A Review on Experimental Investigation of GMAW for AISI 1045 by using Taguchi Method

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Abstract—Gas Metal Arc Welding (GMAW) process is leading in the development in arc welding process which is higher productivity and good in quality .The shielding gas is used in GMA welding to protect the finished weld from the effects of oxygen and nitrogen in the atmosphere. The shielding gas can influence the weld strength, ductility, and toughness and corrosion resistance. The GMA welding parameters are the most important factors affecting the quality, productivity and cost of welding. In this study, the effects of different parameters on welding strength and hardness will be predicted. A plan of experiments based on Taguchi technique has been used to acquire the data.

Key words: GMAW, AISI 1045, Strength, Hardness, Taguchi Method (Design of Experiment).

I. INTRODUCTION

Gas Metal Arc Welding (GMAW), sometimes referred to by its subtypes Metal Inert Gas (MIG) welding or Metal Active Gas (MAG) welding, is a semi-automatic or automatic 0020 Arc welding process in which a continuous and consumable wire electrode and a shielding gas are fed through a welding gun. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used. There are four primary methods of metal transfer in GMAW, called globular, Short-circuiting, spray, and pulsed-spray, each of which has distinct properties and corresponding advantages and limitations.

Originally developed for welding aluminium and other non-ferrous materials in the 1940s, GMAW was soon applied to steels because it allowed for lower welding time compared to other welding processes. Now a Day, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process to robotic automation. GMAW is currently one of the most popular welding methods, especially in industrial environments.

It is used extensively by the sheet metal industry and, by extension, the automobile industry. There, the method is often used for arc spot welding, thereby replacing riveting or resistance spot welding. It is also popular for automated welding, in which robots handle the work pieces and the welding gun to quicken the manufacturing process. Generally, it is unsuitable for welding outdoors, because the movement of the surrounding air can dissipate the shielding gas and thus make welding more difficult, while also decreasing the quality of the weld.

Design of Experiment (DOE) and statistical techniques are widely used for optimization of process parameters. In the present study the welding process parameters of GMAW can be optimized to maximize the yield strength of the workpiece also reducing the number of experiments without affecting the results. The optimization of process parameters can improve quality of the product and minimize the cost of performing lots of experiments and also reduces the wastage of the resources. The optimal combination of the process parameters can be predicted. This work was concerned with the effects of welding process parameters on the yield strength of AISI 1045 joints.

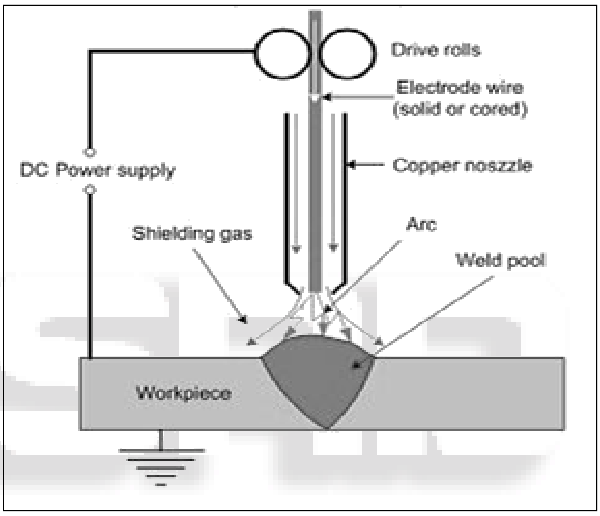

Fig. 1: Gas metal arc welding

AISI 1045 Medium Carbon, Medium Tensile Steel, supplied black as rolled, black as forged or normalised and bright drawn or smooth turned, offering good strength, toughness and wear resistance.

Typical Applications: Axles, bolts, connecting rods, studs, rams, pins, rolls, spindles, ratchets, crankshafts, torsion bars, sockets, worms, light gears, guide rods etc.

