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Review Article

A Review on Advance High Strength Steels

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Abstract

Today, automotive manufactures looking for new materials which are lightweight and by using their applications, strengths that can built a various body part of car and for this the most coefficient way to do this with Advanced High Strength Steel (AHSS). Because it gives car safety, fuel economy and increases performance standard these applications only can achieve by its properties like high strength, Light weight, high stiffness. This paper involves the basic study of Advance High Strength Steel (AHSS), its types, and formability of AHSS.

Keywords: *advance high strength steel, dual phase, complex phase, MS, TRIP.*

1. Introduction

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 (E. Billur, *et al*, 2010).

Assembly cost of aluminum is 20 to 30 times that of steel, Body structure of aluminum costs 60 to 80 % more than steel. All indication shows that steel has big advantage in costs and performance compared to other lightweight materials. With the introduction of AHSS the specific strength of those steels became comparable with those of aluminum and magnesium alloys. Only carbon fiber reinforce polymer have better specific strength values, but their high cost and complicated manufacturing prevent them from being considered for high volume vehicle production. Although the density of aluminum and magnesium alloys is lower than those of steel their yield strength and ductility combinations are much lower than those of other grades of steel (Tohru Yoshida, *et al*, 2013).

The major difference between convention HSS and AHSS is their microstructure. Conventional HSS are single phase ferrite steel whereas AHSS are multi-phase steel that contains ferrite; martensite, bainite and/ or retained austenite the first generation of AHSS derive their strength to a large extent from manipulation of microstructures and not from alloying. Therefore, they can be produced for approximately the same price as traditional HSS (Zhang Y, *et al*, 2013).

2. Types of AHSS

The major attribute of AHSS is their extremely high strength. This means that thinner sheets of AHSS are used to replace current thick steel components in addition advance, in optimization methods and manufacturing processes have increase the mass savings achievable in AHSS. These improvements in technology have enabled, AHSS to be at the same level with aluminum concerning lightweight application. According to this followings are various types of AHSS.
Dual Phase (DP).

It is a high-strength steel which contain ferrite and martensite in its microstructure. Duel phase steel have high ultimate tensile strength which is enable by martensite and low initial yielding stress which is given by the ferrite phase. These features change the state of DPS for ideal materials in automotive-related sheet forming operations (E. Billur, *et al*, 2010).

Their advantages are as follows;

- Low yield strength.
- Low yield to tensile strength ratio, which approximately equal to 0.4 to 0.5.
- High initial strain hardening rates.
- Good uniform elongation
- An energy absorption capacity is high.
- Good fatigue resistance.

Due to these properties D.P steel is mostly used for automotive body panels, wheels, and bumpers.

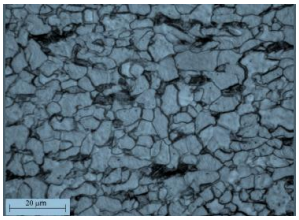

Fig.1 Dual phase steel microstructure

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Transformation Induced Plasticity (TRIP)

It is a high-strength steel commonly used in the automotive industry. TRIP stands for "Transformation induced plasticity." It is known for its excellent combination of Strength and Ductility. Its microstructure consisting of retained austenite in a ferrite matrix. It also contains hard phases like banite and martensite. TRIP steels results in significant volume fractions of retained austenite in the final microstructure because of higher contain of silicon and carbon contain. To obtain sufficient carbon content for stabilizing the retained austenite phase to below ambient temperature, TRIP contain the higher quantity of carbon than duel phase steel. Higher content of silicon and/or aluminum, are also added to avoid formation of carbide in the bainite region. Due to their high energy absorption capacity and fatigue strength, TRIP steels are mostly suited for automotive structural and safety parts like cross members, longitudinal beams, reinforcements, sills and bumper reinforcements. (Tohru Yoshida, *et al*, 2013).

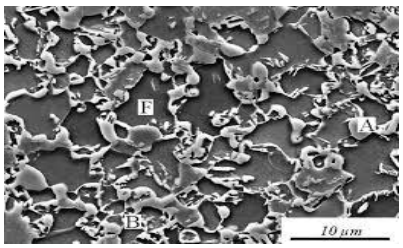

Fig.2 TRIP steel microstructure

2.1 Martensitic Steel (MS)

For the production of MS steels, the austenite is transformed almost entirely to martensite during quenching on the run-out table or in the cooling section of the continuous annealing line which was present during hot rolling or annealing. It is characterized by a martensitic matrix which contains small amounts of ferrite and/or bainite.MS steel show highest tensile strength level among the various multiphase steels. MS steels provide the highest strengths up to 1700MPa of U.T.S. To improve ductility, MS steels are subjected to post-quenching technique and it can provide adequate formability even at extremely high strengths (Paul Geck, 2010).

Fig.3 MS steel microstructure

It gives steel good hardness and high toughness which is used largely for medical tools. Untampered martensite is low in toughness and therefore it is also brittle (Paul Geck, 2010).

2.1 Complex-Phase Steel (CP)

CP steels have all the usual characteristics of steel with very high ultimate tensile strengths. The microstructure of CP steels contains small amounts of martensite, retained austenite and pearlite in ferrite/bainite matrix's steels are characterized by high energy absorption, high residual deformation capacity and good whole expansion. Applications of CP are Rear suspension bracket, fender beam (Zhang Y, *et al*, 2013).

