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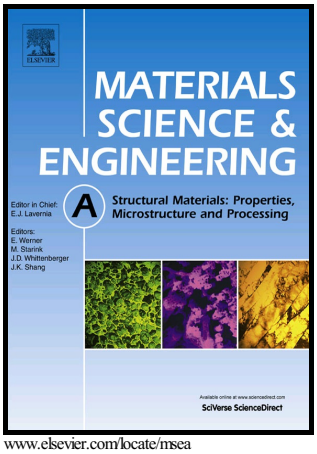

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High toughness and multiphase microstructure transition product of carburizing steel by a novel heat treatment cooling process

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Abstract

A novel heat treatment cooling process was applied to a Fe-0.27C-1.50Mn-1.7Si-0.35Cr-0.64Mo-1.50Ni-0.10V (wt%) carburizing steel. The cooling process was designed based on the continuous cooling transformation (CCT) and time-temperature-transformation (TTT) analyses of the carburizing steel. Mechanical property results of the heat treatment samples show that the carburizing steels exhibit excellent toughness (118J) which is superior to that of the traditional quenching process. Microstructural characterization indicates that high toughness of the carburizing steel subjected to the cooling heat treatment process results from a proper multiphase microstructure transition from the surface to the matrix of the steel. The key factors which greatly improve the toughness are the lower bainite consisting of fine ferrite laths and retained austenite films along the laths at the transition region and the carbide-free lower bainite at the matrix.

Keywords: carburizing steel; toughness; lower bainite; retained austenite.

1. Introduction

In recent years, it has been strongly required to extend the service life of machine components and structures due to economic and environmental reasons. To meet this demand, various surface engineering techniques have become major interest because they can provide additional surface properties such as high strength and wear resistance to structural materials [1]. Low carbon alloy steels have excellent toughness, but they possess relatively low strength and poor wear resistance. Therefore, it is very important to improve those properties by carburizing treatment.

After carburizing treatment, quenching and low temperature tempering process has been generally applied to obtain a good combination of strength and toughness. Many studies have been carried out to investigate the effect of process parameters such as quenching temperature, holding time, tempering temperature and time at a certain cooling rate generally as oil cooling on the mechanical properties of steels [2-6]. Rare studies have focused on the effect of cooling process on the mechanical properties. Chang investigated the microstructure and mechanical properties of 780 MPa grade steel plate manufactured by conventional reheat-quenching and tempering and direct-quenching and tempering processes [7]. Misra described the relationship between microstructure and impact toughness behavior as a function of cooling rate for industrially processed Nb- and V-microalloyed steels [8]. Traditional