7th European Stainless Steel Conference – Science and Market, Como (I) 21-23 September 2011

Summary report, compiled by Euro Inox, Brussels, Belgium

Introduction

The present overview summarizes selected conference papers which are application-oriented and could have short-term practical implications for the development of the stainless steel market. The scope of the conference, however, was much broader – including metallurgy and processes. Users wishing to purchase the full conference proceedings on a CD-ROM are invited to contact the conference organisers, the Associazione Italiana di Metallurgia (AIM) at aim@aimnet.it, indicating their full mailing address and VAT number. The price is € 70 plus mailing expenses. AIM will send a pro-forma invoice. As soon as the advance payment has been made, AIM will send the CD-ROM together with a formal invoice and receipt.

1. New materials and material properties

Duplex stainless steel in fire
M. Andersson et al., Outokumpu, Avesta (S)
Paper no. 29

In real fire situations, duplex stainless steels perform much better than theory would suggest.

In applications in which fire risk requires particular attention (multi-storey buildings, tunnels and bridges), data on mechanical properties at high temperature are necessary to determine the load-bearing capacity of structures under fire conditions. The common understanding is that duplex stainless steel has low strength at high temperatures and that brittle phases are formed between 300–1000°C, resulting in inferior fire properties compared to those of austenitic grades. According to available data, the temperature of steel in a real fire situation will not reach temperature levels that would lead to a substantial loss of strength. Research confirms that duplex grades have somewhat lower strength retention than comparable austenitic grades in the higher temperature range. However, even at the higher temperature range typical of real fire situations, their absolute strength level is still similar to that of austenitic grades. It was also proposed that existing Eurocode 3 retention values for grade 1.4462/2205 should be lowered.

Methodological approach of antibacterial surfaces characterisation
A. Allion et al., Aperam, Isbergues (F)
Paper no. 110

While copper and silver can have anti-microbial effects, their efficiency depends on particular circumstances that are not guaranteed in real-life situations. Their beneficial effects are systematically overestimated.

A study was carried out on stainless steel as the reference material, two “antimicrobial” surface layers (silver applied as a coating and in matrix) and copper. It can be concluded from the results that the antimicrobial activity of copper should be put into perspective. For copper to have an antimicrobial effect requires very close contact between the bacteria and the copper or a higher concentration of copper ions released into the nutrient medium. Moreover, the presence of organic matter in the solution affects copper’s antibacterial efficiency. The solid matter can decrease copper leakage into the solution, acting as a barrier by absorption at the liquid-copper interface.

Corrosion resistance of lean alloy alternatives for 300 series stainless steels
P. Gümpel et al., Hochschule Konstanz, Konstanz (D)
Paper no. 53

Lower-alloyed grades can have a cost-saving potential without compromising the quality of the finished product if their specific properties are taken into account and an appropriate surface finish is selected.

Some lower-alloyed stainless steels (duplex, ferritic and manganese-austenitic grades) were compared with established austenitic grades 1.4301/304 and 1.4401/316. The alternative grades considered were 1.4003/3Cr12, 1.4162/2101, 1.4062/2202, 1.4362/2304, 1.4509/441, 1.4521/444 and 1.4376/H400. In addition, different surface conditions were tested, including as-supplied, dry-ground, shot-peened, electro-polished and welded. It was found that lean duplex steel 1.4362 had better repassivation behaviour than austenitic grade 1.4404/316L up to 50 °C. Also the ferritic, molybdenum-containing stainless steel 1.4521/444 offered excellent corrosion properties compared to austenitic stainless steels, but its mechanical behaviour at low temperatures had to be taken into account. Comparing surface conditions, it was concluded that the shot-peened specimen had the lowest corrosion resistance compared to as-supplied and ground surfaces. In the welded condition, pitting potential decreased most, grade 1.4062/2202 especially showing a drop in pitting potential, measured at 20 °C (this may depend on the welding conditions of the material and not be a general effect). Grade 1.4162/2101 proved especially sensitive to the quality of the surface condition.

Localised corrosion in stainless steels – An integrated approach to identify risk conditions
R. Pettersson et al., Outokumpu, Avesta (S)
Paper no. 27

This paper drafts a methodology for identifying low risk areas, for a given grade, in a three-dimensional matrix of chloride concentration, temperature and applied potential.

The practical usefulness of this approach lies in the fact that (a) relatively simple laboratory tests are used and (b) the risks of pitting corrosion, crevice corrosion and stress corrosion cracking are evaluated in combination and not in isolation. Developed using standard austenitic grade 1.4404/316L and super-duplex grade 1.4410/2507, the methodology was then successfully applied to standard duplex grade 1.4462/2205, as an example. The combined effect of chloride content, applied potential and temperature on critical pitting and crevice corrosion temperature was shown to be a valid indicator of corrosion performance. This integrated approach can be useful in material selection.

