Description

Image

Caption

1. Siemens toaster in brushed austenitic stainless steel (by Porsche Design) © Granta Design 2. Scissors in ferritic stainless steel; it is magnetic, austenitic stainless is not. © Granta Design

The material

Stainless steels are alloys of iron with chromium, nickel, and - often - four of five other elements. The alloying transmutes plain carbon steel that rusts and is prone to brittleness below room temperature into a material that does neither. Indeed, most stainless steels resist corrosion in most normal environments, and they remain ductile to the lowest of temperatures.

Composition (summary)

Fe/<0.25C/16 - 30Cr/3.5 - 37Ni/<10Mn + Si,P,S (+N for 200 series)

General properties

Density	474	-	506	lb/ft^3
Price	* 2.67	-	2.94	USD/lb
Date first used	1915			

Mechanical properties

Young's modulus	27.4	-	30.5	10^6 psi
Shear modulus	10.7	-	12.2	10^6 psi
Bulk modulus	19.4	-	21.9	10^6 psi
Poisson's ratio	0.265	-	0.275	
Yield strength (elastic limit)	24.7	-	145	ksi
Tensile strength	69.6	-	325	ksi
Compressive strength	24.7	-	145	ksi
Elongation	5	-	70	% strain
Hardness - Vickers	130	-	570	HV
Fatigue strength at 10^7 cycles	* 25.4	-	109	ksi
Fracture toughness	56.4	-	137	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 2.9e-4	-	0.00148	

Thermal properties

Melting point	2.51e3	-	2.64e3	°F
Maximum service temperature	1.38e3	-	1.51e3	°F
Minimum service temperature	-458	-	-456	°F
Thermal conductor or insulator?	Poor conductor			
Thermal conductivity	6.93	-	13.9	BTU.ft/h.ft^2.F

Specific heat capacity	0.107	-	0.127	BTU/lb.°F
Thermal expansion coefficient	7.22	-	11.1	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	64	-	107	µohm.cm

Optical properties

Transparency	Opaque			

Processability

Castability	3	-	4	
Formability	2	-	3	
Machinability	2	-	3	
Weldability	5			
Solder/brazability	5			

Eco properties

Embodied energy, primary production	* 8.7e3	-	9.62e3	kcal/lb
CO2 footprint, primary production	* 4.73	-	5.23	lb/lb
Recycle	✓			

