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Investigating the Effect of Varying Parameters of MIG Welding on Mechanical Properties of Dissimilar Metals

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Abstract—*The effect of independent parameters like voltage, current and wire feed speed on metal inert gas welding for joining dissimilar metals stainless steel 304 and mild steel has been investigated. By performing pilot runs the levels of independent parameters were evaluated. The experiments were conducted using design of experiment. Tensile test and impact test were performed on the joint. The relationship between dependent and independent variable has been established. ANOVA test has been conducted to check the adequacy of the model established. Microstructure of the welded joints has also been evaluated and analyzed.*
This experiment validates that joining of dissimilar metals SS304 and Mild Steel possible under some specific parameters value and this benefits industry by giving cheapness of mild steel and corrosion resistance of SS304.

Keywords*: Metal inert gas welding, Mild Steel, Stainless Steel 304.*

1. INTRODUCTION

Welding has been one of the most important processes being utilized in industries and various applications. MIG welding is one of the important variant of the welding techniques. In MIG welding which is one of the arc welding variant, a consumable rod is fed to the weld pool and shielding of the weld pool is provided by the continuous supply of inert gas like argon. Unlike Tungsten Inert Gas Welding (TIG), MIG welding may be used for thicker materials. The MIG welded joints mechanical properties are dependent on various parameters of this welding like voltage, current, wire feed rate and gas flow rate etc. In MIG welding current is one of the prominent factors to affect the penetration [1].

Bead geometry parameters are correlated to various welding parameters of MIG welding [2]. MIG welding is more productive than SMAW as it may be automated due to various factors [3]. Ultimate tensile strength is most influenced by the welding current [4]. Linear and non linear regression analysis has been performed to model the output variables and input variables using full factorial design [5]. Mild steel (cost effective) and stainless Steel SS304 (corrosion resistant) may be welded and seeking the welded joint which may fetch qualities of both the base metals. The process parameters of MIG welding Voltage, current and wire speed may affect the tensile strength and impact strength of the welded joint with dissimilar base metals Mild steel and stainless Steel SS304. The design of experiments is a technique to carry experiments with limited number of runs and availing results up to high percentage of performing entire experiments otherwise.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

Mild steel (MS) and stainless steel (SS304) were chosen as base metals. The dimensions of both the plates were 60mm x 100mm x 3mm. The ultimate tensile strength (UTM) of mild steel and SS304 440MPa and 505MPa respectively. The impact strength of mild steel and SS304 29.5J and 325J respectively. The filler wire is made up of mild steel with copper coating ER70S-3 material wire is used for its silicon island free surface and to meet minimum tensile strength requirements of 70,000 psi. **Table 1** shows the nominal compositions of mild steel, SS304 and ER70S filler metal. The surface of MS as well as 9 S304 were polished by 240# abrasive paper and cleaned with acetone before welding. A direct current MIG welding machine of UNIMECH 250 was used for performing the experiment, the specification of welding machine is given in **Table 2** and also the **fig 1**. The schematic diagram and the actual assembly figure is shown in **fig 2**. The MIG torch was placed on the top and the torch was kept at 90 degree angle. The distance between the surface of plate and tip of torch was 8mm. The base metals were fastened by using C clamp on the surface of mild steel bench table. In fig 2 shown samples for trials runs for getting the level values of parameters before and after which it shows errors in welding bead. For getting the level values of parameters in this have to keep two parameters constant at a nominal value on which we can perform the experiment and the third parameters has to increase or decrease up to a certain limit for getting the level values. After performing the experiment for rest of two parameters also for getting the level values according to it.

The shielding gas used for MIG was carbon dioxide. The flow rate was kept at 15L/min in whole experiment. The detailed experimental parameters are listed in **Table 3.**

In the experiments voltage, current and wire feed rate were the controllable parameters in MIG welding machine. By using the minitab software, put the input values according to it got the desired number of experiment in special order as shown in table 3. The torch is controlled manually by hand and tried to maintain the travel speed constant for all the number of experiments. After welding, the welding bead was grind for preparing it for Wire Cutting operation. Firstly the macrostructure study samples were prepared by using Wire cut for analyzing any defect which can be easily visualized by naked eyes. After this the samples for tensile test, impact test and micro structure samples were prepared by using wire electrical discharge machining process. Then all the samples were analyzed for ultimate tensile test, impact test or charpy test and microstructure study by optical microscope.

