The irresistible rise of duplex

Although the price of nickel has retreated from its record highs, producers have been switching to low- and no-nickel alternatives such as ferritics and duplex grades, as required. And having once made the switch away from nickel-based alloys, they are in no hurry to switch back. This is especially the case in critical applications within the process industries, where duplex, super duplex and hyper-duplex grades are making great headway.

Stainless Steel World highlights some recent trends in the use of duplex grades.

By James Chater

Across a wide range of industries, duplex, super duplex and hyper-duplex stainless steels are increasingly regarded as attractive alternatives to other kinds of stainless steels in terms of both cost and durability. As a result, both suppliers and stockists are focusing more on duplex grades. Outokumpu, which has 50 per cent of the world market share for duplex, has estimated that the market will grow by 20 per cent per year. Moreover, companies are successfully introducing new grades for such industries as chemical, petrochemical and refining, which call for a combination of high corrosion resistance, high mechanical strength (leading to weight reduction) and good weldability.

Oil and gas

In oil and gas, duplex has played a crucial role in helping to withstand tough conditions. This is due not only to its corrosion resistance and mechanical strength, but also because its pitting and crevice corrosion resistance is superior to that of standard austenitic alloys, with pitting resistance equivalent numbers (PREN) often exceeding 40.

The use of duplex is on the increase: it is symptomatic that Sumitomo Metals, which has been supplying Oil Country Tubular Goods (OCTGs) to Statoil since the 1980s, has just signed a new contract (2008-13) with the Norwegian company which for the first time includes OCTGs made of super duplex. Other leading suppliers in this field are Sandvik (SAF 2906; 3207 HD), Outokumpu (Code Plus Two® and Super Duplex 2507; LDX 2101®) and Allegheny (AL 2003™).

The main applications for duplex are process piping systems and equipment like separators, scrubbers and pumps. Subsea the materials are used in downhole production tubing, piping and manifolds, X-mas tree components, flowlines and pipelines transporting corrosive oil and gas. Super duplex (25% chromium) stainless steels are useful for their resistance to design stress, so they are often used on such items as bar, forgings, castings, sheet, plate, tube, fasteners etc. Super duplexes

Statoil's Snøhvit LNG facility on Melkøya Island near Hammerfest, Norway, is Europe's first LNG production plant and also the first ever field development in the Barents Sea. The field has been developed with subsea installations at depths of 250-345 metres. The first tanker with a cargo of LNG left port at Melkøya on 20 October 2007. The facility was constructed using duplex stainless steel supplied by BUTTING. Photo: Even Edland/StatoilHydro.
also have excellent fatigue resistance and galvanic compatibility with other high alloy stainless steels. Unfortunately there have been a number of failures of (super) duplex grades due to hydrogen-induced stress cracking (HISC). This occurs when duplex materials under cathodic protection fail as a result of load/stress combined with hydrogen embrittlement. This has led DNV and NORSOK to issue proposals for revised design guidelines with regard to CRAs.2

**Biofuels**

On land, biofuels (especially ethanol) are a sector in which use of duplex grades is growing. Outokumpu’s LDX 2101® was selected by Dutch tank builder Oostwouder Tank- & Silobouw BV for its tank farm for Noba Vetteredeling BV in a large-scale biofuel project in the Port of Amsterdam. LDX 2101® was also specified for the vessels and pipes of Agroetanol’s expanded ethanol plant on the island of Händelö in Sweden, for which Outokumpu is delivering both flat and piping products.

Outokumpu’s LDX 2101, launched in June 2006, uses only 1.5% nickel and contains 5% manganese. Another candidate grade for biofuels is Allegheny’s lean duplex AL 2003®, which could soon be employed to replace 316L in ethanol service.

**Food and drink**

In the food and drink industries too, LDX 2101 is proving its worth. The material is being used for two projects in Spain, a food storage depot and a wine storage depot. In the Port of Barcelona Emypro SA constructed food storage tanks entirely from LDX 2101® as a replacement for EN 1.4301/1.4307 (304/304L). The wine storage depot, built by Spanish tank builder Martinez Sole y Cia in Daimiel in the south of Spain, is the first to use duplex stainless steel: LDX 2101® and 2304 from Outokumpu were used in the construction of the roof and uppermost level of all new tanks, as a cheaper alternative to 1.4301/1.4404 (304/316L). Outokumpu also supplied austenitic stainless steels.

**Wastewater and desalination**

Wastewater and desalination are two more industries where duplex is being specified. Cadagua’s wastewater treatment plant in Spain is the first to make use of duplex as an alternative to nickel alloys. Outokumpu was awarded the contract to supply approximately 360 tons of duplex 2304 sheet and plate to the project, which will be completed in 2008. Outokumpu is also supplying its grades SAF 2304® and 2205 to the MARAFIQ desalination plant in Saudi Arabia being built by France’s SIDEM. SIDEM’s technology uses steam from an adjacent power plant to evaporate seawater at low temperatures, thereby saving energy consumption. The evaporator chambers will be built using duplex stainless steel plate from Outokumpu.

