Duplex stainless use is expanding in valves and pumps
In the severest process conditions, manufacturers have come to realize that only the very best materials can prevent accidents, reduce maintenance and downtime, and cut costs in the long term. For this reason duplex use is spreading from tubes & pipes, sheet and bar to valves and pumps. In the past there have been difficulties in welding and fabricating these items, but these are gradually being overcome. Valves and pumps already use a variety of duplex and super duplex grades, and this is likely to increase. They will play an increasingly important role in the process and energy industries, from power generation to desalination, pulp & paper, petrochemical and chemical.

By James Chater
**Why is duplex used?**

In recent years, several valve and pump manufacturers have added duplex or super duplex to their materials options, or have expanded their offer of pumps or valves made of these materials. One of the most recent examples of this occurred in November 2014, when Wärtsilä Shipham Valves announced extension of its range of duplex and super duplex stainless steel valves to cover higher pressure ratings. Its whole range of gate, globe, check, ball and butterfly valves can now be specified in duplex and super duplex, with sizes ranging from 15mm to 1200mm and pressure ratings up to ANSI 1500 lbs. Other companies which now offer duplex and super duplex versions of their products include valve makers Emerson, Flowserve, GEMÜ, Kitz, KSB, Metso, Parker Hannifin, Sitecna and Victaulic; and pump makers Cornell Pump, Danfoss, Ebara, Flowserve, Global Pump, Goulds Pumps (ITT), Grundfos, KSB, Pioneer Pump, PSG, Sulzer and Torishima. Many companies offer their valves and pumps in a choice of materials, depending on the severity of the media: standard austenitic, moly 6, Monel, Hastelloy, duplex or super duplex.

If Shipham’s expansion aimed to cover the highest pressure ratings, there are several other reasons for specifying duplex:

1. **Corrosion resistance.** Duplex is more resistant to stress corrosion cracking and pitting corrosion than standard austenitic grades. And this corrosion resistance can be bought at a lower price than nickel alloys or superalloys. This makes duplex and super duplex ideally suitable to marine environments and desalination.

2. **Hardness and erosion resistance.** Duplex stands up relatively well to wood chippings, grit, slurry, sand or other erosive media, and is more wear-resistant. This is an important consideration in mining, waste water, and pulp & paper.

3. **Compactness.** With its higher strength-to-weight ratio, duplex, with its thinner walls, takes up less room than standard grades, an advantage when space is limited. It also means that smaller pumps can deliver the same power as larger models made of other materials, which means that more powerful pumps can replace older models during a refit.

**Disadvantages**

In the past, the limited formability and perceived welding difficulties of duplex grades have inhibited their use in valve and pump manufacture. In 2009 it was noted that some valve suppliers were reluctant to produce duplex stainless valves that are compliant with NACE MR0103 (1). This reluctance had to do with the difficult requirements of welding duplex castings. Poor quality control during welding can result in corrosion failure of duplex valves long after their installation. In a refinery in Kuwait, duplex stainless steel valves failed after three years because the materials were subjected to improper heat treatment during the fabrication stage (2). Traditionally, duplex grades are less ductile than austenitic ones. To address that problem, in May 2013 Outokumpu launched two new duplex grades. In tests, FDX 25™ and FDX 27™ showed better corrosion resistance than 304L and 316L respectively, as well as superior mechanical strength and resistance to stress corrosion cracking, yet that they are as easy to form as austenitic grades. The grades are cold-formed so as to induce TRIP (Transformation Induced Plasticity), which enhances the strength and formability of the steel. Outokumpu believes these strong-yet-ductile alloys are suitable for demanding applications such as pump casings.

**Materials**

Valves and pumps can be made (usually cast) entirely in duplex stainless steel, or the use of duplex can be restricted to those parts that come into contact with aggressive media. Victaulic, for example, offers a port ball valve with grooved ends, the Series 726D, with a super duplex ball, body and end cap. Duplex and super duplex are regularly used in pumps casings and impellers. A common combination is an austenitic cast iron case with a duplex stainless steel impeller, but after a number of failures in the iron cases, it has become usual to specify super duplex for all the components. Lean duplex grades are not normally used in valve or pump manufacture. In theory, cast lean duplex could be used to make pumps, but a lack
of official standards has prevented this development (3). However, Outokumpu’s Forta LDX 2101 (1.4162) lean duplex meets the requirements of ASTM A 961/A 961M for valves. Jiangsu Liangyi Co. in China offers pump impellers made of LDX 2101 and 2304, among other duplex grades.

