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Optimization-Heuristic of Mechanical Properties of Acicular Ferrite Steel

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Abstract. *This paper presents two algorithms, Simulated Annealing and Iterated Local Search. Both metaheuristics use a neighborhood hybrid structure to evaluate their effectiveness and maximize the mechanical strength of microalloyed steel. Tests show that the best metaheuristic for this type of problem, which makes use of a neighborhood structure and a chemical composition, is Iterated Local Search because it gives a better mechanical strength than Simulated Annealing. Acicular Ferrite was developed in the laboratory using the best mechanical properties obtained by the heuristics in computational tests. Then the mechanical strength of the created steel was evaluated. The experimental results show that the yield strength obtained in the laboratory is comparable to that obtained in computational tests.*

Keywords: yield strength; chemical composition; Iterated Local Search; Simulated Annealing;

1. Introduction

Steels constitute a very large group of alloys, with the common feature that iron is the major component. The many types of steels are well defined by their chemical composition ranges and microstructures which produce properties suitable for certain applications. The mechanical properties of steels depend in a complex way on their chemical composition and heat treatment. The strength of low carbon steel is improved by the addition of alloying elements and modification of their microstructure through the introduction of low transformation temperature austenite products. For instance, bainite, acicular ferrite for very low carbon steels, or martensites are possible microstructures which generally lead to diminished ductility in the transformed steel. The design of such steels, with high strength and adequate ductility, from fundamental theories is a very difficult task. Also, what is not achieved or often even considered is an optimized combination of mechanical properties, since an optimal steel strength can often be produced by combining different alloying elements, given a selected microstructure.

High-strength low-alloy (HSLA) steels, also known as microalloyed steels, are a group of alloy steels that have small amounts of alloying elements such as titanium (Ti), niobium (Nb), and vanadium (V), among others. Such additions play a key role in refining the grain size and precipitation hardening (Show et al., 2010) for microalloyed steels. These kinds of steels show outstanding mechanical properties at a cost only moderately higher than that of carbon steels. They are cost-effective for diverse applications such as use in cars, trucks, bridges, oil and gas extraction, construction equipment, and off-road vehicles (Zhao et al., 2013a; Zhao et al., 2013b). Over the past several decades, widespread investigations have been conducted with the goal of refining their toughness and strength in order to meet the mechanical property requirements for several real applications (Zhao et al., 2013c; Zhao et al., 2013d; Mousavi Anijdan, 2012; da Silva, 2006; Bhadeshia, 2001).

The performance of HSLA pipeline steels for oil and gas transport requirements have improved steadily over the years. API X52 class steel was used before 1965, and the practical application of X100 began in 2002. This means that strength requirements have doubled in the past 35 years. As a result, steel products are assuming an ever greater importance in the energy industry.

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