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Comparison of physical, mechanical and corrosive properties of stabilized (1.4571) and low-carbon (1.4404) austenitic stainless steels.

Summary comparing low-carbon and titanium-stabilized stainless steels.		
Properties/ Material	**Mat. no. 1.4571**	**Mat. no. 1.4404** Low carbon content
Corrosion properties		
General corrosion resistance	Same	Same
Pitting resistance	Worse	Better
Crevice corrosion resistance	Same	Same
Stress corrosion cracking resistance	Worse	Better
Intergranular corrosion and knifeline attack	Worse	Better
Mechanical properties		
Strength at high temperatures	Better	Worse
Impact properties	Worse	Better
Cold workability	Worse	Better
Cold heading	Worse	Better
Processing properties		
Machinability	Worse	Better
Polishability	Worse	Better
Surface finishing	Worse	Better
Degree of purity	Worse	Better
Weldability	Same	Same

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Corrosion properties

Pitting resistance

Titanium alloys have a negative impact on the resistance of stainless steels to pitting.
Titanium has an adverse effect on the pitting resistance of stainless steels.

Crevice corrosion resistance

Research results indicate no significant difference between the crevice corrosion resistance of low-carbon and titanium-stabilized stainless steels.

Stress corrosion cracking resistance

Titanium alloys are detrimental to stainless steels' resistance to stress corrosion cracking. Titanium stabilization has an adverse effect on chlorine-induced stress corrosion cracking. Adding titanium is known to impact pitting corrosion resistance, which means that this outcome is to be expected: most cracks induced by stress corrosion occur in areas where pits are exposed to high corrosive stress.

Intergranular corrosion

When stabilized steels are welded, particularly titanium-stabilized ones, carbides go into solution in proximity to the weld seam (the heat-affected zone) due to the heat generated during the welding process. A subsequent second or third weld or heat treatment with additional heat input near the weld seam can cause the formation of chromium carbides.
This is because chromium carbides precipitate more quickly than titanium carbides at temperatures below 850 °C. Chromium carbides tend to form at a certain interval from each side of the weld seam, thus forming a small area susceptible to intergranular corrosion. Because of the characteristic fine lines on both sides of the weld seam, this phenomenon is known as hairline corrosion and only occurs with stabilized grades of stainless steel.

A study was conducted to determine the effect of titanium-carbide formation in stabilized stainless steels on intergranular corrosion resistance; it showed that strong oxidants such as nitric acid can attack titanium carbides (Cihal et al. and Schwaab et al.). Titanium carbides forming at grain boundaries can cause intergranular corrosion. Consequently, niobium stabilization is often preferable to titanium stabilization for certain steels.

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Mechanical properties

Since the addition of titanium has a negative effect on the surface finish, manufacturers have limited the content of carbon and nitrogen so they can reduce the amount of titanium needed but still achieve the same stabilization.

Upper application temperatures

The upper application-temperature limits for stabilized austenistic steel are approximately 400°C, and otherwise they are 50° – 100°C higher than the highest application temperature for unstabilized steels with a low carbon content.

Impact properties and toughness

Adding titanium to austenitic steels causes the formation of large precipitates of Ti (C,N) which lower the impact properties and toughness since they can lead to cracks forming. The negative effect of titanium can even be determined if the added titanium is below the content required for stabilization. Furthermore, greater toughness has an adverse effect on ductility because titanium strengthens solid solutions. . The reduction in ductility can sometimes cause lower formability and other processing problems in comparison to steels with a lower carbon content if formed cold. This is why titanium-stabilized steels are not as good for cold heading, since the process involves an impact.

Processing properties

Machinability

The formation of titanium carbonitrides in stabilized grades lowers the machinability in comparison to titanium-free grades with a low carbon content. The harder particles increase tool wear and lower the optimal speed for cutting and machining.

Polishability

Stabilized steels are not suitable for high-gloss polishing because the presence of hard titanium carbides and titanium carbonitrides cause comet trails on the surface during polishing. Steels with a low carbon content do not contain titanium (Ti [C,N]), which makes them polishable. Polishability is obviously a topic of major interest when it comes to producing components that will be seen.

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Non-metallic inclusion content

Titanium carbides can be found in large quantities in stabilized stainless steels, which means that the non-metallic inclusion content can never be as high as in a steel with a comparatively low carbon content such as **1.4404**. In many applications, the degree of purity is not a significant factor, but the difference is important in pressurized parts or when optical standards are involved.

Weldability

There is a widespread misconception that stabilized stainless steels are easier to weld than low carbon steels. As a matter of fact, however, both grades are equally well suited to welding. These steels usually have niobium-alloyed filler materials, since titanium is very volatile in the welding arc. Consequently, there will not be enough titanium in the weld seam. Low carbon filler metals can successfully be used to weld stabilized austenitic steels. Caution is advised, however, in using low carbon content filler metals if they are used at higher temperatures: the maximum application temperature for low-carbon unstabilized steels is lower than that of stabilized steels.

Summary

The manufacturing-related advantages of stainless steels with a low carbon content (such as **1.4404**) mean that they have replaced titanium stabilized grades (such as 1.4571). Not only do they minimize the possibility of sensitization during welding, low-carbon grades < 0.03% solve the polishability problems of the surface.

Literature

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