Effect of Preheating the Work Piece material on the width of Heat Affected Zone of Cast Iron and Mild Steel Weldments.

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A systematic study on the effects of preheating temperatures of the work piece material on the width of Heat Affected Zone (HAZ) formed during arc welding of Gray Cast iron with Mild Steel reveals that under identical conditions, the width of 'HAZ' on both cast iron and mild steel get reduced initially with preheating temperatures followed by a rise with further increase of the same. It also reveales that under identical conditions, the width of 'HAZ' on cast iron is always less than that on mild steel. All these observations have been explained with the help of proposed temperature distribution model diagrams for the work piece materials based on the effects of preheating temperatures and thermal conductivities of the same.

INTRODUCTION

Heat Affected Zone (HAZ) is the zone on the work piece material which undergoes non-uniform heating effectduring welding and hence non-uniform phase transformations occur in the zone during subsequent air cooling to room temperature. 'HAZ' with non-uniform microostructures exhibites poor mechanical and corrosion resistance properties and hence the same, unless modified, finds limited industrial applications.

Table-1				
Details of Welding Materials Used				
Materials used	Dimensions (cm)	Chemical Compositions	Preheating Temps (°)	Remarks
Gray Cast Iron Plates	200 × 150 × 8	3.2% C, 2.1% Si	100, 200, 300 & 400	Preheating of plates was done with oxy-acetylene flame and checked with a numerical contact thermo-couple.
Steel Plates	200 × 150 × 8	0.1% C, 0.4% Mn	— do —	
Flux coated electrodes	4 (core dia.)	1.5%C, 53% Ni, 0.62% Si	120	Electrodes were baked in oven for 24 hours.

The usual remedial measures for 'HAZ' include post-weld heat treatments, control of welding parameters like preheating temperatures of the work piece material, heat input during welding, thermal conductivity of the work piece material etc. No systematic studies on these factors affecting 'HAZ' of weldments have been reported so far and hence the present investigation has been undertaken in order to reduce the information gap in respect of preheating temperatures and thermal conductivities of work piece materials. The present investigation is a part of the auther's main investigation on 'Metallurgical aspects of fusion welding of Cast Iron with Mild Steel.[1]

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Experimental Procedures :

The details of the work piece materials, preheating temperatures, welding electrodes used in the present investigation have been indicated in Table-1, and the operational details of welding in Table-2.

Table-2			
Operational details of Welding			
Power Source	Arc Current (amps.)	Arc Voltage (volts)	Welding Process
AC with V-I dropping characteristics	95	100	Manual

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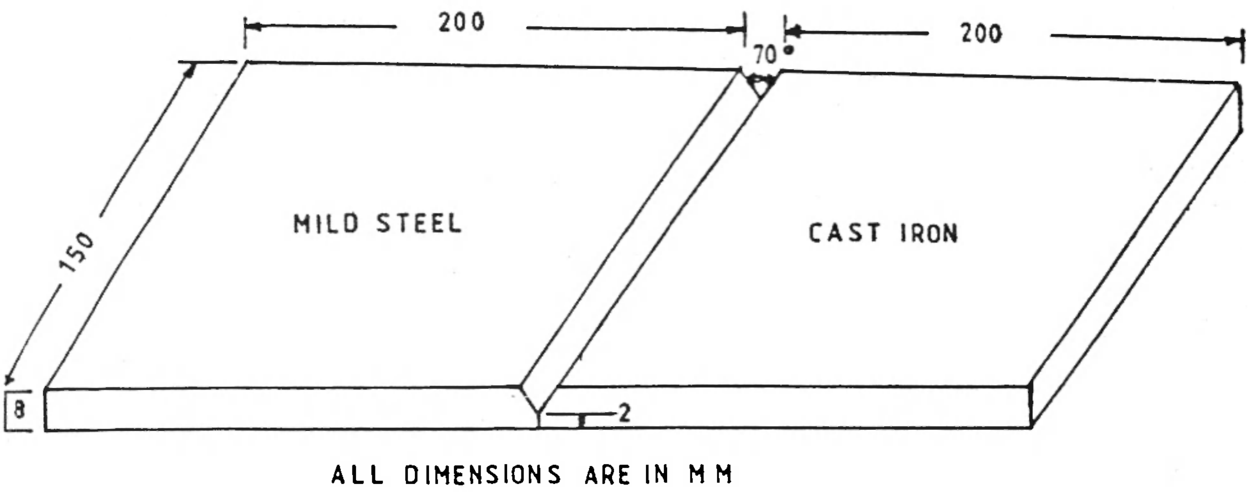

