

Innovative material solutions for lighter, safer and more sustainable automobiles

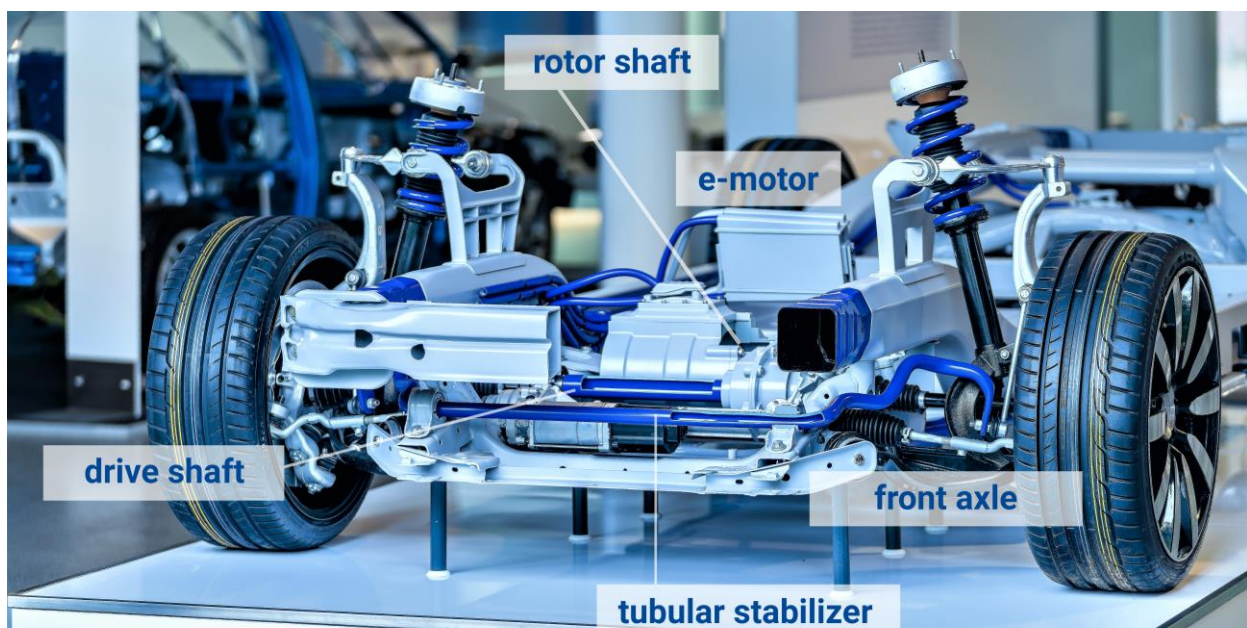
Significant weight savings can be achieved in cars with conventional powertrains by using high-strength tubes. This reduces fuel consumption and thereby also pollutant emissions. In electric vehicles, lightweight solutions lead to a significantly increased range. Therefore, mobility becomes lighter, safer, more sustainable. With its materials expertise, manufacturing expertise in metal processing and know-how for optimal lightweight solutions, BENTELER Steel/Tube is one of the leading experts for future-proof automotive constructions.

Sustainability, in particular the reduction of CO₂ and other emissions (e.g. NO_x), is one of the main drivers of innovation in the automotive market. Lightweight construction, for example, leads directly to a reduction in CO₂ emissions in the case of combustion-based vehicles. In the case of electrically powered automobiles, on the other hand, the focus is on the efficient use of resources in the manufacture of individual components. The development and application of new high-strength steel-based tubes is also one of the main drivers for further weight reduction, for example in chassis components or in the powertrain.

BENTELER Steel/Tube is a sought-after partner of the automotive industry here. The leading international manufacturer of

seamless and welded steel tubes has developed tube solutions that can replace solid bars. This makes automotive components lighter. The basis for this is that BENTELER has a high level of expertise in the production and heat treatment of tubes. As a result, the company ensures that tubes for stabilizers made of high strength quenched and tempered steels up to 40MnB5, for example, meet current and future requirements for component safety and lifetime.

Steels with a strength increase of around 10 to 15 percent allow the use of thinner-walled tubes or the transmission of higher loads in the chassis modules, which will be generated in electric vehicles due to the additional weight of the battery. Innovative tube materials also lead to improved crash safety or help



Lightweight solutions from BENTELER Steel/Tube (©BENTELER)

achieve high process consistency in production.

Weight savings in components

Stabilizers in chassis have the task of compensating for the body rolling and pitching movements of the vehicle and guaranteeing an even distribution of the loads on the individual wheels when cornering. Thereby they make an important contribution to improving driving safety and comfort. In the central section, the stabilizer works like a torsion bar and is mainly stressed by torsion. In the past, solid bars made of quenched and tempered steels alloyed by silicon and chromium were used for this purpose. The highest loads occur at the outer diameter. By using tubular stabilizers instead of solid bars, manufacturers can significantly reduce the weight of the component. Depending on the load and geometry, weight savings of up to 35 percent are possible.

