Effect of Process Parameter on Mechanical And Metallurgical Properties of Dissimilar Metal Weld Using GTAW Process

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Abstract— Gas tungsten arc welding is one of the widely used techniques for joining ferrous and non ferrous metals. GTAW offers several advantages like joining of dissimilar metals, absence of slag, low heat affected zone etc. Gas Tungsten Arc Welding is an electric arc welding process, in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode. During the welding process the electrode, the arc and the weld pool are protected against the damaging effects of the atmospheric air by an inert shielding gas. By means of a gas nozzle the shielding gas is lead to the welding zone where it replaces the atmospheric air. The welding parameters are selected based on experience or from a handbook by operator. However, this does not ensure that the selected welding process parameters can produce the optimal or near optimal weld metal properties for that environment a particular welding machine. The aim of this paper is to effect on mechanical and metallurgical properties of dissimilar metal (304 stainless steel and CP-copper) weld by GTAW process**.**

Key words— 304 stainless steel; CP-copper; Gas Tungsten Arc Welding; Dissimilar metal joining; Mechanical and Metallurgical Properties

I. INTRODUCTION

A. *Welding*

Welding is a materials joining process in which two or more parts are coalesced at their contacting surfaces by a suitable application of heat and/or pressure. Many welding processes are accomplished by heat alone, with no pressure applied; others by a combination of heat and pressure; and still others by pressure alone, with no external heat supplied. In some welding processes a filler material is added to facilitate coalescence. The assemblage of parts that are joined by welding is called a weldment.

B. *Gas Tungsten Arc Welding*

The necessary heat for Gas Tungsten-Arc Welding (GTAW) or Tungsten Inert Gas (TIG) is produced by an electric arc maintained between a non-consumable Tungsten electrode and the part to be welded. The heated weld zone, the molten metal, and the tungsten electrode are shielded from the atmosphere by a blanket of inert gas (He or Ar) fed through the torch. The GTAW process can produce temperatures of up to 35,000° F. The GTAW torch brings heat only to the workpiece. If filler metal is desired, it may be added manually like in oxy-acetylene welding or an automatic filler metal feeding system can be utilized.

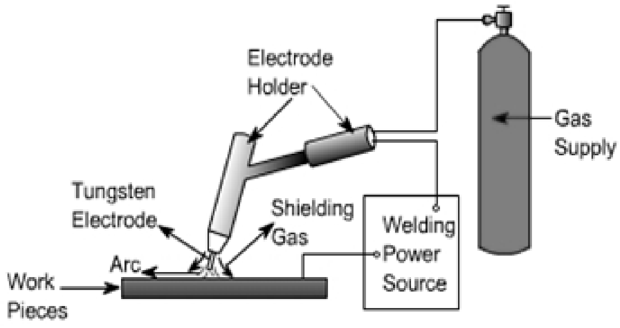

Fig. 1: Schematic diagram of GTAW process

C. *GTAW Applications*

The GTAW process is used for a wide variety of applications and similar and dissimilar metals, particularly stainless steel, copper and copper alloy, aluminum, magnesium, titanium, and refractory metals, and it is especially suitable for thin metals.

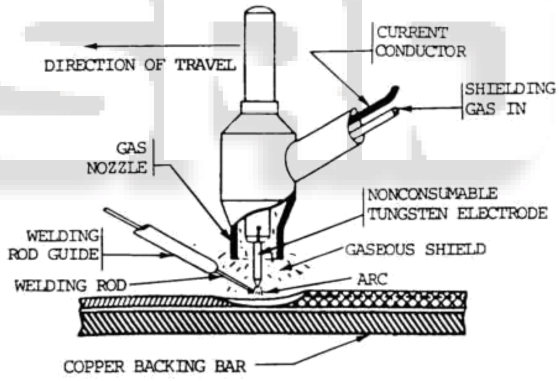

Fig. 1: Schematic diagram of GTAW process

D. *Welding Of Dissimilar Metal*

Welding of dissimilar metals is the joining of metals by different welding processes which has different chemical, physical and metallurgical properties. During welding of dissimilar metals, there are many interesting features that are not completely understood. Physical properties of the two metals being very different from each other lead to complexities in weld pool shape, solidification microstructure and segregation patterns. The Industry needs construction of advance equipment and machinery. Different kinds of metals feature with different chemical, physical, and metallurgical properties. Some are more resistible to corrosion, some are lighter, and some are stronger, so this area got priority among the engineering industry.

E. *Applications Of Copper And Copper Alloys*

Applications of copper and copper alloys include electrical wire, tubing, and parts for building hardware and for electrical, plumbing, heating, and air-conditioning systems.