Fig. 1. : Groove geometry of Welding

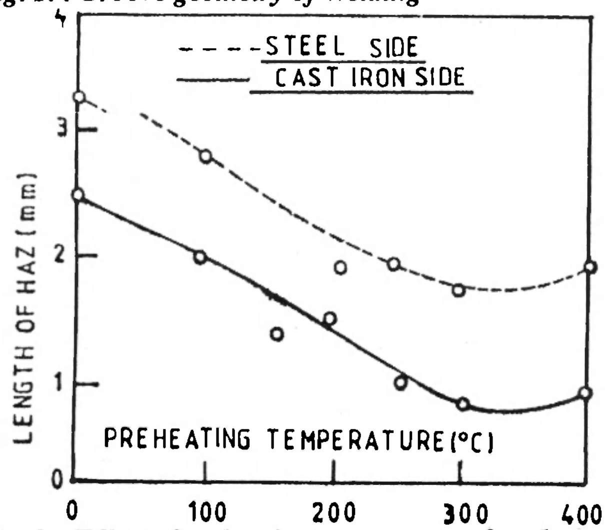

Fig. 2. : Effect of preheating temperature of work piece material on the corresponding 'HAZ'.

Table III				
Width of 'HAZ' on cast iron and mild steel for different welding conditions :				
Preheat Temps (°)	Average width of 'HAZ' (mm) for		Welding variable	
	Mild Steel	Cast Iron	Current (amps.)	Voltage (volts)
30 (Room Temp)	3.5	2.4	95	100
100	2.8	2.0	95	100
200	2.1	1.5	95	100
250	1.9	1.1	95	100
300	1.7	0.8	95	100
400	2.0	1.0	95	100

Plates of both cast iron and mild steel were bevelled at ·70°C as shown in Fig. 1. Before welding, the work pieces were clamped and tack welded followed by preheating as detailed in Table-1. Welding was done immediately after preheating. Number of passes maintained in each case was two. The interpass temperature maintained in each operation was 70°C. At the end of welding the joint was air cooled to room temperature. For measuring the width of 'HAZ' a long piece of about 20 mm width perpendicular to welding direction was machined out from the central zone. The top surface of the specimen was ground, polished and etched for developing microstructures. The width of 'HAZ' was measured on the etched microstructures under a travelling microscope of X200 magnification starting from the interface of the weld deposit up to the stage, away from the deposit, where the zone of double ferrite morphology just disappears. The corresponding distance of travel measuring the width of 'HAZ' was noted from the varnier scale fixed on the platform of the microscope. Following the same procedures five data for the width of 'HAZ' were collected on both steel and cast iron and the corresponding average data have been indicated in Table-3 and in Figure 2.

Results and discussions

Figure 2 indicates that the width of 'HAZ' on both cast iron and mild steel decreases initially with preheating temperature followed by a reverse trend when the corresponding temperature exceeds some 300°C. This figure also indicates that under identical conditions the width of 'HAZ' on cast iron is always less than that for steel. ☞

The effect of preheating temperature of the work piece material on the corresponding 'HAZ' may be explained with the help of the proposed temperature distribution model diagram for the work piece material during welding as shown in Fig. 3. In this figure, the 'Fe—C' diagram has been superimposed on the right so as to predict the width of 'HAZ' based on the critical (eutectoid) temperature. This indicates that with the preheating temperature at 300°C, the corresponding temperature gradient (ef) in the work piece material