For chloride-containing environments, sodium chloride and magnesium chloride were used. There was only a slight difference between critical pitting temperatures in two electrolytes and it was shown that electrolytes could often be used interchangeably. Introducing crevices decreases the critical temperature for localised corrosion, typically by 20–30 °C, while acidification to pH 2 can decrease CPT by approximately 10 °C.

2. New processes

Effect of Kolsterising treatment on surface properties of a duplex stainless steel
V. Bordiga et al., Bodycote Trattamenti Termici S.p.A., Brescia (I)
Paper no. 71

A hardening treatment commonly used for austenitic stainless steels can also be applied to duplex stainless steels without a detrimental effect on corrosion resistance.

The Kolsterising process was invented in the late 1980s. Up to now, the process was mostly applied to austenitic stainless steels, because carbon diffuses easily into austenite due to its better solubility in the fcc lattice. In the case of duplex stainless steels, one would expect a non-homogenous structure, with austenite regions enriched in carbon and ferrite regions lower in carbon content. According to the results presented, the micro-hardness increase was achieved in both phases. Carbon diffusion was not limited to the austenitic surface layer and higher values were achieved in the ferrite phase. No detrimental effect on chloride pitting resistance was observed.

Low-temperature surface hardening of stainless steel through gaseous nitriding and carburising; from fundamentals to applications

T.S. Hummelshøj, Expanite, Lyngby (DK)

Not available in the proceedings, extracted from personal notes and company leaflet

A new surface-hardening process dissolves carbon and nitrogen in the matrix in a gaseous atmosphere, without limitation on size and geometry.

The surface hardening results in enrichment with carbon and nitrogen. The thickness of the newly formed layer is typically in the 20–40 µm range. The process is performed in a controlled gas atmosphere, which allows precise tailoring of the carbon and nitrogen composition profile. The dissolution of nitrogen and carbon inside the austenite expands the lattice and the structure is actually “expanded austenite”. Dissolution of the passive layer on the stainless steel is part of the process. There are no restrictions on geometry and size. The treatment can be performed in standard retort nitriding furnaces, without special modifications. The Expanite process offers scratch-resistant stainless steel surfaces and can be used on austenitic, martensitic and duplex stainless steels.

Mechanical properties of weld joints in a novel high-strength austenitic stainless steel

J. Leinonen, University of Oulu (FI)

Paper no. 114

Welding seams need not be a limiting factor in high-strength assemblies if a novel high-strength austenitic stainless steel is used.

A new process for the production of very fine-grained austenitic stainless steels has recently been discovered and developed. The process is patent pending and not much information is available at the moment. It can easily be applied to current stainless steel production lines. The grain size achieved varies between 0.5 µm and 5 µm, depending on production parameters, with a yield strength of about 900 MPa to 350 MPa respectively. Welding is often the limiting factor when high-strength steels are to be used in constructions. The lower strength in the weld joints of high-strength material is the result of softer weld metal and the heat-affected zone (HAZ). The most important reasons for this are phase transformations, coarsening of the microstructure and welding heat input. On the basis of current results, it is suggested that the novel austenitic stainless steel makes it possible to also achieve high strength in the welded joint, if appropriate welding processes and parameters are used – specifically laser welding, laser-MAG hybrid welding, plasma arc welding and modified short arc MIG/MAG welding (narrow weld fusion zone and HAZ).

3. New applications

Stainless steel and profiling: A solution for the railway industry?
J. De Wilde et al., Aperam (B)
Paper no. 52

One-piece roll-formed sections can replace welded designs and make them a cost-effective solution for the structures of, for instance, railcars.

Roll forming is frequently used in industries such as building (window, door frames and structural parts) or transportation (trucks, buses, railcars and highway infrastructure). The process provides an economic solution by avoiding welded assemblies. Complex parts with high dimensional accuracy can be produced at high speed and with little handling. The research, performed in cooperation with a railcar manufacturer, proved that for 15-17 m-long structural parts, an original welded assembly in grade 1.4571 (316Ti) could be successfully replaced by a one-piece roll-formed design in a 15 % Cr and 7 % Ni grade. The goal of the research was to reduce weight and manufacturing costs (manual welding of different parts) on one hand and integrate several functionalities (structural part of the body plus fastening rail for equipment) on the other. Despite the complex forming operation, the newly selected steel grade performed well in terms of corrosion resistance (even in exposed parts) and fatigue resistance.

Use of 201LN-1.4371. Which benefits?
J. Bridel, Aperam, Isbergues (F)
Paper no. 69

Passenger transport, pressure vessels and pipe and distillation columns can benefit from using steel grade 16-5MnL (201LN-1.4371).

