A REVIEW PAPER ON ANALYSIS ON THE EFFECT OF WELDING PARAMETERS ON THE STRENGTH OF WELD USING GTAW PROCESS

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Abstract: In today's manufacturing industry, welding is crucial. Although many welding techniques have been developed, gas tungsten arc welding has dominated this market because it employs shielded gas, which has drawn the interest of numerous industries. Since there is no slag produced by the GTAW method, it not only results in a clean welded joint but also frees the welders from cleaning. The GTAW welding method is typically used to join the butt, lap, corners, edges, and T-joints. Carbon and alloy steels, stainless steels, refractory metals, copper alloys, aluminium alloys, magnesium alloys, nickel alloys, heat-resistant alloys, etc. can all be welded using GTAW. Despite having such a broad range of uses, its performance is dependent on a few factors to produce the desired level of welded joint quality. These parameters include the heat-affected zone, the voltage that is provided, the heat input, the speed, the filler material, the shielded gas, the material thickness, etc.

In this research, we seek to understand how the GTAW process's speed affects the strength of the welded joint. By carrying out this study, we can learn how changing the speed can affect the joint's mechanical characteristics, as well as its strength and the most effective velocity for a successful finish.

Keywords: Welding, GTAW, Butt joint, Lap joint, T joint, speed of weld, shielding gas.

1.INTRODUCTION:

Using intense heat to melt and cool the parts together to form a fusion, welding is a manufacturing process that joins materials, typically metals. The welded parts come together to form one whole. Low-temperature processes like brazing and soldering, which do not melt the base material but instead deposit another material as a joining material, differentiate themselves from welding. In order to create a pool of molten material, filler metal is typically introduced to the joint along with the base metal to melt it. (weld puddle). The type of weld (butt, complete penetration, fillet, etc.) determines how strong it is compared to the underlying metal as it cools. To form welds, pressure can be used either alone or in conjunction with heat. In order to shelter the filler metal or liquid metal from contamination and oxidation during welding, some kind of shielding is also necessary.

A range of energy sources, such as gas flames (chemical), electrical arcs, lasers, electron beams, friction, and ultrasound, can be used during welding. Although welding is frequently an industrial procedure, it can also be done in a variety of settings, such as the open air, under water, or in space. In order to prevent burns, electric shock, vision impairment, absorption of toxic gases and fumes, and exposure to strong UV radiation, welding must be done carefully.

2. PARAMETERS IN GAS TUNGSTEN ARC WELDING:

2.1 VOLTAGE:

Voltage regulates the width and volume of the arc cone, as well as the duration of the welding arc. As the voltage rises, the arc length (and arc cone) lengthens as well. As it grows smaller, the arc length decreases (and the arc cone narrows). A high initial voltage enables both a wide working point distance range and an easy arc initiation. Depth of penetration decreases with increasing power.

2.2 WELDING CURRENT AND POLARITY:

The amount of heat applied to the component to affect the weld is equivalent to the welding current, which depends on the material being welded, the thickness of the material, the welding speed, and the shield gas. The objective is to create flawless welds with the required penetration.

Current directly affects all aspects of welding, including welding speed, weld quality, and weld bead shape. The majority of GTAW welds use direct current on electrode negative (DCEN) (straight polarity), which results in deeper weld penetration and quicker travel times than direct current on electrode positive (DCEP) (reverse polarity).

2.3 WELDING SPEED:

The rate at which the electrode travels along the seam or the rate at which the work under the electrode travels along the seam is referred to as welding speed. Speed of welding is a crucial factor in GTAW welding. When welding at the same current and voltage, the heat input is reduced as a result of speeding up the process. The electromagnetic force and the arc pressure are dependent on the current, so they are unaffected by the welding speed. Although the penetration depth (D) and weld width (W) also decrease as weld speed increases, there is only a weak relationship between travel speed and the D/W ratio.

2.4 ARC LENGTH:

The arc length is the distance between the electrode tip and the workpiece. The typical arc length in GTAW is between 2 and 5 mm. As the arc length increases, more voltage is needed to maintain arc stability, but the heat input to the workpiece decreases as a result of radiation losses from the arc's column. Therefore, as arc length increases, weld penetration and melted material cross section area decrease.