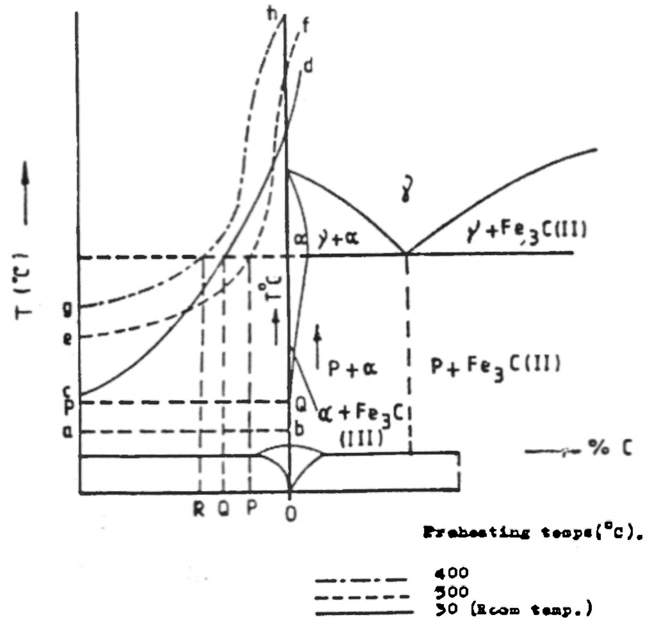

Fig. 3. : Effect of preheating the work piece material on the corresponding temperature distribution model diagram during welding.

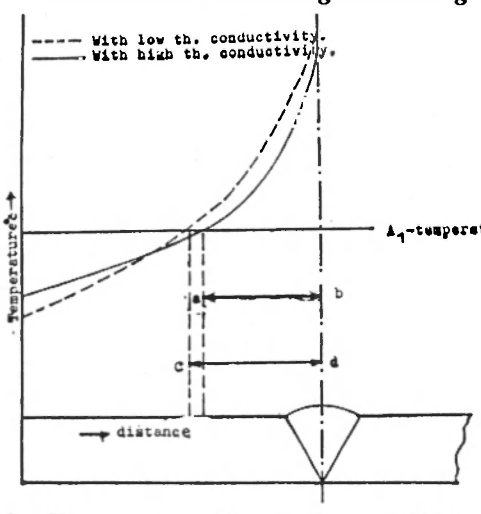

Fig. 4. : Temperature distribution model diagram for work piece material with varying thermal conductivity. (ab = HAZ when thermal conductivity is high, cd = HAZ when thermal conductivity is low.)

during welding, becomes less steel at the free end and more steep near the fusion zone with respect to those developed in absence of preheating (cd). This effect is due to the fact that becuase of preheating the work piece material, the quantity of heat conducted through the work piece material from the fusion zone to the free end gets reduced due to fall of temperature gradient in the work piece material and hence the major part of heat of welding gets concentrated at the fusion zone (ef) resulting a reduced width of 'HAZ' (OP) with respect to that formed in absence of preheating (OQ). Further preheating simply raises the level of the curve (gh) and hence the width of 'HAZ' (OR)[2].

The effect of thermal conductivity of the work piece material on the corresponding 'HAZ' has been explained in Fig. 4. This figure indicates that under identical conditions, the width of 'HAZ' on high thermal conductivity material (gray cast iron) is less (ab) than that on low thermal conductivity material (mild steel) (cd). This phenomenon may be explained by the fact that in the material with high thermal conductivity the quantity of heat flow by conduction will be more towards the free end and thus the corresponding temperature gradient during welding will be more steep near the fusion zone resulting a reduced 'HAZ' (ab) with respect to that for steel (cd) with low thermal conductivity.

Conclusions

(i) The width of Heat Affected Zone of Weldments for both gray cast iron and mild steel fall initially with the preheating temperature of work piece materials followed by a rise with further increase of the same.

(ii) The more is the thermal conductivity of the work piece material the less is the corresponding width of Heat Affected Zone.

(iii) For both cast iron and mild steel a critical preheating temperature exists beyond which no beneficial effect on Heat Affected Zone can be achieved.

References

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2. Welding Metallurgy of Gray and Ductile Cast Irons, R.C. Voigt and R.C. Loper (Jr.), AFS TRansactions, 27 (1986), 133