Steels in chassis applications – challenges today and in the future

Stefan Mütze, Michael Braun, Christian Pelz*, Ingwer A. Denks
Salzgitter Mannesmann Forschung GmbH, Eisenhüttenstraße 99, 38239 Salzgitter, Germany
* Salzgitter Flachstahl GmbH, Eisenhüttenstraße 99, 38239 Salzgitter, Germany

1 Summary

Cost and resource optimization is in today's automotive industry more than ever a driving factor for lightweight construction. Improvement and optimization of part characteristics are growing demands. A direct consequence of these demands is the development of steel materials for different part applications with their wide range of special requirements. In addition to the car structure, chassis parts offer an enormous potential for modern steel grades too. Steel requirements in these cases are directly derived from increasing component-complexity, fatigue-life, and safe reaction in case of overload/misuse. With each new vehicle or component generation these requirements increase. State of the art steel grades in chassis applications are today hot rolled, pickled steel grades with a thickness range from 2.0 to 4.0 mm. Within the near future, ongoing weight reduction efforts will not skip chassis-components and feed design-conceps which decreased material thicknesses, reduced welding volumes and single component solutions – even without welding. Today the full range of micro-alloyed steel grades are used in chassis parts. Tomorrow, steel grades with higher formability levels and increased fatigue-life after forming/welding are needed. Salzgitter has developed steel solutions regarding these requests, like air-hardening steel (LH800) or bainitic steels (SZBS600 and 800). First chassis-designers began using these steel-products for complex part geometries with a high degree of functional integration. In this context, the following article informs on the current state of research at Salzgitter Mannesmann Forschung GmbH (SZMF) in the field of steel materials for use in future chassis applications. Furthermore, the article provides an outlook regarding a new process technology, called semi-hot-forming, which will lift up formability and in particular formability of the trim-cut edges on an outstanding level.

2 Key words

bainitic steel, SZBS800, air-hardening steel, LH800, chassis component

3 Introduction

The automotive industry is more than ever facing a discussion on energy availability, increase of global markets, rising of mobility, challenging safety regulations and environmental legislation. Advanced lightweight construction needs a balance of cost and resource optimization. Dedicated thoughts touch all areas of the vehicle, see Figure 1. It´s worth a look into the chassis area and it´s impact in case of the total carweight.

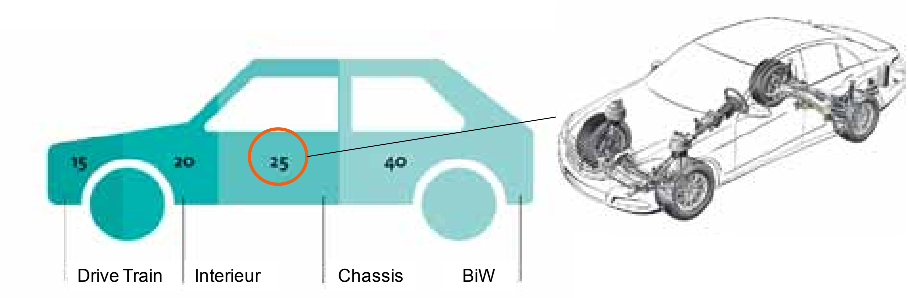


figure 1: areas of the vehicle and its share of total vehicle weight (percent)

25 % of the average car weight of 1350 kg roughly means 338 kg for chassis components. This value offers many opportunities for lightweight design and construction. Different ways of lightweight design concerning chassis components are shown in figure 2.

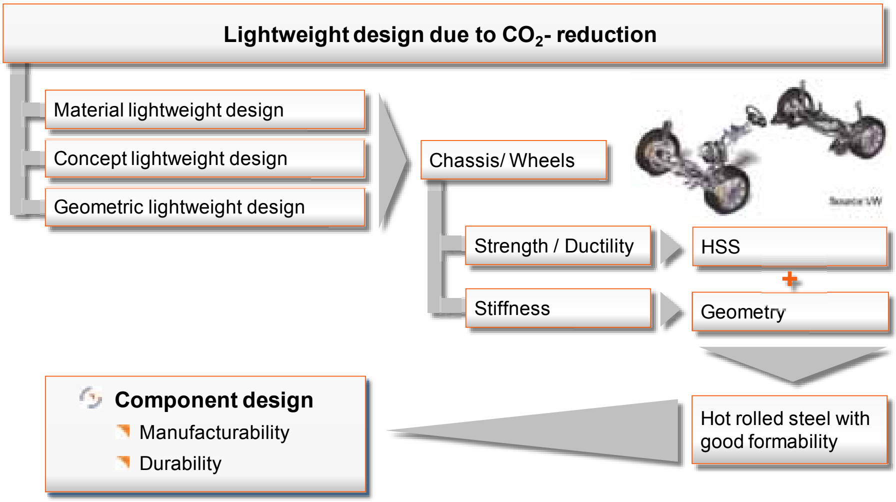


figure 2: well known ways of lightweight construction

Based on the field of application of chassis components, the main challenges are combining high strength, ductility with a very good component stiffness. On the one hand, these challenges can be achieved by using today's high strength materials, and on the other hand enhancing component stiffness leads to very complex

