Alert Stainless & Tool Steel (January 2016)

1. **Effect of Ti addition on carbide modification and the microscopic simulation of impact toughness in high-carbon Cr-V tool steels.** K. Cho, S. Kim, S. Park, W. Choi, H. Moon, H. Kwon. Read more

2. **Beneficial effect of microalloyed rare earth on s segregation in high-purity duplex stainless steel.** L. Chen, X. Ma, M. Jin, J. Wang, H. Long, T. Mao. Read more


4. **Contributions of ε and α TRIP effects to the strength and ductility of AISI 304 (X5CrNi18-10) austenitic stainless steel.** A. Weiß, H. Gutte, J. Mola. Read more

5. **Functionally graded high-alloy CrMnNi TRIP steel produced by local heat treatment using high-energy electron beam.** D. Heinze, A. Buchwalder, A. Jung, A. Weidner, C. Segel, A. Muller, R. Zenker, H. Biermann. Read more

6. **Effect of vanadium nitride precipitation on martensitic transformation and mechanical properties of CrMnNi cast austenitic steels.** M. Wendler, B. Reichel, R. Eckner, O. Fabricchnaya, L. Kruger, A. Weiß, J. Mola. Read more

7. **Effect of strain-induced martensite on tensile properties and hydrogen embrittlement of 304 stainless steel.** Y. Kim, S. Bak, S. Kim. Read more

8. **Precipitation and phase transformations in 2101 lean duplex stainless steel during isothermal aging.** J. Maetz, S. Cazottes, C. Verdu, X. Kleber. Read more

9. **Electrochemical corrosion of stainless steel in thiosulfate solutions relevant to gold leaching.** L. Choudhary, W. Wang, A. Alfantazi. Read more

10. **Microstructural evolution and constitutive equations of Inconel 718 alloy under quasi-static and quasi-dynamic conditions.** M. Azarbarmas, M. Aghaie-Khafri, J.M. Cabrera, J. Calvo. Read more

11. **Test and temperature field of finite element simulation about the effect of scanning speed on 304 stainless layer’s properties by laser cladding.** H. Ju, P. Xu, C. Lin, D. Sun. Read more

12. **Development of the modified high Cr ferritic heat-resistant steel.** C. Liu, Y. Liu, B. Ning. Read more

13. **Micro damage and fracture of SUS304 stainless steel under uniaxial tension.** J. Lan, W. You, L. Hua. Read more

14. **Stability of precipitates under electropulsing in 316L stainless steel.** W. Lu, X. Zhang, R. Qin. Read more

15. **Study on electropulsing assisted turning process for AISI 304 stainless steel.** H. Wang, L. Chen, D. Liu, G. Song, G. Tang. Read more

16. **Improvement of surface properties of 2316 stainless steel with ultrasonic electric surface modification.** D. Liu, X. Li, G. Tang, L. Chen, H. Wang, G. Song. Read more

17. **Fretting corrosion tests on orthopedic plates and screws made of ASTM F138 stainless steel.** C. dos Santos, C. Barbosa, M. de Jesus Monteiro, I. Abud, I. Caminha, C. Roesler. Read more


19. **Latest innovations in converter process modelling.** R. Hübmer, H. Kühböck, K. Pastucha. Read more


**Effect of Ti addition on carbide modification and the microscopic simulation of impact toughness in high-carbon Cr-V tool steels.** K. Cho, S. Kim, S. Park, W. Choi, H. Moon, H. Kwon

In D7 tool steel, which contains high levels of primary carbides, the influence of carbide modification by Ti addition was quantitatively analyzed. Considering the Griffith-Irwin energy criterion for crack growth, the impact energy was evaluated by substituting a microscopic factor of the normalized number density of carbides cracked during hardness indentation tests for the crack length. The impact energy was enhanced with Ti addition because Ti reduced and refined the primary M7C3 carbide phase of elongated morphology, reducing the probability of crack generation.

**Beneficial effect of microalloyed rare earth on s segregation in high-purity duplex stainless steel.** L. Chen, X. Ma, M. Jin, J. Wang, H. Long, T. Mao

S segregation at the a/c interface remains in duplex stainless steel with only 10 ppm S. The interfacial brittle tearing appears during hot deformation due to S segregation. Minor rare earth additions can effectively eliminate the S contamination. In particular, RE enrichment at the a/c interface indicating its microalloying effect is an important cause.

