9th International Conference on Hot Sheet Metal Forming of High-Performance Steel — CHS² 2024
27–29 May 2024, Nashville, Tenn., USA
10.33313/512/B0801

Microstructural Characterization *and Tensile Fracture Behavior of PHS2000 in Comparison With PHS1500*

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Abstract

Crashworthiness is an important characteristic that needs to be considered in design and engineering of vehicles or structures to ensure occupant safety during crashes or collisions. The automotive industry is working hard to develop innovative sustainable solutions, for example by aiming to use less material during manufacturing to reduce energy, with a subsequent reduction in CO_2 emissions. Vehicle weight reduction stands out as a viable strategy and consequently, the development of high strength and thus light weight steel components with maintained crashworthiness properties becomes necessary.

Press hardening technology emerges as a pivotal solution. This process involves heating a steel blank to the austenitization region followed by a simultaneous quenching and forming. In press hardening, thin sheets with ultra-high strength can be transformed into complex shapes, resulting in lightweight yet strong components. However, to comprehensively assess the crashworthiness of these components, an in-depth evaluation of their fracture toughness properties is essential.

The present work investigates the influence of processing on the mechanical properties of two uncoated press hardening steels (conventional PHS1500 and the more novel PHS2000). As reference material, a batch of specimens was produced from blanks produced in a press hardening line. The fracture behaviour was evaluated using the essential work of fracture (EWF) test methodology. Subsequently, the discussion involves a comparison of the absorbed energy with the fractography and microstructure features observed.

1 Introduction

Low and medium carbon steels quenched to martensite are widely used in many applications. These steels are often tempered after quenching to modify microstructure and properties according to the needs of applications. As-quenched martensite is a key microstructure as it can be used as the parent microstructure for subsequent tempering stages. Consequently, different microstructures and mechanical properties can be achieved by tempering [1], [2]. The martensitic transformation is considered a diffusionless transformation, therefore, as-quenched martensite is supersaturated by carbon and other substitutional alloying elements dissolved in austenite prior to quenching [3]. This supersaturation may lead to the precipitation of carbides during subsequent tempering stages resulting in different microstructures and thus different mechanical properties. In most carbon steels, carbide

precipitation may take place even during the fast cooling in the austenite to martensite transformation. This is due to a high driving force that arises when the carbon atoms have to adapt to a bct-bcc lattice structure for which the carbon solubility is limited. This process is termed auto-tempering [4], [5]. The level of auto-tempering is influenced by the temperature interval between the martensite start temperature (Ms) and room temperature as well as the cooling rate [6]. Therefore, the more time provided for the quenching from Ms to room temperature (ΔT) the more auto-tempering is generated. As a result, the mechanical behaviour of the steel can be influenced [6], [7].

The martensite is a key microconstituent that results in ultra-high strength of the steel. Press hardening is an industrial process used to produce automobile parts and components via simultaneous quenching and forming in between dies resulting in a martensitic structure [8].