geometries. These requirements increase with every new vehicle and component generation. At present more than ever there is a great challenge to find new paths and possibilities to produce highly complex components. These challenges are justified by the behavior of materials that with increasing strength result in a decrease in formability. One way to achieve this challenge is to consequently develop new steel grades; a second way is the combination of innovative materials with advanced component manufacturing-technologies. This sort of combination offers the possibility to develop components, which will fulfill future requirements.
State of the art chassis design

Evolution in chassis design follows a simple and clear principle - make it simpler, use less parts, reduce welding seams. Figure 3 shows a simple example of this development in the form of a bearing mount, normally used in a lower control-arm in the front side chassis system.

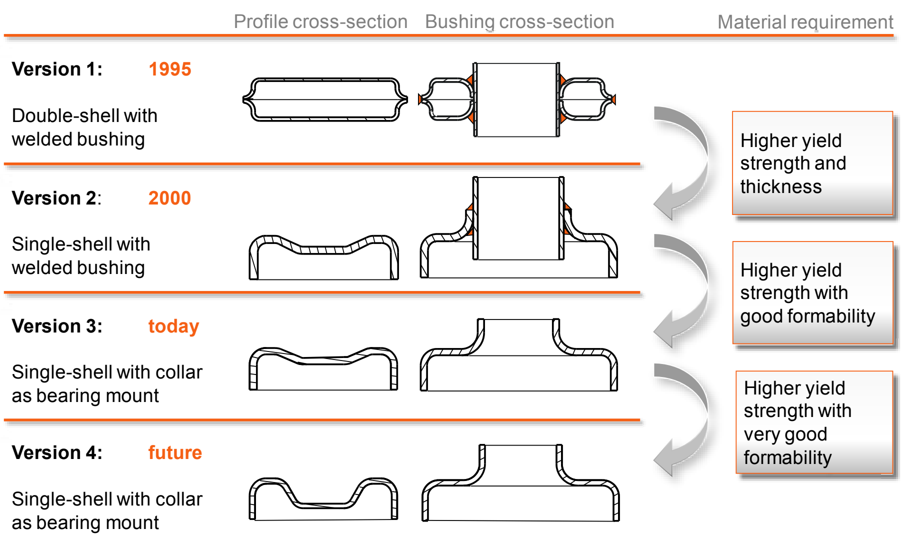


figure 3: Exemplary chassis part through the ages

Every new generation in component design was related to a new stage of material improvements, e.g. higher yield strength and/or better formability, like shown in Figure 3. The nature of all the design-versions 1 to 4 is the same - usage of material which allows easier/safe manufacturing and/or improved component properties and a reduced number of single parts in conjunction with reduced welding-volumes. Today, the possibility of using high-strength and durable materials allows for producing components in single shell design. Thus the manufactured parts have a very high functional integration. The typical thickness range in these components is today from 2 to 4 mm for trailing arms, located in front-/rear axes, sometimes also slightly below 2 mm in case of upper/lower shells for subframes or tubes.

Cars designed for tomorrow are using today's materials. What do the chassis-designers need for the designing of cars for 2020?

4 Steel grades for chassis design today and in the future

In chassis applications mainly pickled and hot rolled grades are used (figure 4).

