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Study and analysis of Electric arc welding in air and underwater by using the mild steel to check the skill of ultimate tensile strength

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Abstract

The paper describes the behavior and fundamental process of underwater welding. Any repair method underwater will require the use of underwater welding. This paper presents sate of the art of underwater welding to assist the development in this field. Commercially available modern electrodes and flux cored wires of special type ensure good quality of welded joints. In this paper we are showing the hardness of air welding with compare with underwater welding. We also shows the systematic diagrams which are suitable to indicated the all process.

Keywords *- underwater welding , ductility , properties*

INTRODUCTION

During the first world war period the underwater welding process will be started. Shielded metal-arc electrodes were utilized in underwater welding soon after their introduction into the welding industry in the late 1920's. Furthermore, because of the offshore exploration, drilling, and recovery of gas and oil in deeper waters today, it is necessary to have the capability to repair pipelines and the portion of drill rigs and production platforms which are deep underwater. Underwater welds were reported to produce about 80% of the tensile strength and 50% of the ductility of corresponding air welds. But these low weld quality properties still provided for joint integrity that was satisfactory for the temporary repair welds and salvage applications for which they were used.The definition of fusion welding, as stated in BS 499: Pt 1 1991 states, "any welding process in which the weld is made between surfaces brought together to a molten state, without hammering or pressure".

Keywords: Underwater welding, Electric arc welding, weld ability of steel, Electric arc welding in underwater, Electric arc welding in air, mild steel.

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Finally, my head bows with reference before the Almighty God and my parents, who has given me strength, wisdom and will to complete the work.

Problem Formulation: Generally the quality of weld joint is strongly influenced by process parameter during the welded process. The welding parameter had much influence on the strength of the welded joint was estimated in this study. In order to achieve high quality welds the heat input rate via welding speed and mechanical properties of the weld metal should be provided accuracy. Results of these studies indicated that numerous process variables of electric arc welding and variety of possible joint configuration have profound effect on tensile strength, hardness (BHN) and impact strength of the weld joint. From the list review it is found that heat input rate and welding speed influenced on tensile strength of welded joint in TIG welding process (Ahmad et al. 2010) and Tensile properties and fracture locations of friction-stir-welded joints of 2017-T351 aluminum alloy of the joints are significantly affected by the welding process parameters (H.J. Liu et al. 2003) the effect of heat input rate on tensile strength and elongation is obvious. With the decreases of heat input, the tensile strength and elongation of joints are enhanced obviously. The effect of heat input on hardness of joint was investigated. The hardness of fusion zone is slightly than that of base metal but the difference is not obvious (Liu Liming et al. 2004).The depth of penetration in electric arc welding varied by varying welding speed which ultimately varied the mechanical properties (Tewari et al. 2010).and The joint strength of friction-welded joints was evaluated by tensile testing and fatigue testing, using the test specimens of SUS304 austenitic stainless steel (Hiizu Ochi 2003). In this project there is discussion of the experimental findings of optimum values of dependent parameter of welded joints (butt joint) prepared at different current, voltage, electrode size and welding technique (Down hand welding) and Heat input rate with electric arc welding in Open Air and Underwater (Wet). The specimens prepared under different current, electrode size, heat input rates and welding speeds are having different effects penetration, strength & toughness.

1-Dependent parameter are current, electrode size, heat input rates and welding speeds.

2-Independent parameters are penetration, strength & toughness.

These are the problem that I have to solve out in present study for electric arc welding (Air and Underwater):

1. Find out the depth of penetration, impact strength & Ultimate Tensile strength of each specimen, in both Open Air and Underwater Welding.
2. Plot the graph between the effects of welding speed on depth of penetration for both welding.
3- Plot the graph between the effects of heat input on depth of penetration for both welding.
4- Plot the graph between the effects of welding speed on impact strength for both welding.
5. Plot the graph between the effect of heat input rate on toughness for both welding.
6. Plot the comparative graph for all variation in both welding and find out the difference between Air and Underwater Welding.

