Effect of Microstructure on Impact Toughness of Press Hardening Steels with Tensile Strength above 1.8GPa

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Abstract

Modern automotive body structures incorporate an increasing amount of press hardening steel (PHS) stampings to simultaneously increase vehicle safety and reduce mass for improved fuel economy. Recent advances in steel metallurgy have increased PHS tensile strengths from 1.5 GPa to 2.0 GPa by increasing carbon content to approximately 0.30-0.35 mass contents in %. However, increased carbon in martensite may lead to lower impact toughness and an increase in the ductile-to-brittle transformation temperature. This paper will examine additional toughening mechanisms that address these deficiencies by utilizing a customized Charpy V-notch (CVN) impact test to quantitatively assess the toughness of selected PHS materials. Microstructural features such as refined prior austenite grain size (PAGs), retained austenite, and surface decarburization zone are shown to enhance impact performance as measured by thickness-normalized CVN energy. A 15% to 50% improvement in upper shelf energy is achieved for selected alloys relative to 22MnB5 utilizing one or more of these toughening mechanisms. On the contrary, incomplete austenitization can dramatically reduce impact toughness. Higher nitrogen content in the boron-bearing steels also impairs toughness because large TiN particles can serve as crack initiation sites. Several toughness-enhanced PHS grades demonstrate a 25% increase in absorbed energy for crack initiation relative to the 22MnB5 as assessed by static 3-point bending tests of the hot stamped hat section components.

1 Introduction

Press hardening steels (PHS) with tensile strengths of approximately1.5 GPa after hot forming are widely used to construct the safety cage of a vehicle body for passenger safety in the case of a crash event. Typical body components such as B-pillar reinforcement, door impact beam and roof rail reinforcement, are made of the same steel grade 22MnB5, and all require high tensile strength and adequate impact toughness to resist intrusion and absorb energy during vehicle collision. Recent progress in hot forming technology in response to the industry-wide demand for vehicle light-weighting, has focused on developing new PHS alloys with tensile strengths of 1.8-2.0 GPa [1-2]. This can be readily increased and is primarily controlled by the carbon content of the martensite in the microstructure after hot forming. However, it is well-known that room temperature impact