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"A Review On Experimental Analysis of MIG Welding Parameters of Dissimilar Metal SS304 and AA6063 Weld Joint by using RSM Method"

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Abstract : The MIG welding parameters are the most important factors affecting welding quality, productivity, and cost. This study discusses the effects of welding parameters on the weld strength and weld pool shape of medium carbon steel throughout the welding process, including welding current, welding voltage, gas flow rate, wire feed rate, etc. The DOE method makes it possible to optimize parameters and find the best combination of parameters to achieve the required quality. Automotive Industry heavy trucks, Aerospace and Shipbuilding structural elements, Oil & Gas and Transportation containers. The Efficiency of welded joints in MIG depends on numerous input process parameters such as welding current, welding voltage, gas flow rate, torch angle, electrode feed rate etc. Wrong selection of these process parameters will lead to bad quality welds. So there is a need to control the process parameters to obtain good quality welded joints. In order to verify its efficacy in the study of weld strength and penetration depth, conformation tests have finally been conducted to compare the calculated values with the experimental results.

I.INTRODUCTION :-

Metal Inert Gas Welding is one of the most fundamental and often used fabrication techniques among the various industrial processes. In welded components, tensile strength, yield strength, and elongation are all desired physical attributes. Steel and aluminum alloys are typically used for complex parts due to their low density, high strength, and formability. However, it is challenging to weld these different materials together. This happens because the materials have different and unique physical characteristics.

Aluminum alloys have notable solidification shrinkage, oxide development, strong heat conductivity and solubility, and a low melting temperature in contrast to steel. Heat is employed as a source of energy during the welding process, and it is well known that aluminum alloy oxidizes readily when exposed to higher temperatures. Because it promotes the formation and growth of intermetallic compounds (IMCs), increasing heat transmission during the welding process often results in decreased joint strength. The depth of the IMC surface has a greater effect on joint reliability and durability.

Due to its easily regulated joining technique for sheets metal, MIG welding machines are commonly used in the automotive production industries. Because of its varied heat input, MIG is an excellent solution for joining aluminum and steel alloys. Furthermore, Dissimilar sheet connects' mechanical properties are enhanced by the spreadability metals utilized for the filler liquid on the welded joint's surface. In such cases, welding and joining processes must be used, with optimization parameters specified to ensure safety and joint ability in working conditions. In general, statistical methodologies can be utilized to determine the best parameter. The RSM Method is well known for determining the elements that have the most impact on the outcome with the least number of experimentations, therefore saving time and money for industry. As a result, the ideal welding condition for dissimilar joining of Stainless steel 304 & aluminium alloy 6063 by MIG welding was identified in this work. Welding current, wire feed rate and Gas flow rate were among the variables will be investigated. The RSM Method was utilized to determine the best welding conditions and parameter optimization.

