The Effect of Heat input on the Mechanical Properties of MIG Welded Dissimilar Joints

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Abstract

The effect of heat input on the mechanical properties of MIG welded dissimilar joints is studied. Two dissimilar joints (IS2062-IS 45 C8) and (IS2062-IS 103 Cr 1) are prepared by Gas Metal Arc Welding and mechanical properties are observed. But these mechanical properties are varied with respect to the heat input. This heat input is depending upon voltage, current and speed flow rate of wire. In this present work input is considered into two conditions. i) low heat input dissimilar joints i.e. in IS 2062-IS 45 C8 (3.6189 kj/mm)and in IS 2062-IS 103 Cr 1 (4.01973 kj/mm) ii)high heat input dissimilar joints i.e. in IS 2062-IS 45 C8 (3.1421kj/mm)and in IS 2062-IS 103 Cr 1 (3.70537 kj/mm) are taken and study the mechanical properties and finally compare the heat input which is suitable in dissimilar joints for the present working conditions.

Key words— *Metal Inert Gas Welding (MIG); Heat Affected Zone (HAZ); Weld Zone (WZ); Base Metal (BM);*

1. Introduction

Joining of dissimilar metals is carried out since ancient times. Nowadays, joining dissimilar metals has become indispensable in the field of manufacturing and construction of equipment, machinery and products. Different kinds of metals feature different chemical, physical, and metallurgical properties. Joining dissimilar metals is, therefore, to compose different properties of metals in order to maximize the performance with minimum cost. Firstly we have do edge preparation for single V butt joint in order to proceed further for MIG (Metal Inert Gas) Welding. When welding two dissimilar materials, there are a number of aspects that need to be addressed, in addition to those associated with welding similar materials. The joining of dissimilar metals by arc welding requires careful consideration of aspects like selection of filler wire to optimize dilution & alloying, melting temperature ranges of the metals, their thermal conductivities, co-efficient of thermal expansion, weld metal-base metal interaction and joint design. Then Dye Penetrate test is to be carried out in order to find out the weld defects.

In the view of the fact that Arc welding processes like GMAW offer a wide Spectrum of thermal energy for joining different thicknesses of steels, it was considered important that undertaking the present study would be beneficial in gaining an understanding about the Mechanical Properties that affect the service performance of these welded joints made using different heat input combinations i.e. Low heat input and High heat input. And then dissimilar joints are to be conducted for Mechanical properties tests (tensile, hardness). So, there is a comparison between the joints i.e. tensile and hardness test values in Low heat input and High heat input.

The dissimilarity of the metals may arise due to the difference in chemical composition. The chemical composition of the steel affects weldability and other mechanical properties. Several elements are purposefully added in the production of structural steel, but other undesirable elements may be present in the scrap materials used to make the steel. Carbon and other elements that increase harden ability increase the risk of "cold" cracking, and therefore higher preheat and inter pass temperatures, better hydrogen control, and sometimes post heat are necessary to avoid cold cracking.

2. Dissimilar Materials

In the Present investigation, The base materials used are in the form of IS 2062, IS 45 C8, IS 103Cr 1 plates of sizes 250 x 100 x 10 mm and the filler was copper coated mild steel wire of 1.2 mm diameter. Table 1 shows the Chemical and Physical Properties of dissimilar Base and Filler material used.

3. Metal Inert Gas Welding

MIG or GMAW (Gas Metal Arc Welding) is a welding process in which an electric arc forms between a consumable electrode and the work piece metals, where the metal is deposited into the weld that often adds strength and mass to the welded joint. Gas metal arc welding is generally used due to the high efficiency of filler metal that can be deposited per hour. In this Process, Shielding gas is used to prevent atmospheric Contamination and protects the weld during Solidification. The Components of GMAW are Consumable Electrode, D.C Supply, Inert Gas Supply, and Electrode Feeding Mechanism. The Equipment is shown in Fig 1. The electrode wire is continuously feed from the wire reels and the electrode wire from the reel passes through the electrode holder (welding gun), which is going to hit the job and by the development of arc the wire gets melted & deposited over the joint resulting weld.

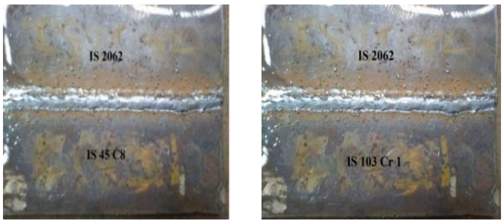
Fig 1: MIG Equipment

Table 1: Chemical Compositions and Physical Properties of Dissimilar materials.

