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Microstructure and mechanical properties of P265GH cast steel after modification with TiCN particles

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ABSTRACT

Particles of TiCN and TiC were produced by means of self-spreading high temperature synthesis and after covering with metal protector were studied in order to be applied for modification of molten steel. After microstructure characterization the TiCN nano- and micron-sized particles were selected for modification of castings of P265GH steel and the microstructure and mechanical properties of the modified steel were studied and compared with those of the steel without modification. The data from microstructure-properties analysis of the modified steel showed that the steel treated with nano- and micro-sized particles has significantly refined microstructure, increased strength and hardness and improved elongation in comparison with the non-modified castings.

1. Introduction

One of the new methods for microstructure refinement and correspondingly improvement of the mechanical properties of metals and alloys is the modification with nano- and micron-sized particles [1–7]. The particles which are used as modifiers are usually nitrides, carbides, or borides with high melting temperature (2000 °C–3000 °C) and dimensions from 4 to 100 nm [8,9]. They are obtained usually by means of plasma chemical synthesis and are covered with metal protector. Their unique physical and chemical properties are prerequisite to be utilized for improvement of microstructure of the existing cast materials as well as for new materials designing. The investigations of nano-modified metal alloys show that the mechanical properties (tensile strength and specific elongation) [10–12] as well as the corrosion and abrasive resistance [13] increase due to the microstructure alternation as grain refinement and changes in the precipitation morphology. Nano-modifiers strongly increase the part of the surface energy in the total energetical balance of the alloy, which determines the phase transformations. Most of the nano-modifiers have low wetability and hence they are difficultly moistened by the molten metals. During the introduction of the modifiers in the melt and their uniform distribution in the volume local overcooling and conditions for volume crystallization with active crystallization nucleus are created by the nano- or/and micron-sized particles [8,10,11]. This leads to a significant grain refinement and crystal morphology alteration [14–16]. The non-metallic inclusions present in the structure also refine which additionally contributes to the improvement of the mechanical and service properties of nano-modified metals and alloys. The introduced nano-modifiers form self-organized dispersive systems which contribute to the heterogeneous nucleation. The nucleus is a solid phase surrounded by atoms accumulating and changing the local chemical composition of the molten metal in the close vicinity of the particle [3]. As a result the concentration overcooling in the adsorption layer is formed. It causes significant changes in the microstructure formation process. The active particles layer must assure conditions favorable for formation of chemical compound which density is close to the melt density and enough stable in the crystallization process. The as formed compound is endogenous formation, made by atoms of the melt which helps the activation of the exogenous high melting particle of nano-modifier. It is supposed that the above described interactions control the melt crystallization but however, a little is known about the exact mechanisms responsible for the improvement of the mechanical and corrosion properties of the nano-modified alloys. Most of the existing studies are made on Al alloys [1,2,9,12,17], Mg alloys [18,19], cast iron [4,8,9] and some on steels with specific application [6–8,13]. However, there is still lack of data about the influence of the micron- and nano-sized particles on the microstructure and properties of cast steels for general application. Depending on the type of the powders, their dimensions

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