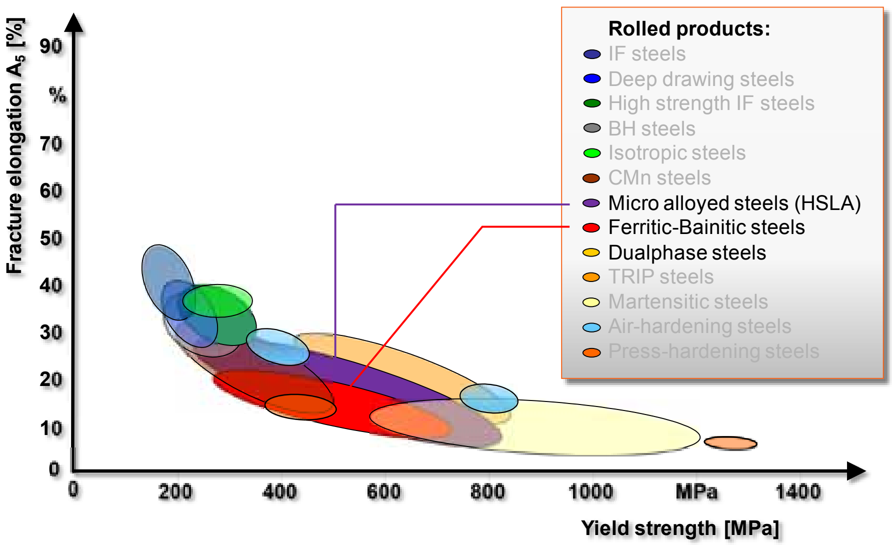


figure 4: today's typical steel grades for chassis applications

Typically, the full range of micro-alloyed steel grades is used in chassis parts, as well as, special steels like air-hardening steel (LH800) or bainitic steels (SZBS600/800). By using these steel grades the customer can produce chassis components that combine complex component geometry with a high degree of functional integrity. Figure 5 shows the main technological properties of frequently used materials. Micro-alloyed steel grades with high tensile strength are the most regularly applied material and are providing the backbone for chassis design. But in the last few years bainitic steel grades successfully entered the industrial stage.

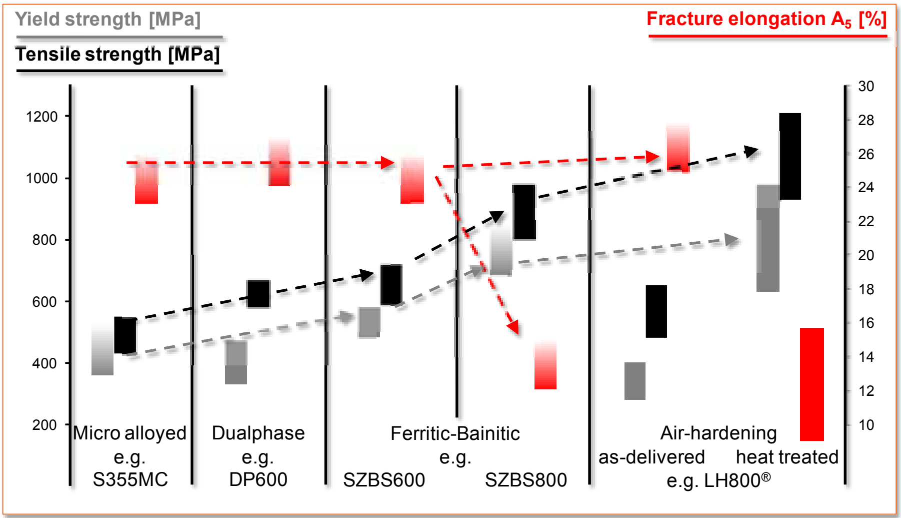


figure 5: Comparison of mechanical properties

In the context of lightweight design and production safety, the bainitic grades have become the reference material for chassis components. The main advantages of bainitic steel grades are the combination of high yield strength of the HSLA-Steels with the good formability of the DP-Steels, a good weldability and a superior hole-expansion behavior – wellknown from the low-strength- steels (LSS). Applications are dynamically heavy loaded control-arm, trail-arm, wishbone suspension and transverse links in the chassis (figure 6). Due to the higher strength class of the SZBS800 and the associated reduction of the formability, new methods to increase the formability are needed to assure the full potential of these steel grades. As can be observed on the right side of figure 5, the air hardening steel LH800 is a very special solution.