II. LITERATURE SURVEY

Y. Ruan et.al was performing their experiments on Twin wire MIG (metal inert gas arc welding) arc welding was employed in 6-mm thick 6082-T6 Al-alloy plate partially with SiO2 activating flux. The micro-structural characteristics of the weld joint were investigated using optical, scanning microscopy and energy dispersive spectroscopy. Mechanical properties were studied with micro-hardness and tensile test. Results show that no obvious difference from the microstructures of the joints prepared with and without SiO2 flux, the joint HAZ (heat affected zone) with SiO2 flux was observed to be slightly wider than the one without the flux. The weld joint penetration with SiO2 flux was about 26% deeper than what without SiO2 flux. The arc constriction and higher arc temperature were the main reasons for deeper penetration on twin wire MIG weld joint. The tensile test specimens prepared with and without the flux all showed plastic dimple fracture surfaces, SiO2 flux did not have any obvious effect on the micro-hardness and strength of the weld joint. [10]

Erdal Karadeniz et.al In this study, the effects of various welding parameters on welding penetration in Erdemir 6842 steels having 2.5 mm thickness welded by robotic gas metal arc welding were investigated. The welding current, arc voltage and welding speed were chosen as variable parameters. The depths of penetration were measured for each specimen after the welding operations and the effects of these parameters on penetration were researched. The welding currents were chosen as 95, 105, 115 A, arc voltages were chosen as 22, 24, and 26 V and the welding speeds were chosen as 40, 60 and 80 cm/min for all experiments.

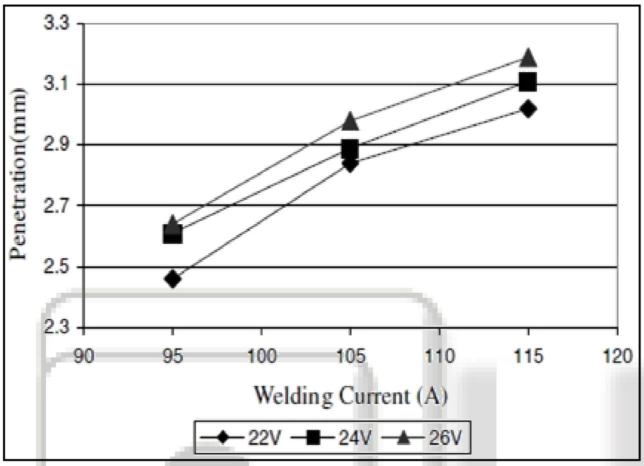

Fig. 2: Penetration vs. Arc voltage diagram

As a result of this study, it can show in the above graph that the increasing welding current increased the depth of penetration. In addition, arc voltage is another parameter in incrimination of penetration. However, its effect is not as much as currents. The highest penetration was observed at 60 cm/min welding speed. Penetration increases with the increase with the welding current that can see in the above diagram. In addition to welding current, arc voltage also increases the penetration value However, its effect is not as much as welding current. The effect of welding current approximately 2.5 times greater than that of arc voltage and welding speeds on penetration. [3]

Ehsan Gharibshahiyan et. al In this paper, the effect of welding parameters and heat input on the HAZ and grain growth has been investigated. The role of grain size on hardness and toughness of low carbon steel has also been studied. It was observed that, at high heat input, coarse grains appear in the HAZ which results in lower hardness values in this zone. High heat input and low cooling rates produced fine austenite grains, resulting in the formation of fine grained polygonal ferrites at ambient temperature.

One of the major factors affecting the toughness of the welded Metal is the formation of a local brittle zone (LBZ). The degree of brittleness in this zone varies with material chemistry and welding conditions [1]. The elevation of heat input and welding speed, can lead to the formation of equating grains [2] [5]. The microstructure of the HAZ depends on chemical composition and the peak welding temperature and welding voltage. The energy transfer per unit length of weld is a function of heat input. The heat input can be calculated by following equation.

$$H = \frac{6 \times I \times V}{1000 \times S} \qquad (2.1)$$

Where H is the heat input (KJ/mm); E the voltage (V); I the current (A); and S is the travel speed (mm/min). high heat input and low cooling rates widen the HAZ and increase the grain size. Raising the voltage decreasing the grain size. It was also observed that high heat input and rapid cooling rates, in the weld metal produced fine grain austenite at high temperature. [6]

K Srinivasan et. al was doing the experiment on effect of heat input on fame and their compositions during gas metal arc welding (GMAW) of AISI 316 stainless steel plates. ANSI/AWS F1. 2 methods are used for the determination of Fume generation rate (FGR) and fume percentage. It was performed with SEM-XEDS and XRF analysis to reveal the particle morphology and chemical composition of the fume particles. The SEM analysis shows the morphology of particles having three different shapes which were spherical, irregular, and agglomerated. Spherical particles .All the fume particle size falls in the range of less than 100 mm. Mechanical properties (strength, hardness and toughness) and microstructural analysis of the weld deposits were evaluated. It is found that heat input of 1. 15 KJ/mm is best to weld stainless steel by GMAW process due to lower levels of welding fume emissions and sound mechanical properties of the joints.

