

Dissimilar Header Welding of Grade 22 to Grade 91 with 9018 B3 Electrode with Preheat and Post Weld Heat Treatment

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ABSTRACT: This paper studies the effect of dissimilar header fillet welding with 9018 B3 electrode on the micro structure and microhardness under the application of constant 220 °C preheat and different conditions of post weld heat treatment (PWHT). Header is an important component of the boiler in which the pipe material under consideration was SA 335 P91 and tube material has been taken as SA 213 T22. By varying the PWHT at nil, 690, 730 and 770 °C, the changes in microstructure and microhardness was examined. Preheat was done constantly at 220 °C and soaking duration for the PWHT was one hour. The variation in microstructure and microhardness was quite distinct as the distance between the two base materials was traversed. Also, effect of preheat and postheat has significant effect on the microstructure and microhardness which will be dealt in detail in this paper.

KEYWORDS: header, preheat, Grade 22, Grade 91, postheat, welding.

I. INTRODUCTION

The demand for energy in India has been on the rising trend and the Ministry of power has predicted an addition of 76000 MW in the current five year plan. Also, much stress is being for cleaner and greener energy production which means that the current sources will have to be optimized to produce more efficient energy in a greener way [1].

Modified enhanced creep resistant steels are quite extensively used in power plants all over the world. These steels are used for high temperature applications and temperatures at which it operates makes it susceptible to cracks if the process parameters are not carefully monitored [2]. Much studies have been done in specifying the origin of cracks by studying the creep performance of grade 91 material. Jonathan et al studied the effect of creep performance of a grade 91 header and found that primary damage location in service is Type IV cracking. With the creep test they confirmed that HAZ is most susceptible to damage formation [3]. Woo Gon Kim et al studied the creep crack growth (CCG) behavior for base metal, weld metal and HAZ and found that CCGR were equal for weld metal & HAZ but were about two times faster than base metal [4]. Mehtap et al studied the effect of molybdenum on microstructure and hardness of intercritical HAZ of low Cr-Mo steel [5].

Headers form a important part of the boiler and it serves as a junction where fluids are received and distributed. Dissimilar header welding also has many challenges associated with it. Joe Bundy has described six precautionary ways in which weld failure can be avoided. These include 1. Use of low hydrogen filler metals. 2. Proper fit up and joint design. 3. Proper preheat and post heat. 4. Good property of filler wire and strength matching with that of the base metals. 5. Proper metal storage like use of baking oven. 6. Proper training to operators [6]. Details about the parameter considered and their effect on microhardness and microstructure will be covered in the coming sections.

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II. DESIGN OF EXPERIMENT

A. Base materials and filler material used

These base materials and the filler material were procured from well know pipe and tube manufacturers from around the world and were supplied in normalized and tempered condition and was subsequently air cooled. The pipe size selected for study was $\Phi 273 \times 30$ mm and is procured from Yangzhou Chengde Steel Tube Co. Ltd., China. The tube size selected for study was $\Phi 50.8 \times 6.1$ mm and is procured from Nippon Steel and Sumitomo Metal Corporation. The filler material used was 9018 B3 which corresponds to 2.25 Cr-1Mo compositions. Throughout the process 220°C preheat was used and the PWHT was carried out for 1 hour. Table 1 gives the chemical composition of the base materials and the filler electrode used.

Table 1
Chemical composition of the base metals and filler (electrodes) materials

Element	C	Mn	Si	S	P	Cr	Ni	Mo	V	Nb
Pipe	0.09	0.38	0.27	0.001	0.015	8.13	0.07	0.9	0.19	0.07
Tube	0.11	0.47	0.22	0.005	0.009	2.29	-	0.92	-	-
9018B3	0.08	0.90	0.79	0.017	0.019	2.19	-	0.97	-	-

B. Experimental methodology

Sequential drilling of holes was done in a contoured way so that tube could properly sit and header welding could be done as shown in figure 1(a). The welding of tubes was started on preheating the job upto 220°C and the same was confirmed by the used of thermal chucks. Figure 2 shows the welding sequence for the header fillet welding that was employed. After the welding of root pass, the second pass is welded from a 12 o'clock position to 4 o'clock position. Lastly, the third and final pass is welded from 10 o'clock position to 6 o'clock position to complete the header fillet weld. This sequence ensures sufficient overlap to accommodate for the start and stop of the weld.

Figure 1(a) – Sequential drilling of holes carried out in the pipe 1(b) Preheating being carried out at 220°C before the start of welding .

(a) (b)

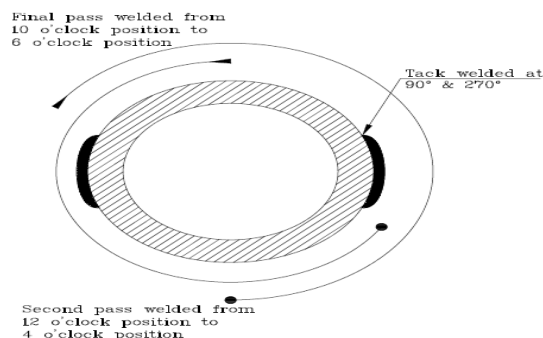


Figure 2 – Welding sequence of header welding used

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III. RESULTS AND DISCUSSIONS

