Automotive Steel Definitions

Today's AHSS

Advanced High-Strength Steels (AHSS) are complex, sophisticated materials, with carefully selected chemical compositions and multiphase microstructures resulting from precisely controlled heating and cooling processes. Various strengthening mechanisms are employed to achieve a range of strength, ductility, toughness, and fatigue properties. These steels aren't the mild steels of yesterday; rather they are uniquely light weight and engineered to meet the challenges of today's vehicles for stringent safety regulations, emissions reduction, solid performance, at affordable costs.

The AHSS family includes Dual Phase (DP), Complex-Phase (CP), Ferritic-Bainitic (FB), Martensitic (MS or MART), Transformation-Induced Plasticity (TRIP), Hot-Formed (HF), and Twinning-Induced Plasticity (TWIP). These 1st and 2nd Generation AHSS grades are uniquely qualified to meet the functional performance demands of certain parts. For example, DP and TRIP steels are excellent in the crash zones of the car for their high energy absorption. For structural elements of the passenger compartment, extremely high-strength steels, such as Martensitic and boron-based Press Hardened Steels (PHS) result in improved safety performance. Recently there has been increased funding and research for the development of the "3rd Generation" of AHSS. These are steels with improved strength-ductility combinations compared to present grades, with potential for more efficient joining capabilities, at lower costs. These grades will reflect unique alloys and microstructures to achieve the desired properties. The broad range of properties is best illustrated by the famous Global Formability Diagram, captured in Figure 2-1 following. Steels with yield strength levels in excess of 550 MPa are generally referred to as AHSS. These steels are also sometimes called "ultrahigh-strength steels" for tensile strengths exceeding 780 MPa. AHSS with tensile strength of at least 1000 MPa are often called "GigaPascal steel" (1000 MPa = 1GPa). Please note another category of steels, represented in Figure 2-1 following as Austenitic Stainless Steel. These materials have excellent strength combined with excellent ductility, and thus meet many vehicle functional requirements. Due to alloying content, however, they are expensive choices for many components, and joining can be a challenge. Third Generation AHSS seeks to offer comparable or improved capabilities at significantly lower cost.

Definitions

Automotive steels can be classified in several different ways. One is a metallurgical designation providing some process information. Common designations include low-strength steels (interstitial-free and mild steels); conventional HSS (carbon-manganese, bake hardenable and high-strength,low-alloy steels); and the new AHSS (dual phase, transformation-induced plasticity, twinning-induced plasticity, ferritic-bainitic, complex phase and martensitic steels). Additional higher strength steels for the automotive market include hot-formed, post-forming heat-treated steels, and steels designed for unique applications that include improved edge stretch and stretch bending.

A second classification method important to part designers is strength of the steel. Therefore, this document will use the general terms HSS and AHSS to designate all higher strength steels. This classification system has a problem with the on-going development of the many new grades for each type of steel. Therefore, a DP or TRIP steel can have strength grades that encompass two or more strength ranges.

A third classification method presents various mechanical properties or forming parameters of different steels, such as total elongation, work hardening exponent (n-value), or hole expansion ratio (λ). As an example, Figure 2-1 compares total elongations – a steel property related to formability – to the tensile strength for the current types of steel. These properties are important for press shop operations and virtual forming analyses.

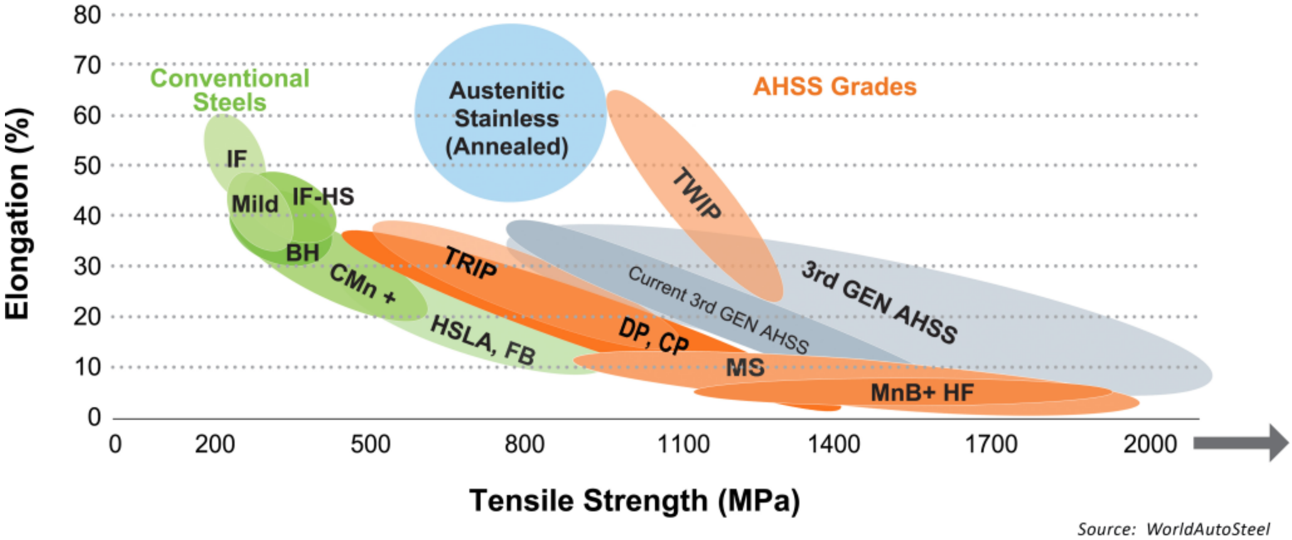

Figure 2-1: ***Global Formability Diagram for Today's AHSS Grades (includes comparison of traditional low-strength and high-strength steels)***

The principal difference between conventional HSS and AHSS is their microstructure. Conventional HSS are single-phase ferritic steels with a potential for some pearlite in C-Mn steels.. AHSS are primarily steels with a microstructure containing a phase other than ferrite, pearlite, or cementite – for example martensite, bainite, austenite, and/or retained austenite in quantities sufficient to produce unique mechanical properties. Some types of AHSS have a higher strain hardening capacity resulting in a strength-ductility balance superior to conventional steels. Other types have ultra-high yield and tensile strengths and show a bake hardening behavior.

Since the terminology used to classicy steel products varies considerably throughout the world, this document uses the WorldAutoSteel format to define the steels. Each steel grade is identified by metallurgical type, minimum yield strength (in MPa), and minimum tensile strength (in MPa). As an example, DP 500/800 means a dual phase steel with 500

MPa minimum yield strength and 800 MPa minimum ultimate tensile strength. The ULSAB-AVC program first used this classification system.

Metallurgy of AHSS

Manufacturers and users of steel products generally understand the fundamental metallurgy of conventional low- and high-strength steels. Section 2.B. provides a brief description of these common steel types. Since the metallurgy and processing of AHSS grades are somewhat novel compared to conventional steels, they are described here to provide a baseline understanding of how their remarkable mechanical properties evolve from their unique processing and structure. All AHSS are produced by controlling the chemistry and cooling rate from the austenite or austenite plus ferrite phase, either on the runout table of the hot mill (for hot-rolled products) or in the cooling section of the continuous annealing furnace (continuously annealed or hot-dip coated products). Research has provided chemical and processing combinations that have created many additional grades and improved properties within each type of AHSS.