The production process of a tube has a major influence on the final fatigue strength. For example, at BENTELER the annealing process is optimized to minimize surface decarburization, grain boundary oxidation or grain growth. Today, manganese-boron alloyed steels in quenched and tempered condition are used as standard materials for stabilizers to withstand the high loading stresses. These usually have a carbon content of about 0.35 percent. BENTELER Steel/Tube, on the other hand, has started initial validations with concepts up to 0.4 percent carbon. Whereas



Processing of quality tubes for lightweight construction at the Rothrist, Switzerland, plant (©BENTELER)

such alloy concepts were previously considered impossible to join with high-frequency induction welding, BENTELER has been able to adjust the manufacturing parameters so that welding is possible.

In addition, modified concepts with contents of up to 0.45 percent carbon are currently being qualified. After quenching and tempering, yield strengths of over 1500 MPa and strengths of up to 2000 MPa are achieved. Therefore, dynamic load cases as well as overload cases of electrically high-powered vehicles can be compensated. BENTELER Steel/Tube has furthermore a special inductive heat treatment equipment for final quenching and tempering of the tubes. This avoids the effect of so-called tempering embrittlement and achieves cold bendability. The customer thus saves the investment in a costly production line.

Stabilizers for automobiles are loaded by larger stress in the bent areas than in the straight areas. Until now, however, the wall thickness has been the same along the entire length of the stabilizer/tube. By using the

VarID® process, BENTELER Steel/Tube is now able to produce tubes with variable wall thicknesses. The wall thickness can thus be optimally adapted to the stress level of the stabilizers. This allows an additional component weight reduction of 15 to 20 percent.

Lightweight tube solutions for axles

Tubes for axle components from BENTELER are a good choice for future mobility concepts. In particular, the use in electric vehicles places high demands on axle components due to the high weight of the batteries. Limited installation space as well as stiffness and load specifications place special requirements on the mechanical properties (e.g. formability). Reliable bending and hydro-forming processes with limited spring back effect in turn place high demands on tolerances. MAG welding processes require only a small variation of hardness in the heat-affected zone.

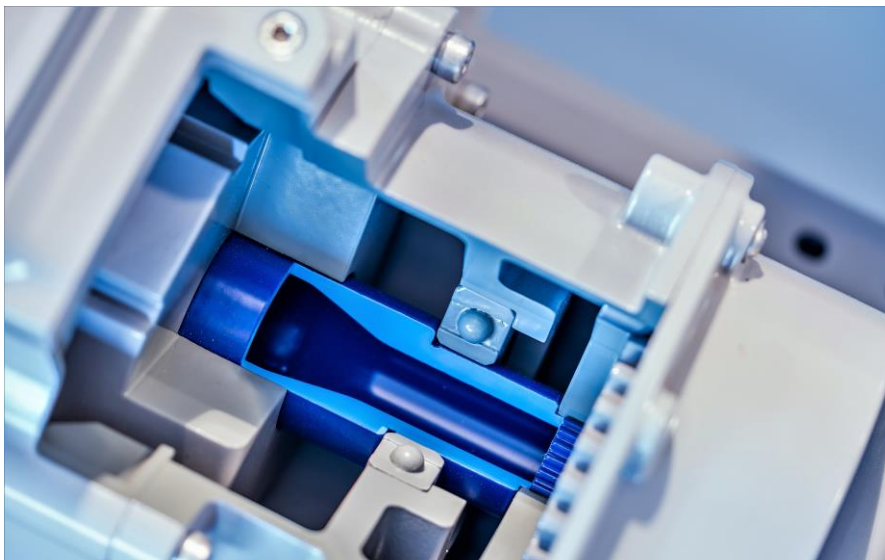
To date, conventional carbon-manganese steels (C-Mn) with lower or medium strength levels, which are additionally normalized to ensure formability, have been used for many tubular components in front and rear

subframes, twist beams or multi-link suspensions. The advantage of a uniform strength distribution is countered by higher differences in hardness when welded to the component. Existing alloying concepts limit these steels to yield strengths of up to about 450 MPa and strengths of up to 600 MPa.

High strength low alloy (HSLA) steels are thermo-mechanically rolled low carbon steels. Typically, these steels are processed into welded tubes with a calculated work hardening effect without a subsequent normalizing process. More recent developments are based on highly ductile steels with a pearlite-free microstructure and work hardening effect due to very fine grains and nano-precipitates. The tubes provided by BENTELER Steel/Tube are characterized by higher plasticity and excellent process stability with a constant level of mechanical properties in a tensile strength range up to 800 MPa. Weight reductions of up to 15 percent per tube are reachable at the same load level.