Name of Material	Composition in % of Weight							Thermal Conductivity (W/m-k)	Density (Kg/m^3)	Melting Point (^{0}C)
	C	Mn	Si	Cr	S	P	Mg			
Mild steel IS-2062	0.22	1.5	0.40	-	0.045	0.045	-	53	7850	1540
EN-8 Or IS-45C8	0.4	0.8	0.2	-	0.06	0.06	-	46	7850	1540
EN-31 Or IS103Cr1	1.5	0.52	0.22	1.3	0.05	0.05	-	46.6	7810	1540
Copper Coated Mild Steel	0.10	1.86	0.73	0.20	0.30	0.030	-	-	-	-

As the chemical and Physical properties are given above in the table, then we have to choose the material combinations. The material Combinations used in this investigation are IS 2062 & IS 45 C8 and IS 2062 & IS 103 Cr 1 as shown in Fig 2.

Joints during Low heat input



Joints during High heat input

Fig 2: joints for different heat inputs

4. Experimental Procedure

A. Welding Procedure

Firstly, the dissimilar materials in plate form which are of the size (250 x 100 x 10) mm are to be taken. Weld groove bevelling is done on the Universal milling machine. Then fix the plates in the Machine vise or milling vise, then milling is done on both sides of the dissimilar plates by using T-max φ 80 cutter with speed of 450 rpm. For bevelling we have to turn the facing head up to 300 and feed is given slowly. So the Edge Preparation is done to do welding as Single V butt joint. After Edge preparation we have select the combinations of material pair for further purpose, IS 2062 & IS 45 C8, IS 2062 & IS 103 Cr1. As we consider 10mm thickness of plate, before doing Welding we have to preheat (100o-150oC) the materials in order to prevent the moisture in the metal, distortion control and also for cracks rectification. Here we consider the MIG (Metal Inert Gas) Welding where as MIG wire (Copper Coated Mild Steel) with diameter 1.2mm is taken. The importance of copper coating on Mild steel is used to prevent rust and also current is passed easily. Anti spatter spray is sprayed on the MIG wire for easy clean up for a flux core mig welder. Then welding is done for 3 passes with respect to voltage, current, Co2 flow and wire feed rate and Welding Speed. After tacking the plates together the first pass is given using GMAW with welding conditions as mentioned in table 2 and 3. Then we have to divide the joints into two group's i.e. low heat and high heat input. Then we have to conduct the mechanical properties tests (tensile, hardness) on base metals and the welded joints at each locations i.e. Welded zone, Heat effected zone, and Base metal.

It is a well established fact that among all the welding variables in arc welding processes welding current is the most influential variable since it affects the current density and thus the melting rate of the filler as well as the base materials. So according with fundamental fact two different heat input combinations corresponding to different welding currents i.e. 160 A (low heat input), 180 A (high heat input) combinations were selected for the present study.

Heat Input (Q) = [(V x A x 60) / (S x 1000)] x Efficiency

For MIG, Efficiency = 0.9, TIG = 0.8, Shielded Arc Welding = 0.75.

Table 2: Process parameters used for fabricating IS 2062 & IS 45 C8 joints

Specimen no.	Pass	Current (A)	Voltage (V)	Avg welding speed (mm/s)	heat input per unit length per pass (kj/mm)	Total heat input per unit length of the weld (kj/mm)
A(Low heat)	First	160	26	3.437	1.1574	3.6189
	Second	160	26	3.0233	1.3157	
	Third	160	26	3.4717	1.1458	
B(High heat)	First	180	30	3.52425	1.3790	4.01973
	Second	180	30	3.5983	1.35063	
	Third	180	30	3.767	1.2901	

Table 3: Process parameters used for fabricating IS 2062 & IS 103 Cr 1 joints.

Specimen no.	Pass	Current (A)	Voltage (V)	Avg welding speed (mm/s)	heat input per unit length per pass (kj/mm)	Total heat input per unit length of the weld (kj/mm)
A(Low heat)	First	160	25	3.3909	1.0616	3.1421
	Second	160	25	3.42900	1.0498	
	Third	160	25	3.4925	1.0307	
B(High heat)	First	180	28	3.55600	1.2755	3.70537
	Second	180	28	3.7041	1.22458	
	Third	180	28	3.7634	1.20529	

B. Specimen Sampling

The specimens are to be prepared as per dimensions for tensile testing, hardness testing as shown in fig 3 and 4.