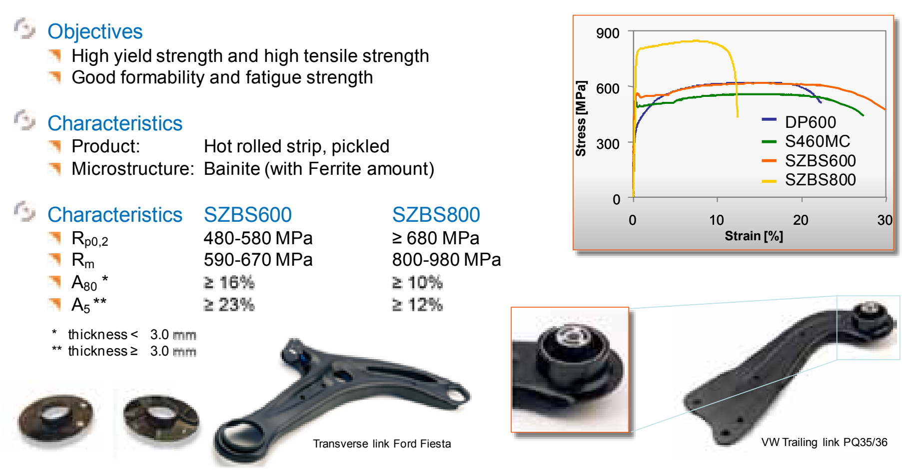


figure 6: Typical properties of available bainitic steels and some applications

The LH800 can be cold formed and tempered (figure 7). Particularly interesting and innovative is the fact that a cold formed component can also be partially heat-treated. The heat-treated areas of the component obtain higher strength than the rest of the component by cooling at room temperature. The result is a component with very special tailored properties supporting smallest radii in extreme tight packages. This material shows a good possibility to do creative lightweight design with an enormous functional integrity.

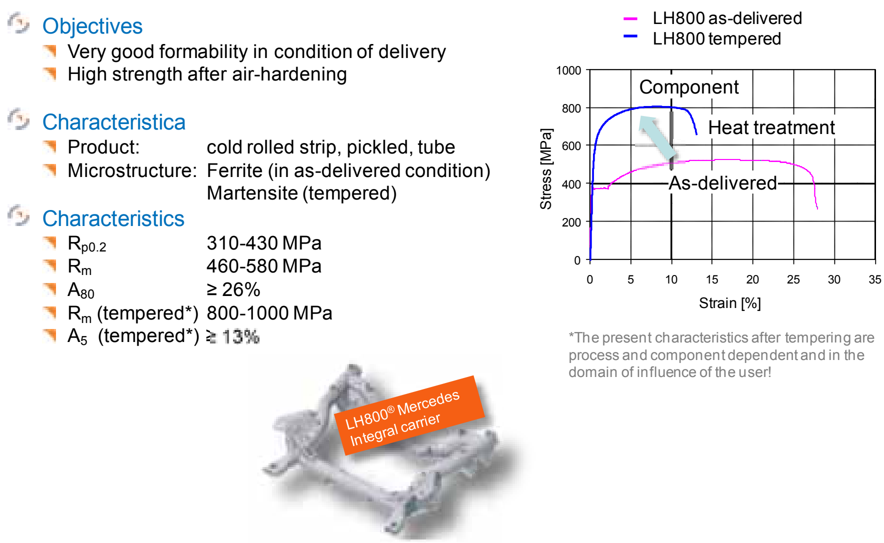


figure 7: properties of air hardening steel and application

5 Salzgitter's ideas for efficient lightweight design and construction

In the structure area of a vehicle, a very effective kind of lightweight design is used, the so called "tailored blanks". Tailored blanking means to form a part from one blank made-up of different steel grades and / or different sheet thicknesses. The used blanks in this case are laser welded. As a result, a complex part can be manufactured in one forming operation that is optimally adapted to the installation and expected load. In one region the material is exactly in the right thickness and strength required. Tailored blanks are absolutely state of the art in body- in-white (BIW-) applications but their use in chassis components was till today totally uncommon due to lack of suitable and available materials. A welded seam in the middle of a component that is exposed to high dynamic loading was out of thoughts. The main reason was that a weak spot on the component is produced by weld. In this area the mechanical properties are very different to the properties of the base material. Today it is possible to produce a tailored welded blank from the air hardening steel, LH800, for use as a chassis component. It is also possible to use one blank to form the component which is welded from two different thicknesses. Due to the fact that the material after austenitization and after cooling down to room temperature has been reached, for the properties at least of the base material there is no observed artificial weak spot on the component. Therefore, with air hardening steel grades design freedoms are possible which did not exist in former times. Figure 8 shows the durability of the air hardening steel grade LH800 and of a micro-alloyed steel grade HX340LAD. Figure 8 shows the properties of the respective base material and the properties of a weld specimen. The figure illustrates the durability-performance of LH800 in welded condition, which is recommending this type of steel for the prefered use in chassis components.

