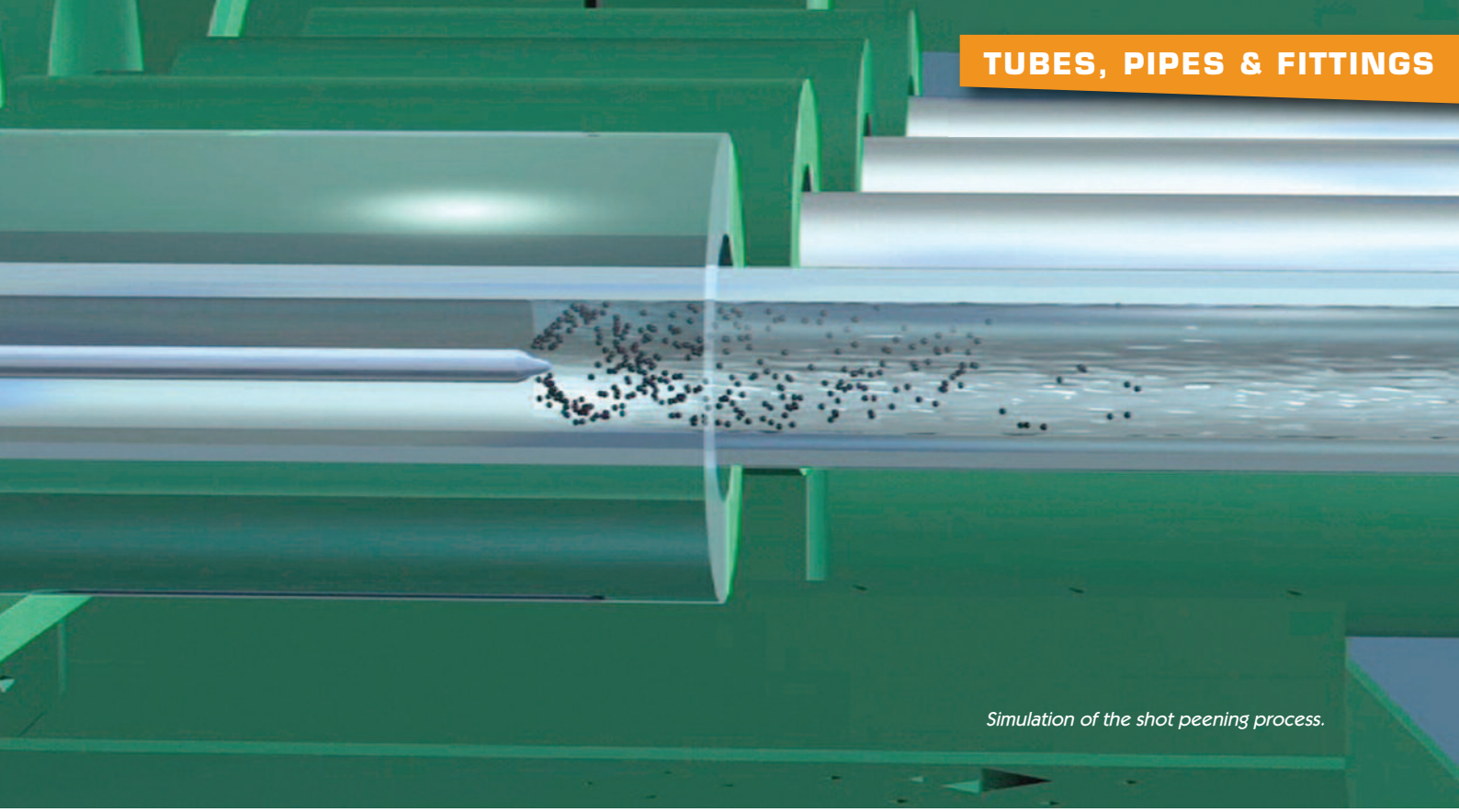


Simulation of the shot peening process.

Boiler tubes for 700°C applications by Salzgitter Mannesmann Stainless Tubes

Fossil fuels are limited, CO_2 emissions are more and more limited but energy need is growing. Efficiency increase is one of the major tasks and tubes from Salzgitter Mannesmann Stainless Tubes (SMST-TUBES) bring a significant support for this solution.

