THE DUPLEX AND SUPERDUPLEX GRADES IN PIPING: PROS & CONS BASED ON CENTRAVIS EXPERIENCE

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Duplex and superduplex stainless steels are nowadays common for subsea piping systems. Midstream applications for seamless tubes include such products as flowlines, spools, manifolds, line pipes and hydraulic lines, with diameters from as small as 10 mm to as big as 10 inches. These steels are more expensive in production compared to the regular austenitic grades. Despite this, their superior mechanical properties and corrosion resistance, coupled with enhanced manufacturing quality standards, provide tangible economic benefits to the end users. This paper briefly describes how the user's value is captured and created by Centravis, a tube and pipe manufacturer from Ukraine.

Added value to the end user

Challenging conditions, such as high pressures, low temperatures, and corrosive environments involving salt water, have made the use of duplex and superduplex stainless steel that much more relevant in the production of tubes and pipes today. As a result, the oil and gas industry have been eagerly championing the application of these materials in their production processes. By introducing the application of austenite-ferrite, savings in production cost, installation, and maintenance are ultimately being made thanks to the dual material's higher strength and resistance to pitting corrosion, especially when compared to the base 18-8 grades. But can the duplex and superduplex models really ensure such benefits?

Duplex and superduplex grades contain lower amounts of nickel, which may constitute for around 50 per cent of the cost of regular austenitic stainless steel. Less nickel may theoretically lead to the material's lower cost, and, it is hoped, to lower cost volatility in its price changes.

Analysis of the billet price index shows that duplex and superduplex grades (like S32750) do not demonstrate significant savings in terms of their material cost as compared to the TP304L grade for common round billets used in the production of cold-deformed tubes. This may be explained not only by the steels' more complex metallurgy, but also due to the fact that they are less common grades, with the smelters able to charge more margins compared to the basic metals.

Almost the same situation we observe with regards to production cost of seamless stainless steel pipes added by the manufacturing processes in relation to the cost of material, based on a relatively common cold-deformed tube size. Higher values for the duplex and superduplex models indicate increased complexity in their manufacture. This of course should come as no surprise given their higher strength and lower formability attributes.

These two factors combined result in the observed price differences in the final products, with Duplex steels being the more expensive option.

But what about elasticity with respect to nickel prices? Fortunately or unfortunately, the mechanism of dampening nickel volatility works better in theory than in practice, as prices are still dictated by the rules of supply and demand (see Figure 1). Additionally, Figure 1 illustrates that there is no obvious correlation between the content of nickel and its price growth, apart from maybe the comparison between S31803 and S32750 grades where the observed difference does make sense.

So, at first glance, the results are not promising – duplex and superduplex grades are more expensive and no less sensitive to nickel price variations than regular austenitic grades. So the question remains: will the end user benefit from the use of these tubes and pipes at all?

Well, let's take a look from another

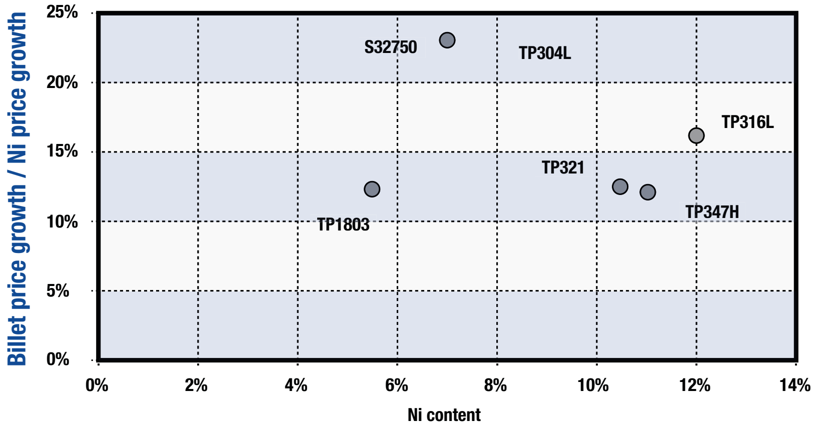

Figure 1 – Relative growth of billet price vs Nickel content

perspective. Compared to TP304L, Duplex S32750 is 3.2 times stronger and superduplex S31803 is 2.6 times stronger when yield strength is considered. Stronger grades allow for lower wall thicknesses, despite having the same diameters, resulting in savings of material. Applying Barlow's formula for the bursting pressure of thin-walled tubes, one can calculate weight savings as follows:

$\bar{m}=\bar{\rho}\bar{\sigma}\ (D/\delta_0-\bar{\sigma})/(D/\delta_0-1)$,
where $\bar{\rho}=\rho_1/\rho_0$ – ratio of densities of the material 1 and 0 (in our case TP304L);
$\bar{\sigma}=\sigma_0/\sigma_1$ – ratio of yield strength values;
$\bar{m}=m_1/m_0$ – ratio of the masses;
D,δ_0 – outside diameter and wall thickness of the base material, respectively.

