniya, Arokia Jesu Prabhu Lazar, Julian Webber, Dilip Kumar Sharma, Santhosh Jayagopalan, Kousalya K, Pallavi Singh, Regin Rajan, Sharnil Pandya, Sudhakar Sengan

First published: 01 December 2021 | https://doi.org/10.1111/exsy.12899 | Citations: 14



## Abstract

Health complications during the gestation period have evolved as a global issue. These complications sometimes result in the mortality of the fetus, which is more prevalent in developing and underdeveloped countries. The genesis of machine learning (ML) algorithms in the healthcare domain have brought remarkable progress in disease diagnosis, treatment, and prognosis. This research deploys various ML algorithms to predict fetal health from the cardiotocographic (CTG) data by labelling the health state into normal, needs guarantee, and pathology. This work assesses the influence of various factors measured through CTG to predict the health state of the fetus through algorithms like support vector machine, random forest (RF), multi-layer perceptron, and K-nearest neighbours. In addition to this, the regression analysis and correlation analysis revealed the influence of the attributes on fetal health. The results of the algorithms show that RF performs better than its peers in terms of accuracy, precision, recall, F1-score, and support. This work can further enhance more promising results by performing suitable feature engineering in the CTG data.

# Effect of filler wires on mechanical properties of super-duplex stainless steel UNS S32750 and austenitic stainless steel 304 dissimilar joints welded with PCGTAW technique

Balram Yelamasetti*, Venkat Ramana G., and Tirupathi Kadam

*Department of Mechanical Engineering, CMR Institute of Technology, Hyderabad, 501401 India*

Received: 3 September 2020; Revised: 25 March 2021; Accepted: 8 April 2021

**Abstract**

This study addresses the effects of fillers (ERNiCrMo-3, ERNiCrMo-4 and ER309L) for joining 5 mm dissimilar metals of super-duplex steel (UNS S32750) and austenitic stainless steel (AISI 304) by using pulsed current gas tungsten arc welding. Welding parameters were fixed across all cases with the three alternative filler wires. Mechanical properties of weldments were evaluated by conducting impact, tensile and microhardness tests. Microstructural changes were studied by optical microscopy. The ratio of proof stress to ultimate tensile strength, and the ultimate tensile strength were found to be higher with ERNiCrMo-4 (0.6, 642 MPa) filler weldment than with ERNiCrMo-3 (0.57, 624 MPa) or ER309L (0.56, 612 MPa) filler weldments. Microhardness of the weldment with ERNiCrMo-4 filler was higher than with the other two fillers. It was observed from the impact test results that the ERNiCrMo-4 filler weldment exhibited superior toughness of 189 J.

**Keywords**: super-duplex stainless steel, austenitic stainless steel, PCGTAW technique, mechanical properties, microstructural studies

## 1. Introduction

Super-Duplex Stainless Steel (SDSS) use in critical structural applications, such as submarines and natural gas pipelines, is increasing and replacing other materials that were used owing to their high mechanical strength and corrosion resistance. The combined mechanical and corrosion resistance properties have been attributed to the presence of ferrite (α) and austenite (γ) phases in equal proportions (Lippold & Damian, 2005). UNS S32750 duplex stainless steel is also known to have comparatively high pitting resistance among stainless steels. The austenite stainless steels were mainly used in many industrial applications as a substitute of structural steel when corrosion resistance at elevated utilization of austenitic and super duplex stainless steels are due to their corrosion resistance and mechanical properties, and this has gained major attention in the industries. Joining dissimilar stainless steels is most challenging as regards producing quality weld structures, and the challenges are overcome by selecting suitable filler materials and welding techniques (Yelamasetti *et al.*, 2020). Some of the problems encountered are related to the weld quality, especially solidification cracks near the weld zone while joining austenitic dissimilar metals. Formation of phase structures with desired metallurgical properties depends on filler wire, which improves fatigue and corrosion resistances (Balram *et al.*, 2019). The composition of filler and its essential alloying elements affects the development of new phases in the fusion

# Effect of titanium oxide, alumina oxide and silicon carbide on mechanical properties and thermal properties of reinforced nylon composites for industrial applications

S. Sathees Kumar and V. Vignesh

Published Online: December 9, 2021 · pp 119-131 · https://doi.org/10.1504/IJCAET.2022.119540



## Abstract

This study deals with the determination of mechanical and thermal performances of titanium oxide ($TiO_2$), alumina oxide (AO) and silicon carbide (SC) reinforced nylon 6 (N6) composites. The composites are prepared by injection moulding method by varying the weight percentages. The effects of adding $TiO_2$, AO and SC particles reinforced with N6 composites has investigated and result observed by tensile strength, impact and hardness test. The fracture surface morphologies have observed through scanning electron microscope (SEM) method. Thermal performances of N6 composites are reviewed by the thermogravimetric (TG) analysis. The exploratory comes about to show that upon expanding the addition of $TiO_2$ (5 wt.%), AO (10 wt.%) and SC (5 wt.%) particles improved the tensile properties and thermal stability of the N6 polymer matrix composites. In addition, the impact strength and hardness properties escalate the expansion of SC (10 wt.%), $TiO_2$ (5 wt.%), AO (5 wt.%) content with N6. For substantiate the work, the composite gear has fabricated for industrial and vehicle




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Keywords