Analysis on Mechanical Properties of a Butt Weld Using a Damaged Electrode

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***Abstract*: Arc welding (AW) is a high quality, high deposition rate welding process commonly used to join plates of higher thickness in load bearing components. This process of arc welding provides a purer and cleaner high-volume element that has relatively a higher material deposition rate compared to the traditional welding methods. The filler material has a similar composition and melting point less than that of the base metal. The filler rod is used to supply the extra material, to fill the gap between joint and to produce a round, oval or fillet. So here we are performing an experiment using damaged welding electrodes of three different kinds. Finally, various sorts of strength testing tests are performed to determine the quality of welding done in three layers.**

***Keywords*: Mechanical Properties, Butt Weld**

1. Introduction

Welding is a common process for joining metals using a large variety of applications. Welding occurs in several locations, from outdoors settings on rural farms and construction sites to inside locations, such as factories and job shops. Welding processes are fairly simple to understand, and basic techniques can be learned quickly. Welding is the joining of metals at a molecular level. A weld is a homogeneous bond between two or more pieces of metal, where the strength of the welded joint exceeds the strength of the base pieces of metal. At the simplest level, welding involves the use of four components: the metals, a heat source, filler metal, and some kind of shield from the air. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce a single piece of metal. It can be performed with or without filler metal and with or without pressure. There are several types of welding that are used today. Gas Metal Arc Welding (GMAW) or MIG, Gas Tungsten Arc Welding (GTAW) or TIG, Flux Core Arc Welding, and Stick Welding are the most common found types in industrial environments.

2. Literature survey

Swenn Anton Halvorse (2015) investigated the key effects and factors influencing and in particular causing, a major breakage of a soderberg electrode. During normal operation in an electric furnace an electrode is subject to high temperature gradients and temperature changes as the electrode is moved down (typically at about 1m/day) but with these slow changes over time, thermal stresses cause no significant damage. If the furnace is temporarily shut down for some reason, the differing changes in temperature in the outer and inner parts of the electrode causing various thermal expansion. Based upon the present study it is recommended that for the multi pass welding by using SMAW process the low heat input should be preferred because of the reason that it gives good hardness, toughness and ductility to the material. Bend test also turns positive for low heat input [1].

Y. H. Guo (2018) explained the impact energy of the repeated welding specimens is dependent on the grain size of the austenite and contents of delta ferrite. the highest impact energy of 272 J for the RW3 specimen corresponded to the larger grain size of 45.5micrometer.the crack growth energy accounted for a very large proportion of total impact energy. as the grain size was big, a high roughness, and a long crack path length was generated. the energy required for crack propagation increased [2].

R.A. Mohammed (2013) investigated the mechanical and metallurgical properties of mild steel using shielded metal arc welding process (SMAW) with weld metal, heat affected zone and parent metal. From the results, shielded metal arc welding (SMAW) of mild steel increased the strength of the welded joint in particular the heat affected zone, as revealed by lower impact strength, higher tensile strength and hardness values as compared with the parent and lower than the weld metal which is attributed to the fine ferrite matrix and fine pearlite distribution as compared to the parent metal. However, there was a loss of ductility at the welded joint resulting to brittleness of the material. The parent metal (un-welded specimen) had the highest toughness and is the most ductile as compared to the heat affected zone and the weld metal.

The weld metal possessed an appreciable amount of hardness and a deep in toughness showing less ductility than the parent metal, but more ductile than the heat affected zone. The heat affected zone possessed the highest hardness, tensile strength and least impact strength showing that it is the most brittle as compared to the parent metal. That shielded metal arc welding (SMAW) of mild steel increased the strength of the welded joint in particular. The heat affected zone, as revealed by lower impact strength, higher tensile strength and hardness values as compared to the parent metal [3].