The second largest category is electrical and electronic products, including those for telecommunications, electronics, wiring devices, electric motors, and power utilities. The industrial machinery and equipment category includes industrial valves and fittings; industrial, chemical, and marine heat exchangers; and various other types of heavy equipment, off- road vehicles, and machine tools. Transportation applications include road vehicles, railroad equipment, and aircraft parts; automobile radiators and wiring harnesses are the most important products in this category. Finally, consumer and general products include electrical appliances, fasteners, ordinance, coinage, and jewelry.

F. Applications of Stainless Steel

TIG welding is widely used for welding stainless steel and it produces welds of good appearance and quality. Stainless steel resistance to corrosion and staining, low maintenance and familiar lustre make it an ideal material for many applications. There are over 150 grades of stainless steel, of which fifteen are most commonly used. The alloy is milled into coil, sheets, plates, bars, wire, and tubing to be used in cookware, cutlery, household hardware, surgical instrument, major application, industrial equipments, as an automotive and aerospace structural alloy and construction material in large building. Also include transport equipments, oil and gas, medical, food and drink, general such as springs, fasteners (bolt, nuts and washers), wire, cryogenic vessels and components, evaporators, escalators, daily handling equipments.

G. Process Parameter Selection

The welding parameters are selected based on experience or from a handbook by operator. However, this does not ensure that the selected welding process parameters can produce the optimal or near optimal weld metal properties for that environment and particular welding machine. A literature review has been done in this regards and an attempt has been made to analyse the effect of different process parameters on weld metal properties.

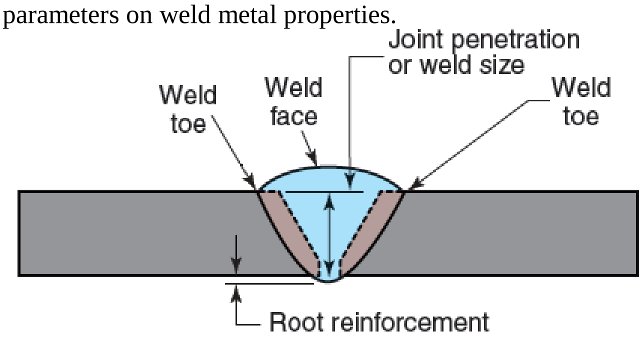

Fig. 3: Schematic diagram of weld metal geometry

H. Process Parameter Selection

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II. LITERATURE REVIEW

Madduru Phanindra Reddy, A. Aldrin Sam William, M. Mohan Prashanth, S.N. Sabaresh Kumar, K. Devendranath Ramkumar, N. Arivazhagan, S. Narayanan presented investigation the weldability of AISI 4140 AND AISI 316 by Gas Tungsten Arc Welding (GTAW) process with and without filler metal. The filler material employed for joining dissimilar metal was ER309L. The process parameter employed such as voltage, current, shielding gas flow and filler wire diameter. The NDT analysis and microstructure examination that there were no observable macro/micro-scale deficiencies such as porosity, undercut and lack of fusion etc. Microscopic examination was carried out across the composite region of the weldment. Hardness profile on the GTA weldments employing with and without filler wire clearly opitimized that the maximum hardness was found to be at the HAZ of AISI 4140 in both the weldments and weld zone in autogeneous GTA weldments. Tensile studies were conducted on the ASTM E8 standard samples to assess the strength and ductility of the weldments. The tensile failure occurred at the parent metal of AISI 316. The hardness studies, the lower hardness values are found be at the parent metal side of AISI 316. Hence the tensile failures were occurred at the parent metal of AISI 316 side. Successful welds of AISI 4140 and AISI 316 could be obtained by GTA welding process employing with and without filler wire [1].

Savyasachi Pandit, Vaibhav Joshi, Meghna Agrawal, M. Manikandan, K. Devendranath Ramkumar, N. Arivazhagan, S. Narayanan was investigates the weldability of dissimilar metals (Monel 400 and Hastelloy C276) by Gas Tungsten Arc Welding technique employing ERNiCrMo-3 filler wire. The studies were carried out to characterize the weldments of mechanical and metallurgical properties. The input parameter used to voltage current and filler wire diameter. The weldments were characterized to determine for any macro/microscopic defects using X-Ray radiographic technique. The weldments were characterized to determine for any macro/microscopic defects using X-Ray radiographic technique. Hardness profile of the dissimilar weldments clearly showed that Monel 400 side has lower hardness as compared to the Hastelloy C276. The tensile failure occurred at the parent metal side of Monel 400 in all the trials. Fracture occurred at the parent metal of Monel 400 contributing for the ductile mode of failure. Overall defect free welds of parent metal could be obtained by GTA welding process employing ERNiCrMo-3 filler metal. SEM/EDAX analysis reports the formation of inter-metallics at the weld zone and the HAZ of Hastelloy C276 contributed for greater strength and hardness [2].

