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Advanced High Strength Steels for Light-Weight Automotive

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1. Introduction

Automotive is an inseparable part of the modern society and accounts for a sizeable share of our economy. It is a complex engineering product today, demanding a combination of properties for its variety of components. Notwithstanding the development of new materials and their increasing use, the iron-base materials still occupy the dominant position amongst the materials of construction of an automobile and represent around 64 percent of the weight, in which the share of steel is around 57 percent in a typical passenger car today. In a passenger vehicle . In a passenger car, the body-in-white (BIW) accounts for ~ 35% of the total weight and is a very demanding area, particularly because it is singularly responsible for the safety of the passenger (against crash).

The BIW demands a range of attributes such as: physical characteristics (e.g. strength, stiffness, durability); amenability to production (e.g. formability, joinability, paintability); styling / space optimization (e.g. designing freedom, cross-sections, & so on) and over all, environmental impact (e.g. energy consumption, CO_2 emission), costs (e.g. manufacturing, use and maintenance) and safety (e.g. a variety of crash resistance). It is also known from conventional knowledge that a number of these properties run counter to each other; and it has therefore been the main thrust of research to combine apparently opposing properties (e.g. strength & formability).

During the fuel crisis and subsequently when the world became more conscious of the CO2 foot-print, the importance of light-weighting was even more acutely felt. Consequently, research-efforts are being directed towards weight reduction of vehicles without sacrificing safety and with limited or no cost-penalty. Several international efforts were launched (e.g. ULSAB, ULSAS, ULSAC & ULSAB-AVC) that saw the use of new processes such as tailored blanks, hydro-forming (of roof and tubes) etc. that are today accepted in manufacturing car body (BIW). Simultaneously, increasing proportion of high-strength steel sheets combining good formability for the car body and high strength with stiffness for other parts, are becoming attractive for reputed car manufacturers. The mass-saving capability has been shown to be as much as 25 percent concurrently with better crash-resistance and no cost-enhancement.

The current presentation shall draw attention to the high-performing grades of steels in use in automotive. Thus, application of some of the

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Advanced High Strength Steels (AHSS) such as Dual-Phase (DP); Complex-Phase (CP); Transformation –induced Plasticity (TRIP); & Martensitic (Mart) shall be demonstrated, showing examples of use in a car body In the case of TRIP, the meta-stability aspect of the retained austenite, as a function of strain and strain rate would be highlighted. It would be shown that the use of such steels, now described as 'First Generation' AHSS, have not grown visibly, estimated to be just over 12 percent on an average, even in advanced societies such as Europe , USA and Japan.

It would then be shown that in view of greater demand for mass-saving (up to 35 percent) with high fuel efficiency, even better combination of properties compared to First Generation AHSS is desired. Thus, steels such as austenitic AHSS include twinning induced plasticity (TWIP) steels; Al-added lightweight steels with induced plasticity (L-IP), and shear band strengthened steels (SIP steels) are being developed. These have been designated as 'Second Generation' AHSS steels. Commercialization of these steels however, again are not in sight immediately.

Over the past five years, there has been a growing interest in the development of the 'Third Generation' of Advanced High Strength Steels (AHSS) where the strength-ductility combinations are appreciably better than those displayed by the first generation AHSS but at a cost significantly lower than that required for second generation AHSS. There are a number of academia and industries where massive efforts in this direction through varied approaches, including Void Nucleation Resistance, Quenching & Partitioning (Q & P) etc. are in evidence.

Using the foregoing results it would be shown that steels that have completed nearly a century of application in the modern sense, and believed by many to be representing a 'sun-set' industrial sector, are displaying characteristics of an ultra-modern material capable of meeting challenges thrown in by designers of new automobiles. The presentation would deal with the developments in advanced steels and their applications that have recently taken place as well as those emerging in the horizon.

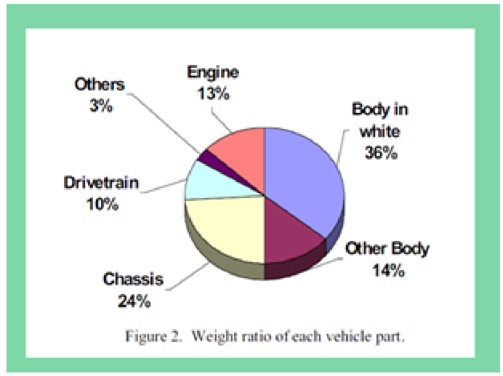

Figure 1. Share of BIW in Weight in a typical Car.

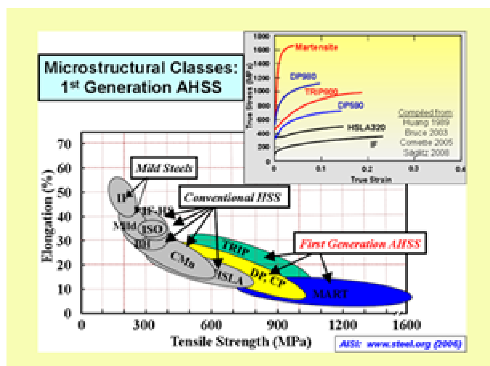

Figure 2. Adv. High Str. Steels - Gen.I.

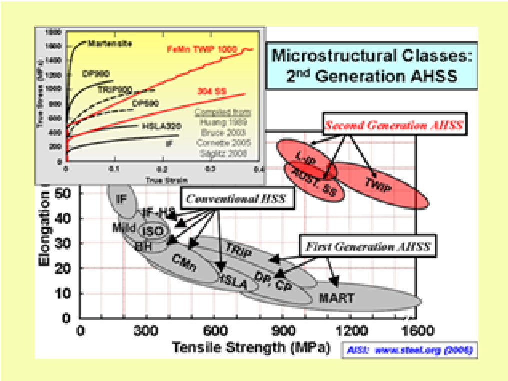

Figure 3. Adv. High Str. Steels – Gen.II.

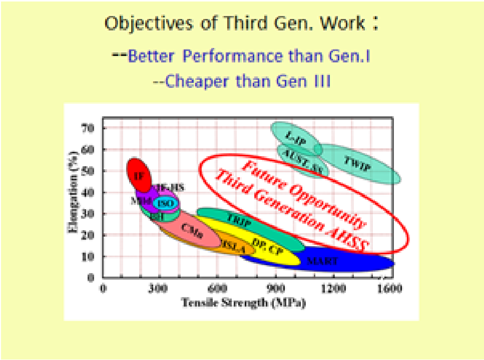

Figure 4. Adv. High Str. Steels – Gen. III.