The increase in tensile strength is due to the presence of acicular δ ferrite in a plain austenitic matrix, and the inherent nature of the acicularity gives the both combinations of good tensile strength and also good impact toughness. By same experiment can say that further increase in heat input is not improving the mechanical properties like tensile strength and impact toughness. Increase the heat input increases the arc temperature and the length of the arc promoting increased vaporization, which increases the amount of fume generated. The result can also show that increasing the heat input promotes coarser fume particles. The chemical composition of welding fume is not affected significantly by the wire feed rate of GMAW

Process. Morphological analysis revealed that the fume particles were typically spherical, either as individual particles or multiparticle agglomerates. [7]

Stefano Maggiolino et. al was performing the experiment in comparison of the corrosion resistance of AA6060T5 and AA6082T6 aluminium alloy material. Using joint by Friction Stir Welding (FSW) and Metal Inert Gas (MIG. The test was perfume on welded and polished samples in an acid salt solution. The corrosion resistance was detected by morphological analysis of the same material surface. The attack was localized an index referred to the pit density was used for the comparison. By analysis of paper can conclude that joint welded via friction stir is more resistant than that welded by Metal inert gas technique. The welded surfaces were polished with emery paper (Silicon Carbide) and finished with diamond paste till 1µm; the MIG welded samples were first milled and then polished. [4]

C.W. Mohd Noor et. al performs their experiment on **aluminium** and its alloys are which are mostly used in marine applications because of their corrosion resistance and lightweight properties. The aluminium alloys require special tools and skill to weld due to high thermal conductivity. The aluminium welded joint specimens were prepared using the Metal Inert Gas (MIG) welding process by certified welders at different current and voltage settings. The mechanical characteristics of the welded alloys were carried out for tensile and hardness tests. Further, metallography examination was conducted to identify and observe the various fusion zones. The results of these tests are presented in this paper. Experiments show that, the different welding voltage and current settings in which specimens were prepared remarkably affect the mechanical properties of 5083-aluminium alloy joints. It was observed that increasing the welding current caused the decreasing in mechanical properties of welded metal. These phenomena can be related to the metallurgical behavior of weld It related when increasing in arc voltage and welding current or reducing in welding speed increases the welding heat input. By increasing the input energy, grain size in welded microstructure increases and grain boundaries are reduced in the background. Reduction in grain boundaries as locks for movement of dislocations increases the possibility and amount of dislocation movement as line defects in the structure. That turns reduction in strength and hardness of welded metal. The increasing of arc welding current in 5083 aluminium alloy will increase the welding heat input so there is chance to defect of formation that will affect the properties and quality of weld metal. [11]

S. V. Sapakal et. Al was performing their experiments on Metal Inert Gas welding (MIG) process. The GMA welding parameters are the most important factors affecting the quality, productivity and cost of welding. This paper presents the influence of welding parameters like welding current, welding voltage, welding speed on the penetration depth of Mild steel C20 material during welding. Experiments based on Taguchi technique has been used to acquire the data. An Orthogonal array, signal to noise (S/N) ratio and analysis of variance (ANOVA) are employed to investigate the welding characteristics of MS C20 material & optimize the welding parameters. Final tests have been carried out to compare the predicted values with the experimental values confirm its effectiveness in the analysis of penetration. The Taguchi method has become a powerful tool for improving productivity during research and development, so that high quality products can be produced quickly and at low cost Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments. In this experiment welding current, voltage and speed are the main parameter and shielding gas is co_2 where L9 orthogonal array is used for the same experiment. On the basis of this experiment we can conclude that welding current and voltage affect over the penetration. Penetration increase with increasing welding current and voltage. [8]