Table 1: Chemical composition of material (wt %)

Materials Elements	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**Al**	**V**	**Cu**	**W**	**Fe**
MS	0.1106	0.181	0.3023	0.0517	0.0125	<0.0200	0.0881	0	0.078	0.0165	0	0.0549	98.8289
ER70S-3	0.06-0.15	0.45-0.75	0.90-1.40	0.025	0.035	0.15	0.15	0.15		0.03	0.5		97.5
SS 307	0.0769	0.5051	1.5869	0.0396	0.0243	18.2143	0.0592	0.3523	0.0137	0.0708	0.4666	0	69.7917

Table 2: Machine specifications (UNIMECH 250)

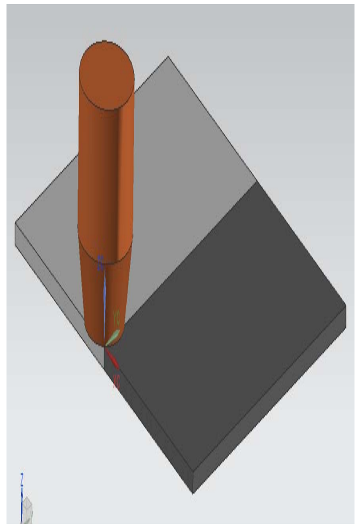
S.No	MODEl/ Parameter	MIG 250
1	frequency input power voltage(v/hz)	AC 380V+-15% 50/60
2	Rate input power voltage (kVA)	9.2
3	Input current(A)	14
4	Rated output current(A)	250
5	Rated output voltage (V)	26.5
6	Output current range (A)	50-250
7	Output voltage range (V)	15-29
8	Duty cycle	60
9	Efficiency(%)	85
10	Power factor	0.9
11	Insulation class	F
12	protection class of case	IP23
13	Wire feed speed(m/min)	1 to 15
14	Diameter of wire (mm)	0.8
15	Diameter of coil (mm)	270
16	weight(kg)	15
17	Dimension(mm)	500x273x440

Table 3: Design of Experiment parameter values

Design of Experiment

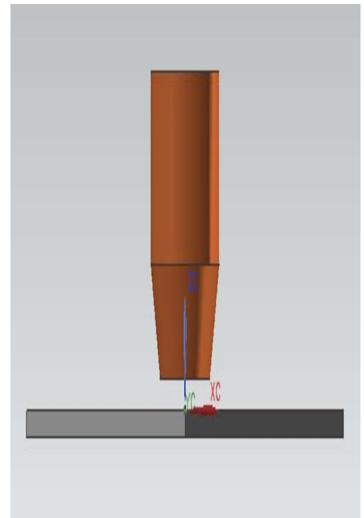
S. No.	Voltage (V)	Current (A)	Wire Speed (cm/s)
1	23	60	4
2	23	60	5.5
3	23	110	4
4	23	110	5.5
5	20	60	4
6	20	60	5.5
7	20	110	4
8	20	110	5.5

Fig. 1 Showing the machine by which the experiments done



2(a)

Fig. 2 (a) showing the schematic assembly drawing of welding setup



2(b)

2(b) Its showing the actual assembly of the setup

(a) (b)

Fig. 3: Showing the trial runs and final samples

3. RESULTS

After done with welding between the two grades of metal with welding bead here is the same Fig. 3 which is showing the welding bead on the metal with some trial samples. It becomes necessary for grind the welding bead for wire cut itself because wire cut don't work efficiently on the welding bead. Here is also a Fig. 4 which is showing the removal process of welding bead and welding plates after removal of welding bead. After wire cut the samples are shown in figure 5. The test results of tensile test and impact test are also shown in table 4. The ANOVA is also done and the results also shown by graphs in figure 6. Afterwards a conclusion of the whole is shown in the conclusion paragraph.