**The Portevin–Le Chatelier effect in a metastable austenitic stainless steel.** A. Muller, C. Segel, M. Linderov, A. Vinogradov, A. Weidner, H. Biermann

The Portevin–Le Chatelier (PLC) effect was investigated in a high-alloy metastable CrMnNi cast steel during tensile tests for the range of deformation temperatures between 293 K and 413 K (20 °C and 140 °C) and for nominal strain rates ranging between 10−4 and 10−1 s−1. Analysis of the stress–strain curves was complemented by in situ measurements of thermal and acoustic emissions as well as by digital image correlation, enabling determination of various local characteristics of plastic flow and clarification of individual contributions of different microscopic mechanisms involved in plastic deformation. It was shown that the PLC effect in the investigated CrMnNi steel was caused by the diffusion of interstitial atoms in the bcc phases.

**Contributions of e and α′ TRIP effects to the strength and ductility of AISI 304 (X5CrNi18-10) austenitic stainless steel.** A. Weiß, H. Gutte, J. Mola

The deformation-induced processes by tensile loading of X5CrNi18-10 austenitic stainless steel in the temperature range of 77 K to 413 K (196 °C to 140 °C) were investigated. The results were presented in the form of stress–temperature-transformation (STT) and strain–temperature transformation (DTT) diagrams. The thermodynamic stability of the austenite with respect to the e- and α′-martensite transformations was reflected in the STT and DTT diagrams. Furthermore, conclusions could be drawn from the transformation diagrams about the kinetics of stress- and strain-induced martensitic transformations. The diagrams laid foundations for the development of a new method of quantitative determination of strength and elongation contributions by means of induced and often overlapping deformation processes in the austenite. In this context, the plastic strains contributed by the glide and shearing of austenite were quantified and presented in connection with the e and α′ TRansformation-Induced Plasticity effects. Each deformation process was shown to have made a contribution to the strength and ductility, with a magnitude proportional to its dominance. The summation of such contributions provided the tensile strength and the uniform elongation of the steel. In other words, tensile strength and uniform elongation could be derived from a rule of mixtures. The newly proposed method was capable of explaining the anomalous temperature dependence of uniform elongation in the alloy investigated.
Functionally graded high-alloy CrMnNi TRIP steel produced by local heat treatment using high-energy electron beam. D. Heinze, A. Buchwalder, A. Jung, A. Weidner, C. Segel, A. Muller, R. Zenker, H. Biermann

Cold-rolled, high-alloy CrMnNi TRIP steel was heat treated by electron beam (EB) treatment. After cold rolling to a deformation degree of 70 pct, the microstructure was mainly martensitic with residual austenite. The aim of the subsequent EB treatment was to improve mechanical properties regarding strength and ductility by grain refinement. The process is influenced by EB specific parameters, resulting in different temperature-time regimes due to different heating and cooling rates. Grain size gradients over the cross section could not be completely suppressed, but minimized. Investigations included optical microscopy, scanning electron microscopy, hardness measurements, quasi static tensile tests, digital image correlation, and thermography for functionally graded tensile specimens. The local heat treatment was used to set specific tailored properties.

Effect of vanadium nitride precipitation on martensitic transformation and mechanical properties of CrMnNi cast austenitic steels. M. Wendler, B. Reichel, R. Eckner, O. Fabrichnaya, L. Kruger, A. Weiß, J. Mola

The microstructural evolution and mechanical properties of two cast Fe-15Cr-6Mn-3Ni-0.5Si-0.2N-0.1C (concentrations in wt pct) steels containing no vanadium and 0.65 wt pct vanadium were investigated under uniaxial tensile loading for room temperature (RT) and 373 K (100 C). The alloy development was focused on the formation of nanosized vanadium nitride precipitates in the austenite to serve as obstacles to dislocation motion. The austenitic steels exhibited transformation- and twinning-induced plasticity (TRIP/TWIP) effects and the planar glide of dislocations in the austenite. The triggering stress for the RT strain-induced rcfia¢ formation increased by 190 MPa, and the transformation occurred at higher strain levels due to the presence of VN precipitates. The occurrence of the TWIP effect during tensile testing at 373 K (100 C) of both steels resulted in engineering strains above 50 pct. The yield strength (YS) of the VN-containing steel was 420 MPa at RT, 52 MPa higher than the vanadium-free alloy. The difference increased to 59 MPa at 373 K (100 C) with the VN-containing alloy exhibiting a YS of 311 MPa.

