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Classification of Stainless Steel Types

Stainless steels are a group of corrosion resistant alloy steels containing a minimum of 10.5 per cent of chromium. This produces a "passive" surface layer, which forms whenever the steel is exposed to media having sufficient oxygen. The passive layer has the property of being self-repairing and so forms the basis of the corrosion resistance of these alloys.
Additions of nickel, molybdenum, titanium, niobium and other elements can be added to enhance corrosion resistance and other properties of the steels such as mechanical properties, formability, magnetic properties, cryogenic toughness etc.
Careful selection of the most appropriate steel type and grade is vital for successful performance and durability.

Types of Stainless Steel

There are five *types* of stainless steel, the names describing their atomic structures: - Ferritic, Martensitic, Austenitic, Duplex and Precipitation Hardening.

Ferritic stainless steels have a "body-centred-cubic" (bcc) crystal structure, which is the same as pure iron at room temperature. The main alloying element is chromium, with contents typically between 11 and 17%. Carbon is kept low which results in these steels having limited strength. They are not hardenable by heat treatment and have annealed yield strengths in the range of 275 to 350 Mpa.
The ferritics are a low cost type but have limited corrosion resistance compared to the more popular austenitics. Similarly they have limited toughness, formability & weldability in comparison to the austenitics.
The section sizes available (i.e. thickness') are restricted by their poor toughness.
They are however a "soft " ferro-magnetic group and so do have some special uses, for example as solenoid cores.
Examples of ferritic grades are 1.4003 (3Cr12) and 1.4016 (430).

Martensitic stainless steels are similar to low alloy or carbon steels, having a structure similar to the ferritics but due the addition of carbon, they can be hardened and strengthened by heat treatment, in a similar way to carbon steels.
The main alloying element is chromium, typically 12 to 15%, and their structures are "body-centred tetragonal" (bct). They are classed as a "hard" ferro-magnetic group
In the annealed condition, they have tensile yield strengths of about 275 Mpa and so they are usually machined, cold formed, or cold worked in this condition. The strength obtained by heat treatment depends on the carbon content of the alloy. Increasing the carbon content increases the strength and hardness potential but decreases ductility and toughness. The higher carbon grades are capable of being heat treated to harnesses of 60 HRC. Optimum corrosion resistance is attained in the heat-treated i.e. hardened and tempered condition. Martensitic grades have been developed with nitrogen and nickel additions but with lower carbon levels than the traditional grades. These steels have improved toughness, weldability and corrosion resistance

Examples of martensitic grades are 1.4028 (420S45), 1.4057 (431) as traditional carbon hardenable grades and 1.4418 (248SV) as one of the low carbon / nitrogen grades.

Austenitic stainless steels are the largest group, in terms of the number of alloys and usage. Like the ferritic types, they cannot be hardened by heat treatment, as the carbon levels are restricted, but additions principally of nickel change the ambient temperature structure into a "face-centred-cubic" (fcc) atomic arrangement.
The widely used 1.4301 (304) grade has a chromium level of 17% and nickel of 8%
The structure is non-magnetic (i.e. has a low "permeability") and has excellent ductility, formability, and toughness, even at cryogenic temperatures.
Depending on the nickel content the austenitics respond to cold working by increases in strength, which can surprisingly be useful in severe forming operations, avoiding premature tearing and cracking. Cold work hardening is accompanied by partial changes in structure, the ferro-magnetic martensite "phase" being formed, which explains why cold working can appear to make austenitic steels "magnetic".
Molybdenum is added to some of the austenitic grades to improve their resistance to "localised" corrosion mechanisms such as crevice corrosion and pitting.
Examples of austenitic grades are 1.4301 (304/304S31), 1.4307 (304L/304S11), 1.4401 (316/316S31) and 1.4404 (316L/316S11).

Duplex stainless steels have a balanced or mixed structure of austenite and ferrite and as a result, have characteristics of both these "basic" types.
A typical composition has 22% chromium, 5% nickel and 3% molybdenum with a small addition of nitrogen.
The duplex types are not hardenable by heat treatment but are stronger than either the ferritic or austenitic types in the softened (annealed) condition and have typical proof strengths of around 450Mpa.
Like the ferritics, they are ferro-magnetic, but have the good formability & weldability of the austenitics (although greater forces are needed in forming due to their higher strength).
These steels can be used in thinner design sections than austenitics but their main advantage is their improved stress corrosion cracking (SCC) resistance.
Molybdenum is usually added to also enhance crevice and pitting corrosion resistance.
Examples of duplex grades are 1.4462 (2205/318S13) and 1.4501.

Precipitation-hardenable (PH) stainless steels are hardenable by "ageing treatments" and so have some similarities to the martensitic types, although the metallurgical mechanism for hardening is different and are capable of strengths of up to 1700 Mpa.
They generally have a martensitic structure and so are usually ferro-magnetic.
The "PH" types have good ductility and toughness, depending on the heat-treated condition. Their corrosion resistance is comparable to the 1.4301 (304) austenitic. They can be welded more readily than "conventional" martensitic types and have been developed and used more widely in the US than in the UK for example in aerospace applications.
Examples of PH grades are 1.4542 (17/4PH) and 1.4594 (520B).

This Information Sheet is based on a draft supplied by Avesta Sheffield Ltd.

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