(a) (b) (c)

Fig. 4 (a) showing grinding process for removing welding bead (b) plate with welding bead on the surface (c) Surface of plate after removal of welding bead.

Table 5: Showing results on specimens

Test No.	Ultimate Tensile strength (N/mm2)	Impact Strength(J)
1	20.56	13
2	5.47	20
3	5.34	13
4	30.56	13
5	26.5	26
6	10.8	20
7	11.52	33
8	19.42	23

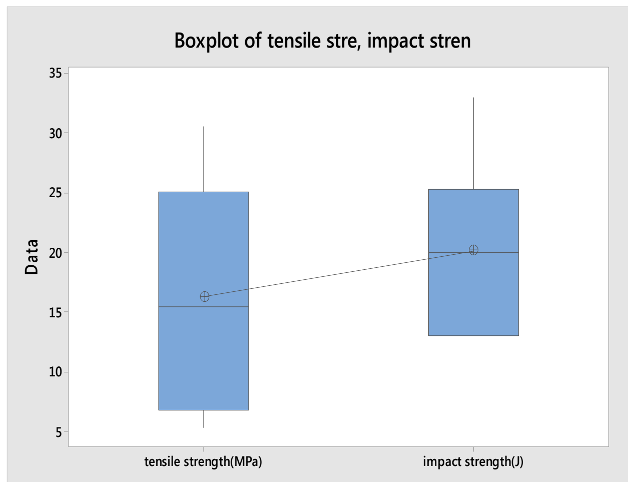
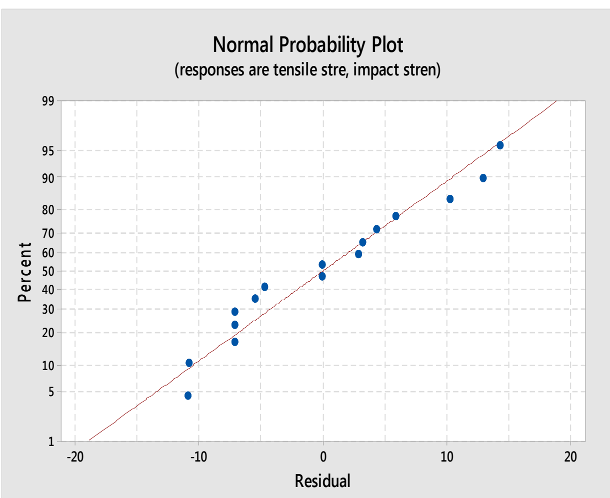
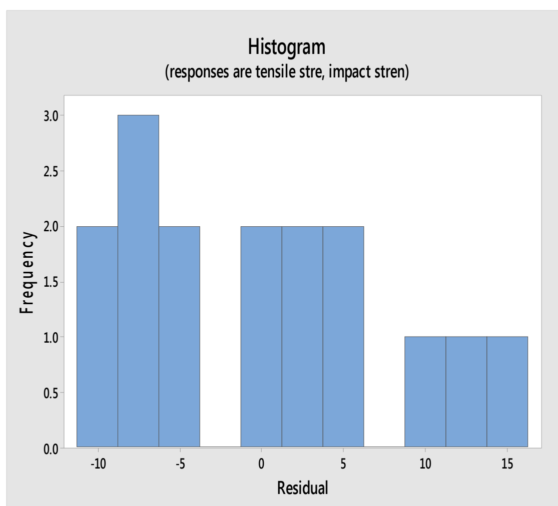


Fig. 5: Showing different graphs of ANOVA results

(a)





(b) (c)

4. CONCLUSION

According to the given results by ANOVA as well as macrostructure study ,tensile test and impact test sample no. 4 has good tensile strength of joint but sample 7 has good impact strength under parameters value given in table 3.

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