2.5 FILLER MATERIAL

In general, filler metals with chemical compositions comparable to the parent material are used for plate thicknesses greater than 2 mm. In automatic devices, filler metal is usually added unheated from a roll of metal or a coil and has a diameter of between 1.6 and 3.2 millimetres. Many austenitic stainless steels, but not all of them, can be welded without filler metal and without further thermal treatment. For the majority of super austenitic alloys, filler metal is necessary to ensure that the weld has the appropriate corrosion resistance. Typically, the weld metal can satisfy the base material's minimum yield and tensile strength requirements. The welds are still very ductile despite having a typically lower ductility than base metal.

3.LITERATURE REVIEW:

According to **D. Devkumar** et al., stainless steel is used by many industries, including the chemical and automobile industries, because of its superior mechanical strength and non-corrosive qualities compared to other structural steels. In their research, they attempted to observe various experiments and learn how GTAW was used to weld stainless steel material. He also looked at failures brought on by welding metals that aren't compatible in his paper. Therefore, this needs to be carefully observed in order to reduce weld defects. He stated that it is crucial to optimize the process parameters in order to achieve high weld joint strength. They looked at how the bead geometry of SS304 was affected by TIG welding process parameters like weld current, gas flow rate, and work piece thickness. In addition, they found that welding speed has an impact on the tensile strength of joints welded in aluminum alloys using the GTAW process. Experiments were carried out on specimens of a single V-butt joint with different bevel angles and bevel heights. The experimental result shows that weld bead penetration depth decreases as bevel height increases. The tensile strength increased with a slower weld speed and lower heat input rate. It was also found that the tensile strength is significantly affected by the bevel angle of the weld joint. The experiment showed that high travel speeds prevented fusion in welding while low current values resulted in a lack of penetration.

The number of passes and welding current are two elements that affect the mechanical properties of HAZ, according to **Kessel et al.** As welding current is increased, both peak width and residual stress rise. In fact, plastic deformation is brought on by the higher welding current, which also helps to release any remaining tensions. As is well known, materials become less corrosion resistant under tensile pressures than under compressive stresses. The relaxing of residual stress caused by the welding current improves corrosion resistance.

The effects of welding current, welding speed, and flow rate on penetration depth were investigated by **Kurume et al**. He examines GTAW welding of austenitic stainless steels in his review study. The impacts of the activated flux welding mechanisms, the flux chemical composition, thickness, flux particle size welding current, arc voltage, arc length, welding speed, and composition of the shielding gas are all detailed in detail, as well as the weld geometry of austenitic stainless-steel made using a-TIG. When the oxygen level of the weld metal hits 70 weight ppm, the Marangoni convection in the weld pool turns from outward to inward. A deep, thin weld form results as a result. The A-TIG welding procedure results in fewer welding distortions and stronger welds.

Palani P. K. et al. using the Response Surface Methodology, studies were conducted to examine the effects of TIG welding process parameters on the welding of Aluminum-65032. The procedure's chosen controls are welding speed, current, and gas flow rate. The strength of the welded joints was evaluated using a UTM.

L Suresh Kumar et al. investigated the mechanical properties of austenitic steel using the TIG and MIG methods in order to ascertain the features of metal after it has been welded. While maintaining a constant voltage, a number of properties were investigated, including as strength, hardness, ductility, grain structure, elastic modulus, breaking point, etc. They found that while working with austenitic steel, MIG welding is more durable than TIG welding.

Seo D W et al. in his paper, implemented the features emphasising the TIG as a superior possibility for welding than other procedures, particularly for connecting of two different metals with heating the material, applying pressure, or employing the filler material for boosting productivity with less time and cost constraint. Utilising the philosophy of optimisation, they made an effort to comprehend the impact of TIG welding parameters such as welding current, gas flow rate, and welding speed that have an impact on responsive output parameters such as weld hardness and tensile strength.

