INFLUENCE OF HEAT INPUT ON MICROSTRUCTURE AND IMPACT STRENGTH IN DISSIMILAR JOINING USING MIG WELDING

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Abstract: *Arc welding processes are widely used joining processes in the fabrication industry. In general, it's the similar materials that are joined by the process. There are however situations where two dissimilar materials are required to be joined. Such situations are generally avoided because of the metallurgical incompatibility of such materials that will result in poor joints or no joints at all. In spite of this problem, different materials welding has been a topic of research for past many years. In the present research work attempt has made to weld two dissimilar materials which are Stainless steel 304 and mild steel. The process used for joining is MIG welding which has a wide presence in industry due to its many salient features like all position welding, clean joints, portability of equipment, capability to weld wide range of materials and adaptability to automation. The reason for selecting these materials is their increasing application in thermal power plants in heat exchanger assembly, and steam generator of power plants. Aim of the study is to test the impact strength of the specimens followed by metallurgical analysis. The value of heat input to these specimens was varied by varying the input parameters like wire freed rate, voltage and welding speeds. It is expected that the results of this work could be of practical use to the concerned industry. The effects of heat on impact strength and metallurgical transformations is analyzed and presented in easy to understand form*.

Key words: arc welding, dissimilar materials, heat input, impact strength, metallurgical changes.

1. INTRODUCTION

Literature review clearly shows that lot of work is going on dissimilar material welding. However influence of heat inputs and metallurgical analysis on dissimilar welded joints still needs to be investigated. The present research paper investigate on the influence of heat input and microstructure on stainless steel 304 and mild steel. Stainless steel 304 and mild steel is selected because of its broad application, easy availability and low cost. Optical spectroscopy was done to check the authentication of samples used. After that samples were prepared for MIG welding using power hacksaw. Different heat input values was selected varying voltage, welding speed and wire feed rate and results were obtained using trial experiments Wire feed rate should not be too high as it will produce lot of weld splatter and non-uniform weld and tack welds should be twice as many as normal.

After welding different samples 5 samples were chosen based on visual weld quality and desired shape were cut for charpy impact testing.

The Charpy impact test was conducted to determine the amount of energy absorbed during fracture. The test was carried out for 2 samples in one group and average of the test result was calculated. The average impact strength of the samples was noticed.

For microstructure testing samples were duly polished with the help of emery paper of different grade and etching was done with the help of nital as etching agent.

2. LITERATURE REVIEW

Metal inert gas (mig) welding is an arc welding process that uses a consumable electrode to produce weld with help of shielding gas like argon or helium. The current scenario demands light weight, high strength structures and desired product properties which lead to the joining of dissimilar material. Dissimilar weld is generally required in applications where benefits of both the metals whether it's in the form of cost or enhanced properties are required in order to have an optimal solution. The joining of stainless steels with mild steel is a commonly established practice in thermal power industries for boiling water reactors and heat exchanger assembly exposed to high temperature and pressure. The mild steel provides the benefit of low cost, good mechanical strength, high ductility and the stainless steel provides the benefit of corrosion resistance.

Nandwaniet et.al [1] investigated on weld joint of stainless steel 316 and mild steel by MIG welding. The influence of gas flow rate, wire speed and current on the weld joint was noticed. It was found that increases in these parameter leads to decrease in tensile strength. Chennaiaha et.al [2] examined influence of Heat Input on mild steel and carbon steel (EN 8) joints prepared by using MIG welding process and it was found as heat input decreases, there is an increase in the tensile strength, impact strength and also hardness. It was also seen that the mechanical properties of the weld bead depends great extent on the type of filler material used ,pre heating and post welding condition.

Suresh Kumar et.al [3] investigated the process parameter like gas flow rate ,welding current, welding voltage, in MIG welding of stainless steel and mild steel using grey relational methods for 6 mm thick plates.

Maurya et.al [4] conducted the experimental analysis of dissimilar metal welds of mild steel and stainless steel using taguchi method. Influence of gas pressure, voltage and current and their effect on tensile strength was noticed.

Muda1 et.al [5] investigated effect of welding heat input on mechanical properties and microstructure of heat affected zone of abs grade a steel. The results of the investigation shows that the joints made by using low heat input exhibit higher hardness and impact toughness value than those welded with medium and high heat input.

Wang et.al [6] investigated effect of welding process on the microstructure and properties of dissimilar weld joints between low alloy steel and duplex stainless steel. The corrosion morphology and microstructure of dissimilar weld joints were examined by scanning electron microscopy (SEM).