II. METAL INERT GAS WELDING WORKING PRINCIPLE:-

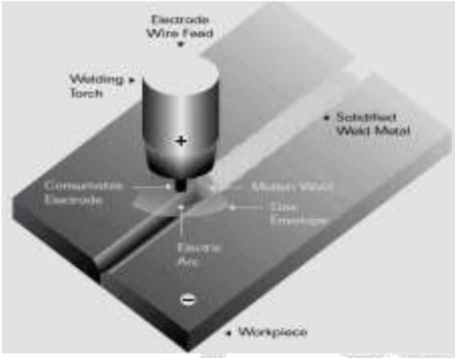

FIG. NO.1 WORKING OF WORK PIECE

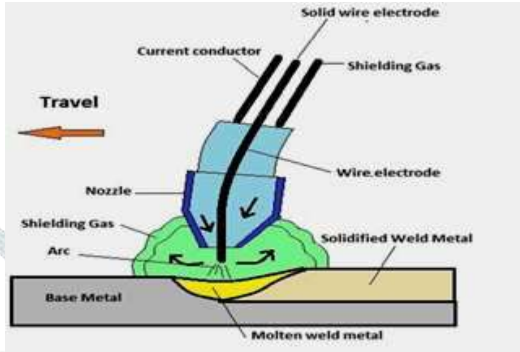

FIG. NO.02 MIG WELDING WORKING PRINCIPLE

In gas metal-arc welding (GMAW) developed in the 1950. The GMAW procedure heats the metal pieces by creating an electric arc between the metal and a wire electrode. By melting and fusing the components as shown in fig. no. 01, a permanent link is created. Metal inert gas (MIG) welding is an alternative term for GMAW. A continuous solid wire electrode and a shielding gas, which guards against airborne pollutants, pass through the welding gun in the MIG and GMAW procedures. Aluminum and other nonferrous materials, as well as thick and thin metal sheets, can all be welded using this method.

When an arc forms between the work piece and a wire electrode during GMAW welding, a pool of molten material is created. As mentioned before, a shielding gas is used and the electrode is continually fed. The method is considered semi-automatic since the wire feed and arc length are controlled by power, while the travel speed and placement are controlled by hand. To succeed, welders must understand how to maximize the wire-feed rate, current, and flow rate as well as how to properly clean and direct the gun. The travel speed that the welder employs will affect the weld's quality and shape. Because they protect the weld pool from airborne contaminants, shielding gases are essential for GMAW welding. Inert gases like argon and helium are most commonly used during the process. As a result, they will not undergo any chemical reactions. But other active gases, such carbon monoxide, can also be used. Metal-active gas welding is the term for this procedure. Welders occasionally mix active and inert gas. Different penetration profiles are provided by active gases, inert gases, and a combination of the two, which also protect the weld pool from impurities.

Constant-voltage power sources are necessary for the majority of GMAW welding and other semi-automated procedures. The power supply maintains a constant voltage across the arc length during the process. The self-correcting arc length is one feature that contributes to steady welding circumstances. GMAW welding processes operate with reverse welding polarity when the wire electrode is positive. This is because there is more heat being generated, which reduces the likelihood of problems arising from a lack of fusion**.** The following are some essential tools for GMAW welding. For MIG welding, nozzles, Hammer for chipping, clamps and pliers**,**Safety equipment such as darkening helmets, gloves, and protective clothing are also used during MIG welding.

III.LITERATURE REVIEW:-

The purpose of this Project is to provide a review of past research efforts related to MIG Welding. There is also an overview of additional relevant research studies. The Literature review is done to offer insight to how past research efforts have laid the groundwork for subsequent studies, including the present research effort. The review is comprehensive in order to support the current effort's scope and direction and to ensure that it is appropriately customized to contribute to the existing body of literature.

1] Shuhei Kanemaru, Tomoaki Sasaki, Toyoyuki Sato, Hisashi Mishima, Shinichi Tashiro, Manabu Tanaka [2013]

This research includes The MIG arc can remain stable even in pure inert shielding gas by hybridizing with the TIG arc, enabling the TIG-MIG hybrid welding technique to achieve the benefits of high efficiency and MIG as well as high quality and TIG. The authors of this study thought about the best torch setup for the procedure for real-world use.For every torch angle, the bead shape properties—such as penetration, width, and height of reinforcement—were taken into account. The chosen angle (TIG0r/MIG+45r) was verified to be a reasonably good condition for the form, flatness, and penetration depth of the bead as determined by cross section. With its fixed and unified structure on optimal design, the original torch for the TIG-MIG hybrid welding process was created, and its good weldability on actual joint welding was verified.[1]

2] S. R. Patil, C. A. Waghmare [2014]

This study investigates the effects of welding parameters, including welding current, welding voltage, and welding speed, on the ultimate tensile strength (UTS) of AISI 1030 mild steel material during the welding process. A Taguchi technique-based experimental approach has been used. To enhance the welding settings and examine the material's welding characteristics, orthogonal arrays, analysis of variance (ANOVA), and signal to noise (S/N) ratio are employed. Each parameter's contribution is displayed in the computed result to help identify the optimal settings for maximum tensile strength. This study indicates that welding current and welding speed are the two primary parameters affecting a welded joint's tensile strength.[2]

