IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AN INVESTIGATION ON THE EFFECT OF WELDING HEAT INPUT IN MANUAL METAL ARC WELDED MILD STEEL PLATES

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Abstract: Welding heat input is the most important factor in any fusion welding process which is basically an outcome of the combination of different process variables. It offers significant contribution towards the quality of weldment particularly in weld zone and heat affected zone. Manual Metal Arc Welding (MMAW) is the widely used welding process in the industries because of its low cost and versatile applications. The consumable electrodes with flux coating are used in this welding process which produces shielding gases to protect the weld zone from atmospheric contamination during welding. A lot of research work has been performed in order to investigate the effect of process parameters on the weldment of mild steel plates developed by MMAW process. In this study, an effort has been taken to understand the influence of welding heat input in weld zone and heat effected zone in butt joint of manual metal arc welded mild steel plates with a variation in process parameters.

Keywords: Heat input, Heat affected zone, MMAW, Mild Steel, Process Parameters, Weld zone.

1. INTRODUCTION

A significant amount of heat is produced during any fusion type of welding process. This heat energy melts the base metal and develops fusion zone (FZ) which ultimately develops the solidified weld joint [1]. A lot of research work has been carried out on the nature of heat source which includes both experimental and simulation based activities [2]. The heat input in Manual Metal Arc Welding (MMAW) process is dependent on different variables like average welding speed, welding current and welding voltage. The variation in the magnitudes of the variables generates differences in the field of welding heat input [3]. Mild steel is a frequently used engineering and construction material which is other otherwise known as low carbon steel for its carbon content in the range of 0.05% to 0.15% by weight. It is found to be used in many sectors of our lives like automobiles, construction related products, refrigerators, washing machines and cargo ships. Mild steel cannot be considered as alloy steel as it does not contain large amount of other elements like chromium, molybdenum, nickel, cobalt etc. Since the presence of carbon and other alloying elements in this steel are relatively low, the thermal and mechanical properties of mild steel are different from higher carbon and alloy steels [4]**.** Some important grades of mild steel are IS 808, IS 1173, IS 1252, IS 1730, IS 1732, IS 1863, IS 2314 and IS 3954 which are standardised based on the elements' content.

2. LITERATURE REVIEW

A lot research works have been carried out on the welded mild steel plates in order to observe the influence of variable heat sources in the weldment. Kumar Vikas et al. have examined the effect of random variations in current and voltage affecting the heat input rate on the mild steel plates [5]. In a very interesting study, oxidation phenomenon has been carefully tested by Ravindra Kumar, et al. by MMAW on butt welded plates of ASTM SA210 GrA1. The oxidation study has been conducted on the specimens related to base metal, weld metal and heat affected zone (HAZ) after an approximate exposure to air at 900^0C for a certain duration. The resistance to oxidation has been found to be the maximum in HAZ with a formation of inner oxide scale with respect to other zones [6]. Brajesh Kumar Singh et al. has performed the butt welded joint of mild steel plates of IS 2062 to observe the effect of the variations in joint designs on the quality of the weldment. The welding has been done by MMAW on different types of butt-joint like square butt-joint, single V-joint, double V-joint and single J-joint. It has been observed that Double-V joint gives the best quality of weld in respect of mechanical and micro structural analysis [7].

3. SET UP AND EXPERIMENTAL DETAILS

The present investigation has been focused to understand the welding heat input developed by MMAW in the butt-welded mild steel plates with 6mm thickness. The chemical properties of the mentioned steel plates have been placed in the table no.1.

Table 1. Chemical composition of the investigated mild steel plates (% weight).

Material type	% C	% Mn	% Si	% S	% Ph	% CE
Mild steel	0.12	0.93	0.141	0.016	0.025	0.31

The dimensions of the plates are taken as 150 mm x 75 mm x 6mm and a root gap of 2mm has been kept between the plates to make a square butt-joint. Following steps are followed to prepare the butt joint:-

- At first, the specimens are cut properly as per the dimension using power saw.
- Surfaces of the specimens have been cleaned using emery paper and then, acetone is used for removal the oil stain.
- Accurate gap (2mm) has been maintained between the plates and plates are tack welded in order to avoid any movement during welding.
- Proper electrodes (3.15mm X 350 mm) are selected for welding and preparedness of the equipments is checked.
- Few trial runs have been given to find out the desired combination of welding parameters.

