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Investigation of Mechanical and Welding Defect of Metal Piece Welded Through ARC and TIG Welding

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Abstract-To improve welding quality of mild steel plate, an automated Tungsten Inert Gas (TIG) welding system has been developed, by which welding speed can be control during welding process. In this study, Welding of mild steel plate has been performed in two phases. In first phase by using Conventional Arc welding and in second phase by using TIG. The hardness and microstructure of Tungsten Inert Gas (TIG) weld and arc weld of a mild steel joint has been calculated and compared. The hardness of the weld joint and the Heat Affected Zone (HAZ) of a mild steel is important when considering its performance during its application in industries. The process parameters such as current, voltage, gas flow rate and electrode diameter for TIG process are chosen carefully. The hardness test was conducted using the Rockwell hardness scale B while the microstructure was evaluated using the metallurgical microscope. The hardness values in the weld cross section was observed and it was noted that the Weld zone has the highest hardness values followed by the HAZ and finally the base metal. With choice of the process parameters, current was also noted to have highest contribution on the hardness.
Keywords: Hardness, Microstructure, Parameters, Rockwell and Scale

I. INTRODUCTION

A. Welding

Welding is a process of joining two metal pieces by the application of heat. Welding is the least expensive process and widely used now a days in fabrication [1]. Welding joints different metals with the help of a number of processes in which heat is supplied either electrically or by mean of a gas torch. Different welding processes are used in the manufacturing of Auto mobiles bodies, structural work, tanks, and general machine repair work. In the industries, welding is used in refineries and pipe line fabrication. It may be called a secondary manufacturing process.

TIG welding process is used to analyzed the data and evaluate the influence of input parameters on tensile strength and hardness of mild steel specimen [2].Welding current , gas flow rate and welding speed are the input parameters which affect output responses of mild steel welded joints . To improve welding quality of mild steel plate pre and post welding precautions must be taken during welding process. TIG welding is a high quality welding process used to weld the mild steel. Welding of AL plate by varying input parameters, the output parameters get studied optimized so that better quality of welded joints will develop [3].

Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) welding or metal active gas (MAG) welding, is a welding process in which an electric arc forms between a consumable wire electrode and the workpiece metal(s), which heats the workpiece metal(s), causing them to melt, and join. Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air. The process can be semi-automatic or automatic [4]. 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 aluminum and other non-ferrous materials in the 1940s, GMAW was soon applied to steels because it provided faster welding time compared to other welding processes. The cost of inert gas limited its use in steels until several years later, when the use of semi-inert gases such as carbon dioxide became common. Further developments during the 1950s and 1960s gave the process more versatility and as a result, it became a highly used industrial process. Today, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process to robotic automation. Unlike welding processes that do not employ a shielding gas, such as shielded metal arc welding, it is rarely used outdoors or in other areas of air

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volatility [5]. A related process, flux cored arc welding, often does not use a shielding gas, but instead employs an electrode wire that is hollow and filled with flux.

1) *Gas Tungsten Arc Welding:* Gas tungsten arc welding (GTAW), or tungsten inert gas (TIG) welding, is a manual welding process that uses a nonconsumable tungsten electrode, an inert or semi-inert gas mixture, and a separate filler material. Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds [6].

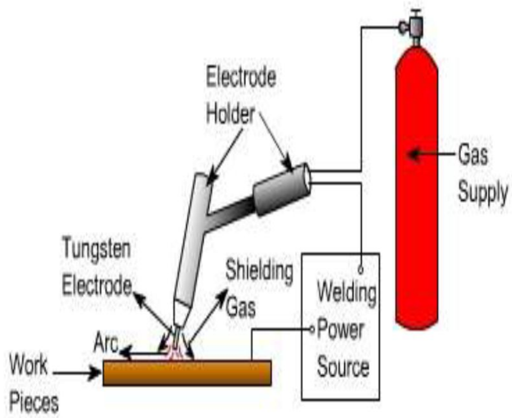

Fig. 1 schametric diagram of TIG welding

2) *Metal Arc Welding:* The process is versatile and can be performed with relatively inexpensive equipment, making it well suited to shop jobs and field work [7]. An operator can become reasonably proficient with a modest amount of training and can achieve mastery with experience. Weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding. Furthermore, the process is generally limited to welding ferrous materials, though special electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals.