Effect of strain-induced martensite on tensile properties and hydrogen embrittlement of 304 stainless steel. Y. Kim, S. Bak, S. Kim

Room temperature tensile tests have been conducted at different strain rates ranging from 2 x 10^-6 to 1 x 10^-2/s on hydrogen-free and hydrogen-charged 304 stainless steel (SS). Using a ferritescoppe and neutron diffraction, the amount of strain-induced martensite (SIM) has been in situ measured at the center region of the gage section of the tensile specimens or ex situ measured on the fractured tensile specimens. The ductility, tensile stress, hardness, and the amount of SIM increase with decreasing strain rate in hydrogen-free 304 SS and decrease in hydrogen-charged one. Specifically, SIM that forms during tensile tests is beneficial in increasing the ductility, strain hardening, and tensile stress of 304 SS, irrespective of the presence of hydrogen. A correlation of the tensile properties of hydrogen-free and hydrogen-charged 304 SS and the amount of SIM shows that hydrogen suppresses the formation of SIM in hydrogen-charged 304 SS, leading to a ductility loss and localized brittle fracture. Consequently, we demonstrate that hydrogen embrittlement of 304 SS is related to hydrogen-suppressed formation of SIM, corresponding to the disordered phase, according to our proposition. Compelling evidence is provided by the observations of the increased lattice expansion of martensite with decreasing strain rate in hydrogen-free 304 SS and its lattice contraction in hydrogen-charged one.

Precipitation and phase transformations in 2101 lean duplex stainless steel during isothermal aging. J. Maetz, S. Cazottes, C. Verdu, X. Kleber
The effect of isothermal aging at 963 K (690 °C) on the microstructure of a 2101 lean duplex stainless steel, with the composition Fe-21.5Cr-5Mn-1.6Ni-0.22N-0.3Mo, was investigated using a multi-technique and multi-scale approach. The kinetics of phase transformation and precipitation was followed from a few minutes to thousands of hours using thermoelectric power measurements; based on these results, certain aging states were selected for electron microscopy characterization. Scanning electron microscopy, electron back-scattered diffraction, and transmission electron microscopy were used to quantitatively describe the microstructural evolution through crystallographic analysis, chemical analysis, and volume fraction measurements from the macroscopic scale down to the nanometric scale. During aging, the precipitation of M23C6 carbides, Cr2N nitrides, and r phase as well as the transformation of ferrite into austenite and austenite into martensite was observed. These complex microstructural changes are controlled by Cr volume diffusion. The precipitation and phase transformation mechanisms are described.

Electrochemical corrosion of stainless steel in thiosulfate solutions relevant to gold leaching. L. Choudhary, W. Wang, A. Alfantazi
This study aims to characterize the electrochemical corrosion behavior of stainless steel in the ammoniacal thiosulfate gold leaching solutions. Electrochemical corrosion response was investigated using potentiodynamic polarization and electrochemical impedance spectroscopy, while the semi-conductive properties and the chemical composition of the surface film were characterized using Mott–Schottky analysis and X-ray photoelectron spectroscopy, respectively. The morphology of the corroded specimens was analyzed using scanning electron microscopy. The stainless steel 316L showed no signs of pitting in the ammoniacal thiosulfate solutions.

The deformation behavior of IN718 superalloy was investigated using the hot compression tests in the temperature range of 950–1100 °C, and strain rates covering the quasi-static to the quasi-dynamic regions (0.001–10 s−1). The shape of flow curves as well as the corresponding work hardening rates analysis was utilized to reveal the dynamic recrystallization (DRX) phenomena. DRX was the dominant restoration mechanism in the whole temperature and strain rate domains, which was characterized by the optical and EBSD images. Extended flow softening was observed at high strain rates due to the adiabatic heating and dislocations interaction. In addition to the assessment the capability of Sellars equations, a new constitutive equation based on the multiple variable regression analysis was proposed for modeling the peak stress as a function of strain rate and temperature. Besides the simple form of the proposed model, it has a good accuracy for predicting the peak stress.

Test and temperature field of finite element simulation about the effect of scanning speed on 304 stainless layer’s properties by laser cladding. H. Ju, P. Xu, C. Lin, D. Sun
A 304 stainless layer was obtained by laser cladding on the surface of 45 steel using the way of pre-setting powder with the equipment of 5 kW transverse flow CO2 laser processing. Temperature field of 304 stainless layer in the laser cladding process was finite analysed by the software of ANSYS. The analysing process considered the heat source model the latent heat of phase change the unit of surface effect the mesh generation and the technology of element birth, etc. Effect of scanning speed on the dilution rate was analysed, and was compared with actual results. Then, results were analysed. The finite element analysis and result of experiment showed that the highest
temperature the dilution rate and the width of the cladding laser were inversely proportional to the scanning speed of laser, and the height of cladding layer is in directly proportional to the scanning speed; the finite element analysis of temperature field sufficiently reflected the characteristic of rapid heating and cooling in the laser cladding process; the trend and numerical value of the dilution rate between experiments and finite element simulations about laser cladding 304 stainless steel are basically anastomosing.