Design of Experiment

Process Parameters

i) Independent parameter (input)

1- Welding speed varied, via arc time.

2- Heat input rate varied via welding speed.
3- Constant voltage (25V).
4- Constant current (200Amp).
ii) Dependent parameter (out comes).
1- Ultimate tensile strength (UTS).
2- Hardness (BHN).
3- Impact strength.

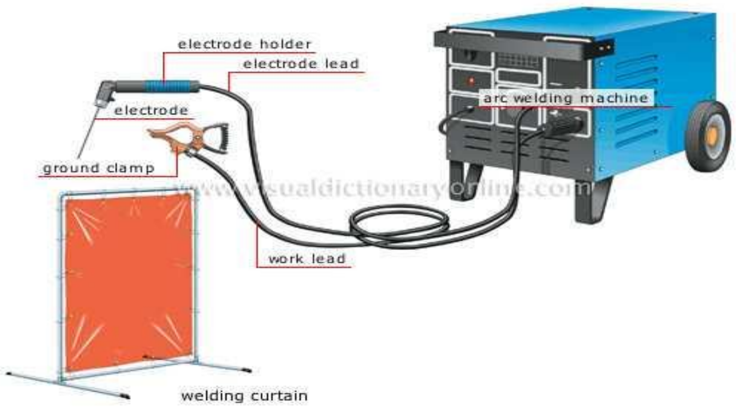
Material Used

In this analysis mild steel specimen are used. The chemical composition and dimension of base metal used in the experiment is given below;
Base metal dimension-300mm×30mm×6mm.

Chemical Composition of Mild Steel

Element	% Weight
Carbon	0.25%
Manganese	0.4%-0.7%
Silicon	0.1%-0.5%

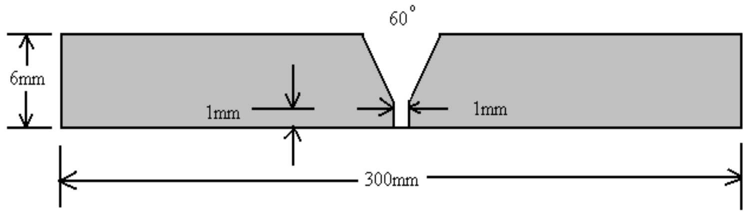
Experimental Set-up

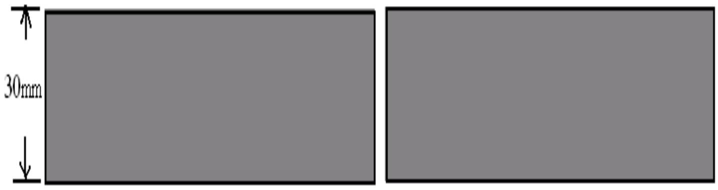


Schematic Diagram of Experimental Setup for Air & Underwater welding

Electric Arc Welding Machine: Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding and shielded metal arc welding, because they maintain a relatively constant current even as the voltage varies[1-9]. This is important because in manual welding, it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate[10-18].

Methodology: In this analysis, metal arc welding is used[19-25]. It is a process which yields coalescence of metals by heating with a welding arc between a continuous filler metal electrode and the work piece[26-40].Firstly, mild steel plate with the dimensions 300mm×30mm×6mm of are prepared with single V-groove with the groove angle is 60° with the help of grinder and 1mm root face these specimens are then welded with a root gap distance 1mm.