By Patrik Schraven, Salzgitter Mannesmann Stainless Tubes GmbH

Salzgitter Mannesmann Stainless Tubes is one of the leading manufacturers of seamless stainless steel and nickel alloy tubes and pipes with one of the largest product portfolios in this sector. Top quality products and efficient service contribute to the long-term success of the customers. Top priority is to establish and maintain positive long-term relationships with business partners and bring added value to customers through additional technical service.

In order to support stockist and project business, with good quality, innovative materials and modern production technologies, experts are constantly working to keep up with the latest trends. This is not only proven by the qualification for three new stainless steels (DMV304HCu, DMV310N and DMV347HFG) but also by investing in innovative processes like “shot peening”.

The conventional power generation

The optimisation of power plant efficiency is one of the few options which are economically and ecologically useful. On a global scale, more energy is produced by using fewer resources and by emitting less CO_2 if efficiency increases. Coal fired power plants which were built in the 60s and 70s of the last century usually have a net efficiency of ~35%. The annual improvement at this time was less than 1%. Once technology changed to (ultra-) supercritical parameters, efficiency jumped to over 40%. Today values up to 47% are realised.

But the next step is waiting: To reach this goal of an efficiency increase over 50%, not only continuous improvement is necessary. The basics of thermodynamics require a live steam temperature of at least

Tubes during the solution annealing process.

700°C and a pressure of >350 bar. New power plant components which can withstand these extreme parameters for many years are urgently required.

Table 1: Design example for power plants and the relation of pressure, temperature and efficiency

Pressure / Steam Temperature		Efficiency
Subcritical	170 bar/ 540 – 565°C	40%
Supercritcal	250 bar/ 540 – 565°C	43%
Ultra Supercritical	290 bar/ 600 – 620°C	46%
Future	350 bar/ 700 – 720°C	>50%

Special material development is needed to respond to the increasingly aggressive parameters. The complete setting of material concepts will change in a way which has never happened in the steam power generation industry before. At many levels, even stainless steel components will not resist against requirements and this is the domain of the Ni base alloys from SMST-TUBES. With decades of experience in its works in Remscheid (Germany), Costa Volpino (Italy), Montbard (France) and Houston (USA) in the seamless tube production in these special materials, SMST-TUBES is prepared for this challenge.

Ni base alloys

The most common Ni base alloy for power plant application is DMV617 mod (UNS N06617, 2.4673). This material has been tested for a long time, especially due to its approval for the use in nuclear applications (German fast breeder project). Its feasibility for tube production has been proven over many years.

Due to its high content of expensive alloying materials (see Table 2), Ni base alloys increase the material costs for the construction of coal fired power plants.

Table 2: Chemical analysis of major Ni base materials for power generation

Alloy	DMV617 mod	DMV263
Element (%)		
C	0.05 – 0.10	0.04 – 0.08
Ni	54 (Rest)	52 (Rest)
Cr	20.0 – 23.0	19.0 – 21.0
Mo	8.0 – 10.0	5.6 – 6.1
Co	10.0 – 13.0	19.0 – 21.0
Al	0.60 – 1.50	0.30 – 0.60
Ti	0.20 – 0.60	1.90 – 2.40
Mn	<0.70	<0.6
Fe	<1.5	<0.7
Si	<0.70	<0.4

Boiler tubes in different sizes.

