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Influence of carbon content on the mechanical properties of 0.5 to 0.7% C steels with and without niobium and molybdenum addition

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The influence of molybdenum and niobium microaddition on the microstructure and mechanical properties of 0.5 to 0.7 %C steels used in railway wheels was studied. The deformation was applied by rolling, in a thermomechanical processing laboratory, simulating the forging in the real process of manufacture. The samples were heated to 1250 °C and hot rolled in four passes, starting at 1200 °C, undergoing a total reduction of 67%, followed by air cooling. Steel samples, before and after rolling were analyzed by optical, SEM and TEM. Mechanical tests were performed on the all conditions. As the samples were austenitized at 1250 °C, part of the niobium carbide present in steel was dissolved and reprecipitated in the form of fine particles (2 to 5 nm) during the deformation, restricting the austenitic grain growth. Thus, for the same amount of carbon, microalloyed steels presented austenitic grain size 30-40% smaller than non-microalloyed steels. It was also observed that the lower the carbon content of the steel, the lower the austenitic grain size for both microalloyed and non-microalloyed, indicating an important role of the carbon content on the austenitic grain size. For microalloyed steel de austenitic grain diameter (AGD) was $AGD\ (\mu m) = 53 \times \%C - 20$ and for carbon steel $AGD\ (\mu m) = 62 \times \%C - 19$. The niobium in solid solution decreased in 60 °C the temperature to start the pearlite formation, regardless of the carbon content, with consequent reduction of the pearlite interllamelar spacing near 50%. The pearlite refinement and the niobium carbide precipitation in the ferrite of the pearlite increased the hardness for steels with the same carbon content. Increasing the carbon content resulted in a higher pearlite volume fraction and an increase in the hardness of steels with and without Nb + Mo. Microalloying addition increased the yield strength and the ultimate tensile strength with small reduction in the ductility, expressed by the reduction of area and elongation, although it has not affected significantly the energy absorbed in the Charpy test.

Keywords: Carbides, Niobium, Molybdenum, Carbon steel.