I. Hajiannia, M. Shamanian, M. Kasiri present study of microstructure and mechanical properties of AISI 347 austenitic stainless steel/ ASTM A335 low alloy steel dissimilar joint were investigated. Employed two filler metals including ER309L and ERNiCr-3 were selected to be used during the gas tungsten arc welding process. The welding process parameters including current, voltage, welding speed, heat input to calculated elongation ratio, tensile strength and yield strength. The microstructure was examined by optical microscopy (OM) and scanning electron microscopy (SCM). In tension tests observed that all weldments failed in the HAZ of A335. The impact test results indicated that all specimens exhibited ductile fracture. The maximum fracture energy was related to the ERNiCr-3 weld metal specimen. The maximum and minimum hardness corresponded to the ERNICr-3 and ER309L. ERNiCr-3 filler material presented the optimum mechanical properties [3].

Mehdi Rahmani, Abbas Eghlimi, and Morteza Shamanian used to study the effect of chemical composition on microstructural features and mechanical properties of dissimilar joints between super duplex stainless steel (alloy 2507) and austenitic stainless steel (AISI 304L), welding was attempted by gas tungsten arc welding process with a super duplex (ER2594) and an austenitic (ER309LMo) stainless steel filler metal. The input process parameter was current, voltage, welding speed and heat input. The ferrite content of samples was measured using Clemex Vision image analysis point counting software and also a Fisher FMP30 ferrite-scope and Microhardness was measured using a Vickers hardness tester. The fracture surfaces were examined by a Philips scanning electron microscope. The heat-affected zone of austenitic base metal comprised of large austenite grains with little amounts of ferrite, whereas a coarse-grained ferrite region was observed in the heat-affected zone of super duplex base metal. Although both welded joints showed acceptable mechanical properties, the hardness and impact strength of the weld metal produced using super duplex filler metal were found to be better than that obtained by austenitic filler metal [4].

Palani.P.K, Saju.Mapplied investigate the effect of TIG welding process parameters are welding speed, current and gas flow rate. Response Surface Methodology was used to conduct the experiments. Strength of weld and percent elongation was calculated. From the results of the experiments, mathematical models have been developed to study the effect of process parameters on tensile strength and percent elongation. Optimization was done to find optimum welding conditions to maximize tensile strength and percent elongation of welded specimen [5].

Prachya Peasura, Anucha Watanapab studying types of shield gas and gas flow rate which affect to mechanical properties and microstructures of HAZ and fusion zone on gas tungsten arc welding (GTAW) in aluminum alloy AA 5083. The factors of AA 5083 weld used in the study types of shielding gas in argon and helium, gas flow rate at 6, 10 and 14 liters per minute. The factorial experiment was designed for this research. Then the results were using microstructure and Vickers hardness test. The result showed that types of shielding gas and gas flow rate interaction hardness at heat-affected zone and fusion zone with a P–value $< .05$. The factor which was the most effective to the hardness at heat-affected zone and fusion zone was argon with a flow rate of 14 liters per minute at heat-affected zone with 74.27HV and fusion zone with 68.97HV. Experimental results showed that the argon condition provided smaller grain size, suitable size resulting in higher hardness both in weld metal and HAZ. They also indicated that the grain size and precipitation Mg affect the hardness of sample [6].

III. CONCLUDING REMARKS

From above literature review it is indicated that

– Welding current, arc voltage, welding speed, type of shielding gas, shielding gas flow rate, etc. are control parameters of Gas Tungsten Arc Welding process.
– Due to change in input parameters, they affect the weld quality in terms of mechanical properties and microstructure properties.
– The methods that can be applied for welding process parameter optimization work are Grey Relation Analysis and ANOVA (Analysis of variance).
– The Factorial Design and Response Surface Methodology can be applied as the DOE (Design of Experiment).
– MINITAB software is a useful aid for the above purpose

IV. SCOPE OF WORK

Gas Tungsten Arc Welding is one of the widely used techniques for joining ferrous and non ferrous metals. TIG welding offers several advantages like joining of dissimilar metals, absence of slag, low heat affected zone etc. TIG weld quality is strongly characterized by weld metal properties. This means a good quality of the weld.

The copper and stainless steel are challenging to weld due to their different properties and composition. Hence it is proposed to go for GTAW of copper and stainless steel. It is proposed to perform the process parameter optimization work for Gas Tungsten Arc Welding. The DOE (Design of Experiment) shall be done by Response Surface Method.

Response Surface Methodology was used to conduct the experiments. Strength of weld and percent elongation was calculated. From the results of the experiments, mathematical models have been developed to study the effect of process parameters on tensile strength and percent elongation. Optimization was done to find optimum welding conditions to maximize tensile strength and percent elongation of welded specimen.

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