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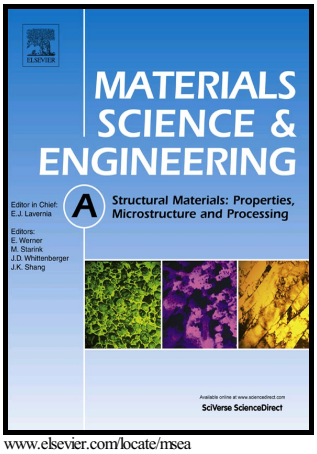

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PII: S0921-5093(18)31103-1
DOI: https://doi.org/10.1016/j.msea.2018.08.052
Reference: MSA36823

To appear in: *Materials Science & Engineering A*

Received date: 6 April 2018
Revised date: 14 August 2018
Accepted date: 14 August 2018

Cite this article as: Jae Ik Yoon, Hak Hyeon Lee, Jaimyun Jung and Hyoung Seop Kim, Effect of grain size on stretch-flangeability of twinning-induced plasticity steels, *Materials Science & Engineering A*, https://doi.org/10.1016/j.msea.2018.08.052

Effect of grain size on stretch-flangeability of twinning-induced plasticity steels

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ABSTRACT

The effect of grain size on stretch-flangeability was investigated to determine its influence on stretch-flangeability of high strength steels. To avoid other effects of microstructure, single-phase twinning-induced plasticity (TWIP) steels were selected for the investigation. To control the grain size of two types of TWIP steels, 1) the initial specimen was annealed at 1100 ℃ to increase its grain size, or 2) subjected to high-pressure torsion then annealed at 650 ℃ to reduce the grain size. The microstructural features were analyzed using the electron backscatter diffraction. The stretch-flangeability of TWIP steels with various grain sizes was evaluated using a hole-expansion test. It was found that the hole-expansion ratio follows the Hall-Petch correlation as does fracture toughness. To improve the stretch-flangeability of high strength steels, microstructural features should be designed to increase their fracture toughness.

Keywords: Hall-Petch correlation; Microstructural effects; Hole-expansion test; High-pressure torsion; Recrystallization

1. Introduction

Nowadays, development of advanced high strength steels (AHSS) or ultra-high strength steels (UHSS) for lightweight vehicles has become more and more important due to the increasing trends of saving environment and strict safety regulations around the world. Third-generation steels (e.g., quenching-and-partitioning steels; medium Mn steels) [1-4] with tensile properties superior to conventional AHSS (e.g., dual-phase (DP) steels; transformation induced plasticity (TRIP) steels; twinning induced plasticity (TWIP) steels) are being developed [5-10]. Although the developed AHSS or UHSS have excellent tensile properties, these steels are inferior in other ways, such as high susceptibility to hydrogen embrittlement [11-13], inferior bendability [14], and poor stretch-flangeability [14,15]. From among these, stretch-flangeability is an essential requirement to allow steel sheets to be formed successfully into automotive parts [16].

Microstructures of steels affect their macroscale characteristics, and knowledge of this relationship is used to guide development of steels that have desired properties. However, few systematic studies have considered how microstructures affect the stretch-flangeability of AHSS or UHSS. For this reason, it is difficult to set the direction of developing AHSS or