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High Strength Steel for Automotive Applications

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Abstract - *The automobile industry has to meet the demands of fuel efficiency and consumer safety along with stringent government norms. moreover, the factors like air pollution and the weight of the vehicle also needs to be taken into consideration. as a result, the choice of the material becomes a key decision in automobile industry. High Strength Steels(HSS)have proved to be satisfying all the above demands as they offer good balance of low cost, light weight and good mechanical properties.*

Key Words: High Strength Steels, formability, weldability, Ultra HSS, crash safety

1.INTRODUCTION

In automobile industry, vehicle designers face pressure to achieve the need of attaining good fuel economy, crash safety standards imposed by the government and to meet stringent consumer demands[4]. Out of many possibilities, reduction in the weight of the vehicle proved to be an excellent solution for the above stated problems. along with this, the material also needs to posses the qualities like good formability, joinability, weldability, pointability and also good mechanical behavior. this paper intends to present the advantages of using High Strength Steels (HSS) instead of the conventional materials used in the automobile industry along with their metallurgical properties.

1.1 High Strength Steels(HSS) classification:

Automotive steels can be defined in several different ways. The first is by metallurgical designation. Common descriptions include low-strength steels (interstitial-free and mild steels); conventional high-strength steels (carbon-manganese, bake hardenable, isotropic, high-strength IF, and high strength, low-alloy steels); and the newer types of advanced high-strength steels (dual phase, transformation induced plasticity, complex phase, and martensitic steels). The second classification method is based on one of the mechanical properties - strength. High- Strength Steels (HSS) are defined as those steels with tensile strengths from 270–700 MPa. Ultra- High-Strength Steels (UHSS) are defined as steels with tensile strengths greater than 700 MPa. A third classification method uses another of the mechanical properties – total elongation. As an example, chart 1-1compares total elongations – a steel property related to formability – for the different steel types. Note that the tensile strengths of HSS overlap both the HSS and UHSS range of strengths. In general, the HSS family has greater total elongations than conventional HSS of similar tensile strengths.

1.2 High Strength Steel Grades:

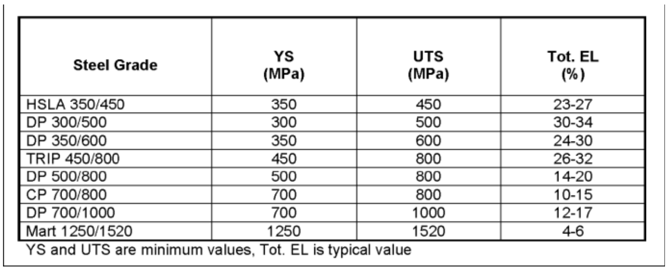
High Strength Steels(HSS) are defined as steels with yield strength from 210-550 MPa. Ultra High Strength Steels(UHSS) reach yield strength above 550MPa. The high strength steels grades include interstitial free(IF), brake hardenable(BH), carbon-Mn(C-Mn), dual phase(DP), complex phase(CP), martensitic steel(MP)and High Strength Low Alloy steels.

2. Metallurgy of HSS:

HSS include the following steel types:
DP(dual phase)steels, Dual phase steels consist of a ferritic matrix containing a hard martensitic second phase in the form of islands. These islands create a higher initial work hardening rate plus excellent elongation. This gives DP steels much higher ultimate tensile strengths than conventional steels of similar yield strength. **TRIP**(Transformation Induced Plasticity Steel) The microstructure of TRIP steels is retained austenite embedded in a primary matrix of ferrite. In addition to a minimum of 5% by volume of retained austenite, hard phases such as martensite and bainite are present in varying amounts. The retained austenite progressively transforms to martensite with increasing strain, thereby increasing the work hardening rate at higher strain levels. **Complex Phase(CP)**steels CP steels consist of a very fine microstructure of ferrite and a higher volume fraction of hard phases that are further strengthened by fine precipitates. They use many of the same alloy elements found in DP and TRIP steels, but also often have small quantities of niobium, titanium, and/or vanadium to form fine strengthening

precipitates. CP steels display higher yield strengths for equal tensile strength levels of 800 MPa and greater. CP steels are characterized by high deformability, high energy absorption, and high residual deformation capacity, **Martensitic Steels,** the austenite that exists during hot-rolling or annealing is transformed almost entirely to martensite during quenching on the run-out table or in the cooling section of the continuous annealing line. This structure can also be developed with post-forming heat treatment. Martensitic steels provide the highest strengths, up to 1700 MPa ultimate tensile strength. Martensitic steels are often subjected to post quench tempering to improve ductility, and can provide substantial formability even at extremely high strengths.