3] E. O. Ogundimu, E. T. Akinlabi, M. F. Erinosho [2014]

The material characterization of type 304 austenitic stainless steel weld made using TIG and MIG welding techniques was investigated. A uniform distribution of iron (Fe), chromium (Cr), and nickel (Ni) was found at the welded junction of all six samples, indicating that the goal of this study is to determine the ideal process parameters that will produce a weld joint free of defects.Compared to TIG welds, MIG weld penetrations are deeper. Welding parameters like welding speed and current were used to alter the UTS of the weld joint. At the same welding current, the TIG welded joint's UTS values are higher than the MIG joint's.[3]

4] Ajay S. Karwande [2016]

Current study is subjected, to evaluate the influence of Tungsten inert gas (TIG) and Metal Active Gas (MAG) are one of the mostly used Gas-shielded arc-welding processes in many industrial fields during manufacturing of pressure vessels, fusion reactor. Nowadays, in welding operation cost reduction and productivity improvement can generate considerable impacts on competitiveness of various manufacturing industries. The other factors as tensile strength, hardness, bending test plays a major role in determination of weld quality. The high thickness SS materials in the range of 20-60 mm based on the required protocols are mainly used for the fabrication of sub components in vacuum vessel. Therefore, the Combination of TIG-MAG is proposed. This paper reports preliminary investigation of the tensile strength, bending test and hardness test for the TIG-MAG welding process using the material SS316 thicknesses up to 30mm and also examined the radiographic test of welded sample.[4]

5] Nabendu Ghosh, Pradip Kumar Pal, Goutam Nandi [2017]

In this work, ferritic stainless steel samples (AISI 409) were welded using MIG welding. They have built butt joints. The thickness of the plate remains constant at 3mm. During welding, a few crucial factors have been changed. Consequently, a number of butt-welded joints have been created. A specific set of welding parameters has been used to prepare each joint sample. In the current work, welding current, gas flow rate, and nozzle to plate distance were the parameters taken into consideration for variation. The welded specimens' ultimate strength, yield strength, and percentage of elongation have all been used to assess the weld's quality. Using principal component analysis (PCA), the observed data have been interpreted, debated, and examined. The ideal parametric configuration has also been anticipated and confirmed.[5]

6] S. Maheshwaran, Dr. T. Senthilkumar [2017]

According to this study, metal inert gas welding is a widely used welding process in modern businesses. MIG welding can be used as semiautomatic or completely automatic, and it is flexible and loses fewer alloying elements. The impact of MIG welding on the mechanical characteristics of AA 6061 T6 will be examined. The most often utilized material in the aerospace industry is aluminum. After steel, aluminum is the second most consumed material annually. Compared to mild steel, aluminum alloys have superior mechanical qualities and are lighter. Thus, we thought about studying aluminum alloys. The welded specimens' microstructure will be determined by a variety of mechanical testing, such as tensile and hardness tests. As variable process parameters, the MIG welding input parameters welding current, arc voltage, and welding speed may be crucial in determining various attributes.[6]

7] N. Abu Basim, N. Rahul Raj, S.J. Sajin, W. Vimal Pradeep, S. Vishal Nagaraj [2017]

Gas metal arc welding (GMAW) is used in this study's experiments on SS 304L stainless steel and EN8 mild steel plate in order to optimize the welding parameters. The Taguchi Method will be used to conduct research on a stainless steel and mild steel specimen, taking into account arc voltage, arc current, and gas pressure as the different characteristics. Sample 6 with the specifications of 160 amp welding current, 26V welding voltage, and 4psi gas pressure had the best welded joint in terms of mechanical qualities, according to an experimental investigation on MIG welding settings. It is assumed that a higher voltage and a lower gas pressure are necessary to achieve good welds on mild and stainless steel.[7]

8] Sahil Angaria, P. S. Rao, S. S. Dhami [2017]