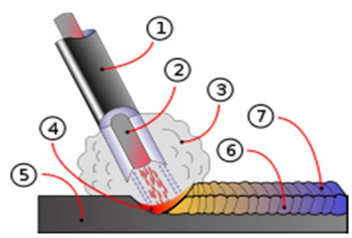

Fig-2 schmatic diagram of arc welding

3) *Working procedure for TIG welding:* Turn on welding current, water and inert gas supply according to the parameters given. Strike the arc by touching the electrode with scrap metal tungsten piece or using a high frequency unit .Repeat the process twice or thrice to warm up the tungsten electrode [8]. A high frequency current is super imposed on the welding current. Bring the welding torch nearer to the job, when electrode tip reaches within a distance of 3 to 2 mm from the job, allow to impinge on the job to create a weld pool. Move the torch along the joint as in oxyacetylene welding. At the far end of the job arc is broken by increasing the arc length. The shielding gas is allowed to impinge on the solidifying weld pool for few seconds even after the arc is extinguished. During welding, torch and filler metal are generally kept inclined at angles of 70°-80° and 10°-20° respectively with the flat work piece. A left work welding technique is used for welding .Filler metal if required should be added by dipping the filler rod in the weld pool. During welding operation alternatively filler rod tungsten electrode will withdraw and come closer to the weld pool.

II. MECHANICAL PROPERTIES

A. Hardness

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is

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applied. Some materials, such as metal, are harder than others. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: *scratch hardness*, *indentation hardness*, and *rebound hardness*.

Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, visco elasticity and viscosity [9].

Common examples of hard matter are ceramics, concrete, certain metals, and superhard materials, which can be contrasted with soft matter.

B. Microstructure

Microstructure is the small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25× magnification [10]. The microstructure of a material (such as metals, polymers, ceramics or composites) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. These properties in turn govern the application of these materials in industrial practice. Microstructure at scales smaller than can be viewed with optical microscopes is often called nanostructure, while the structure in which individual atoms are arranged is known as crystal structure.

After the weldingof mild steel by tig and arc welding we removed the extra particles in the two meatl plates and keep the welding parts in order to check microstructure , hardness and compressive analysis.

FIG-1:-Indicates joiningof two plates by tig welding

Fig-2:-Indicates welded tig and arc metal plates

C. Microstructure Analysis

At first the specimen by double grinding wheel then we polished the rectangular specimen in different grade emercy paper then the final polishing is done by diamond compound (1µm particle size) in polish machine . Then the specimen is polished with 98 % of ethanol and 2% of nitric acid (black). After that the surface was analysed by using metallurgical microscope to get clear view welded zone.

Fig-3; Indicates removal of extra partical from meal

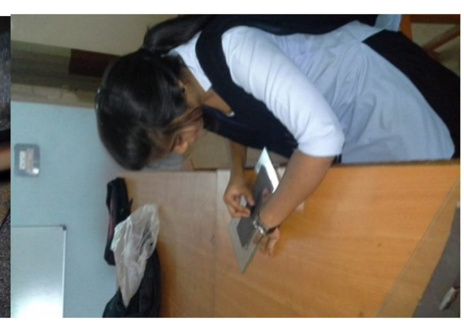

Fig-4 Indicates polishing of specimen by plate after welding emercy paper

Hardness: The Rockwell Hardness test is a hardness measurement based on the net increase in depth of impression on a material as a load is applied. The higher the number on the scale, the harder the material.

The mild steel specimen of 6.0 mm thickness was placed on the surface of the Rockwell Hardness tester.