Among super duplex grades, Zeron 100 was used in cast pump housing in the North Sea from the 1980s. Pumps made from austenitic had become too large and offered too little corrosion resistance, as was also the case with standard duplex grades. Only super duplex provided adequate corrosion resistance as well as offering weight savings. Zeron 100 (A995-6A; Superduplex F55) proved successful for injection, seawater lift and firewater pumps. A great many other duplex and super duplex grades have been developed for cast valves and pumps. Here are some of the commonest grades (4):

ASTM A890-1A (CD4MCu). Duplex. Widely used in pumps, especially in abrasive applications, such as the casing and impeller.

ASTM A890-1B, ASTM A995-1B (CD4MCuN). Duplex. Same as above, with added nitrogen. Chemically identical to this is Wilfley’s WCD4™, but with improved mechanical properties and corrosion resistance.

ASTM A890-3A (1.4468). Duplex. Used in process industry and seawater applications. Resistant to pitting in chloride-bearing media; used for valves and pumps in chemical and crude oil installations. Added copper for corrosion resistance in e.g. weak sulphuric acid conditions, and molybdenum for general corrosion resistance.

ASTM A890-4A, ASTM A995-4A (1.4462). Duplex. Better know as 2205, one of the most common of the standard duplex grades.

ASTM A890-5A, ASTM A995-5A (1.4410, Alloy 2507). Super duplex. Used in a wide range of process industries to resist chloride corrosion. Good resistance to seawater. Used in pumps and pump impellers. Ugitech’s new super duplex grade UGI® 4410 is apparently similar: it meet NORSOK standards, is suitable for valves, flanges and filter systems in the oil & gas and petrochemical industries. It is designed to withstand high-temperature, high-pressure chloride environments.

FDX 25™ (1.4635) and FDX 27™ (1.4637). Duplex. As stated above, these grades were developed by Outokumpu to overcome forming difficulties.

Seawater desalination
Because of drought and climate chaos, demand for water management of all kinds is growing rapidly. The shortage for drinking water is especially high in the world’s driest regions, including Africa the Middle East and East Asia. As an industry, desalination is growing by 9% a year. In China, capacity increase attained 18% in 2104.

In seawater desalination plants, the severest applications occur in the earliest stages, during intake of saltwater. Experience has shown that mild austenitic grades are inadequate against saline conditions. For a while there was a move towards the more highly alloyed grades such as moly 6 or nickel alloys, but duplex is gradually gaining ground as a cost-effective alternative. Duplex can now be found in the toughest pump applications,

Super duplex valves
In early 2009, a customer contacted Flowserve regarding an offshore platform shutdown in the Asia Pacific region. The issue was caused by two severe service valves (purchased from a different valve company) that had failed hydro testing. The body walls were cracked and leaking. When attempting to repair by welding, the bodies fell apart and disintegrated so the valves had to be scrapped. Flowserve explained that the original body material was duplex, which was susceptible to cracking in this pressure vessel application. Because the problem was costing USD 1 million dollars per day in lost production, Flowserve committed to deliver the valves in less than 16 weeks, using a version of super duplex that has better resistance against cracking. The valves were completed, tested, air freighted to the platform and installed within 14 weeks.
Recent contracts for duplex valves and pumps