Specimens with Single V-Groove (Groove Angle 60◦)

After preparation the plates are placed on the work bench. all the specimens are welded by keeping voltage constant(25V via welder) and current is constant (200Amp via welding machine).by changing the welding speeds to 134.32, 142.81, 146.34, 147.17, 151.89, 157.75, 160.71, 167.91, 195.43 mm/min all the sample are welded, first by using Air welding and then by Underwater welding, keeping other parameter constant. There are nine sample welded by nine welding speed and every sample have five specimens, first two specimen are subjected to tensile testing, second two subjected to hardness test and third one is subjected to impact test. Butt joints are made by these specimens after welding the specimens are shown below;

Specimen after air weldingSpecimen after underwater welding

Thus in our investigation a total of 18 specimens are subjected to tensile load and a total of 18 specimens are subjected to impact load and a total of 9 specimens are subjected to hardness test**.**

Before welding, edges of the work pieces and single V-groove are suitably prepared. The edges and the area adjoining them are cleared of dust using wire brush. And then the work pieces are clamped with C-clamp. Maintain dimensions by controlling distortion. Afterwards, the work pieces to be welded by electric arc welding were positioned with respect to each other. An electric current is used to strike an arc between the base material and a consumable electrode rod or 'stick'. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that protects the weld area from oxidation and contamination by producing CO_2 gas during the welding process.

During the welding process, following data are chosen:

M.S. (Mild Steel) electrode (E 6013) of dimensions 3.15×350 mm was used.

Current = 200 Amp
Terminal voltage = 25 V
Only arc time was varied during the welding of nine samples keeping voltage and current are constant at a value of 25volts and 200amp, the electrode used are a medium coated electrodes. It is suitable for light and medium structural works the weld deposit is consistent mechanical radiographic quality. The slag is easy remove the electrode welds with least amount of spatter and smoke arc time is calculated by stopwatch for each specimen. Welding speed was calculated for each welded specimen, having finished the welding processes.
Calculation: Speed of welding is defined as the rate of travel of the electrode along the seam or the rate of travel of the work under the electrode along the seam.
Speed of welding = Travel of electrode/ arc time mm/min.
Heat input rate or arc energy = V×I×60 /v joules per mm
Where, V is arc voltage in volts,
I is welding current in ampere,
v is speed of welding in mm/min.

RESULTS

The results of tensile testing, hardness (BHN) and impact strength have shown below. Test performed on welded specimen sand their consequences are tabulated below:

	Ultimate tensile strength(MPa)	Hardness (BHN)	Impact strength(joule)
Air weldedSpecimen	180.00-240.00	73.00-104.45	34.30-54.45
Unwedded specimen	260	122	65
Underwater Welding(wet)	192.34-265.67	80.24-117.45	40.78-57.45

Mechanical Properties of Tested Specimens

This Investigation deals with the results and discussions of the experimental findings of welded joints prepared at constant current, voltage, different welding speed, heat input rate and welding technique flat (Down hand electric arc welding). The specimens prepared under constant current, voltage, different heat input rates and welding speeds are having different effects.

All the statistical analysis was performed using spss-17, the result of multivariable analysis of variance (MANOVA) for dependent; ultimate tensile strength (UTS), hardness (BHN) and Impact strength. Independent; variable welding speed and heat input rate.

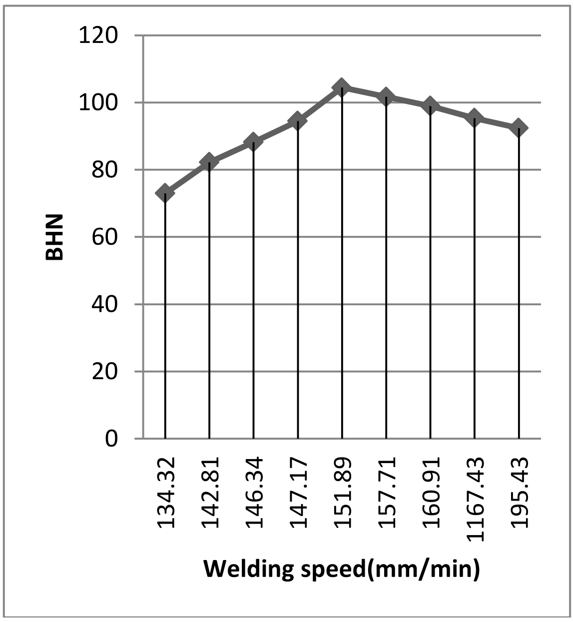
Observation sheet for welding speed and their effect on Impact strength for both Air and underwater welding

