Effects of microstructure on tensile behaviour in aluminum-containing TRIP steel

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Introduction

Transformation-induced plasticity (TRIP) steels undergo a phenomenon where the metastable retained austenite phase transforms into martensite during deformation. This “TRIP effect” results in high strength, high elongation and good crashworthiness that make the material ideal for automotive structural applications. Traditionally, the main alloying element in these steels is silicon, but new compositions have been introduced where the silicon is replaced with aluminum to improve the steel’s galvanizing properties. The current work studies two distinct microstructures in aluminum TRIP steel (labelled as equiaxed and lamellar) and how microstructure affects the austenite transformation during uniaxial tensile loading.

Methods and Results

The as-received material is a hot-band aluminum TRIP steel. After cold-rolling to a thickness of 1 mm, different heat treatment schedules were employed to obtain the two microstructures, shown in figure 1. A set of preliminary heat treatments were conducted where the temperatures and times of the heat treatments were varied to produce a TRIP microstructure with the maximum volume fraction of retained austenite, as determined via magnetic measurements. The volume fraction of retained austenite was used to evaluate the heat treatments because of its direct correlation to high ultimate tensile strength and high uniform elongation values. Results from uniaxial tensile tests (figure 2) show that the equiaxed microstructure exhibits higher strength and lower ductility than the lamellar microstructure, which is similar to findings from previous work with a silicon TRIP steel. Magnetic measurements will be conducted on a set of samples that are deformed to various strains to track the TRIP effect throughout the deformation process and to examine the retained austenite stability in each of the microstructures.

Figure 1: Optical micrographs of lamellar (top) and equiaxed (bottom) microstructures. Ferrite is tan, bainite is dark brown, martensite/retained austenite is white

Figure 2: Engineering stress-strain curves for both microstructures