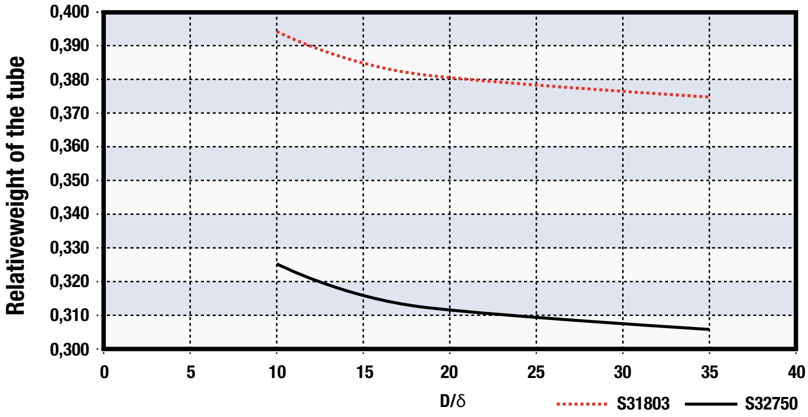

Figure 2 – Relative weight of the tubes

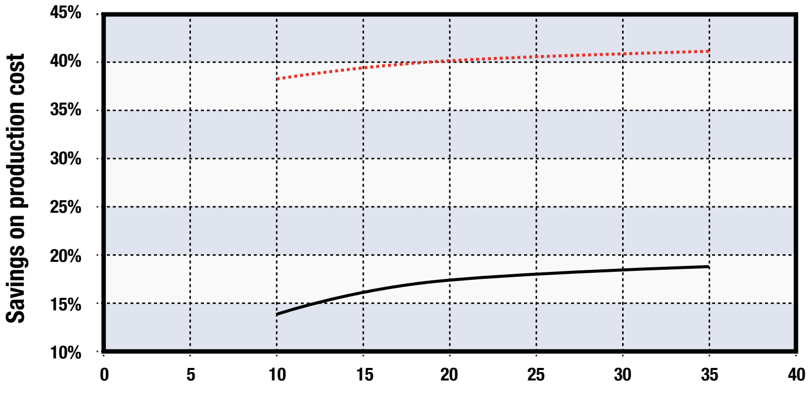

Figure 3 – Production cost savings

Figure 2 – shows the relative weight of the tubes subject to the same internal working pressure for the two materials in relation to the TP304L base grade. Thinner-walled tubes demonstrate higher savings in terms of weight, which translates into savings on production costs, as shown in Figure 3 (including also the price of materials).

Figure 3 – Production cost savings

In addition, lower susceptibility to stress corrosion cracking and pitting corrosion matching the austenitic grades is known and well-studied. So, despite the higher costs of material and the complexity in production of duplex and superduplex tubes, the overall economic advantages for the end user are clear.

The need for stable technology

Of course not every producer is able to supply high-quality duplex and superduplex piping solutions. On the one hand one needs to have all necessary certifications and what's more important – a stable technology, which ensures optimum proportions of austenite and ferrite in the final production phase. For example, Centravis spent a lot of time and money to develop the effective in-house technology, including the fine-tuned heat treatment for cold-drawn duplex/super-duplex materials resulted in significantly improved corrosion resistance, which exceeds the requirements of the ASTM/ASME/DIN standards, and provides resistance to inter-crystalline corrosion even after the sensitisation heat treatment. Figure 4 shows the typical gamma-alpha phase distribution in tubes and pipes of the Duplex class, where red areas show ferrite, and blue ones – austenite.

Figure 4 – Phase distribution at 500x magnification

The higher resistance to inter-crystalline corrosion greatly improves mechanical properties of tubes: the strength and plasticity values of the steel are up to 30-40 per cent higher than the minimum values required by the aforementioned standards; something that only brings additional value to the customer (Table 1). Besides the degradation of yield strength versus temperature (average values) demonstrates that the minimum required strength at room temperature is in reality achieved at around 280°C.

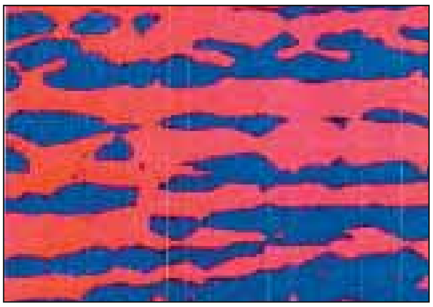

Figure 4 – Phase distribution at 500x magnification

Table 1 – Mechanical properties of S31803, after the production of tubes and pipes at Centravis

Tensile Strength, MPa		Yield strength, MPa		Elongation, %	
Actual*	Minimum**	Actual*	Minimum**	Actual*	Minimum**
804±6	620	632±10	450	32±1	25

* The confidence interval for 99% probability, based on 193 samples
** As required by ASTM A789/A790