Grade 1.4371/201LN-was discussed as an alternative to 1.4318/301LN or 1.4301/304 and 1.4307/304L. Its advantages compared to the classic reference austenitic grades include less price volatility (because of the partial substitution of manganese for nickel), a significantly higher tensile strength and greater elongation at rupture. High strength at cryogenic temperatures and a marked tendency to work-harden were also clearly demonstrated. While the corrosion resistance of grade 1.4371/201LN was shown to be slightly below that of 1.4301/304, 1.4404/316L and 1.4318/301LN, weldability proved to be good, especially when overmatching filler metal was used. As reported, the grade has found its entrance in passenger transport (railways), frames and structural profiles for trailers as well as cryogenic tanks, pressure vessels, pipes and distillation columns.

Stainless steel and its finishes – A resource for architecture and design
E. Rizkallah, Steel Color, Pescarolo ed Uniti (I)
Paper no. 146

Digital printing on stainless steel is a new solution in addition to well-established colouring techniques.

Special finishes on stainless steel and their applications in architecture and design are the subject of increasing market interest. These finishes include coloration through interference and PVD, electro-chemical etching, decorative embossing and digital printing. Digital printing on stainless steels offers new opportunities for designers. The technology uses transparent colours and allows any picture to be printed on a stainless steel support with the underlying finish remaining visible. Another interesting solution in architecture is a mixture of stainless steel sheets and supports with an aluminium honeycomb structure.

Functional and decorative coatings onto stainless steel sheets and strips by high-rate physical vapour deposition
B. Scheffel, Fraunhofer Institute, Munich (D)
Paper no. 115

The latest development in PVD coating techniques makes possible pore-free layers with high hardness. Such layers can have easy-to-clean, antifogging, antibacterial or other outstanding properties.

The latest PVD coating technologies for decorative and functional purposes were presented, with a special focus on photo-induced TiO_2 layers. These make it possible to create products with new easy-to-clean, antifogging, antibacterial or photo-catalytic purification properties. It was also shown that the scratch resistance of a stainless steel surface was remarkably increased by the deposition of thin silicon oxide layers. The properties of the coatings could be improved by organic modification of the layer materials. The most common PVD processes in industry include magnetron sputtering and vacuum arc evaporation. However, both techniques have limitations in deposition rate. Lately, it has become possible to greatly extend this limit, using a high-power electron beam PVD process. The layers grown under plasma influence are nearly ideally stoichiometric and probably free of physically adsorbed oxygen. Hardness is therefore dramatically raised. In addition, layers deposited with plasma activation have a high refractive index, providing strong colour effects, due to the thin film interference.

On-site generation of free chlorine for cleaning and disinfection purposes: Its compatibility with stainless steels used in the food industry

V. Boneschi et al., Centro Inox, Milan (I)

Paper no. 140

The on-site electrochemical production of free chlorine via electrolysis of aqueous NaCl is an effective solution for applications where surface cleaning and sanitising requirements must be met.

The development of a new, highly efficient system capable of producing 1,000–8,000 ppm of active chlorine on-site using tap water was described. In addition, the tests performed on steel grades most commonly used in the food industry were performed. These tests prove that the use of two test solutions –1-1,000 ppm sodium hypochlorite (active chlorine) with 3500 ppm sodium chloride and 2-5,000 ppm sodium hypochlorite with 15,000 ppm sodium chloride – followed by a correct rinsing process, left all tested materials unaffected. Three different stainless steels can withstand a continuous 1,000 ppm sodium hypochlorite solution for:

- 8 hours, in the case of 1.4301/304
- one day, in the case of 1.4401/316
- a few minutes only, in the case of 1.4016/430

The results are valid for room temperature, but temperature increase may reduce these times. In everyday practice, the presence of disinfectant chemicals should be minimised and always followed by proper rinsing.

Electropolishing of austenitic and duplex stainless steels

B. Henkel, Henkel Beiz- und Elektropoliertechnik, Neustadt (D)

Paper not available in the proceedings

Duplex stainless steels can be successfully electropolished with standard sulphuric-phosphoric electrolytes because, given correct parameters, equal removal of austenite and ferrite can be obtained.

The electropolishing of duplex stainless steels is more complex than that of austenitic materials, because the microstructure is composed of ferrite and austenite, which do not normally show the same reactions to electropolishing. The different alloying composition of the two phases results in different electrochemical behaviour. To study this effect in more detail, an electrochemical setup was used which made possible measurements in single austenitic or ferritic grains. The results show that the active peak of ferrite appears at higher potentials than that of austenite. Austenite has higher current density at the peak and the plateau. For optimal electropolishing of the two-phase material, this gap in current density should be minimised. Current density potential curves can be influenced by varying temperature, electrolyte flow and electrolyte composition (for basic composition and composition with additives). Compared to austenitic stainless steels, duplex grades can be successfully electropolished with standard sulphuric-phosphoric electrolytes at a somewhat lower temperature. Adapting the electrolyte and electropolishing parameters makes it possible to obtain equal removal of austenite and ferrite using commercially available sulphuric-phosphoric electrolytes.