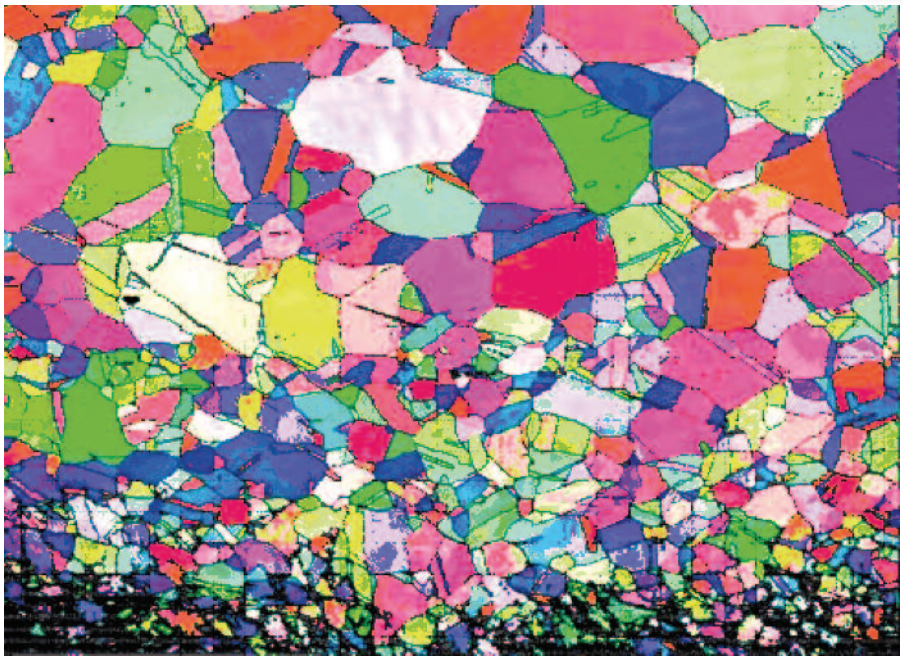
New materials are developed by SMST-TUBES to compensate for this cost increase. Compared to today's materials, these alloys are designed to have significantly higher long term properties at high temperatures. Creep rupture strength is one of the most important values for these applications. To prove this material property, long term testing for many years is done at the application temperature.

A major development for power plant application is DMV263 (UNS N07263; 2.4650) boiler tube. The improvement of the creep strength allows the designer to decrease the wall thickness significantly. By this reduction not only is the total weight of the boiler tubes reduced but also the requirement for the whole boiler construction is simplified. Total costs of

material and construction are conclusively lower due to this development.
On the other hand elevated high temperature properties have a big influence on the parameters of the extrusion capability of the tubes. The hot deformability decreases and the requirements of tube production increase substantially. In recent years SMST-TUBES has managed to successfully produce tubes in DMV617 mod as well as DMV263 in industrial scale.

Testing

In summer 2008 the first 700°C test went into operation – the VGB-test closed loop COMTES 700 at the EON coal fired power plant in Scholven, Germany. Different materials were tested under realistic conditions to prove their capability. Boiler tubes of DMV 263 were installed at the hottest stage of the loop to withstand steam temperatures up to 700°C. During this qualification trial DMV 263 was not the only material of interest. In the colder sections of the loop, the high temperature resistant austenitic stainless steel DMV310N as well as the Ni base material DMV617 mod were proved. As a speciality, the wall panel to create enough steam for the superheater test loop, was tested and qualified. Due to its lower thermal expansion coefficient compared to stainless steels,



SEM picture of a shot peened surface.

DMV617 mod was used for this application.
Parallel to the industrial testing of DMV617 mod and DMV263, laboratory trials were done in the frame of the Cooretec Initiative (**CO_2-Re**duction-**Tec**hnology) of the Germany ministry of economics and technology (BMWi).
In addition to the developments for the practical application, basic know-how is created to better understand and optimise materials and power plant components.

This level of engagement allows SMST-TUBES to continuously improve its processes and products.
As a follow up of the COMTES 700 activities, SMST-TUBES is participating in the two new test loop projects ENCIO and HWT2. Both test loops are running at minimum 700°C steam temperature and SMST-TUBES is the supplier of DMV617 mod and DMV263 superheater tubes for the heating surfaces.

Conclusion and outlook

The future generation of power plants requires a change and challenge in the material selection for waterwall, superheater and reheater components for coal fired power plants. Alloy steels and stainless steels will be partly replaced by Ni base materials for the hotter, more aggressive boiler environments. SMST-TUBES is the leading company for the pressure part equipment of these power plants. In addition to the modern stainless steel grades DMV304HCu, DMV310N and DMV347HFG, SMST-TUBES tested and qualified high alloyed Ni base materials like DMV263 and DMV617 mod for this application. Successful industrial scale testing under real power plant conditions confirmed that SMST-TUBES is a reliable partner for the development of sophisticated seamless tube products for special applications.

Application of boiler tubes during manufacturing of power plant equipment.