Development of the modified high Cr ferritic heat-resistant steel. C. Liu, Y. Liu, B. Ning
High Cr ferritic heat-resistant steels have been the important structural materials for elevated temperature application in the advanced power plants. Owing to the severe difficulties encountered by energy shortage and environment pollution, it is imperative to improve the serving temperature up to 650° which would largely elevate the thermal efficiency of generating station. In this paper, the phase transformation behaviours, strengthening mechanism and the formation the precipitates of high Cr ferritic steels were summarised. Based on these, the modified high Cr ferritic steel for 650 °C condition was developed by our group. The tensile and creep tests indicate that the modified steel has the outstanding mechanical properties, suggesting it may be the candidate materials in advanced power plants for 650 °C grade. Furthermore, developments of the modified high Cr ferritic steels will be presented and discussed in views of microstructural control, alloy design, phase transformation behaviours and high-temperature performance.

Micro damage and fracture of SUS304 stainless steel under uniaxial tension. J. Lan, W. You, L. Hua
The SUS304 stainless steel is widely used in many industries, and the prediction and detection of fracture tendency in these stainless steel applications are very important for their safety and serviceability. The ductile fracture is caused by micro damage and its accumulation, whose mechanism can be described by the micro void nucleation, growth and final extension to failure. The nucleation, growth and extension of the micro voids are related with the movement of the dislocations. In this paper, the optic microscope, X-ray diffraction and scanning electron microscope were used to observe the changes of the sample during uniaxial tensile tests, and analyse the relationship between micro void and dislocation density, and finally establish a dislocation density-strain model. This model provides a new idea for non-destructive testing, which can be applied to the early identification of fracture tendency.

Materials Science and Technology – Electrical Processing of Materials, October 2015
Stability of precipitates under electropulsing in 316L stainless steel. W. Lu, X. Zhang, R. Qin
Precipitation takes place when the austenite stainless steel is heated to a high temperature. This is found significantly different when the electropulsing is implemented during the heat treatment. Considerable less number density and much smaller particle size of precipitates are formed in the sample treated with electropulsing. Electropulsing helps to dissolve precipitates. The effect is not due to Ohm heat. Instead, it is attributed to the electric current induced change of thermodynamic sequences of the phases and the electric current accelerated mass diffusion.

Study on electropulsing assisted turning process for AISI 304 stainless steel. H. Wang, L. Chen, D. Liu, G. Song, G. Tang
Electropulsing was introduced into the turning process of the AISI 304 stainless steel. The results indicate that the main cutting force, microhardness and axial roughness on machined surface are reduced dramatically under appropriate electropulsing
parameters. For AISI 304 stainless steel, the electropulsing applied in turning process can improve the plastic deformation ability in cutting area, increase lubricating property and change friction state between the tool and the workpiece in the forming process of the chip. It causes the arising of plastic stripping tear based on pure shear plastic deformation and brings obvious changes on morphologies of the machined surface and the corresponding chip.

**Improvement of surface properties of 2316 stainless steel with ultrasonic electric surface modification.** D. Liu, X. Li, G. Tang, L. Chen, H. Wang, G. Song

An ultrasonic electric surface modification treatment was employed to improve the surface properties of 2316 stainless steel. The surface properties of the specimens after conventional cutting, ultrasonic surface modification treatment and ultrasonic electric surface modification treatment were characterised respectively. A grain refinement layer was formed on the specimen’s surface after ultrasonic electric surface modification treatment. The average grain size on the top surface was refined into the submicrometre or nanometre scale. This is caused mainly by two aspects: one is the accumulation of initial tiny particles during deformation, and the other is that the ferrite is smashed into pieces due to microfatigue damage. Moreover, it was found out that the specimen after ultrasonic electric surface modification treatment at four times had shown the optimal surface properties.

