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PAPER

Influence of the carburization time on the structural and mechanical properties of XC20 steel

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Abstract

This study focuses on the effect of carburization time on the structural and mechanical properties of low carbon XC20 mild steel (C. Wt.% <0.25). The XC20 steel was carburized with activated carbon with a carbon potential $Cp_1 = 1.1\%$, at 910 °C at different carburization times of 2, 4 and 6 h. The results obtained show that XC20 steel (non-carburized) has a ferrite-pearlitic structure with a hardness and a Young's modulus of the order of (150 HV, 26 KN/mm^2). After carburization, the structure of the carburized layer is transformed in martensite (Fe γ) in which cementite (Fe_3C) is imbricated. The depth of the carburized layer and the amount of carbon on the surface gradually increase with increasing carburization time. In addition, the carburized XC20 steel becomes hard and brittle where the hardness and Young's modulus have been increased for a high holding time until reaching maximum values (845 HV, 48 KN mm^{-2}) after 6 h of carburization . However, the toughness of XC20 steel has been reduced from 163 to 40 J cm^{-2}.

1. Introduction

Currently, steels are one of the most widely used materials in various industrial activities intended for the manufacture of piston pins, camshafts, levers, pump shafts, …because they are readily available, workable and weldable [1]. However mild steels with a low carbon content have less important chemical-physical and mechanical properties. For industrial applications, the middle steels have been considered a ferrite material due to its low carbon and used for automotive clutch parts, chain parts, automotive seat belt parts, springs and washers. However, the mechanical properties such as harness, toughness and resistance to stress are very poor as compared with other based carbon steels [2].

The surface layer is the area of a component that is the most exposed and stressed to chemical attack, friction and external forces. Generally, the enhanced mechanical properties superficial of steels can be achieved by changing the microstructure and chemical composition. This is typically controlled by the applied of different thermal or thermochemical treatments [3]. The usefulness of applying heat treatments to carbon steels (C% <0.25) remains limited, because this type of treatment does not improve sufficiently the surface's properties (hardness, resistance to wear and impact, fatigue, ...) to meet the severe requirements of contacting and moving parts [4–6]. Among them, carburization is one of the most effective thermochemical treatments, which aims at superficially enriching the surface with carbon in the atomic state (between 0.7 and 0.9 Wt. %) by diffusion in the austenitic phase (870 to 980 °C depending on the process) followed by quenching and eventual tempering in order to improve the surface's properties according to a decreasing gradient over a very limited depth without reaching the core [7–15]. Other hand, the presence of carbon would confine the grain refinement the steel surface, which inhibits the mobility of plastic deformation during solid-solid interactions [8, 11]. The resulting