Salleh et al. said that a number of variables, including welding current, voltage, speed, kind of shielding gas, and welding location, affect the quality of the welded connections. The Groove design is one of the key elements in the welding position. This is so that the welded connections can withstand a variety of loads, including tensile, compressive, and bending. Because of this, it's crucial to design welded constructions with the best groove layout possible, taking into account the potential pressures that the welded joints may experience.

Atma R M R et al. Noticed the most important factor affecting arc welding process variables such as electrode burn off rate, depth of fusion, and weldment shape is welding current. Weld bead form, welding speed, and weld quality are all directly influenced by current. Because it results in greater weld penetration depth and travel speed than on electrode positive (DCEP) (reverse polarity), direct current on electrode negative (DCEN) (straight polarity) is used in the majority of GTAW welds. In addition, because the anode in a gas tungsten electric arc is heated more than the cathode, reversal polarity induces fast heating and degradation of the electrode tip. In GTA welding, a higher current can cause spatter and work piece damage. Again, a lower current setting in GTA welding leads to the filler wire to stick.

"This is the difference in electrical potential between the welding wire's tip and the molten weld pool's surface. Based on the GTA welding equipment, welding voltage might be either set or adjustable. It establishes how the fusion zone and the welding buttress will ultimately be shaped. A large working tip distance range and simple arc initiation are both made possible by a high starting voltage. Although depth of penetration is at its maximum at the optimal arc voltage, high welding voltages produce wider, flatter, and less deeply embedded welds than inadequate welding voltages. On the other hand, high welding voltages are likely to result in substantial differences in the quality of the weld", **Tewari et al.** wrote in his paper.

Yuri, Apurv C et al. in their papers stated that the heat supplied is a comparative indicator of the amount of energy delivered per weld length. The rate of cooling decreases with rising temperature input. In contrast, the rate of cooling rises as the heat input decreases. As a result, just as preheat and interpass temperature, heat input is a crucial factor that affects cooling rate, which in turn may have an impact on the weld's mechanical characteristics and metallurgical structure as well as the HAZ. It is well knowledge that an electric arc used in arc welding transfers energy from the electrode used to weld to the base metal. The electrode receives an adequate supply of energy as well as power density when the arc is generated. As a result, to make the weld, both the base metal and the metal that serves as the filler are melted.

Ghazvinloo et al. through his work studied that in GTAW, shielding gases are employed to keep the metal being joined from being contaminated by the atmosphere. This contamination may result in porosity, scale, weld cracking, and even a change in the chemical makeup of melted material. Along with shielding gas, there is also a significant impact on the electric arc's stability. Low thermal conductivity gases tend to promote arc stability whereas low ionisation potential gases make it easier for an electric arc to ignite. The most used GTAW shielding gas is argon. It provides a great shield for the molten weld pool since it is heavier than air and has a low ionisation potential. Additionally, it is more affordable than helium, the other inert shielding gas employed in the process. The use of helium is advised for welding thick aluminium workpieces and other highly conductive materials like copper alloys since it has a larger ionisation potential than argon and requires a higher voltage for arc initiation and maintenance while also creating more heat. Air (oxygen and nitrogen) is prevented from coming into touch with the molten metal or hot tungsten electrode by the shielding gas, which emerges from the welding torch and surrounds the hot tungsten and liquid weld metal.

[13] examined the impact of pulse and non-pulse current on the mechanical characteristics of 304 SS. The task required the employment of pulsed current at various frequencies of 3 Hz, 5 Hz, and 10 Hz on a sheet of 304 SS that was 3 mm thick. According to the report, both non-pulse and pulse currents had differing effects on the weldments' microstructure, hardness, and tensile qualities.

In their article, **Aamir et al.** looked at the effects of TIG pulse rate, pulse frequency, arc travel speed, and wire feed rate on the tensile and hardness properties of girth welding of SS 304 L. The pipes were joined together utilising orbital welding technology, and ER 308 L filler wire was used to strengthen the joint. The acquired results showed that the sample, when it was welded employing a 90 A pulse current, was superior in terms of tensile strength and hardness. The tensile property was 605 MPa, while the hardness values for the base metal, HAZ, and weld metal were 160 HB, 114 HB, and 99 HB, respectively. As pulse current increased, it was observed that tensile strength and joint soundness increased as well.