**Revista Brasileira de Engenharia Biomédica, July 2015**

Fretting corrosion tests on orthopedic plates and screws made of ASTM F138 stainless steel. C. dos Santos, C. Barbosa, M. de Jesus Monteiro, I. Abud, I. Caminha, C. Roesler

Although there has been significant progress in the design of implants for osteosynthesis, the occurrence of failures in these medical devices are still frequent. These implants are prone to suffer from fretting corrosion due to micromotion that takes place between the screw heads and plate holes. Consequently, fretting corrosion has been the subject of research in order to understand its influence on the structural integrity of osteosynthesis implants. The aim of this paper is to correlate the surface finish characteristics of bone plate-screw systems with fretting corrosion. The surface finish (machined and polished) of five specimens taken from three commercial dynamic compression plates (DCP) were evaluated. For testing, the specimens were fixed with bone screws, immersed in a solution of 0.90% NaCl and subjected to a rocking motion with an amplitude of 1.70 mm and frequency of 1.0 Hz for 1.0 × 106 cycles, according to the ASTM F897 standard. Both, plate and screws were manufactured in Brazil with ASTM F138 stainless steel. Flaws on the hole countersink area and on the screw thread of some specimens were identified stereoscopically. At the end of the test all the specimens showed evidence of fretting corrosion with an average metal loss of 4.80 mg/million cycles. Conclusion: An inadequate surface finish in some areas of the plates and screws may have favored the incidence of damage to the passive film, accelerating the fretting corrosion at the interfaces between the plate hole countersink and the screw head.

**Journal of Materials Engineering and Performance, July 2015**


Stainless steels are among the most economical and highly practicable materials widely used in industrial areas due to their mechanical and corrosion resistances. In this study, a dissimilar weld joint consisting of an AISI 316L austenitic stainless steel (ASS) and a UNS S32750 dual-phase stainless steel was obtained under optimized welding conditions by gas tungsten arc welding technique using AWS A5.4:ER2594 filler metal. The effect of welding on the evolution of the microstructure, crystallographic texture,
and microhardness distribution was also studied. The weld metal (WM) was found to be dual-phased; the microstructure is obtained by a fully ferritic solidification mode followed by austenite precipitation at both ferrite boundaries and ferrite grains through solid-state transformation. It is found that welding process can affect the ferrite content and grain growth phenomenon. The strong textures were found in the base metals for both steels. The AISI 316L ASS texture is composed of strong cube component. In the UNS S32750 dual-phase stainless steel, an important difference between the two phases can be seen in the texture evolution. Austenite phase is composed of a major cube component, whereas the ferrite texture mainly contains a major rotated cube component. The texture of the ferrite is stronger than that of austenite. In the WM, Kurdjumov-Sachs crystallographic orientation relationship is found in the solidification microstructure. The analysis of the Kernel average misorientation distribution shows that the residual strain is more concentrated in the austenite phase than in the other phase. The welding resulted in a significant hardness increase in the WM compared to initial ASS.

METEC & 2nd ESTAD, June 2015
Latest innovations in converter process modelling. R. Hubmer, H. Kühböck, K. Pastucha
BOF converter shops are being forced to operate at higher than traditional phosphorous loadings which impacts turndown performance especially for lower phosphorous grades. In stainless steel production the traditional scrap-based EAF - AOD route is substituted by alternative process routes. These process changes have to be reflected by the Steel Expert process model package for carbon and stainless converters. The Steel Expert process model package comprises dynamic process guidance, a prediction model for simulation of the complete production process and a number of setpoint models for the different production steps. The extended functionality for BOF converters comprises enhanced MgO and lime saturation model; a calculation of solid and liquid slag weight and analysis based on the results from the saturation model; automatic blow-stop functionality for BOF converters equipped with sublance measurement in analogy to the existing auto-blow stop functionality for BOF converters with dynamic off gas measurement device. For AOD converter the functionality has been upgraded by introduction of a desiliconization phase for premelts coming with high Si-content, heating with FeSi and intermediate deslagging functionality. In addition a completely new human machine interface (HMI) for the Level 2 automation system has been developed and successfully installed within the last projects.

Journal of Materials Science, June 2015
The demand for increased efficiency of industrial gas turbines and aero engines drives the search for the next generation of materials. Promising candidates for such new materials are Co-based superalloys. We characterize the microsegregation and solidification of a multi-component Co-based superalloy and compare it to a ternary Co–Al–W compound and to two exemplary Ni-based superalloys by combining the experimental characterization of the as-cast microstructures with complementary modelling of phase stability. On the experimental side, we characterize the microstructure and precipitates by electron microscopy and energy-dispersive X-ray spectroscopy and determine the element distributions and microsegregation coefficients by electron probe microanalysis (EPMA). On the modelling side, we carry out solidification simulations and a structure map analysis in order to relate the local chemical composition with phase stability. We find that the microsegregation
coefficients for the individual elements are very similar in the investigated Co-based and Ni-based superalloys.