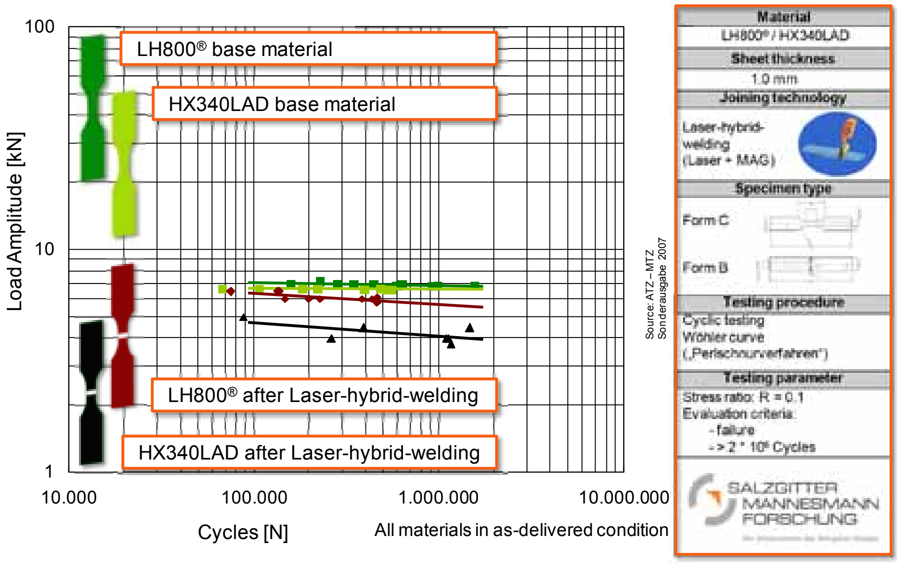
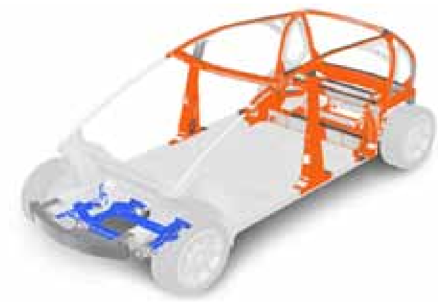


figure 8: Influence of welding on durability of LH800® & HX340LAD

Another possibility to perform effective lightweight construction with a high degree of functional integrity is semi-hot-forming. Semi-hot-forming is the combination of heat treatment and forming. In comparison to hot forming, also known as "press hardening", the material is not austenitized (figure 9). The semi-hot-forming is carried out by a very special adaption to the material that is to be formed under heat treatment. The following forming operation on a special semi-hot-forming-material can be done with conventional machines and tools. In comparison to press hardening, uncoated material can be used due to little or no scaling of the material. The main benefits of the heat-treatment are such that under the influence of temperature the tolerable elongation increases (figure 10).

temperature: 870-950 C
strength: 1.500 MPa



temperature : < 700 C
strength : 800-1.100 MPa

hot forming
parts for safety components in structure
requirements:
• high strength
• dimensionally stable parts
• challenging part geometry
steel grade: CMnB
coating: AlSi, Zn, ZnFe, ZnNi

semi-hot-forming
chassis parts
requirements:
• high strengt under fatigue load
• dimensionally stable parts
• challenging part geometry
• ductile fracture behavior
steel grade: confidential but affordable
coating: none, Zn or Zn optimized

figure 9:differences between hot forming and semi-hot-forming

This effect has to follow analogous to press hardening so that highly complex components can be produced in one forming step. Another positive benefit is the decrease of the forming force. Due to the expansion of the forming limits and boundaries, it is possible to form significantly higher collar to components. Therefore, the possibility exists to improve the required functional integration.

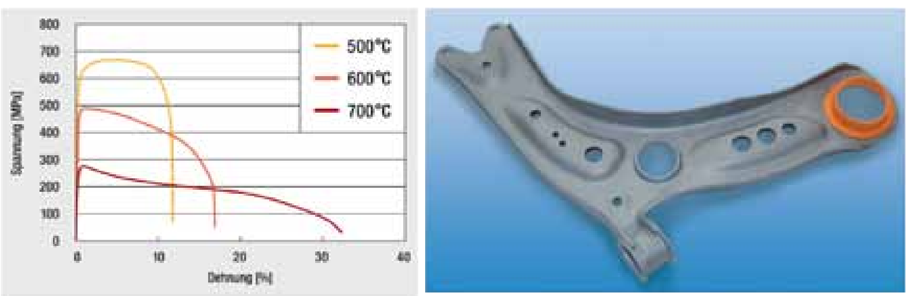


figure 10:effect of semi-hot-forming and possible application

6 Conclusion

With the example of the LH800 it was shown that it is possible to expand the application range of base material steel into new areas. The combination of new designed materials and innovative design concepts offers the possibility of effective lightweight constructions. Tailored welded blanks, well known from BIW, could add further benefits. Another way to produce a very complex part with less weight and a higher degree of functional integration than actual chassis parts is the combination of appropriate steels with a semi-hot-forming capability and a new forming procedure.