S. H. Zoalfakar (2017) studied the effect of welding parameters on mechanical and micro structural properties of welded joints produced by shielded metal arc welding (SMAW) was analysed. Different heat inputs (H) were applied to butt-welding joints by controlling current. The specimens were machined with different groove angles 40˚, 60˚, 80˚ and 100˚. In order to determine the effect of welding process on the local heat affected zone thermal cycle during welding, three different conditions were chosen, temperatures were recorded by using K-type thermocouples and a data acquisition system card of USB 6008, National Instrument type. The mechanical properties were evaluated by means of micro hardness and tensile tests at room temperature. Taguchi approach was applied to determine the most influential control factors which will yield better mechanical properties of the joints, where Taguchi's tools such as signal-to- noise ratio (S/N) have been used to observe the significant parameters and the optimal combination level of SMAW parameters. In this study, the effect of experimental parameters namely groove angle, C.E, heat input, and preheating on UTS, elongation and average hardness are investigated experimentally and statistically Taguchi technique and ANOVA. Specific findings of this research include the followings: The combined effect of both carbon equivalent and groove angle play an important role in improving tensile strength while keeping ductility at relatively high level. In this annealing is effect to reduce the hardening effect during and after welding via reducing crack susceptibility. The error between the experimental results at the optimum settings and the predicted values for UTS, elongation%, and average hardness lie within 2.1, 3.1, and 4% respectively [4].

R. P. Singh (2012) explained the effects of various welding parameters on penetration in mild steel having 5 mm thickness welded by shielded metal arc welding. 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. Welding currents were chosen as 90 and 110 Ampere (A), arc voltages were chosen as 20, and 24Volt (V), the welding speeds were chosen as 40, and 80 mm/min and external magnetic field strengths were used as 60 and 80. It was observed that on increasing welding current, the depth of penetration increased. In addition, arc voltage is another important parameter for penetration. However, its effect is not as much as current. The highest penetration was observed for 110 A current, 24 V voltage, 80 Gauss magnetic field and 77 mm/min welding speed. The welding speed was kept constant with the help of a lathe machine. Using the experimental data, a multi-layer feed forward artificial neural network with back propagation algorithm was modeled to predict the effects of welding input process parameters on weld bead geometry. A strong joint of mild steel is found to be produced in this work by using the SMAW technique. If amperage is increased, depth of penetration generally increases. If voltage of the arc is increased, depth of penetration decreases. If travel speed is increased, depth of penetration of weld decreases. If magnetic field is increased, depth of penetration of weld decreases. Artificial neural networks based approaches can be used successfully for predicting the output parameters like weld width, reinforcement height and depth of penetration of weld [5].

Rajeev Ranjan (2014) had studied to optimize various parameters for Shielded Metal Arc Welding process, including welding voltage, welding current and welding speed. Factorial design approach has been applied for finding the relationship between the various process parameters and weld deposit area. The study revealed that the weld deposit area varies directly with welding voltage and welding current and inverse relationship is found between welding speeds with weld deposit area. A strong joint of mild steel is found to be produced in this work by using the SMAW technique. If amperage is increased, welding deposition area generally increases. If voltage of the arc is increased, welding deposition area generally increases. Weld voltage was found to be most influencing variable to weld deposit area (WDA). If travel speed is increased welding deposition area generally decreases. The two level fractional half area fractional designs are found to be very effective tool for quantifying to main and interaction effects of variable on weld bead area [6].

3. Methodology

A. Material and Method

The material IS 2062 Grade B Mild Steel of the required dimension was purchased from the local market and the test specimen was prepared from it. The chemical composition of IS2062 Grade B mild steel by weight (wt %) is given as follow C-0.22, Mn1.50, Si-0.40, CE-0.41,P-0.045, S-0.045 a

Fig. 1. Specimen before welding

B. Preparations of The Specimen

The test specimen for analysis of mechanical properties of hardness and tensile strength were prepared as per ASTM standard and its description is given below:
Specimen for hardness test and tensile test and bending test: An impact test specimen as per ASTM A370 is prepared with the following dimensions.
Length 100mm
Width 50mm
Thickness 5mm

C. V-Groove preparation

Initially the given specimen has unequal dimensions so for achieving the smooth specimen we have done the grinding around the specimen. At the top of the both specimens we remove some excess metal i.e,3mm and within angle of 30deg i.e., 60deg for two specimens. The main purpose of making angle is for achieving the 'V' with help of 'V' shape we have to maintain the cap during welding.

Fig. 2. Preparation of v groove

D. Welding Process

The IS2062 GRADE B Mild Steel has been join together using SMAW at different current which is at 70A, 80A,90A,100, 110A.The electrode that is used for this experiment is E6013.

