In the SPOTLIGHT:

STABILITY OF S³P TREATED STAINLESS STEELS AT ELEVATED TEMPERATURES

S³P was developed to increase surface hardness and wear resistance of corrosion resistant alloys. By means of a low temperature process, carbon or carbon and nitrogen diffuse into the work piece's surface without changing the lattice structure or causing chromium carbide or nitride precipitation. Thus the corrosion resistance of the material can be maintained. During the process high compressive stresses are generated in the diffusion zone, which leads to an increase in hardness, improved wear-resistance and good tribological properties. The diffusion zone is also known as S-phase.

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S^3P – Specialty Stainless Steel Processes
Stability at Elevated Temperatures

At high operating temperatures the S-phase is destabilized. Hardness and corrosion resistance are reduced. The right material selection in conjunction with the S^3P the will determine the behavior at elevated temperatures. If high operating temperatures are required the impact on such properties should be evaluated by laboratory or component testing. Presented below is the summary of an extensive research program carried out to identify the suitable surface treated material for an exhaust gas system.

Experiments

S^3P treated specimens of different stainless steel alloys were tested for changes of microstructure, case hardness and corrosion resistance after annealing at elevated temperatures between 350 and 700 °C for up to 30 hours (See fig.1).

The hardness was measured in HV$_{0.01}$. The corrosion resistance was measured for two different forms of corrosion, pitting and intercrystalline. A change in resistance against pitting was tested by comparing the not heat-treated pitting potential to the S^3P treated one. Intercrystalline corrosion was tested by means of a Strauss Test (according to DIN EN ISO 3651-2).

Results

The change of microstructure and hardness after annealing at elevated temperatures is shown descriptively in fig. 2.

The diagram presented in fig. 3 shows the relationship between annealing temperature/time and reduction of pitting resistance. As shown annealing at elevated temperatures leads to a reduction of pitting resistance. The tested material is the same S^3P treated stainless steel as seen in fig. 2. An evaluation of hardness reduction, intercrystalline corrosion resistance and the change of microstructure was conducted in the same manner.

For an operation at elevated temperatures the S^3P treated austenitic stainless steel 1.4539 showed the most favorable properties. All other tested materials destabilize at lower temperatures and/or show lower values of hardness and corrosion resistance (See fig. 4).

Steel No.		Structure
1.4301	X5CrNi18-10	Austenitic
1.4404	X2CrNiMo17-12-2	Austenitic
1.4539	X1NiCrMoCu25-20-5	Austenitic
1.4462	X2CrNiMoN22-5-2	Duplex
1.4362	X2CrNiN23-4	Duplex
1.4162	X2CrMnNiN22-5-2	Duplex
1.4640	X6CrNiMnN19-7-2	Austenitic
1.4376	X8CrMnNi19-6-3	Manganese-Austenitic
1.4373	X12CrMnNiN18-9-5	Manganese-Austenitic

Fig. 1 Overview of tested materials.

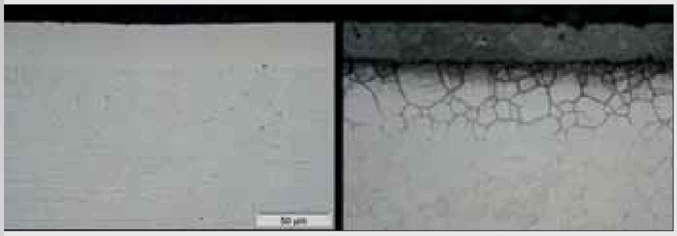

Fig. 2 Microstructure of S^3P treated 1.4539. Left: not annealed (1000 HV$_{0.01}$); right: after annealing for 4 h at 700 °C (250 HV$_{0.01}$). No loss of hardness up to an annealing temperature of 550 °C.

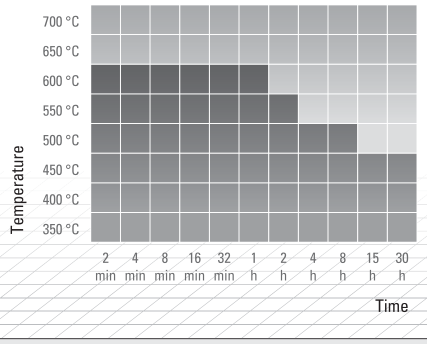

Fig. 3 Reduced pitting resistance after heat treatment of S^3P treated 1.4539 (light grey areas).

Limit temperature of stability after annealing for 30 hours					
Steel No.	Structure	Hardness	Micro-structure	IC corrosion resistance	Pitting resistance
1.4539	Austenite	550 °C	500 °C	400 °C	450 °C
1.4301	Austenite	450 °C	500 °C	400 °C	450 °C
1.4462	Duplex	500 °C	450 °C	350 °C	400 °C
1.4373	Manganese-A.	500 °C	500 °C	400 °C	350 °C

Fig. 4 Limit temperatures for the stability of tested properties after annealing for 30 hours.

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