If, on the other hand, good forming properties are required, the BHFS-420HD steel modified by BENTELER Steel/Tube - with a lowered yield strength/tensile strength ratio and an elongation of over 26 percent - offers the potential for lightweight construction and cost efficiency. This ensures short production chains without additional heat treatment and superior process stability.

Two-phase or multi-phase steels for tube applications consist of ferrite with a regular dispersion of bainite or martensite.



Rotor shaft manufactured by BENTELER/Steel Tube (©BENTELER)

These steel grades exhibit excellent fatigue and crash behavior when used as tubes for twist beam axles or hydroformed axle components. More recent developments achieve strengths of up to 1000 MPa as well as improved ductility and reduced crack sensitivity due to an optimized microstructure. For very sensitive surfaces and weld requirements, laser-welded tubes made from these steels are a very good alternative.

Diverse tube solutions for car seat and structural parts

Similar to axle tube applications, tubes for car seat and structural parts are often bent, hydroformed or subjected to other advanced forming processes. Additionally, these parts are almost always subject to crash and lightweight requirements. Another HSLA steel has established itself in structural applications and car

seats - BHFS-HD355. It has mechanical values similar to an S355MC and elongation of over 26 percent on the tube. Due to the low weld hardness, the tube still has a very high forming capacity and remains cost-ef-

ficient because heat treatment is no longer necessary. Due to the very high possible forming rates, it is possible to eliminate the welds in the seat area, which were previously used to realize a connection with the seat structure.



Proprietary material developments make mobility lighter, safer, more sustainable (©BENTELER)

A multiphase steel with optimized analysis and adapted microstructure with a strength of over 600 MPa and elongation values on the tube of over 20 percent offers significantly more lightweight potential in this area. In addition to the possibility of saving weight, BENTELER Steel/Tube customers benefit from the comparatively low hardness of the weld seam for this strength level. This results in a high forming capacity even in this area of the tube. In structural applications, tubes from this steel family are even used up to a strength of over 1000 MPa.

Wide-ranging materials expertise

Steel plays an essential and important role in meeting future requirements in the automotive industry. Steel is one of the most important materials, if not the most important material, in automotive construction. Among

other things, high-strength, higher-strength and ultra-high-strength steels are used, enabling not only lower vehicle weight but also maximum crash safety and new designs.

Material and product expertise play a central role in the development of innova-

tive steels. By focusing on the functions and properties of its customers' products, BENTELER Steel/Tube succeeds in creating application-specific requirement profiles for usable steel developments. BENTELER Steel/Tube's value chain includes its own electric steel mill, which has very low CO₂

emissions compared with the blast furnace route. BENTELER Steel/Tube uses this steel mill specifically to optimize materials according to the requirement profiles of its customers and to move quickly from laboratory scale to industrial implementation for new developments.

One example is the development of the high-strength, air-hardening steel BAH120plus at strength levels up to 1200MPa. The requirement profile focuses on dynamic strength, tempering resistance and economy. The steel has the special feature of maintaining a constant yield strength throughout the component despite the application of heat, such as in the manufacture of welded structures. The dynamic strength of welded structures in the heat-affected zone of a weld can be significantly increased by using the steel. This results in two advantages for our customers: We reduce the component weight of welded constructions, and the customer can save a process step by eliminating a quenching and tempering process. This reduces costs.

With our new innovative material BAH120plus, for example, we are supporting a major German commercial vehicle manufacturer in the area of crash management. Our high-strength material enables the customer to significantly reduce the weight of the roll cages. At the same time this improves crash performance. Responsible for this is the used combination of the material properties strength, weldability and tempering resistance.

Conclusion and outlook

BENTELER Steel/Tube develops and produces steel as well as seamless and welded high quality steel tubes. As one of the leading manufacturers, the company offers its customers worldwide solutions along the entire value chain - from materials development to tube applications. Products for the automotive industry are characterized by particularly high strength, low weight and value optimization along the integrated value chain. In this context, BENTELER is continuously working on innovative materials to optimally support manufacturers in the challenge of producing lighter, safer and more sustainable cars. BENTELER Steel/Tube always keeps an eye on customer requirements: Solution-oriented product development in close cooperation with customers and partners has always been the focus. This cooperation between suppliers, manufacturers and partners in the automotive industry will continue to gain in importance. The focus is on the series introduction of material concepts with improved performance for new platforms with electric drives, which will replace conventionally powered vehicles in the long term. A contribution to CO₂ reduction will be achieved through reduced material usage both in the production process and in driving operations. The particularly resource-friendly use of steel tube concepts can be demonstrated by the potential use of recycling material and the production route via an electric steel mill.