A. Microstructure evaluation:

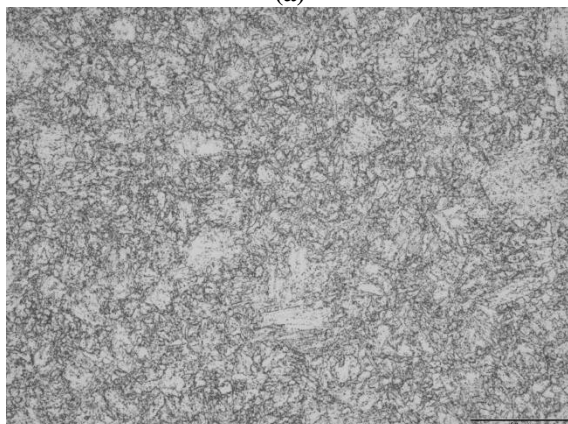
The optical micrograph shown in Figure 3 shows the transition between base materials i.e. grade 22 microstructure to weldment i.e. grade 91 microstructure. The microstructure shows a transition from lath like bainitic microstructure to uniformly dispersed bainite on the base material side. This is followed by a heat affected zone (HAZ) in which the appearance of carbon migration is distinctly visible. This creates a zone of carbon enriched and carbon denuded zones in the HAZ. Sohaj et al studied the microstructural evolution for welds between creep resistant steels P24, P22, P91 and saw that in the due course of high temperature exposure carbon gets redistributed thereby forming carbon enriched and carbon depleted zones near the weld. Further, the weldment is seen to behaving tempered martensitic microstructure [7].



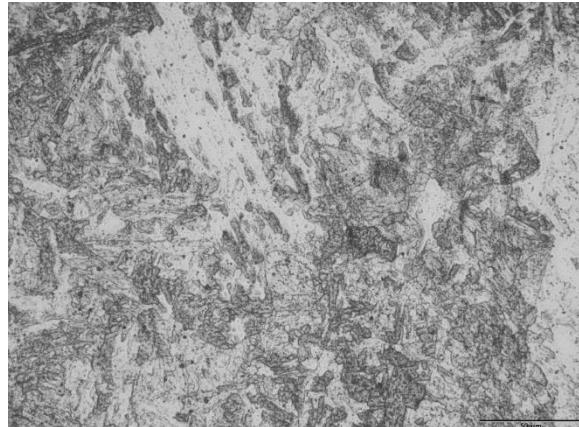
Figure3 shows the optical micrograph for SA 213 T22 to weld metal (9018 B9)



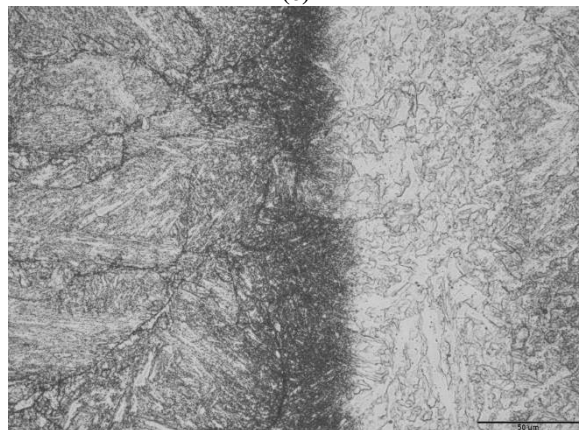
(a)



(b)



(c)



(d)

Figure 4 –(a)22 Fusion line (b) 91 HAZ (c) Weld metal (d) Grade 91 fusion line when welded with 9018 B3 electrode and at 220 °C preheat and 730 °C PWHT

Figure 4 (a) shows the fusion line between the SA 213 T22 base material and 9018 B3 weldment when welded at 220 °C preheat and 730 °C PWHT. Figure 4 (b) is the heat affected zone which is finely distributed tempered martensite. Figure 4 (c) is the weld metal which is tempered bainite structure. Figure 4 (d) is the fusion line between 9018 B3 weldment to SA 335 P 91 pipe base metal which has a distinct carbon redistributed area. Carbon from weldment has got migrated towards the pipe material and therefore the weldment has been decarburized. As seen from the microhardness variations, the more the PWHT, the more the decarburized zones and therefore one has to reach an optimal point wherein the tempering process and the decarburized zones stand in balance for the better performance of the boiler over the decades to come. Hasan HS et al studied the tempering of bainite and concluded that the tempering treatments are to be limited to below 750 °C in order to avoid the formation of austenite [8].

B. Microhardness variation

As observed from Figure 5, the nil PWHT gives high values of hardness mainly in the HAZ region where transition occurs from SA 335 P91 base material to 9018 B3 weldment i.e. from 2000 to 4000 microns along the weldment. At 690 °C the PWHT remains insufficient to provide sufficient tempering of the header as the hardness value in HAZ are much above the permissible limit. At 730 °C and 770 °C the tempering results in better values of hardness and the variation remains within the permissible manufacturing limits.

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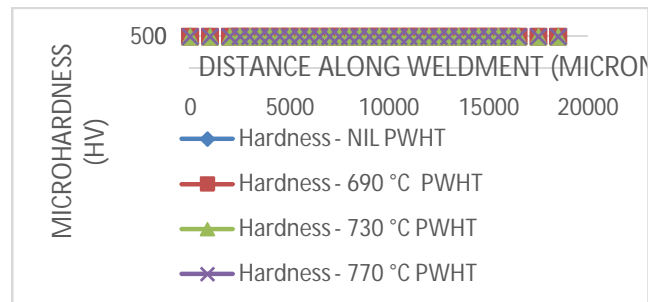


Figure 5 -Variation of microhardness along the header weldment for 9018 B3 electrode with 220 °C preheat.

IV. CONCLUSION

Based on the variation in microhardness along the header weldment, it is evident that microhardness values are very much in range when the weldment is post weld heat treated either at 730 °C or 770 °C. At these temperatures the hardness values are within the 300 HV range and are therefore less susceptible to creep cracks at a later stage during the cycle of operation.

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