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<tr>
<th>Manufacturer</th>
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<tr>
<td>Metso</td>
<td>Sappi Ngodwana</td>
<td>Automated process valves for fibre line expansion in the Ngodwana mill in South Africa. Materials: stainless steel, duplex stainless, titanium, SMO and ceramic material.</td>
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<tr>
<td>Pioneer Pump</td>
<td>British Nuclear Group</td>
<td>Duplex stainless seismically tested self-priming pumps to nuclear power station.</td>
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<td>Sulzer</td>
<td>CMPC Celulose Riograndense</td>
<td>For expansion project for the Guaíba 2 pulp line in Southern Brazil. Package included AHLSTAR process pumps. MBN multistage pumps. ZPP double suction pumps. medium consistency pumps (developed in collaboration with Metso), submersible pumps from the ABS XFP and Scavenger series, etc.</td>
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<tr>
<td>Sulzer</td>
<td>Sabesp and Araucária Saneamento</td>
<td>Aeration, mixing and pumping applications to a new wastewater plant in Campos do Jordão, Brazil. Includes 13 sewage submersible pumps of type ABS XFP.</td>
</tr>
<tr>
<td>Sulzer</td>
<td>Suzano Papel e Celulose SA</td>
<td>Around 400 pumps and mixers, including double-suction pumps type Z22, AHLSTAR and BE process pumps. submersible pumps types ABS XFP. ABS AFP and Scavenger. Solomix and Scaba agitators as well as medium consistency pumps.</td>
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<tr>
<td>Torishima</td>
<td>Eren</td>
<td>Six SPV1800 cooling pumps for the Zetes III thermal power plant in the Zonguldak region of Turkey. Material: all duplex stainless.</td>
</tr>
<tr>
<td>Torishima</td>
<td>MARAFIQ</td>
<td>Two seawater cooling pumps for Jubail-2 main seawater cooling pumping station in Saudi Arabia. Major wetted parts in super duplex stainless.</td>
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Conclusion

The future prospects for duplex use in valves and pumps depend on a number of factors, including perception, the introduction of new standards and (perhaps most important) technological developments. Welding and forming duplex has always been perceived as more difficult than with other stainless steels, though part of this perception is due simply to habit and conservatism. With the appearance of grades that are easier to fabricate or to weld, duplex use in valves and pumps will likely increase.

References

(2) www.nace.org/cstm/Store/Product.aspx?id=d8666019-82ed-e111-ac69-0080569a007e.
(4) Reference is made to ASTM A890/A890M (specifications for duplex grades in general applications) and ASTM A998/A998M (specifications for duplex grades in pressure-containing parts).

Pulp & paper

As in desalination, the use of duplex in the pulp & paper came about after milder alternatives (carbon steel, mild austenitic stainless steel) proved inadequate against the corrosive and abrasive conditions of pulp & paper mills. The environment is especially challenging because of the presence of corrosive chemicals and bleaches, together with that of wood chips early on in the process. Moreover, pulp & paper processing has evolved over time. Whereas previously mills simply dumped processed water downstream, now the water has to be recycled in a closed loop. This water is full of chemicals and is highly corrosive.

All these considerations make duplex and other high alloys more or less obligatory.

Duplex is used in digesters, reactors, washing, screening, oxygen reactors, piping, chemical recovery equipment, pulp processing, and in the head boxes and suction rolls of paper machines. Type 2205 has been in use since the 1980s and is still used in valves and pumps. Other grades used in valves and pumps include CD-6MN (3A) (wrought equivalent 329) and CD-4MCuN (1B). The first is used in for pulp stock feed pumps in the chlorine and chlorine dioxide stages (5). Metso delivers automated valves to pulp & paper plants in materials varying from standard stainless steel to duplex stainless steel, moly 6, Hastelloy and titanium.

Fertiliser

Valves and pumps made of duplex are used in a number of chemical process applications, including fertiliser. To deal with the exceptionally aggressive media, Sandvik, together with Stamicarbon, developed its Safurex super duplex grade. It is used in a wide range of equipment, including valves. The Indian company BHDT produces a high-pressure sampling valve made of Safurex. LESER produces an urea synthesis safety valve from the same material.

About the author

James Chater (D.Phil.) was born and educated in the UK. He has also lived and worked in the United States, Canada and the Netherlands. He worked as Editor for KCI Publications from 2000 to 2008, then moved to France, where he lives with his two children and works as a freelance journalist. James researches and writes feature articles for KCI publishing and is a regular contributor to Stainless Steel World magazine. His hobbies include chess and music.

such as the source pump, the filter feed and booster pump, the high-pressure feed pump (duplex or super duplex) and the high-pressure booster pump.

Desalination also provides opportunities for duplex valves, such as GEMÜ’s new C480, a butterfly valve with a valve disc in super duplex, which can be used in water treatment, seawater desalination and power plants.