The welding process is carried out with a manual metal arc welding machine, AC type, where a single run is used to fill up the gap. Electrodes are sufficiently pre-heated to avoid the content of moisture. After welding, the solidified flux has been removed from the weld bead with a chipping hammer and plates are kept ready for further investigation.

3.1. Welding Heat Input

Welding heat input rate is an important criterion in this investigation process which can be derived from the following equation:-

$$Q = \frac{\eta VI}{S}$$

In the mentioned equation, Q is the amount of heat input (J/mm),η stands for the heat transfer efficiency (taken as 0.7 for MMAW), V relates to welding voltage (V), I indicates welding current (A) and S is the welding speed (mm/S) [8].

Table 3.1.MMAW process parameters and related heat input

Sl. no	Thickness (mm)	Welding voltage (V)	Welding Current (A)	Welding speed (mm/min)	Heat Input (J/mm)
1	6	30	150	176.36	1071.67
2	6	30	150	194.52	971.62
3	6	30	175	214.84	1026.34
4	6	32	175	180.46	1303.33
5	6	32	200	192.34	1397.52

4. RESULT :-

During welding, variables have been changed based on the values of earlier trial runs and all the observations have been recorded with respect to weld zone and heat affected zone of the weldment. Specimens are prepared from the welded plates adopting suitable methodologies which include cleaning, polishing and chemical- etching. After the completion of specimen preparation, these are subsequently used for conducting different investigation and a comparison on the basis of linear measurement performed by stereo zoom microscope has been done particularly, in WZ and HAZ. The measured dimensions are noted and typically compared in the following table.

Table 4.1 Characteristics of WZ and HAZ

Sl.no	Average width of WZ (mm)	Average width of HAZ (mm)	Reinforcement height (mm)
1	6.27	2.53	1.87
2	5.35	2.28	1.35
3	5.68	2.71	1.79
4	6.12	2.86	2.13
5	6.57	3.04	2.21

5. CONCLUSION

It is observed from the experimental investigation that average width of WZ, HAZ and the height of the reinforcement are not same for all specimens. The amount of deviation, as observed, might be correlated with the amount of welding heat input which is further dependent on the welding variables like welding voltage, welding current and welding speed. However, based on the study related to the different amount of heat input, the following observations are noted:-

a) It appears clearly that welding current, arc voltage and welding speed are the key factors which affect the heat input in welding.
b) The maximum width of WZ and HAZ has been found to be developed against maximum amount of heat input of 1397.52 J/mm.
c) Higher welding voltage (32V) has developed the wider WZ (6.57mm) in combined with the maximum welding current (200A). In all the cases, through penetration is observed and satisfactory joints are developed.
d) Heat input affects the cooling rate and heat sink being the same for all specimens, the cooling rate would be the maximum for the lowest heat input. The formation of WZ may be correlated to this phenomenon.
e) The minimum width of WZ and HAZ has been developed against the minimum amount of heat input of 971.62 J/mm. The corresponding values of welding current and welding voltage are recorded as 30V and 150 A respectively.
f) Further, the welding speed has a significant contribution in heat generation where the heat source is transient in nature. Consequently, the maximum welding speed 214.84mm/min is related to the heat input of 1026.34J/mm.
g) The minimum value of reinforcement (1.35mm) has been noted against the least amount of heat input of 971.62 J/mm with an appreciable welding speed of 194.52mm/min.

. However, the influence of welding heat input on the weldment is a complex phenomenon which is associated with many variables and critically dependent on different assumptions. It can be stated from the present investigation that the maximum width of WZ, HAZ and reinforcement height has been observed with the highest heat input of 1397.52 J/mm in the butt welded mild steel plates of 6mm thickness.

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