Fig. 4 C.P. steel microstructure

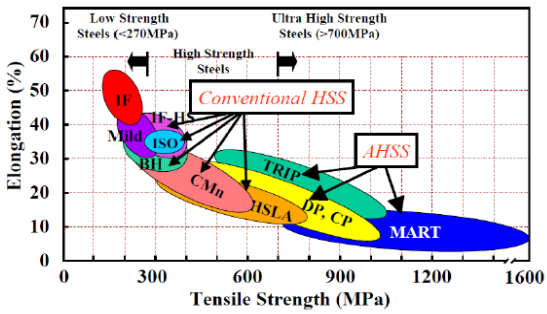

Fig. 5 Location of conventional HSS and first generation AHSS in strength elongation space

3. Material Properties

Steels are mostly used as structural member and therefore their mechanical properties like strength, toughness, stiffness and ductility are well studied for engineering application. The various properties of AHSS are given as follows (E. Billur, ***et al***, 2010).

3.1 Flow stress

Flow stress curves are often fit to Holloman's equation $\sigma = k\varepsilon^n$ in this equation, the strain hardening coefficient (n) is also referred as uniform elongation. Therefore, in AHSS, the strain hardening characteristic is not constant due to the multi-phase microstructure and the phase transformations during deformation.Holloman's

equation may not be valid for AHSS, since there is no constant value of *n* (Paul Geck, 2010).

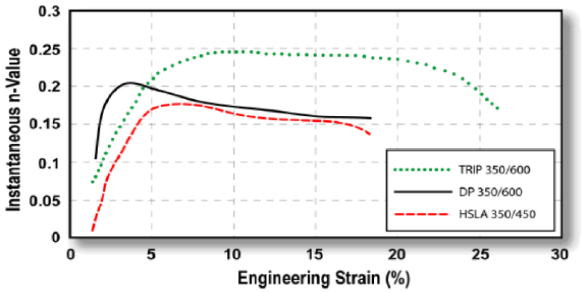

Fig. 6 Variation of instantaneous n-value with Engineering strain

3.2 Elastic Modulus

Elastic modulus consists of both loading (also known as Young's) and unloading (also known as apparent) modulus. Usually, it is assumed that both are same and constant for a material at given temperature. Although, studies shows that the loading and unloading moduli for AHSS are different. Unloading modulus decreases with plastic strain. For accurate spring back predictions, it is require considering the variation in unloading modulus (Paul Geck, 2010).

3.3 Strength

It is mainly depends on component geometry. AHSS provide an advantage in the design flexibility because of higher formability and work hardening characteristics (E. Billur, *et al*, 2010).

3.4 *Stiffness*

It is defined as the resistance to deflection the stiffness of panel depends upon the modulus of elasticity of material and its geometry, which is equal to the slope of elastic potion of the stress-strain curve (Tohru Yoshida, *et al*, 2013).

3.5 Toughness

It is defined as resistance of metal to facture for a metal to be tough both strength and ductility must be high the larger area under the stress-strain curve the more the energy that can be absorbed before facture the superior energy absorption capabilities of two AHSS (TRIP,DP) are evident compared to low carbon rephosphorized. The outstanding energy absorption of AHSS steel is the result of its high strength & excellent ductility (Professor J Billingham, *et al*, 2003).

4. Forming of AHSS

Compared to mild steels, AHSS grades have different failure mechanisms, which are caused by local failures that are observed highly common in forming of AHSS, during deformation because of multi-phase structure and phase changes (Paul Geck, 2010).

The high strength of martensite is get retain due to the combination of phases which keeps AHSS formable. Formability of the component is especially important in automotive manufacturing, where large presses and dies produce parts (Tohru Yoshida, *et al*, 2013). AHSS have a higher initial work hardening rate, their higher UTS &, especially dual phase steels, have lower ratio of yield strength to tensile strength. All these advantages combined with an excellent elongation show that AHSS have both high strength with good formability (Zhang Y, *et al*, 2013).

4.1 Spring back and Work hardening

During the stamping of automotive parts, dimensional control is important as well as necessary. New steels shows specific stress-strain curves, resulting in unique spring back levels and behaviors. It is having tendency for a material to return to its pre-formed position and has negative consequences for part dimensions, which referred as spring back. It is require to take an attention to make the spring back effect better by studding all the parameters in the manufacturing process. AHSS research has resulted in the development of new steels, like DP 980 and DP 1180 grades (Nazim Baluch, *et al*, 2014).

4. Future scope for AHSS

1) In the upcoming years, automobile manufactures will increase the addition of HSS and AHSS into vehicles, especially for the structural and safety component (Curt D. Horvath, 2004).
2) To improved vehicle performance in fuel efficiency, affordability and quality, AHSS will have to be used in number of new application (Professor J Billingham, *et al*, 2003).
3) To meet the future fuel economy targets for the majority of vehicles, AHSS already proven that the mass reduction of 25 percent or more (Karen Blanco, 2016).
4) First generation AHSS offer improved formability over wide range of strength compared to conventional steel. In this DP, FB, CP, MS, and TRIP are included (Karen Blanco, 2016).
5) Second generation AHSS, includes Twinning induced plasticity i.e. TWIP. Which are extremely strong and formable (Karen Blanco, 2016).
6) Third generation of AHSS have increased formability compared to first generation AHSS. These are currently being introduced commercially (Karen Blanco, 2016).

Conclusions

AHSS is fastest growing material in automotive application according to the 2015 report of Ducker worldwide. Also it gives various advantages like the car safety, fuel economy and increase performance. Compared to the AHSS, steel has more recycling ability.

The different types of AHSS like DP, CP, MS, and TRIP possess different types of advantages according to their microstructure. Although, the forming of the advance high strength steel involves various challenges because of the high strength, low formability along with the deflection in material properties, but with the combination of Duel phase and MS steel gives good strength, formability and weldability. This together with the addition of cost-effective process like cold-forming result in very much required and excellent application in automotive industry.

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