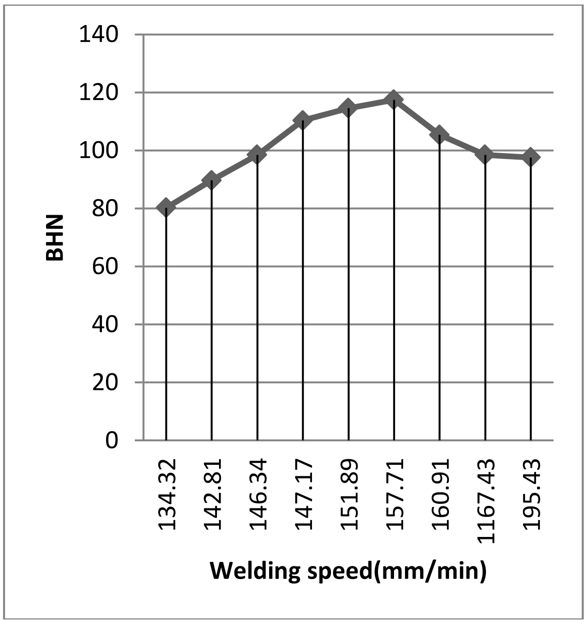
S.No.	Welding speed (mm/sec)	Impact Strength(Joule) Air welding	Impact Strength(Joule) Underwater welding
1.	134.32	34.30	40.78
2.	142.81	39.20	44.78
3.	146.34	44.50	49.34
4.	147.17	48.34	52.56
5.	151.89	54.54	54.67
6.	157.71	52.75	57.45
7.	160.91	49.36	55.98
8.	1167.43	47.20	50.56
9.	195.43	46.45	47.90

For Air Welding for underwater welding

Observation sheet for welding speed and their effect on BHN of both Air and underwater welding

S.No.	Welding speed (mm/sec)	BHN Air welding	BHN Underwater welding
1.	134.32	73.00	80.24
2.	142.81	82.24	89.67
3.	146.34	88.20	98.45
4.	147.17	94.50	110.34
5.	151.89	104.45	114.56
6.	157.71	101.67	117.45
7.	160.91	98.97	105.34
8.	1167.43	95.34	98.45
9.	195.43	92.40	97.56