The goal of the current project is to optimize the MIG welding process parameters that are currently being used by an industrial company that fabricates fuel tanks for generator sets. By achieving the desired hardness of the fusion zone, the process parameters that have been tuned will enhance the overall quality of the weld. Using Design Expert software, an experiment design based on the Box Behnken Design of Response Surface Methodology was created, and the findings were analyzed. By employing the best welding conditions, the hardness rose from 178 HV to 230 HV, a 29.21% increase. Voltage, current, and gas flow rate all had Prob>F values below 0.05, indicating a significant impact on hardness.[8]

9] Manik Gupta, Sanjeev Kumar Shukla, Vipin Kumar Sharma, Hemant Kumar [2018]

There are several different welding techniques, including arc welding, solid state welding, high intensity beam welding, gas welding, and resistance welding. The thickness of the metal, the welding speed, the available current, the metal's surface condition, the coefficient of thermal expansion, and other variables are all dependent on the welding technique. This study attempted to examine the effects of two significant arc welding processes, gas metal arc welding (MIG) and gas tungsten arc welding (TIG), on the mechanical and microstructural characteristics of weldments made of different metals. Mechanical characteristics of weldments of different materials are compared under various conditions, including yield strength, ultimate tensile strength, % reduction in area, and percentage elongation values. Other significant process factors and structural characteristics are also examined. [9]

10] Surendra, B. Krishna Murthy, M. V. Kiran Kumar [2019]

Tensile strength studies are conducted in this paper in relation to changes in current, voltage, and gas flow rate. Nine experimental readings are obtained using the L9 orthogonal array to vary the input parameters. ASTM A36 mild steel plates can be successfully joined using the MIG welding procedure. MINITAB 18 software was used to forecast the ideal value. Tensile strength is influenced by process parameter values, as determined by the signal to noise ratio and confirmatory test results. The ideal tensile strength (A3 B1 C2) parameter values are 170 amps of current, 20 volts of voltage, and 25 lit/min of gas flow.[10]

11] Mayank Pandit, Shruti Sood, Prithu Mishra, Pradeep Khanna [2020]

The current study is to investigate the impact of various individually adjustable input factors on the resulting angular distortion of Stainless Steel 202 plates. These parameters include wire feed rate, welding speed, voltage, standoff distance, and torch angle. Manganese alloyed austenitic stainless steel, or SS 202, is intended to be a more affordable substitute for 304 grades while maintaining comparable mechanical and corrosion characteristics at lower temperatures and in less corrosive conditions. A minimal angular distortion of 2.75 degrees was achieved at wire feed rate of 0.65 m/min, welding speed of 43 cm/min, voltage of 16 V, standoff distance of 13 mm, and torch angle of 105 degrees, respectively, following process parameter optimization. From the outside, none of the welds created during this work had any visible flaws or fissures.[11]

12] V. A. Setyowati, Suhen, F. Abdul, S. Ariyadi [2021]

This study compares the mechanical properties and morphological analysis of three distinct welding techniques: TIG (tungsten inert gas), SMAW (shielded metal arc welding), and MIG (metal inert gas). The characterizations were carried out using metallography, XRD, and tensile testing. According to the study's findings, MIG produces greater tensile strength than TIG and SMAW. The material with MIG welding has the highest tensile stress value, 679.64 MPa, while the material with SMAW welding has the lowest, 604.89 MPa. According to microstructure study, the phases of austenite, ferrite, and Cr carbide are found in both materials.[12]

13] Seeram Roopa, Dr. S. N. Tirlangi, V. Jaideep Reddy [2021]

Stainless steel grades 310 and 316 were welded in this study using Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) procedures with a compound flux of 50% SiO_2 + 50% TiO_2. The mechanical characteristics of both identical and dissimilar metal joints were examined, including their hardness, tensile strength, and bending characteristics. The combined Vicker hardness (HV) of ATG and MIG is 258.16 and 244.12, respectively. Testicles' tensile strength (MPa) MIG and TIG welding have maximum capacities of 551 MPa and 589 MPa, respectively. 676.37 MPa Testicular joints with various metal fractures that are flexible and TIG welded MIG frames are ideal for a variety of frames with 316L filler material because of their 603.13 MPa fracture load.[13]