3. PLAN OF INVESTIGATION

The present investigative work was carried out in the following steps.

1. Selection of material
2. Identification of input parameters
3. Selection of input parameter working values
4. Carrying out of experiments
5. Preparation of specimen
6. Results
7. Analysis of results
8. conclusions

4. SELECTION OF MATERIAL

The two different materials selected for the present study are mild steel and stainless steel

304 with approximate composition shown in tables 1 and 2 respectively. These materials were selected on the basis of literature survey and increasing utility of both of them in the industry. The chemistry of both these materials was ascertained by carrying out spectrum-analysis process. On the basis of the report the mild steel conforms to IS-1079:2009 Design HR specification and the stainless steel as AISI 304 grade.

Table-1: Chemical composition of stainless steel

C	Mn	Si	Cr	Ni	Mo	Cu	V
0.077	1.36	0.31	18.08	8.28	0.25	0.43	0.084

Table-2: Chemical composition of mild steel sample

C	Mn	Si	S	P	Cr	Ni	Cu
0.090	0.30	0.19	0.011	0.01	0.10	0.045	0.019

5. IDENTIFICATION OF INPUT PARAMETER

In this research work effect of heat input was investigated on the mechanical properties of the weld and in welding, the amount of heat input is largely dependent upon the selection of input parameters like, welding current, voltage and welding speed. It was found on the basis of trial experiments and literature survey that increase in voltage and welding current increases heat input whereas, the welding speed had negative effect on the heat input. The heat input into the weld pool is given by the following formula

Heat input = (V* I)/v Where V = voltage in volts

I = welding current in Ampere v = welding speed in cm/min.

6. SELECTION OF INPUT PARAMETER WORKING VALUES

Selection of input parameter was done on the basis of literature survey and trial experiments. The trial experiments were conducted at different values of input parameters and the suitability of the same was decided on the basis of visual weld quality. A total of five weldments were produced by keeping the input parameters as shown in the table-3 below. The other welding parameters with their respective values are shown in table-4

Table-3: Input Parameters

S.No.	Welding current(A)	voltage (V)	Welding speed (cm/min)
1	120	20	32
2	125	20	26
3	140	24	32
4	128	24	26
5	200	24	32

Table -4 other process parameters

Process Parameters	Value
Electrode wire diameter (mm)	1.2
Electrode positioning wrt workpiece	90
Nozzle to plate distance (mm)	15
Electrode polarity	DCEP
Root gap	1.5 mm
Shielding gas	Argon

7. CARRING OUT EXPERIMENT

Five samples each of mild steel and stainless steel were cut of size 75 mm x 27.5 mm x 5 mm with the help of power hacksaw machine. Edge preparation was done by filing for square butt welding. Austenitic stainless steel filler wire of grade 308L was used to weld the samples together. The power source used was MIG welding machine with 400 amps rated capacity and based on flat V-I characteristics. The welding set-up is shown in the fig. 1 below.

Fig 1: The Welding set-up

Stainless steel and mild steel samples were filed and kept at a distance of 1.5 mm. 2 tacks welds were made after properly aligning workpieces. The welding was performed on a mechanized carriage to ensure the desired welding speed consistently. The system had the capability of varying the speed from 0-50 cm/min. The welded pieces are shown in fig. 2 below.

Fig. 2: The welded pieces

(a) PREPERATION OF SAMPLE

It was desired to conduct impact test and microstructure test for the welded pieces. Specimens were prepared according to international standard conforming to ASTM A370.

Specimens of 55 mm x 10 mm x 5 mm welded at different heat inputs were thus prepared as per the fig. 3 shown below. For each heat input two specimens were prepared for testing thereby making a total of ten specimens.

55mm

Impact testing

Charpy test is a standardized high strain-rate test which calculate the energy absorbed during fracture by a material. The test was performed on the machine shown in fig.5 .The energy absorbed by each specimen during fracture on this machine is directly measured in Joules and is an indicator of the toughness of the specimen. The fractured specimen after the impact test is shown in fig. 6

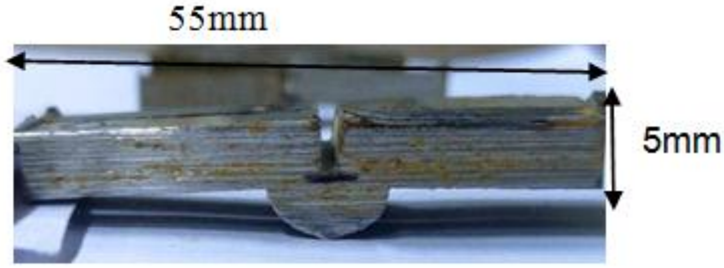

Fig 3: Sample for Charpy test

(b) PREPERATION OF SAMPLE FOR MICROSTRUCTURE TEST

The samples for microstructural analysis were prepared by following standard polishing techniques which included rubbing on emery discs at grades 400, 600, 800, 1000. Lavigated alumina grade 1 was used with valet paper for micro polishing. For etching nital was used as the solution. The solution may contain 1up to 3% (by volume) concentrated nitric acid in ethanol. Nital solution was applied on weld bead and left for 40 seconds to dry, after that sample was washed with clean water.