Table -1: - Examples of Steel Grade Properties



Steel Grade	YS (MPa)	UTS (MPa)	Tot. EL (%)
HSLA 350/450	350	450	23-27
DP 300/500	300	500	30-34
DP 350/600	350	600	24-30
TRIP 450/800	450	800	26-32
DP 500/800	500	800	14-20
CP 700/800	700	800	10-15
DP 700/1000	700	1000	12-17
Mart 1250/1520	1250	1520	4-6

YS and UTS are minimum values, Tot. EL is typical value

It is important to note that different specification criteria have been adopted by different automotive companies throughout the world and that steel companies have different production capabilities and commercial availability. Therefore, typical mechanical properties are shown above simply to illustrate the broad range of HSS grades that may be available. It is imperative to communicate directly with individual steel companies to determine specific grade availability and the specific associated properties such as:

1. Mechanical properties and ranges.

2. Thickness and width capabilities.

3. Hot-rolled, cold-rolled, and coating availability.

4. Chemical composition specifications.

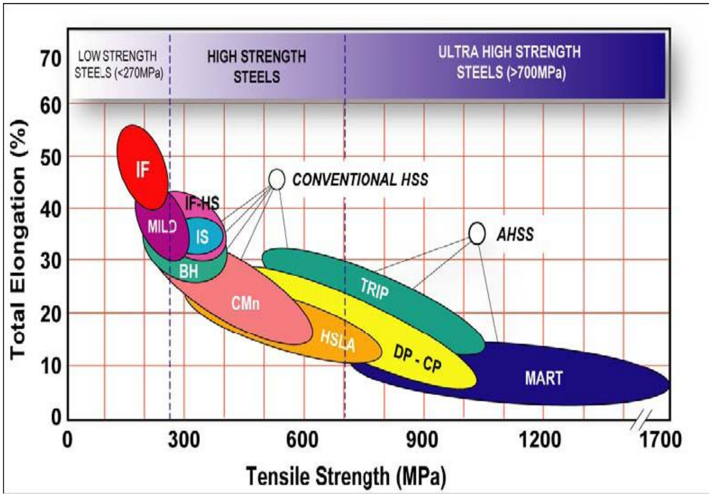


Chart -1: Strength-Elongation relationships for low strength, conventional HSS, and Advanced HSS steels

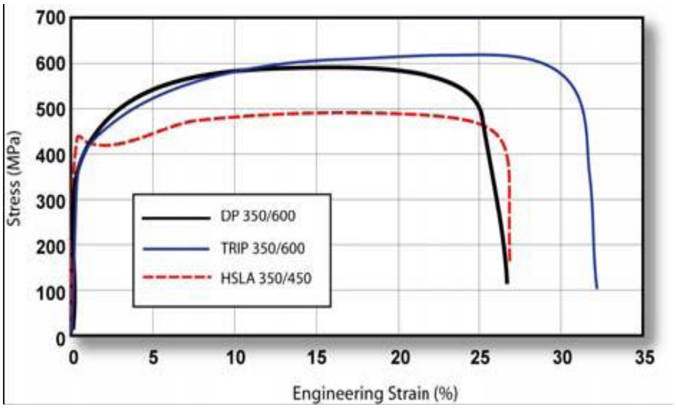


Fig -1: The quasi-static stress-strain behavior of high-strength, low-alloy (HSLA) steel to a DP steel of similar yield strength

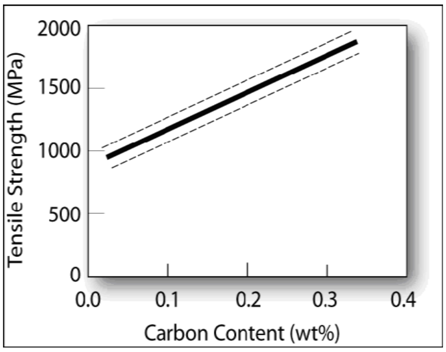


Fig-2: Relation of carbon content and tensile strength in untempered martensite.

Properties of High Strength Steels(HSS)[2]:

Tensile properties: The primary tensile properties of high strength steels are the yield stress, the (ultimate) tensile strength, the strains at rupture and strain hardening, the reduction of area, and the yield-to tensile strength ratio.

Toughness: High strength steels show much improved toughness properties compared to conventional steel grades even at very low temperatures (transition to brittle fracture occurs at lower temperatures than conventional steel grades).

Weldability: High strength steels (HSS) show generally improved weldability compared to conventional structural steels and they are suitable for all current welding methods.

Formability: Developments and production of fine grain structural steel have allowed for HSS and VHSS to combine strength and weldability with excellent formability.

3. CONCLUSIONS

High strength steels are increasingly being used in automobile applications They offer a number of advantages over conventional steels, particularly where weight is important. Their mechanical properties, their weldability, fatigue, static strength, cathodic protection and hydrogen embrittlement performance are proving to be a boon for the automobile industry. in this paper, we have tried to study High Strength Steels, their classification, their grades, metallurgical and their properties. In general, the strength of a steel is controlled by its microstructure which varies according to its chemical composition, its thermal history and the deformation processes it undergoes during its production schedule.

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