Abstract

The effect of heat treatment processes (hardening and tempering) on microstructure, hardness, and impact properties at different test temperatures of as rolled 41Cr4, 42CrMo4, and 34CrNiMo6 medium carbon low alloy steels locally produced in Egypt has been studied. The impact specimens were hardened and tempered at different tempering temperatures, then tested at temperature range from room temperature to -70 °C.

The results showed that hardness decreases as the tempering temperature increases. The drop in hardness can be due to the microstructure changes from martensitic, hard phase, to spheroidal carbides in ferrite matrix, softer phase., The secondary hardening effect due to the precipitation of alloy carbides was not observed at the tempering temperatures lower than 650 °C in the present work.

The impact strength decreases when the tempering temperature increases from 200 °C to 300 °C then increases when the tempering temperature increases from 300 °C to 650 °C, So, minimum values of impact toughness were observed when the alloys are quenched and tempered round 300 °C. This minimum value is referred to, as tempered martensite embrittlement, (TME). For all alloys, tempered martensite embrittlement was observed at test temperature range from room temperature to -70 °C.

At constant tempering temperature, the impact strength of quenched and tempered alloys deceases as the test temperature decreases, since the fracture mode of alloys changes from ductile mode at or above room temperature to brittle mode at or below -70 °C.

The fracture surface of impact samples were examined using SEM. The fracture behavior of TME of alloys was intergranular fracture. So the occurrence of TME can be attributed to the formation of grain boundary carbides at prior austenite grain boundaries, and the impurity segregation, primarily phosphorus, to austenite grain boundaries during austenitization.

Intergranular fracture was detected at tempering temperature, 550 °C, in 34CrNiMo6 steel. This can be attributed to two-step temper embrittlement. Two-step temper embrittlement may occur, due to the fact that the nickel addition stimulates phosphorus to segregate to the prior austenite grain boundaries.

The fracture mode of quenched and tempered alloys changes from mixture of ductile rupture, quasicleavage, and intergranular fracture, at low tempering temperature (200 °C), to mainly ductile rupture, at high tempering temperature (650 °C).

In addition, the effect of tempering temperature on the ductile to brittle transition temperature (DBTT) was studied. The results showed that the ductile to brittle transition temperature (DBTT) decreases when the tempering temperature increases.