Table 1
Electrodes used in the process

Layer	Electrode gauge	Current (amps)	diameter
Root layer	12 SWG	90 amps	2.5 mm
Second layer	10 SWG	120 amps	3.15 mm
Third layer	8 SWG	140 amps	4.00 mm

E. Rockwell's Hardness Test

The Rockwell hardness test method, as defined in ASTM E-18, is the most commonly used hardness test method. You should obtain a copy of this standard, read and understand the standard completely before attempting a Rockwell test. The Rockwell test is generally easier to perform, and more accurate than other types of hardness testing methods. The Rockwell test method is used on all metals, except in condition where the test metal structure or surface conditions would introduce too much variations; where the indentations would be too large for the application; or where the sample size or sample shape prohibits its use.

The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter.

Fig. 3. Hardness test machine

F. Dye Penetration (DP) Test

The test was done by using the optical microscope to observe the characteristics of the microstructure of the welded joint using a damaged electrode. Before the test can be done, the sample needs to be grinded to ensure the surface is flat and polishing is done to give a mirror-like finish. Then, etching was done to reveal the microstructure under the optical microscope. The basic technique for acid metal aching is to apply a resist to the area of metal plate, specifically on the surface of the IS2062 Grade B mild steel. The surface of the material was swabbed and immersed into a specific solution that reacts with the specific metal.

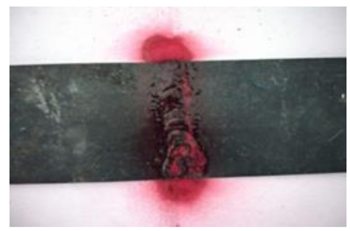

Fig. 4. Joint after spray

G. Testing process

Grinding of the surface: The surface is grinded with the various sizes of emery cloth.120, 220, 320, 400 and 800 grain/m2.Grinding was done at 90^0 in a straight line. The direction of the straight line is changed with emery paper. After completion of surface grinding we are applying pre cleaner on the specimen after some time clean it by cotton. Now, we are applying developer on the specimen and wait for some time leads to the formation of defects.

H. Bending Test

The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. It is often used as a quality control test for butt-welded joints, having the advantage of simplicity of both test piece and equipment. The Fig. shows Bending of work piece before and after application of load.

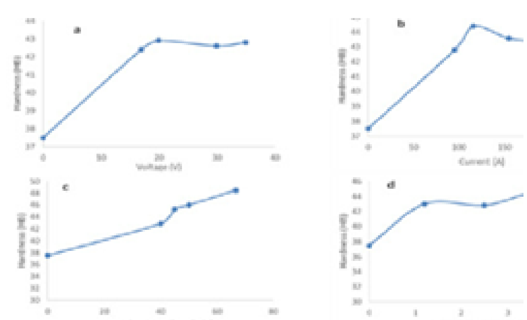

Fig. 5. Graph of hardness

I. Tensile test

This test is generally performed to determine the tensile strength in a "I" shaped specimen. The specimen is placed in between the two vices and the load is gradually applied. Finally the tensile strength is determined when the specimen or work piece breaks. We generally make the work piece into "I" section using a pre made template.

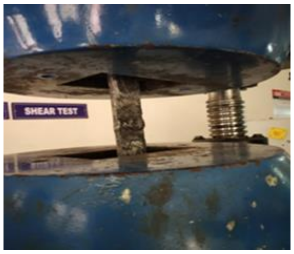

Fig. 6. During tensile test

4. Results

A. Results for Rockwell Hardness Test

For Face

Table 2
Values of welded joints

Position	A	B	C
Top (T)	43	37	60

For Root

Values of welded joint on root position

Table 3
Values of root

Position	A	B	C
Top (T)	60	38	44

B. Results of Bending Test

Table 4
Values of bending test

Specification	Current 80 A
Length	300 mm
Width	50 mm
Load	92.5 KN
Deflection	85mm

Table 5
Results of tensile test

Length	300 mm
Width	50 mm
Load	85 KN
Deflection	85 mm

C. Dye Penetration (DP) Test

The requirements are intended to detect discontinuities that are open to test-surface and free from contaminants by interpreting the surface indications and evaluating them in accordance with the applicable referenced codes, standards or specifications by certified NDT personnel qualified in PT to Level II.

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