14] Arun Pratap Singh, Dr. Shahnawaz Alam [2022]

Investigating the ideal welding conditions for connecting SAPH 440 steel and aluminum alloy 6063 was the aim of this study. The goal of this study is to assess the impacts of the fusion and its welding speed as well as other variables. The welding variables assessed in this case study included welding current, wire feed rate, torch distance, and angles. Taguchi's technique approach serves as the foundation for a fruitful strategy, and the S/N ratio was employed to maximize responsiveness on shear strength. The results showed that welding parameters significantly affected the behavior of shear strength. Using the L27 orthogonal array from the Taguchi method, experiments were conducted by varying the welding speed, welding current, wire feed rate, and torch distance and its angles.[14]

15] ISMAIL ACAR, BEKIR CEVIK, BEHCET, GULENC [2023]

Metal inert gas (MIG) welding with various combinations of shielding gases was used to join AISI 316 austenitic stainless steel and AISI 430 ferritic stainless steel. 100% Ar, 97% Ar 3% H_2, and 93% Ar 7% H_2 gas mixtures were employed in welding operations. In addition to metallographic testing, the welded sheets underwent bending, tensile, and hardness tests. MIG welding of AISI 316 austenitic and AISI 430 ferritic stainless steel sheets was accomplished satisfactorily in shielding gas atmospheres. The maximum hardness values in the welded samples were found in the HAZs on the ferritic stainless steel side of AISI 430.[15]

16] Shuwan Cui, Yunhe Yu, Rong Ma, Fuyuan Tian, Shuwen Pang [2023]

This work describes the use of a metal inert gas (MIG) shielded welding technique to achieve high-quality welding of a 2.5 mm thick sheet of 6063-T6 aluminum alloy. A combination of a Gaussian body heat source and a double ellipsoidal heat source was used to calculate the welding temperature field and thermal cycle curve, as well as to precisely replicate the MIG welding process. The reinforcing phase that precipitated beneath the joint's microstructure progressively grew larger and re-solidified into the body as the welding current increased from 75 A to 90 A, which led to a decrease in mechanical characteristics. The joint's tensile strength, elongation, and Vickers Microhardness are currently up to 110.9 MPa, 16.3%, and 46.9 HV, respectively.[16]

17] G. B Veeresh Kumar, Pragada Sai Ganesh, Atul Pandey, G. Surya Bharath ,K. Vinay Kumar [2024]

The characteristics of stainless steel 304 welded joints employing hybrid welding, metal inert gas (MIG) welding, and submerged arc welding (SAW) are the main emphasis of this article. The welding phases that are employed are hybrid welding with currents of 105/170 A, SAW welding with a current of 105 A, and MIG welding with a current of 170 A. In MIG, SAW, and hybrid SAW-MIG weldments, hardness, flexural strength, and tensile strength are tested. The hybrid welded sample had the highest peak load of 15.09 KN, the submerged arc welding sample had the lowest peak load of 10.17 KN, and the MIG welded sample's peak load was in the middle of the two. The same is true for displacement; a hybrid weld's maximum displacement was 59.4 mm.[17]

18] Hoang Van Huong, Thanh Tan Nguyen, Van-Thuc Nguyen, Van Thanh Tien Nguyen [2024]

The mechanical properties and microstructure of MIG welding on SUS 304 stainless steel and S20C steel are investigated in this study in relation to stick-out, welding current, welding speed, and voltage. To optimize the experiment's results, the Taguchi method was applied. δ-ferrite phases with dark lines and shapes accumulated between the austenite phases and the fusion line, while fine columnar dendrites developed at the fusion sites. Ultimate tensile strength (UTS) was best achieved with a stick-out of 12 mm, welding speed of 500 mm/min, voltage of 15 V, and welding current of 110 A.. The predicted value calculated using the Taguchi approach agrees with the UTS value confirmation, which was 469.4 MPa.The Taguchi method's efficacy was demonstrated by the confirmation of the ideal flexural strength, which was 1937.45 MPa, greater than the other samples. Flexural strength was most significantly impacted by the welding current.[18]