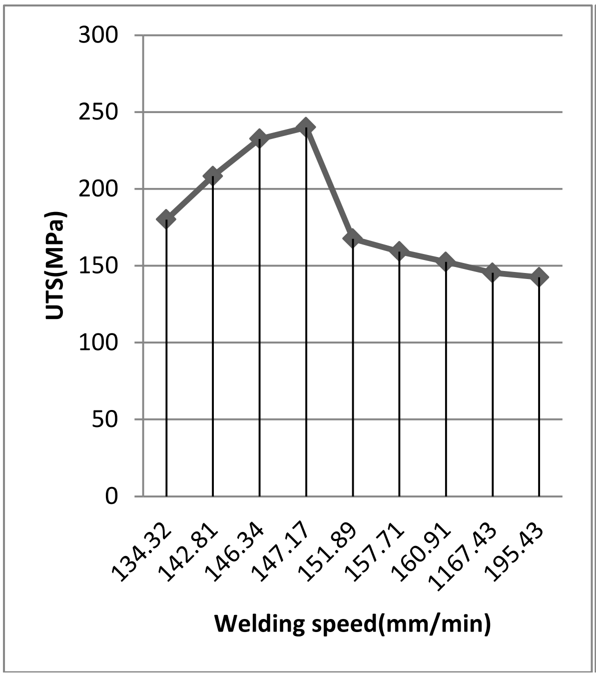


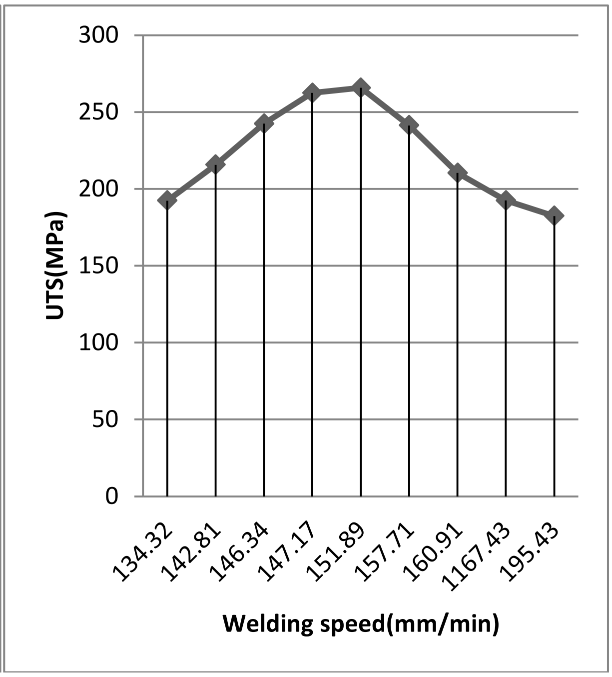


For Air welding for underwater welding

Observation sheet for welding speed and their effect on UTS of both Air and underwater welding

S.No.	Welding speed (mm/sec)	UTS Air welding	UTS Underwater welding
1.	134.32	180.00	192.34
2.	142.81	208.24	215.67
3.	146.34	232.54	242.34
4.	147.17	240.00	262.34
5.	151.89	167.50	265.67
6.	157.71	159.20	241.23
7.	160.91	152.50	210.34
8.	1167.43	145.38	192.45
9.	195.43	142.46	182.34

