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Effect of Preheating Temperature on the Microstructural Features of Welded Rail Head

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Preheating can be defined as heating the base metal(s) to a certain temperature before welding. Preheating serves four major purposes: (a) to decrease cooling rate, which produces ductile microstructure that increases resistance to cracking and helps in diffusion of hydrogen, (b) to reduce shrinkage stress between the weld zone and base metal, (c) to prevent chilling effect ('cold start') and ensure proper fusion, and (d) to eliminate moisture from the sample surface [1, 2]. However, excessive preheating is expensive and yields defects such as thermal distortion in the welded component [3]. On the other hand, inadequate preheating results in different types of cracking, insufficient fusion, and penetration [4]. Carbon equivalent (CE) is used as a tool for approximating proper preheats [2]. Besides CE, optimum preheating temperature also depends on section thickness, restraint, ambient temperature, filler metal hydrogen content, and previous cracking problems [1].

The focus of this research was to evaluate the microstructure of welded pearlitic rail steels preheated at different temperatures. Multipass gas metal arc welding (GMAW) was used to weld the rail steels. Four different preheating temperatures were used (200^{o}C, 300^{o}C, 350^{o}C and 400^{o}C). Mechanical testing, metallographic analysis, and fracture behavior analysis were carried out on the welded samples. The optimum preheat temperature has been identified in view of the welding efficiency and the fracture resistance of the welded rail head.

The microstructures of the weld zones for all the welded samples with different preheat temperatures were similar and mostly evident of a mixture of acicular ferrite and bainite. However, a different weld microstructure, which is a mixture of martensite and bainite, was observed for the samples welded with no preheat (RT). Figures 1 and 2 represent micrographs taken at the fusion and weld zones for both room temperature and 200 ^{o}C preheated samples. In the case of dissimilar filler welding, a small portion of the base metal melts and mixes with the filler material to form a weldment. The percentage of the weld that comes from base metal during welding is known as the dilution percentage. In the present work, since there is a large difference in the chemistries of the parent rail and the filler material (especially wt% C), the weld composition might vary depending on the percentage of dilution. Considering the base metal dilution, the carbon percentage of the weld for different preheating conditions was determined by weld cross-section and the composition calculation. It is clear that the wt% C for the weld increases with increasing preheat temperature. Another important factor of preheating is that it decreases the cooling rate.

Since an increasing preheat temperature will increase the wt% C in the weld, the CCT diagram will shift to right. In contrast, a higher preheat temperature will reduce the cooling rate and will also shift the cooling curve to the right. Due to the above mentioned combined effects, the cooling curves for different preheat temperatures most likely cut the CCT diagram in the same region. Hence, we can expect a similar weld microstructure for different preheat temperatures. However, for welded sample with no preheat (RT), the cooling rate will be much higher when compared to other preheated samples, as well as to the parent rail, and will act as a heat sink. It is believed that due to this very high cooling rate, martensite and bainite were formed in their microstructures. Since a higher preheat temperature involves extra energy to achieve, 200^{o} C can be a recommended preheat for welding of pearlitic rail steel.

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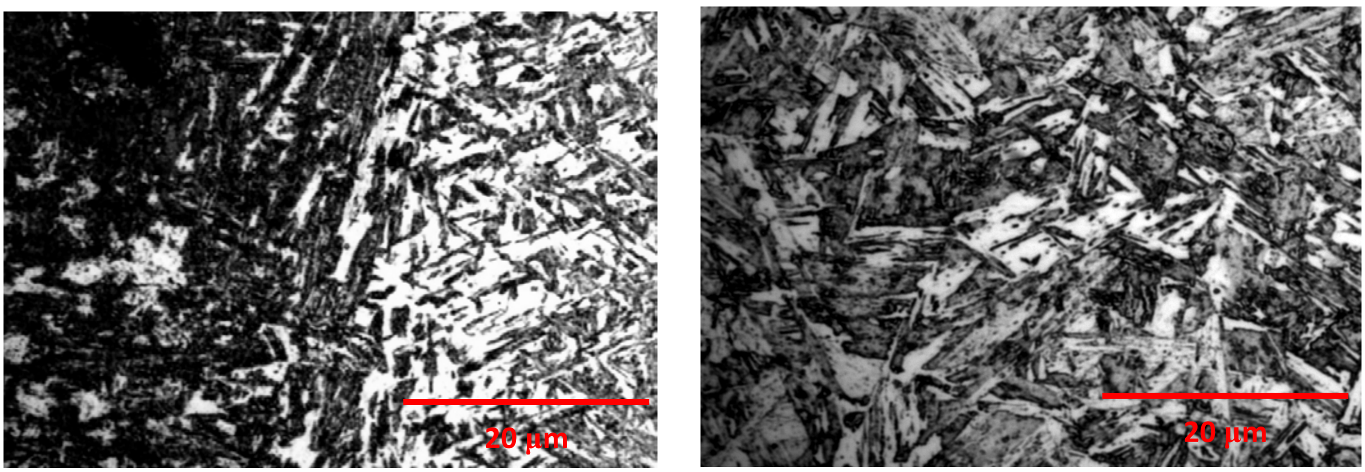
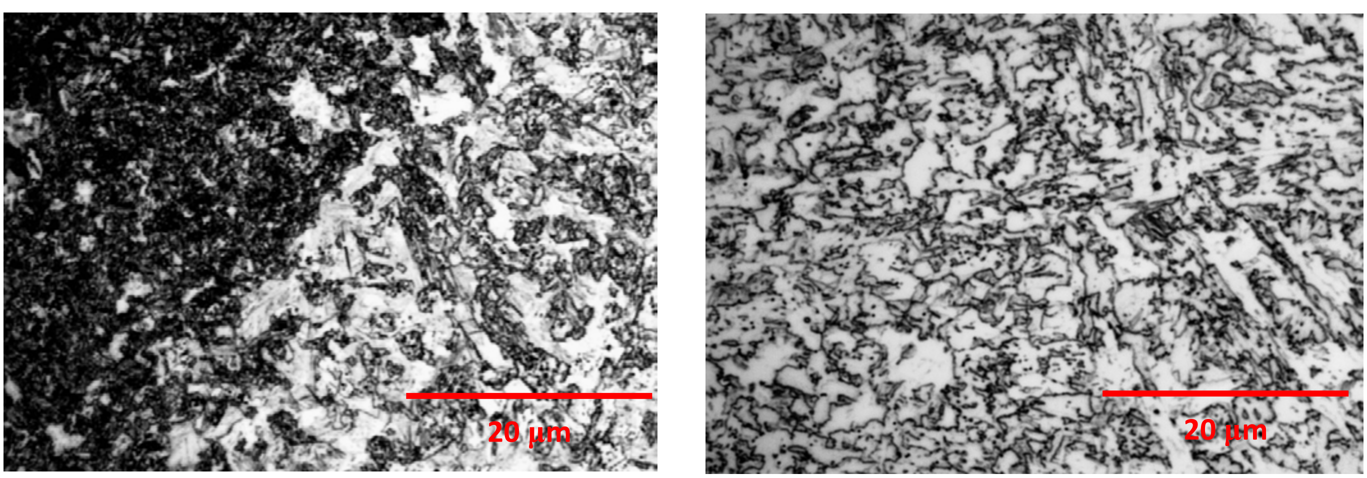


(a) (b)

Figure 1. Micrographs of welded sample with no preheat, (a) near fusion (b) weld



(a) (b)

Figure 2. Micrographs of welded sample at 200°C preheat, (a) near fusion (b) weld