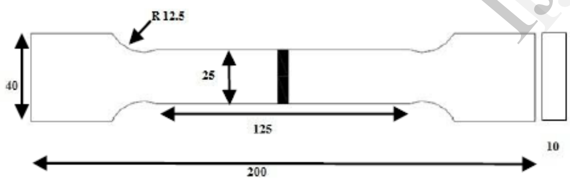


Fig 3: Tensile Specimen

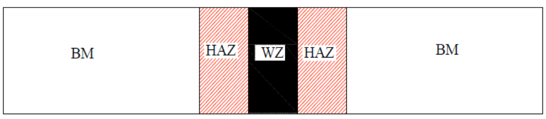


Fig 4: Hardness testing Specimens

C. Tensile test

Six specimens as per heat input combinations are machined out from the weld pads as mentioned in fig 5. Each specimen is prepared as per dimensions as shown in fig 6. The specimens were tested on Tensile Testing Machine of model UTN-40 with a capacity of 400 KN.

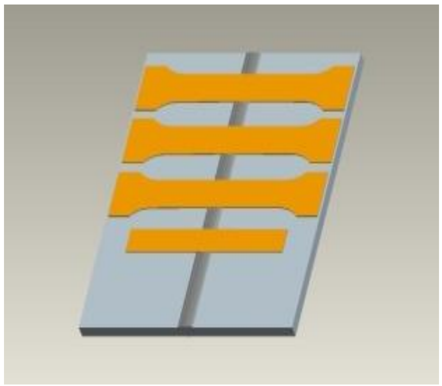
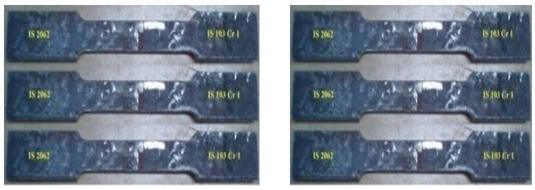


Fig 5: Specimen sampling from the weld pads

(a) Low heat input High heat input



(b) Low heat input High heat input

Fig 6: Tensile Specimens (a) IS 2062 & IS 45 C8
(b) IS 2062 & IS 103Cr 1

D. Hardness

Hardness test (i.e. Rock well) is conducted for both the joints in different zones of the weldments at different heat inputs. In this Testing we conduct hardness test under Scale B. Three values are to be measured at every zone and Average is to be calculated. Comparison is done for both the joints in different heat input combinations.

5. Results

A. Tensile Properties

(i) Low Heat Input:

IS 2062 & IS 45 C8:

Table 4: Tensile values for IS 2062 & IS 45 C8 joint at low heat input

S.NO	TENSILE LOAD (N/mm^2)	TENSILE STRENGTH (N)
1.	157000	632.768
2.	158000	635.533
3.	159000	636.459
4.	160000	638.782
5.	160000	639.120
6.	163000	640.520
Avg		637.197

IS 2062 & IS 103 Cr 1:

Table 5: Tensile values for IS 2062 & IS 103 Cr 1 joint at high heat input

S.NO	TENSILE LOAD (N/mm^2)	TENSILE STRENGTH (N)
1.	120000	487.034
2.	121000	490.52
3.	122000	492.634
4.	123000	495.23
5.	124000	498.99
6.	125000	510.90
Avg		495.88

(ii) High Heat input

IS 2062 & IS 45 C8:

Table 6: Tensile values for IS 2062 & IS 103 Cr1 joint at low heat input

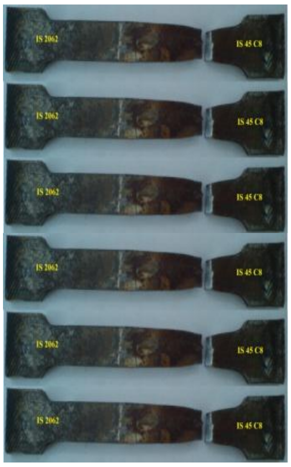
S.NO	TENSILE LOAD (N/mm^2)	TENSILE STRENGTH (N)
1.	146000	619.045
2.	147000	620.523
3.	147000	621.045
4.	149000	623.025
5.	151000	625.120
6.	153000	625.520
Avg		622.37

IS 2062 & IS 103 Cr 1:

Table 7: Tensile values for IS 2062 & IS 103 Cr1 joint at High heat input

S.NO	TENSILE LOAD (N/mm^2)	TENSILE STRENGTH (N)
1.	110000	473.034
2.	112000	473.52
3.	114000	474.634
4.	116000	475.23
5.	118000	477.89
6.	120000	480.90
Avg		475.868

The tensile strength of all the joints made using different heat input conditions has been evaluated. In each condition six specimens were tested and the average tensile strength of six specimens per heat input and their corresponding percentage elongations thus obtained is mentioned in table 4 to 7. The tensile results show that the maximum tensile strength 637.197 MPa is possessed by Low Heat Input and 622.37 MPa by High Heat Input. So, the tensile strength in low heat input is greater than that of High heat input as shown in graphs 1 and 2. Tensile specimens fractured in the base metal are shown in fig 7.



(a) Low heat input High heat input

(b) Low heat input High heat input

Fig 7: Fracture Tensile Specimens (a) IS 2062 & IS 45 C8 (b) IS 2062 & IS 103Cr 1

B. Hardness

(i) Low Heat Input

IS 2062 & IS 45 C8:

Table 8: Hardness values at specified locations in IS 2062 & IS 45 C8 joint in low heat input

S.NO	IS 2062	HAZ(IS 2062)	WELD ZONE	HAZ(IS 45 C8)	IS 45 C8
1.	68	70	94	80	78
2.	70	76	96	88	81
3.	72	78	98	92	82
Avg	70	74.6	96	86.66	80.3

IS 2062 & IS 103 Cr 1:

Table 9: Hardness values at specified locations in IS 2062 & IS 103 Cr 1 joint in low heat input

S.NO	IS 2062	HAZ(IS 2062)	WELD ZONE	HAZ(IS 103 Cr 1)	IS 103 Cr 1
1.	71	76	95	87	80
2.	75	78	101	88	81
3.	75	76	103	88	79
Avg	73.6	76.6	99.66	87.6	80

(ii) High Heat Input

IS 2062 & IS 45 C8:

Table 10: Hardness values at specified locations in IS 2062 & IS 45 C8 joint in high heat input

S.NO	IS 2062	HAZ(IS 2062)	WELD ZONE	HAZ(IS 45 C8)	IS 45 C8
1.	60	60	83	70	68
2.	62	64	82	77	71
3.	59	65	81	78	67
Avg	60.33	63	82	75	68.66

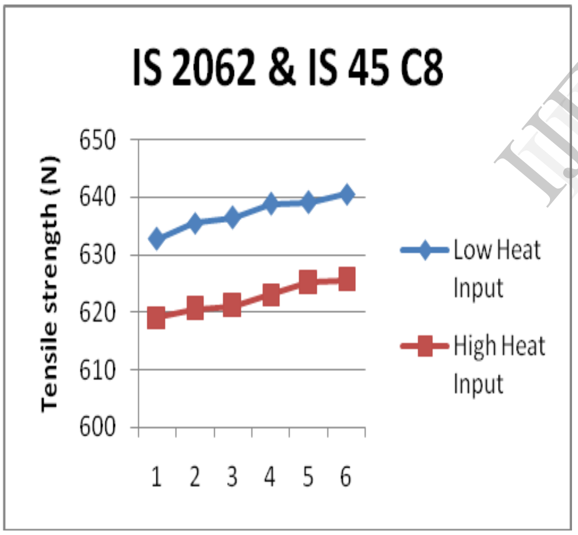
IS 2062 & IS 103 Cr 1:

Table 11: Hardness values at specified locations in IS 2062 & IS 103 Cr 1 joint in high heat input

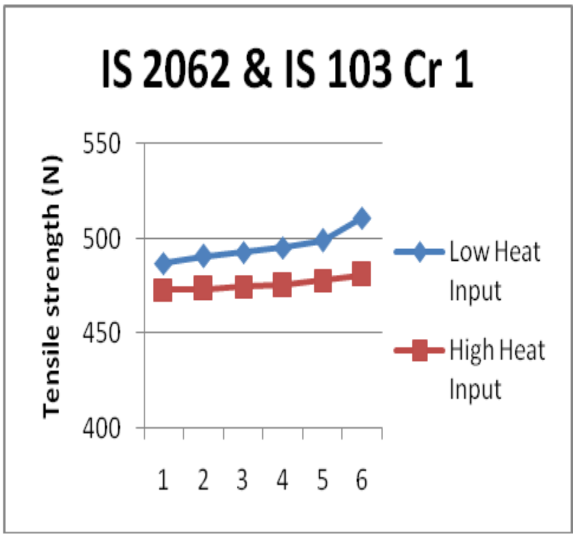
S.NO	IS 2062	HAZ(IS 2062)	WELD ZONE	HAZ(IS 103 Cr 1)	IS 103 Cr 1
1.	60	66	95	88	75
2.	58	65	94	86	72
3.	57	64	93	85	70
Avg	58.33	65	94	86.33	72.33