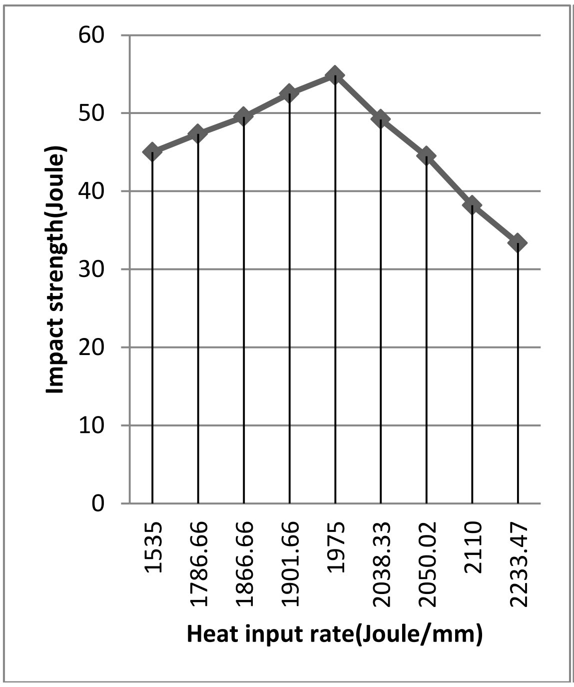


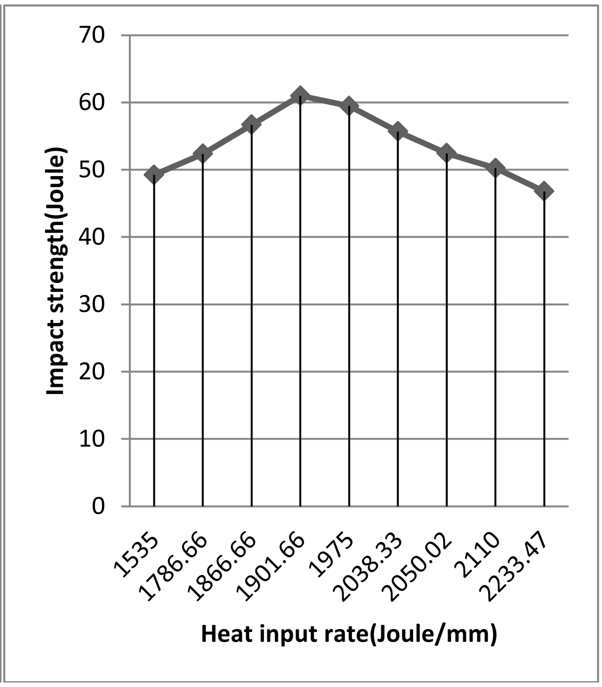


For Air welding for underwater welding

Observation sheet for Heat input rate and their effect on Impact strength for both Air and underwater welding

S.No.	Heat input rate (joule/mm)	Impact Strength(Joule) Air welding	Impact Strength(Joule) Underwater welding
1.	1535.00	45.00	49.23
2.	1786.66	47.34	52.34
3.	1866.66	49.54	56.68
4.	1901.66	52.50	60.98
5.	1975.00	54.85	59.45
6.	2038.33	49.20	55.67
7.	2050.02	44.50	52.45
8.	2110.00	38.20	50.23
9.	2233.47	33.36	46.78

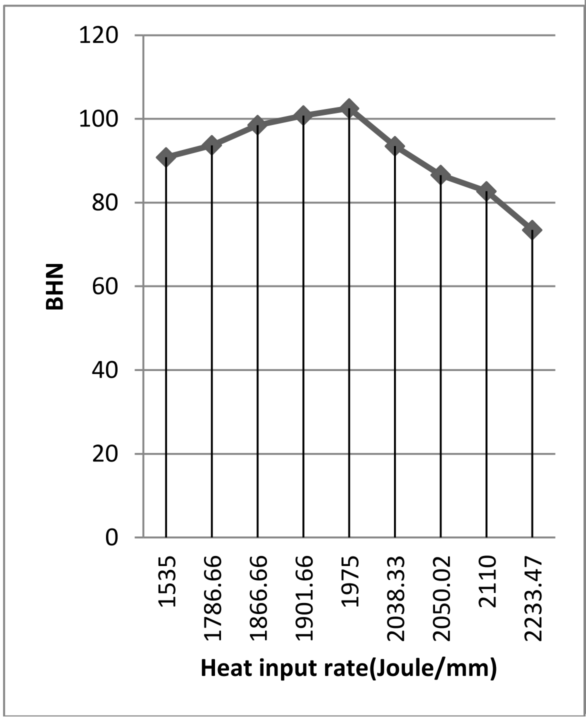




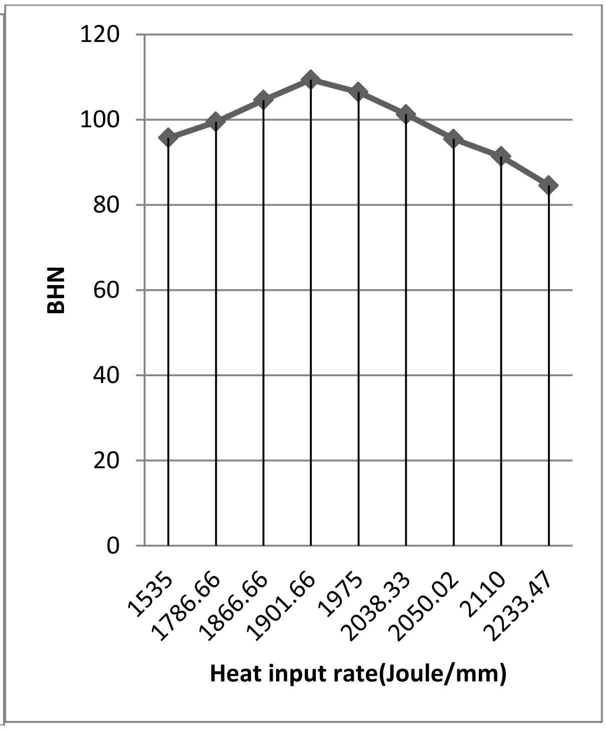
For Air welding for underwater welding

Observation sheet for Heat input rate and their effect on BHN for both Air and underwater welding

