ABSTRACT

EN24 steel is widely used to fabricate components for power transmission in industry due to its high strength to weight ratio. The hardness of this steel in tempered (T) condition, EN24T, is between 265 HV10 and 320HV10 and tensile strength between 850MPa and 1000MPa. On request, some manufacturers can supply the material in annealed condition, EN24A, with a hardness value of approximately 220HV10 and slightly lower strength. This steel can be fusion welded using a wide range of filler materials. However, no data has been provided for microstructure and property changes when EN24 steel is welded with austenitic electrodes in its Annealed and in Tempered condition in the presence of preheat and Post Weld Heat Treatment (PWHT).

In this work, comparative mechanical properties and microstructural features of the weldment and the Heat Affected Zone (HAZ) in EN24T and EN24A steel have been investigated. EN24T steel and EN24A steel bars were first preheated to 288 °C, arc welded with austenitic filler rods (A5.4 E312-16) then subjected to PWHT at 350 °C, 620 and 675 °C. Ultrasonic tests and X-Ray radiography were done to rule out discontinuities in weldment. Mechanical properties of resultant welded joint were considered to be a function of the filler rod material, base metal microstructure prior to welding and PWHT. The morphological features of microstructure in the Coarse Grained Heat Affected Zone (CGHAZ) and their evolution during PWHT were examined.

Charpy impact energies of the CGHAZ, microstructure and tensile properties of welded materials in relation to PWHT were evaluated. Hardness of EN24T steel bought from local market was found to be 328 HV10 and it softened to 233 HV10 after annealing. Hardness of as bought EN24T steel reduced with increase in PWHT temperature. Hardness of EN24A steel was not affected by PWHT. The hardest location in welded specimens was found to be in the HAZ at approximately 0.6 mm from the fusion line. Multi-pass welding was found to temper the previous HAZ and to increase the band of the hardest region from CGHAZ to the Fine Grained HAZ. The same effect was found to occur during PWHT. PWHT at 620 and 675 °C was found to temper all specimens to hardness below 300HV and a minimum difference in hardness levels between base metal and HAZ was found during PWHT at 675 °C. The tensile test specimens failed with a brittle fracture as no significant necking was observed on all welded specimens at all the PWHT conditions in this study. Generally, PWHT had no effect on the Ultimate Tensile Strength (UTS) of all specimens. Temper embrittlement in the CGHAZ was observed from results of hardness level and impact energy from EN24A steel subjected to PWHT at 350 °C. The same was not observed on EN24T steel specimens. The CGHAZ of single-pass welded specimens of EN24A and EN24T steel presented a martensitic structure. The CGHAZ microstructure of specimens that were subjected to PWHT at 620 and 675 °C comprised of carbide precipitates in ferrite. The microstructure of EN24A steel was not altered by PWHT but that of EN24T steel was transformed from tempered martensite to ferrite and cementite at 675 °C. PWHT had no effect on the microstructure and hardness of austenitic filler material comprising the weld metal.

At the PWHT temperature of 675 °C the room temperature - impact energy of CGHAZ in EN24A steel was higher than that of CGHAZ in EN24T steel by 22%.