On the Relationship of mechanical properties to magnetic response in plain carbon steel parts subjected to tempering treatment

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The present paper investigates the potential of nondestructive magnetic hysteresis loop (MHL) method to determine mechanical properties of plain carbon steels with unknown carbon and microstructure (resulting from various heat-treating processes). To simultaneously evaluate the effects of carbon content and microstructure on the magnetic and mechanical properties, four grades of hypoeutectoid steel samples (AISI 1035, AISI 1045, AISI 1055, and AISI 1070 containing respectively 0.30, 0.46, 0.54, and 0.71 wt.% carbon) were subjected to quench/tempering treatments. In the heat treating processes, after austenitizing the samples at 950 °C, they were quenched in water. Then, except for one sample in each group of the steels (as quenched state), others were tempered in the temperature range of 200 to 600 °C. Then, mechanical properties including tensile strength, yield strength, elongation, and hardness were measured using tensile and hardness tests, respectively. In the third section to study the magnetic responses of the samples to the external field, nondestructive MHL method was applied on the heat-treated samples. Plotting the hysteresis loop (B-H curve), maximum flux density, coercivity, and hysteresis loss were extracted as the MHL outputs. Finally, the relationships between mechanical properties and magnetic parameters were investigated. The results revealed that the proposed methodology is an effective tool to estimate the mechanical properties of the hypoeutectic plain carbon steel sample after tempering treatment

Fig. 1 demonstrates the variations in mechanical properties as a function of tempering temperature for the samples with different carbon contents. A considerable reduction in strength is observed with temperature which is due to the microstructural changes occured during tempering. The trend for the samples with different carbon contents is similar. Fig. 1 also shows the relationships of the Bmax extracted from hysteresis loops and tempering temperature. An insignificant decrease in Bmax is observed for the sample tempered at 200 °C which is attributed to the formation of transition carbides as a result of carbon diffusion from martensite structure. An increasing trend is observed for Bmax with increasing the tempering temperature from 200 °C to 600 °C. These variations are due to the releasing the residual stress (decreasing crystallographic defects) which facilitate the magnetization process which in turn results in larger values of Bmax. Besides, lower values of Bmax for the samples with higher carbon contents are directly attribute to the limiting role of carbon in the magnetization process [1, 2].

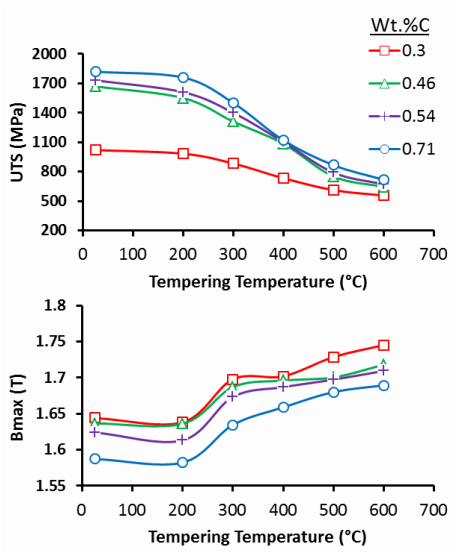

Figure 1. Variations of UTS and Bmax with tempering temperature for the samples with various carbon contents

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