In this hardness test, we have taken three values at each zone as shown in tables 8 to 11. So we can observe that in both the joints the hardness values are higher in the low heat input than high heat input as shown in graphs 3 and 4. In general it is observed that from these hardness studies that hardness follows an increasing trend in the order of weld metal, HAZ, base metal for all the joints made at different heat inputs.

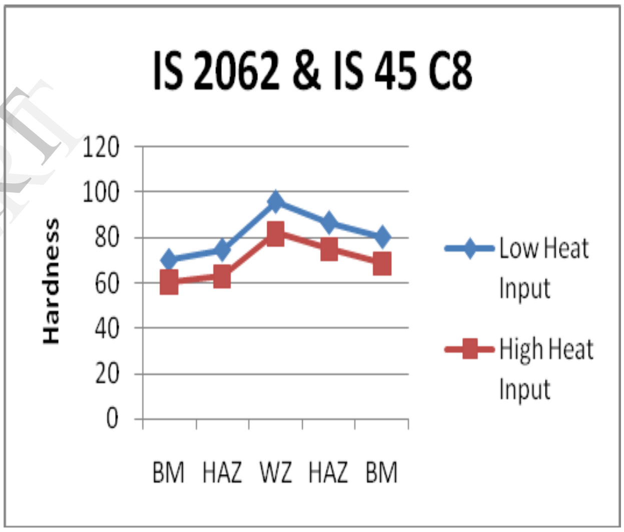
6. Graphs



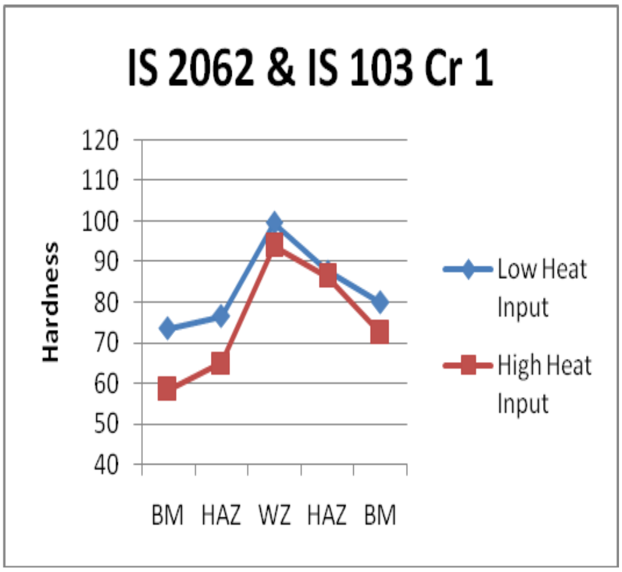
Graph 1: Tensile Strength for IS 2062 & IS 45 C8 joint at different heat inputs



Graph 2: Tensile Strength for IS 2062 & IS 103 Cr 1 joint at different heat inputs



Graph 3: Hardness values for IS 2062 & IS 45 C8 joint at different heat inputs



Graph 4: Hardness values for IS 2062 & IS 103 Cr 1 joint at different heat inputs

7. Conclusions

The following conclusions can be drawn from the present work:-

(i) As the Heat input decreases, there an increase in the tensile strength in both the joints (IS 2062 & IS 45 C8) and (IS 2062 & IS 103 Cr1)

(ii) As the heat input decreases, there is an increase in the hardness in both the joints (IS 2062 & IS 45 C8) and (IS 2062 & IS 103 Cr1)

(iii) And also hardness follows an increasing trend in the order of weld metal, HAZ, base metal for both the heat inputs.

Based upon the present study it is recommended that low heat input should be preferred when welding joints (IS 2062 & IS 45 C8) and (IS 2062 & IS 103 Cr1) using MIG Welding process because of the reason that besides giving good tensile strength and hardness.

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Biography

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