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Application of Quenching and Partitioning Treatment During Press Hardening

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Abstract

Quenching and Partitioning (Q&P) is an advanced heat treatment for production of high strength steels, with the aim of having martensitic matrix with some amount of lath type retained austenite. In this microstructure, martensite gives a high strength while the retained austenite improves the ductility as well as toughness of the component.

In this study, the concept of Q&P treatment has been utilized on a low carbon-high silicon steel during a press hardening process by controlling the quench temperature of the die and adding an subsequent heating step. High strength at the same time as good ductility combined with low production costs make this method attractive for automotive applications. The resulting mechanical properties in correlation with microstructure of samples out of different processing conditions are discussed in the paper, while PHS1500 was used as reference for comparison in this work.

1 Introduction

The continuous interest in lightweight and high-performance materials has become priority in various industries, especially in the automotive industry[1]. For this ambition, press hardening of steel has received a large attention as a manufacturing process which offers an exceptional combination of formability, strength, and weight reduction. To further optimize the mechanical properties of press-hardened steels, researchers from academia and industries have been working on combining the press hardening process with advanced heat treatment techniques. Among these, the Quenching and Partitioning (Q&P) treatment has earned major interest due to its potential to tailor the microstructure and boost the mechanical performance of sheet steel products[2,3].

This paper investigates the effect of different Quenching and Partitioning treatment cycles on microstructure and mechanical properties of a press-hardened steel. By strategically combining rapid quenching with controlled partitioning, the Q&P treatment enables the creation of complex microstructures, leading to improved strength, ductility, and toughness [4,5]. Understanding the intricacies of this treatment within the press hardening context is crucial for employing its full potential and developing the capabilities of press-hardened steel components.

Through an in-depth analysis of the underlying mechanisms, process parameters, resulting microstructural changes and corresponding performance induced by the Q&P treatment during press hardening, this paper aims to contribute to the growing body of knowledge in this field and developing new insights for designing lightweight yet robust components, helping to produce more sustainable steel products considering the advancements in performance and fuel efficiency across diverse applications.

2 Materials and Methods

2.1 Materials

In this study, a new steel grade developed by SSAB for Q&P application with the thickness of 2.5 mm has been used, while PHS1500 from the same company has been used as reference for comparison. The carbon and silicon content of the steels and experimentally measured Ms temperatures are reported in Table 1.