IV. DESIGN OF EXPERIMENT:-

In the 1920s, R. A. Fisher created the powerful statistical technique known as the Design of Experiments (DOE) in England to investigate the effects of multiple variables simultaneously. By using the RSM technique, DOE may meet the demands of problem-solving and product/process design optimization projects at a reasonable cost. By learning and applying this technique, researchers, scientists, and engineers can significantly reduce the time required for experimental experiments. In order to identify the optimal combination for a multi-factor experiment, DOE defines and assesses every possible combination. This lists a number of factors along with their respective levels.

In order to achieve the greatest findings with the least amount of fluctuation around the ideal outcomes, it is also helpful to design tests that mix the components at the right amounts, each with its own acceptable range. Therefore, identifying the set of factors in a process that have the most impact on performance and figuring out the optimal levels for these variables to achieve excellent output functional performance in goods are the goals of a well-planned, constructed experiment.

The following are some benefits of experiment design:

1. There are far fewer trials.
2. Key decision factors that regulate and enhance the process or performance can be found.
3. It is possible to estimate parameters qualitatively.
4. It is possible to minimize experimental error.
5. It is possible to draw conclusions about how parameters affect the process's properties.

Accordingly, the Design of Experiment (DOE) is a technique for determining the key elements in a process, locating and resolving process issues, and determining the potential for interaction estimation. DOE to investigate the effects of welding process parameters. In welding, the DOE methods included process parameter optimization.

1) Central Composite design, or Response Surface approach
2) The technique of fractional factorial
3) An orthogonal array of Taguchi
4) The full factorial method

ANOVA, or analysis for variance, is a technique for analyzing the relationship between each process parameter and the response parameter. Mathematical models are used to establish the connection between the input and output parameters in welding procedures. ANOVA and DOE procedures are performed using the programs "MINITAB" and "Design Expert."

V. CONCLUSION REMARK:-

Numerous investigations have been carried out on DOE or optimization techniques for process parameters for mechanical characteristics, weld penetration, and weld bead geometry. We would like to look into this material, though, as I found that not much research has been done on the dissimilar metals SS304 and AA6063. We like to use design of experiment for parametric optimization. Welding current, gas flow rate, and wire feed rate are the main control variables for the Metal Inert Gas Welding process. They affect the form of the weld bead and its mechanical properties. Grain boundaries in the microstructure were altered by changing the welding settings, and a deeper penetration was achieved by increasing the welding current..

I will be performing this Experimental Investigation at DIEMS Aurangabad by the Availability of the setup. Experimental setup is an important step for any experimental research. It plays a vital role in the completion of the research. In this study, MIG welding machine which will be used to perform the experiments is the Lincoln Electric Power IND 250c is a semi-automatic, constant Primary working voltage (CV) DC welding power source. The Power IND 250c MIG welding machine has been used for the experimentation work

The experiments will be carried out using the RSM Technique. The Response Surface approach has emerged as a powerful instrument for enhancing research and development output, enabling the rapid and economical production of higher-quality goods. RSM is a set of statistical and mathematical methods for modelling and analysing problems when several variables influence the objective function that needs to be optimised. The RSM includes optimisations using the estimated responses, experiment design to acquire the least variances of the responses, and regression surface fitting to provide approximate responses. Intended to establish a mathematical connection between the experimental responses and the controllable factors. It is employed to investigate the connection between a group of experimental parameters and one or more response variables..

The DOE (Design of Experiment) can be used in conjunction with the Response Surface approach. Other optimisation methods, such as the Taguchi Method and the S/N ratio, can also be employed. For the aforementioned function, MINITAB software is a helpful tool.

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