S.No.	Heat input rate (jule/sec)	BHN Air welding	BHN Underwater welding
1.	1535.00	90.8	95.70
2.	1786.66	93.7	99.45
3.	1866.66	98.5	104.56
4.	1901.66	100.8	109.34
5.	1975.00	102.5	106.45
6.	2038.33	93.5	101.23
7.	2050.02	86.56	95.45
8.	2110.00	82.70	91.34
9.	2233.47	73.45	84.56



For Air welding



for underwater welding

Observation sheet for Heat input rate and their effect on UTS for both Air and underwater welding

S.No.	Heat input rate (jule/sec)	UTS(MPa) Air welding	UTS(MPa) Underwater welding
1.	1535.00	144.00	156.34
2.	1786.66	146.24	164.56
3.	1866.66	149.35	189.34
4.	1901.66	159.50	210.98
5.	1975.00	164.56	255.45
6.	2038.33	240.00	245.34
7.	2050.02	230.20	230.56
8.	2110.00	208.52	216.67
9.	2233.47	168.50	185.34

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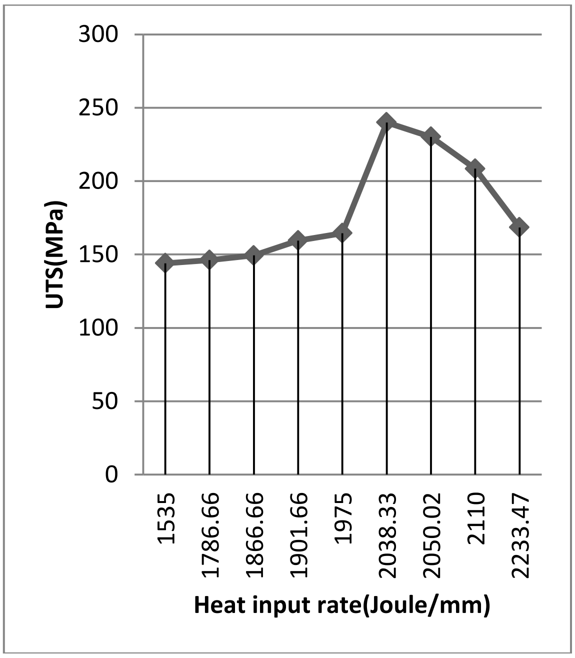

