Three generations of advanced high-strength steels for automotive applications, Part II

The second generation

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Editor's Note: This article is Part II of a three-part series summarizing the three generations of advanced high-strength steels (AHSS) used in automotive applications. Part I, which appeared in the November/December 2013 issue, discussed first-generation AHSS. Part III, which will appear in the March/April 2014 issue, will discuss third-generation AHSS.

Typical advanced high-strength steels (AHSS) have limited formability that decreases even more as strength increases. Thus, over a strength level of 1,000 to 1,200 MPa (145 to 175 KSI), cold forming of AHSS is limited to very simple geometries. Hot-stamped components, on the other hand, are limited to 5 to 7 percent total elongation after quenching and do not absorb as much energy under crash conditions as other AHSS do.

Steels with higher tensile elongation have better cold formability for stamping and more energy-absorbing capacity for automotive applications. First-generation AHSS typically get their formability from ferrite microstructure and their strength from martensite microstructures.

Induced Plasticity Effects

The difference in second generation AHSS is its austenitic microstructure—the key to the transformation-induced plasticity (TRIP) effect. When austenite is deformed, it transforms into martensite and thus gets stronger. This delays local necking and fracture in sheet metal forming. Regular TRIP steels, which are first-generation AHSS such as TRIP 980, have retained austenite that is only 10 to 15 percent of volume, but their formability is significantly better than that of other first-generation steels (see **Figure 1**).

Austenite is not stable in most steels at room temperature. However, high-alloy elements such as in austenitic stainless steels allow for up to 100 percent austenite, so these materials are more formable than the TRIP steels. Austenitic stainless steels are classified as second-generation AHSS, as they exhibit both high strength and elongation.

Another strengthening mechanism is twinning-induced plasticity (TWIP). TWIP steels also are 100 percent austenite at room temperature. However, in these steels, high-alloy elements (greater than 15 percent manganese) cause formation of twins when the steel is deformed. The twin boundaries act like grain boundaries to strengthen the steel. These steels typically have more than 50 percent elongation at a strength level of about 1,000 MPa (about 145 KSI).

In addition to TWIP and austenitic stainless steels, new triplex steels are being developed. They have very high manganese alloy (15 to 30 percent), among other elements.

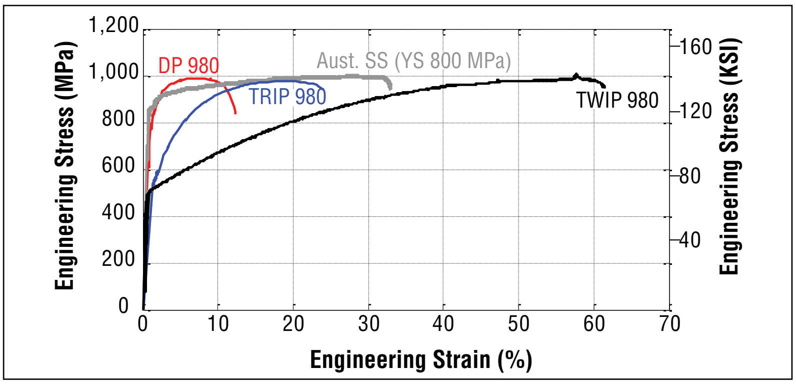

Figure 1

The formability of second-generation AHSS is significantly higher than first-generation AHSS at a tensile strength of 980 MPa (140 KSI).

Current Applications of Second-generation AHSS

Second-generation AHSS have very high formability and strength, but their use in the automotive industry still is limited. This can be attributed to two main factors:

1. High alloying elements increase the cost of steel.
2. The material has a tendency for delayed cracking—fracture after the part is formed and stored.

Currently only several high-end

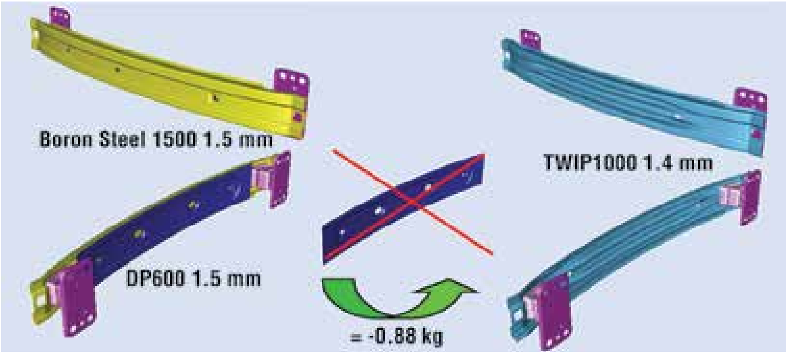

Figure 2

The bumper assembly of the FIAT® 500 has been replaced with a one-piece TWIP steel in the FIAT Panda.

vehicles such as the Audi A6®, A8®, and Porsche Panamera® have austenitic stainless steel components in their chassis and bodies. The additional cost of this steel can be justified by light weight and the ability to fit the component in a limited space. Several studies have shown that it is possible to cold-form complex components (such as B-pillars) with stainless steel. It also is possible to hot-form and quench the steels to gain even more strength.

Steelmakers are preparing guidelines that can solve the issues of welding and delayed cracking in TWIP steels. One solution for delayed cracking, for instance, is to add more alloying elements such as aluminum.

Several steel companies currently offer TWIP grades with 980-MPa (140-KSI) strength, and even higher strengths may be possible. TWIP steel has found only one major automotive application at this point: In the FIAT Panda, the front bumper assembly has been replaced with a one-piece TWIP steel bumper beam (see **Figure 2**).

Although these steels have not been used extensively in the automotive industry, according to a recent survey at the Materials in Car Body Engineering conference (May 2013, Bad Nauheim, Germany, sponsored by Automotive Circle Intl.), 87 percent of the participants from the automotive industry believe that TWIP steels can be applied in mass production in select applications with further improvements. ST

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