Okonji et al. looked into how welding current and filler metal types affected a 3 mm thick austenitic steel (304L grade) welded joint's % elongation. They employed three different types of filler metal—ER308L, ER309L, and ER316Ld—and five welding currents between 91 and 95 amperes at 1 ampere intervals to create square butt weld connections. To calculate % elongation, standard tools and ASTM standard practises were employed. On the basis of the findings, it was stated that the % elongation for all filler metal types rose with increasing welding current, but that it was typically lower than that of the base metal.

According to **Amit Pal et al.**, one of the most often utilised welding processes in industry is MIG welding. An expendable metal electrode is used in this. The weld quality, strength, cost, and speed in MIG welding are significantly influenced by the input parameters. Manufacturers frequently struggle to choose the best process variables for a high-quality weld. This work attempts to demonstrate the impact of various welding parameters, such as welding voltage, filler wire rate, and v-butt angle, on the tensile test-induced elongation and joint strength. Each of these variables affects welding quality in a different way.

Using heat input as a factor, **Monika K. et al**. examined the mechanical properties of MIG-welded dissimilar joints. The amount of heat input depends on the welding current, voltage, and wire speed. The foundation material was IS2062, IS45C8, and IS103Cr1. As a filler wire, 1.2 mm diameter mild steel coated with copper was employed. When the heat input was increased, both joints—IS2062 & IS45C8 and IS2062 & IS103Cr1—increased the tensile strength. When the heat input was decreased, they also increased the hardness value.

M. Aghakhani et al.'s study on gas metal arc welding process parameter optimisation aims to improve weld quality and productivity. Weld dilution was taken into consideration as an output parameter in this study to improve the quality and productivity of the weldment, and the impact of the input parameters wire feed rate (W), welding voltage (V), nozzle-to-plate distance (N), welding speed (S), and gas flow rate (G) was discovered.

By using Taguchi's approach and Grey Relational Analysis (GRA), **C. N. Patel et al.** analysed the welding current, wire diameter, and wire feed rate to examine their effects on weld bead hardness for MIG welding and TIG welding. The study's findings led to the conclusion that the welding current was the most important factor in MIG and TIG welding.

Alloy steel, carbon steel, stainless steel, and aluminium may all be worked using GMAW. Metal can be transferred via an arc in short-circuit, globular, spray, or pulsed forms. Weld bead quality is influenced by welding current, arc voltage, electrode composition and size, welding travel speed, gradient, and shielding gas flow. The butt joint, corner joint, edge joint, lap joint, and T-joint may all be worked on with GMAW said **Chayda S et al.**

Izzatul Aini Ibrahim et al. conducted studies to determine how certain conditions affected welding penetration. Using robotic gas welding, it was possible to determine the microstructure and hardness of mild steel with a base metal thickness of 6mm. The microstructure of the weld metal has an impact on variations in welding process parameters. The effect of increased welding current, welding speed, and arc voltage on microstructure grain size.

On the back bead shape for CO2 welding, **Winchan Chuaiphan et al.** looked into the impact of welding process factors. They created a model utilising multiple regression analysis to forecast welding process variables, including current, arc voltage, and welding speed, for the required weld bead shape in butt welding. They have concentrated their research on methodically determining the complex relationship between weld pool shape and a welding process parameter. By utilising multiple regression analysis, the equation for determining the ideal weld pool shape was further refined. The findings of the multiple regression analysis are found to be reasonably accurate, with an observed error of less than 6.5%.

CONCLUSION:

The present research focuses on the parameters influencing the weld strength and other mechanical properties. Through our research we have come to know that various researchers conducted experiments using numerous methods to test the weld strength and the factors effecting the weld like, weld speed, electrode size, weld current, voltage supplied, arc length, direction of weld, position of weld, shielding Gas, Gas flow rate, etc. In conclusion, to obtain weld joint with desired properties, the above mentioned parameters have to be optimised for a good result.

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