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# Advanced high strength steels for automotive industry

R. KUZIAK
Instytut Metalurgii Żelaza, ul. Karola Miarki 12-14, 44-100 Gliwice, Poland

R. KAWALLA, S. WAENGLER
Institute for Metal Forming, Bernhard v. Cotta Str. 4, 09596 Freiberg, Germany

The aim of this paper is to present the basic concepts of advanced high strength steels (AHSS) for use in the automobile industry, including chemical composition design, microstructure and mechanical properties development during thermomechanical processing, production technology characterisation, potential applications and performance in service. AHSS steels are considered to be the major materials for future applications in this production sector. As opposed to the cold formable single phase deep-drawable grades, the mechanical properties of AHSS steels are controlled by many factors, including: phase composition and distribution in the overall microstructure, volume fraction, size and morphology of phase constituents, as well as stability of metastable constituents. The main feature of these steels is that they do not permit to rely on the well-established traditional microstructure-properties relationships. Therefore, many different alloy concepts and alternative processing routes are still under development by different steel producers for comparable steel grades.

Keywords: a*dvanced high strength steels, automobile industry, microstructure, mechanical properties, thermomechanical treatment, weldability, crash worthiness*

## 1. Introduction

Over the last decade, a strong competition between steel and low density metal industries has been observed as a result of increasing requirements of passenger safety, vehicle performance and fuel economy. The response of steel industry to the new challenges is a rapid development of higher strength steels, named Advanced High Strength Steels (AHSS) [1]. These steels area characterised by improved formability and crash worthiness compared to conventional steel grades. The category of AHSS covers the following generic types: dual phase (DP), transformation induced plasticity (TRIP), complex phase (CP) and martensitic steels (MART).

The AHSS may be distinguished based upon the strength properties that roughly can be defined: yield strength > 300 MPa and tensile strength > 600 MPa. As opposed to the conventional high strength steels, in which ductility decreases with strength, modern AHSS steels combine high strength and formability/ductility. General classification of these steels is as follows:

- Highs strength steels with a high energy absorption potential (DP and TRIP steels with UTS < 1000 MPa), for dynamic loading occurring during car crashes or collisions.

• Extremely high strength steels, typically martensitic steels, with a very high UTS (>1200 MPa), providing high stiffness, anti-intrusion, load-transferring barriers for the protection of automotive passengers.

• The rationales for increased use of the AHSS in the automotive industry are as follows:

• The reduction of the car weight resulting from the use of high strength thinner gauge sheet steel, reducing the fuel consumption.

• Increased passenger safety by an improved crash worthiness.

• The strong competition from the light-weight materials, such as Al and Mg alloys and plastics.

AHSS derive their properties from multi-phase complex microstructure. Since these steels are relatively new, their classification differs from conventional high strength steels and was developed by Ultra-Light Steel Automotive Body – Advanced Vehicle Concept (ULSAB-AVC) Consortium [1]. The accepted practice involves specification of both yield strength (YS) and ultimate tensile strength (UTS) in the following way:

*XX aaa*/*bbb*,

where *XX* is type of steel, *aaa* is minimum YS in MPA and *bbb* is minimum UTS in MPA.

For example DP 280/600 designates dual phase steel with 280 MPa minimum yield strength and 600 MPa minimum ultimate tensile strength.

## 2. Microstructure – mechanical properties characterisation

### 2.1. Dual phase steels

Microstructure of dual phase steels is composed of soft ferrite matrix and 10–40% of hard mastensite or matrensite-austenite (M–A) particles (Figure 1). This type of microstructure allows achieving the ultimate tensile strength in the range of 500–1200 MPA. When the volume fraction of martensite exceeds 20%, DP steels are often called partial martensitic. For some applications, also baintic constituent may be desirable in the DP steel microstructure. This dual phase type of microstructure can exhibit the following advantageous features over the conventional high strength steels:

• The strength of the DP steel microstructure is controlled by the amount of martensite and ductility by the size and distribution of this phase,

• DP steels do not exhibit yield point elongation,

• DP steels posses low UTS/YS ratio (around 0.5) and high strain hardening characteristics (high *n* value), especially at the beginning of plastic deformation,

• They can be strengthened by static or dynamic strain ageing (BH effect),