A minor load is applied and the gauge is set to zero. Then different loads were applied by tripping a lever. After 15 seconds the major load is removed and the specimen was allowed to recover for 15 seconds and then the hardness was read off the dial with the minor load still applied. Numerous aspects of the Rockwell hardness test can influence the measurement result. the testing cycle that is used, the testing environment, the condition of the test material, and the operator. When considering all of these influences, it seems remarkable that the Rockwell test has provided such a reliable test throughout its long usage.

Fig-5:- Indicates UTM machine to measure the hardness of a standard specimen.

III. TEST AND RESULTS

A. Microstructure

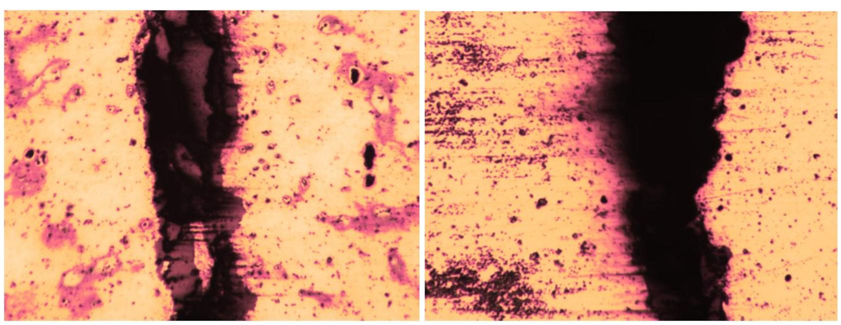

Fig- 6 and 7 Cross-sectional area of TIG Welding.

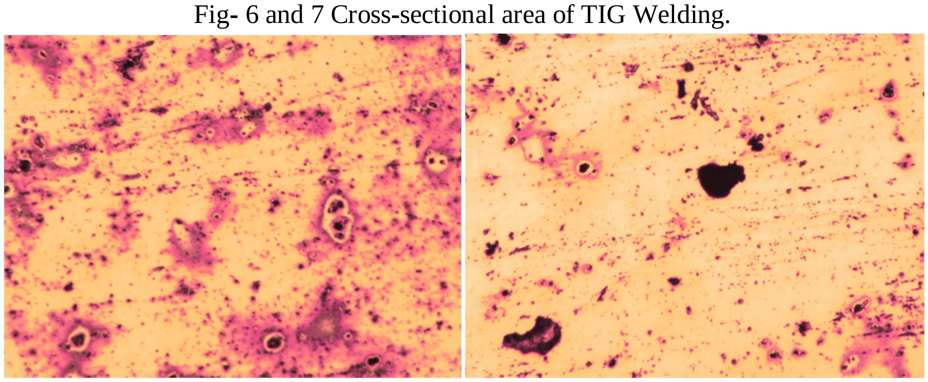

Fig-8 and 9 Cross-sectional area of ARC Welding.

After final polishing, the specimen is observed in the metallurgical microscope. The microscope of the above specimen can be observed.

B. Hardness

TABLE 1
HARDNESS OF MILD STEEL IN ARC WELDING

LOAD(P)	DIA INDICATOR(D)	DIAMETER OF IMPRESSION(d)	BHN= $2P/\pi D(D - \surd D^2 - d^2$
250	5	1.3	187.24
250	5	1.4	159.15
250	5	1.5	138.39
250	5	1.6	122.42
250	5	1.7	109.76

AVERAGE=143.39

By applying a load of 250 kgf and dia of indicator is 5 mm. We observed that the hardness of tig is 177 and that of arc is 143.39.

IV. CONCLUSIONS

From the above experiment we conclude that in arc welding the heat effected zone is wide spread over the weld area. therefore it is not clearly shown in a particular reason .however in fig 6and 7the heat effected zone is clearly observed which is less then arc welding and the hardness of the tig welding is more then the arc welding.so in compare to tig welding arc is the better welding.

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