Izzatul Aini Ibrahim et. al performed experiments in Gas Metal Arc Welding (GMAW) process is leading in the development in arc welding process which is higher productivity and good in quality. In this study, the effects of different parameters on welding penetration, microstructural and hardness measurement was measured in mild steel that having the 6mm thickness of the base metal by using the robotic gas metal arc welding. The variable parameters are arc voltage, welding current and welding speed. The arc voltage and welding current were chosen as 22, 26 and 30 V and 90, 150 and 210 A respectively. The welding speed was chosen as 20, 40 and 60 cm/min. The penetration, microstructure and hardness were measured for each specimen after the welding process and the effect it was studied. As a result, it obvious that increasing the parameter value of welding current increased the value of depth of penetration. Other than that, arc voltage and welding speed is another factor that influenced the value of depth of penetration. In these experiments use 100 % co_2 shielding gas and wire electrode is ER70S 6 with 1.2 diameter nozzle to work distance is 12mm and only one pass on weld plate The welding speed was chosen as 20, 40 and 60 cm/min. In Figure 3 The effect of welding current on penetration was present in welding speed as constant as 20 cm/min and the value of penetration was increased by increasing the value of welding current 90, 150 and 210 A. The highest penetration is 2.98 mm at 22 V and 210 A. Welding speed as constant as 40 cm/min and the value of penetration was increased by increasing the value of welding current 90, 150 and 210 A. The highest penetration is 3.26 mm at 22 V and 210 A.

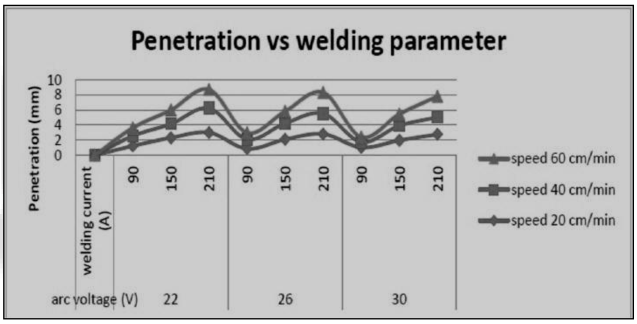

Fig. 3: Penetration vs. Welding Current & voltage

The change in the value depth of penetration is similar at voltage of 26V and 30V. The welding speed as constant as 60 cm/min and the value of penetration was increased by increasing the value of welding current 90, 150 and 210 A. The highest penetration is 2.79 mm at 26 V and 210 A.

The changes in gas metal arc welding parameters are influenced the effect of the microstructure of weld metal. The increased welding current, welding speed and arc voltage the grain size of microstructure also different from one point to another point. So by these experiments we can conclude that depth of penetration increased by increasing the value of welding current. Welding current is a factor that will determine the penetration. Penetration also influences by the factors from welding speed and arc voltage. [9]

K. Abbasi et al. Perform the experiment on metal inert gas welding where the parameters are welding current , arc voltage, welding speed, heat input and depth of penetration and weld width are measured for each mild steel specimen after the welding has done at given current 165 Amp and arc voltage of 16 V. To measure the penetration in welding cut welded portion perpendicular to the direction of welding to measure the penetration depth. It has been found that as the welding speed increases; penetration depth also increases up to speed of 1450 mm/min, which is the optimum value to obtain maximum penetration; beyond which the penetration. Penetration depth increases with the increase in heat input. In this same paper Maximum penetration occurs at a heat input rate of 109.14 J/min., beyond which penetration depth starts decreasing. [12]

III. CONCLUDING REMARKS

In this literature survey of GMAW processes the effect of various welding parameters is investigated. Following conclusions are found from the investigation.

1) The value of depth of penetration increased by increasing the value of welding current.
2) The grain boundaries of the microstructure are varied when the welding parameters are changed.
3) Flux did not have any obvious effect on the microhardness and the strength of the weld.

IV. SCOPE OF THE STUDY

During experiment welds will be prepared by the MIG welding technique and Design of Experiments will be applied for this same work. In this experiment the input parameters for MIG welding will be welding current, arc feed and gas flow rate and the output parameter will be tensile strength. Material use of experiment is AISI 1045. It is medium carbon steel. During the experiment work detail effect of weld parameters on weld strength will be studied.

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