**Architecture**

Duplex continues to play an important role in the construction of bridges, wherever corrosion and saline conditions combine with the need for high load-bearing strength. Two recent examples, both from Asia, are Hong Kong’s Stonecutters Bridge and Singapore’s Marina Bay Pedestrian Bridge, both of which use duplex grade 2205 supplied by Outokumpu. For the Stonecutters Bridge, Outokumpu delivered the 2000 tons of 2205 duplex plate and pipe in late summer 2006. The skin segments were finished by a fabricator in China from plates delivered by Outokumpu in customized sizes with 1K surface. The plates were polished and shot-peened to provide the right level of reflection in both daylight and at night. The Marina Bay Pedestrian Bridge will use 570 tons of duplex supplied by Outokumpu. The bridge’s stunning design comprises two spiralling tubular stainless steel members resembling the structure of DNA, and it is the double-helix and support structures that use duplex 2205 pipes and plates respectively. The stainless steel surfaces will provide nighttime illumination by reflecting lights programmed to enhance the design.

**Company expansions**

Given the intensity of Outokumpu’s activities in the duplex field, it is no surprise to learn that the Finnish company is about to embark on an expansion of its Avesta works in
Sweden over a period of three years (2007-10), at a cost of half a billion euro. The investment will increase the site’s annual capacity to 650,000 tonnes from the current 250,000 tonnes and will mainly affect its duplex stainless steel production. And Outokumpu is also selling its technology abroad: in September 2007 Nippon Steel & Sumikin Stainless (NSSC), already Japan’s largest duplex maker, acquired Outokumpu’s technology for producing its LDX 2101® in an agreement lasting from 2007 to 2021. The opening of Outokumpu’s sales office in New Delhi in November 2006 was also motivated in part by the demand for duplex grades in India.

China too is expanding its duplex production. In January 2007 Baosteel became the first Chinese steel maker to produce 2205 hot-rolled high-strength duplex stainless steel strip. On 25 June 2007 Nantong Special Steel Company, a producer of tubes in duplex 2205 and various austenitic grades, became an approved vendor of Lyondell Chemical Company. Other duplex suppliers include Shanghai Huaxia, Changshu Walsin Speciality Steel, which has just completed a new factory for seamless stainless pipes and duplex, and Jiangsu Huayang Metal Pipes Co. Ltd (Hymco). Tisco is said to be on the verge of launching a super duplex grade containing aluminium. In India, Chandan Steel Ltd announced start of production of its DIN 1.4462 (2205) duplex bright round bars in September 2007. These are to be exported to Germany and China.

In the USA, Rolled Alloys has been increasing its holdings of duplex. In January 2007 it announced availability of its super duplex RA2507 plate products and welding consumables, and in June it added AL 2003 to its line, which also includes LDX 2101® and 2205. According to Rolled Alloys, RA2507 is highly resistant to chloride environments (stress corrosion cracking) and is suitable for seawater applications such as desalination, offshore oil, pulp & paper and flue gas scrubbing.

Stockists have been following the lead of manufacturers. In April Stirlings Australia announced availability of duplex 2507 plate and an extended range of grade 2205. Stahlkontor Hahn, a division of ThyssenKrupp Materials International, has added to its stock range super duplex grade UNS S32760 (1.4501) for seamless tubes from 0.5in to 8in NPS.

The demand for duplex grades has turned one Dutch independent distributor into a tempting take-over target: in April 2007 Teuling Staal BV, which delivers duplex and super duplex grades to the Dutch gas market and exports all over the world, was taken over by Klöckner & Co., a subsidiary of ODS BV.

### Table 1

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Table 1. Nominal chemical composition of two highly alloyed duplex stainless steels, in terms of weight percentage.

*PRE = Pitting Resistance Equivalent (= %Cr + 3.3%Mo + 16%N).

New product

A few months ago Outokumpu’s LDX 2101® promised to fill a large niche in the market, and so it proved. Now Sandvik’s SAF 2707 HD® hyper-duplex stainless steel, launched in March 2007, looks as though it is about to do the same (see table 1). Designed to increase operating performance and extend service life in severely corrosive heat exchanger applications, the new grade is aimed mainly at the chemical, petrochemical and refinery industries. In order to verify that the metal could withstand higher operating temperatures and longer run times, it was extensively tested in a variety of refinery applications over a period of three years. It was confirmed that SAF 2707 HD® is particularly suited to aggressive, acidic, chloride-containing environments (it is recommended for hot seawater) and combines excellent corrosion resistance with high mechanical strength and good weldability. Sandvik has developed welding products (welding wire Sandvik 27.9.5.L for GTAW (TIG)) in parallel with the base material. Stress corrosion cracking properties are similar to Sandvik SAF 2507®, but the new steel has improved mechanical properties and can also replace some Ni-based alloys.

Heat exchanger tubing being produced at Sandvik in Sandviken.