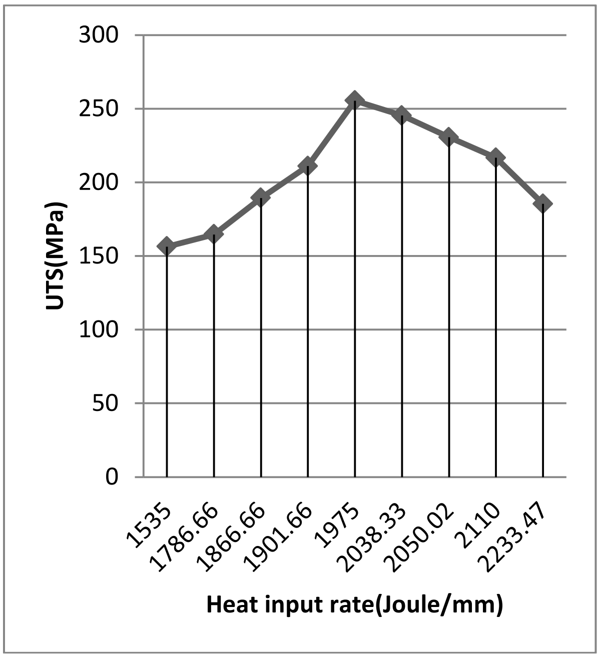

For Air welding for underwater welding

DISCUSSION

These findings are supported by (A K Hussain et al. 2010**)** found that welding speed are much influenced on tensile strength of welded joint in TIG welding process. Tensile strength is higher with lower weld speed. This indicates that lower range of weld speed is suitable for achieving maximum tensile strength. The present findings showed that the ultimate tensile strength of welded joint is 90% of base metal and its value is 240MPa for Air welding, and for underwater welding 262.34MPa. These findings are much similar to the (H J Liu et al. 2003) found that The welding parameters have significant effects on the tensile properties of welded joint .It can be seen that the tensile properties of each joint are all lower than those of the base material. Especially, the elongation of the joint is far lower than that of the base material, and its maximum is merely 3.3%.The maximum ultimate strength is obtained 354MPa, equivalent to 82% that of the base material. The result of the study of (Brahman & Alialhosseini, 2010) illustrated that on increasing of arc voltage & arc current increasing the heat input ;According the change of defeat formation such burns through in weld metal also increase, Besides the high welding current reduced the hardness yield strength and UTS of welded metal; whereas increase in welding speed decrease in welding heat input and change of defeat formation in weld metal thus increasing the welding speed increasing the hardness yield strength and UTS .These finding are very much supportive to the present result that showed the increasing the welding speed decrease the heat input rate and increased the ultimate tensile strength (UTS),hardness (BHN) and impact strength of weld metal.

Range for optimum value for both Air and underwater welding

From the above result if can be concluded that the optimum parameter for mechanical properties of welded joint (butt) of mild steel specimen for both Air welding and Underwater welding, having dimension 300mm ×30mm ×6mm when current is 200Amp, arc voltage is 25V and electrode chosen is E6013, diameter 3.15mm gives the optimum value for UTS, BHN and impact strength at a range of welding speed (147.17-151.89) mm/min and heat rate is (2038.33-1975.00) J/mm for Air welding but for Underwater welding optimum value for UTS, BHN and impact strength at a range of welding speed (151.89-157.71) mm/min and heat input rate (1901.66-1975.00) J/mm gives the best result.

For Air welding:

1. Welding speed (147.17-151.89) mm/min and heat rate is (2038.33-1975.00) J/mm.

   For Underwater Welding:

2. welding speed (151.89-157.71) mm/min and heat input rate (1901.66-1975.00) J/mm.

CONCLUSION

Optimum parameter for mechanical properties for Air and Underwater welding of mild steel specimen of dimension 300×30×6 mm when current is 200A, voltage is 24V and electrode chosen is E6013, diameter 3.15mm, comes out to be:

1- When the welding speed is taken as variable parameter, the maximum ultimate tensile strength (UTS) i.e.240MPa was obtained in 151.89mm/min with Air welding and 262.34MPa was obtained at 157.67mm/min with underwater welding.

2- Maximum ultimate tensile strength (UTS) was obtained when heat input rate was 2038.33J/mm, in case of Air welding but for Underwater welding it comes out to be at 1975.63J/mm.

3- When the welding speed is taken as variable parameter, the maximum BHN and impact strength i.e.104.77 & 55 joule respectively was obtained in 147.7mm/min for Air welding but for Underwater welding the maximum BHN and impact strength i.e.110.34 & 55.67 joule respectively was obtained in 151.89 mm/min.

4- Maximum BHN and impact strength was obtained when heat input rate was 1975.00 J/mm and for Underwater welding, Maximum BHN and impact strength was obtained when heat input rate was 1901.66 J/mm.

Scope for Future Research: In our study voltage and current is constant but if we want to variation in mechanical properties this constant voltage and current may vary. Due to variation in this input parameter we can get the different optimum value in different condition. These optimum values for different welding parameter can be used by welders directly for getting good strength of the welded joints. The mechanical properties is also vary by varying different welding parameter i.e. electrode size, bevel height and bevel height etc.

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