Fig 4: Sample after Finishing

Fig 5: Charpy testing machine

Fig 6. Fractured specimen

RESULTS:

a) The results obtained after conducting the charpy impact test on 10 nos. of specimens are shown in table 5.

Table 5

	Curren t (A)	Voltage (V)	Weldin g speed cm/mi n	Heat Input KJ/cm	Impact strength J/mm^2	Avg. impact strengh h J/mm
1	120	20	32	4.5	i) 3.12 ii) 3.28	3.2
2	125	20	26	5.76	i) 3.12 ii) 2.76	2.94
3	140	24	32	6.3	i)2.4 ii) 2.72	2.56
4	128	24	26	7.08	i)2.6 ii) 2.2	2.4
5	200	24	32	9.0	i)2.31 ii)2.18	2.24

b) The micrographs obtained from the electron microscopy are shown in fig. 8-12. All the photos were taken at 2000X.

Fig 8: Scanning electron microscopy of sample 1

Fig 9: Scanning electron microscopy of sample 2

Fig 10: Scanning electron microscopy of sample 3

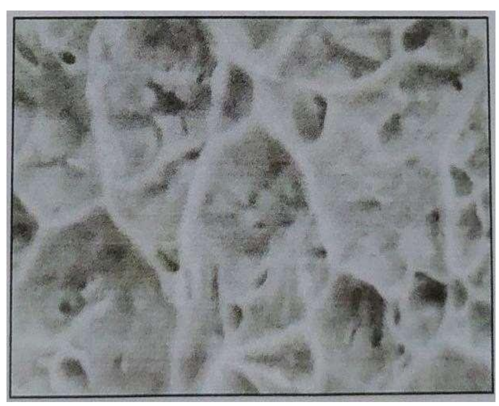

Fig 11: Scanning electron microscopy of sample 4

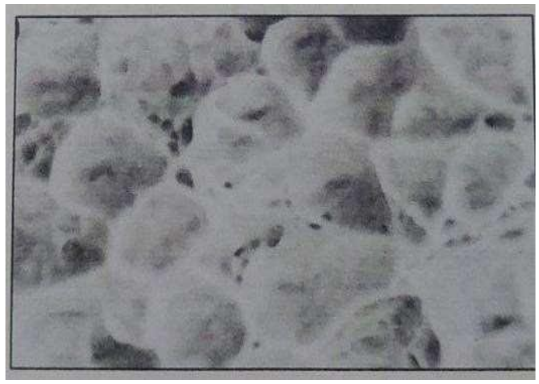

Fig 12: Scanning Electron Microscopy of sample 5

8. ANALYSIS OF RESULT

It was noticed that with increase in heat input the impact strength decreased. Micro structure results show increase in grains size and decrease in grain boundary with increase in heat input. So it can be said that with grain size increase impact strength decreased. The reason behind can be associated with the motion of dislocation. Dislocation can be defined as linear defect which causes abrupt change in arrangement of atoms. As strength is generally a function of dislocation motion. Grain boundaries acts as an obstacle to these dislocations. It can be seen that at low heat input have finer grain with more grain boundaries, so more obstacle are there for dislocation motion which means higher stress is required to cause plastic deformation so higher impact strength. Also, when the heat input is increased in the weld, the rate of cooling also gets decreased. This gives more time to the grains to grow thereby resulting in coarser grains with higher heat inputs and consequently reduced impact strength. It can also be seen that ferrite content increases and austenite content decrease resulting in decrease in impact strength at room temperature. Secondly, the fractured surface of the specimens revealed dull and fibrous structure indicating towards ductile fractures.

9. CONCLUSIONS

a) Impact strength decreases with increase in heat input.

b) At heat input of 4.5 kj/cm maximum impact strength of 3.2 j/mm^2 was noticed and at highest heat input of 9 kj/cm minimum impact strength of 2.24j/mm^2 was obtained.

c) As the fracture surface was found to be dull and fibrous so it was ductile.

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