Stainless Steel Fasteners at Reduced Temperatures

by Jozef Dominik

Briefly About Stainless Steels ////

Stainless steel's resistance to corrosion is achieved by dissolving sufficient chromium in the iron to produce a chromium oxide protective film on the surface. To achieve the effect of stainless steel, it needs to contain at least 12% chromium (Fig. 1).

The addition of other elements such as Ni, Mo, Si, etc., will not only increase corrosion resistance, but also other parameters such as:

Mechanical properties (N)

Machinability (S, Se, P, Pb, Cu)

Resistance to corrosion cracking (content reduction of P, As an Sb)

While conventional structural steel corrodes under certain conditions, stainless steel resists corrosion under the same conditions very well (Fig. 2). This is also the main reason for its application in construction practice.

However, as we will see below, it is not just the corrosion resistance that is important for stainless steels. Uncritical adoration of stainless steels as a universal anticorrosive measure does not pay. Regarding how this could have catastrophic consequences, read my article "Latent Corrosion of Screw Connections". Stainless steels are particularly vulnerable in chlorine-containing environments (Fig. 3). The result is a fatal cross-sectional reduction.

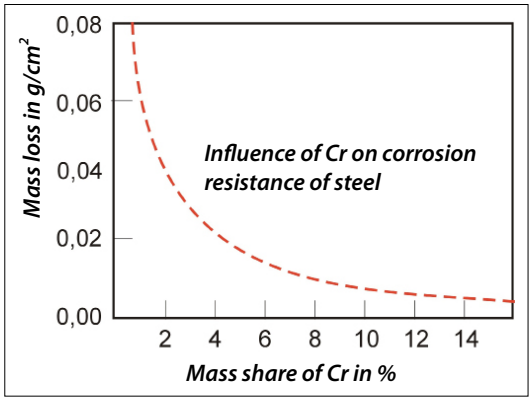

Fig. 1

Fig. 2

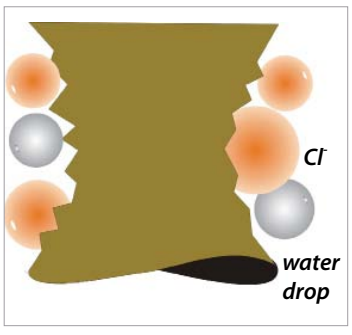

Fig. 3

Mechanical and Thermal Properties ////

Stainless steels for fasteners are standardized in EN ISO 35069:

Mechanical properties of corrosion-resistant stainless steel fasteners — Part 1: Bolts, screws and studs (Table 1).

Table.1 Mechanical properties of stainless steels at ambient temperature

Property	Austenitic Steels	Ferritic Steels	Duplex Aust./Ferrit.	Martensitic Steels
Rp0,2 [MPa]	200 - 280	200 - 320	400 - 530	450 - 600
Rm [Mpa]	500 - 800	380 - 650	630 - 930	650 - 1000
A5 [%]	30 - 45	18 - 25	20 - 30	10 - 15
Rp0,2 - Tensile strength, Yield (Mpa), Rm - Tensile strength, ultimate (Mpa), A5 - Elongation at Break in (%)				

Remarkable are the properties of the most widespread type of stainless steel - austenitic steel type. Table 2 confirms this.

Table. 2 Comparative Properties of the Stainless Steel Alloys (In: Atlas Steels)

Alloy Group	Magnetic Response	Corrosion Resistance	Hardenable	Ductility	High Temperature Resistance	Low Temperature Resistance
Austenitic	No	High	No	Very High	Very High	Very High
Ferritic	Yes	Medium	No	Medium	High	Low
Martensitic	Yes	Medium	Yes	Low	Low	Low

Except that these steels have high toughness that well withstands increased and reduced temperatures. Practice example. Figure 4 shows the outdoor stairs on a railway carriage. A seemingly simple construction case can cause a big problem. It should be noted that railway wagons move in different climatic zones. From -40° C on the Trans-Siberian Highway to +40° C in the Indian Pacific in Australia for example. Not every steel is able to withstand such huge temperature fluctuations. Screw joints suffer the most. Mechanically cold-hardened austenitic stainless steels meet these conditions well. The difference between the rolled, or, mechanically cold-hardened (Fig 5a) and turned (Fig. 5b) threads of the A2 steel bolt is notable.

Fig. 4

In addition, stainless steels, particularly of the austenitic type have high corrosion resistance. For comparison, see Fig. 6.

As shown in the following Table 3 the coefficient of thermal expansion of the austenitic stainless steel is higher than most other grades of steels. It is an important parameter in contact of carbon steel and austenitic stainless steel. The designer must take this into account. The combination of two metals with different thermal expansion is not a good solution.

Table. 3 Coefficient of Thermal Expansion (x 10^{-6}/°C)

Carbon Steel	10
Austenitic Steel	17
Ferritic Steel	11
Martensitic Steel	11

Fig. 5a – rolled threads

Fig. 5b – turned threads

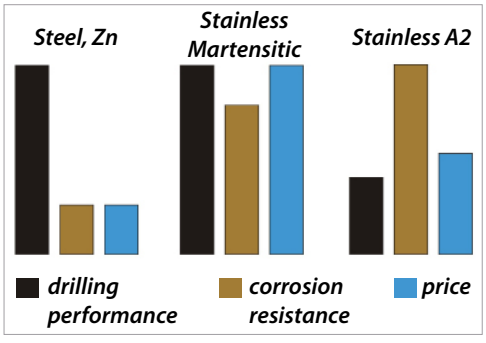

Fig. 6

Summary ////

Stainless steel screws are a good design choice in certain cases. However, its properties and the conditions under which it will work in practice must be understood and fully respected.

The article points out not only the corrosion properties of stainless steels, but also their mechanical and physical properties. Of particular importance is their ability to withstand low temperatures. This unique feature is characterized mainly by austenitic stainless steels.