Supporting information

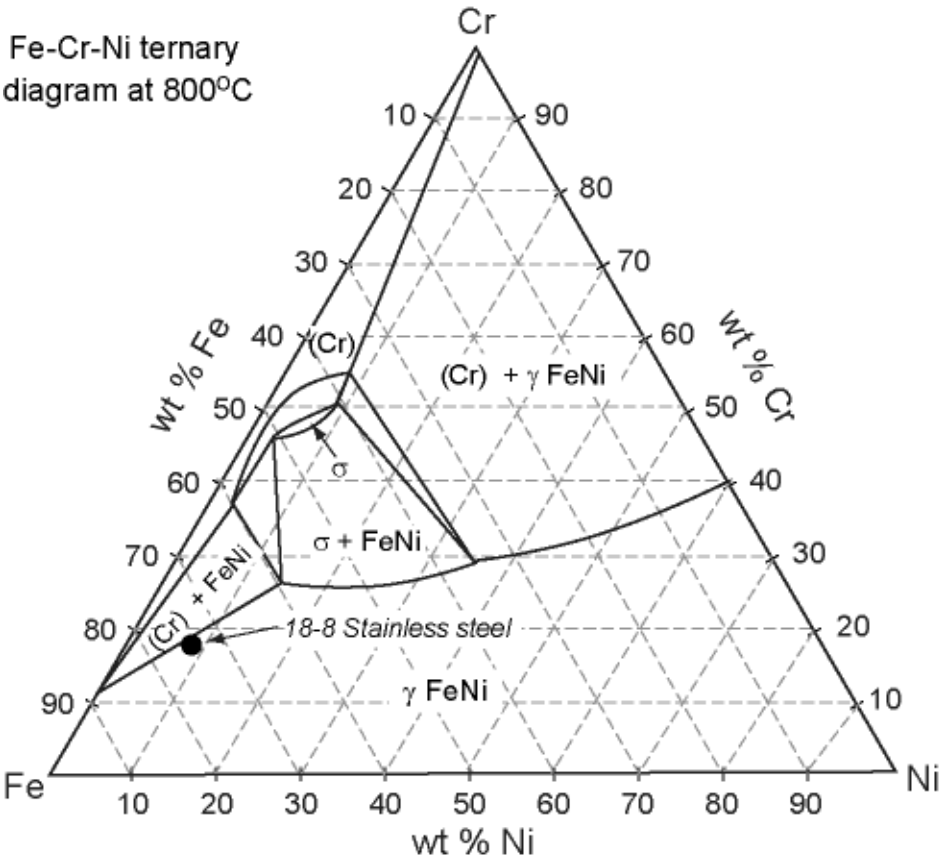
Design guidelines

Stainless steel must be used efficiently to justify its higher costs, exploiting its high strength and corrosion resistance. Economic design uses thin, rolled gauge, simple sections, concealed welds to eliminate refinishing, and grades that are suitable to manufacturing (such as free machining grades when machining is necessary). Surface finish can be controlled by rolling, polishing or blasting. Stainless steels are selected, first, for their corrosion resistance, second, for their strength and third, for their ease of fabrication. Most stainless steels are difficult to bend, draw and cut, requiring slow cutting speeds and special tool geometry. They are available in sheet, strip, plate, bar, wire, tubing and pipe, and can be readily soldered and braised. Welding stainless steel is possible but the filler metal must be selected to ensure an equivalent composition to maintain corrosion resistance. The 300 series are the most weldable; the 400 series are less weldable.

Technical notes

Stainless steels are classified into four categories: the 200and 300 series austenitic (Fe-Cr-Ni-Mn) alloys, the 400 series ferritic (Fe-Cr) alloys, the martensitic (Fe-Cr-C) alloys that also form part of the 400 series, and precipitation hardening or PH (Fe-Cr-Ni-Cu-Nb) alloys with designations starting with S. Typical of the austenitic grades of stainless steel is the grade 304: 74% iron, 18% chromium and 8 % nickel. Here the chromium protects by creating a protective Cr2O3 film on all exposed surfaces, and the nickel stabilizes face-centered cubic austenite, giving ductility and strength both at high and low temperatures; they are non-magnetic (a way of identifying them). The combination of austenitic and ferritic structures (the duplex stainless steels) provide considerably slower growth of stress-induced cracks, they can be hot-rolled or cast and are often heat treated as well. Austenitic stainless steel with high molybdenum content and copper has excellent resistance to pitting and corrosion. High nitrogen content austenitic stainless steel gives higher strength. Superferrites (over 30% chromium) are very resistant to corrosion, even in water containing chlorine. More information on designations and equivalent grades can be found on the Granta Design website at www.grantadesign.com/designations

Phase diagram



Phase diagram description

Most stainless steels are alloys of iron (Fe) with chromium (Cr) and nickel (Ni). This is the ternary phase diagram, at a temperature of 800 C, for those three elements. The position of AISI 302 stainless steel (Fe-18%Cr-8%Ni) is shown.

Typical uses

Railway cars, trucks, trailers, food-processing equipment, sinks, stoves, cooking utensils, cutlery, flatware, scissors and knives, architectural metalwork, laundry equipment, chemical-processing equipment, jet-engine parts, surgical tools, furnace and boiler components, oil-burner parts, petroleum-processing equipment, dairy equipment, heat-treating equipment, automotive trim. Structural uses in corrosive environments, e.g. nuclear plants, ships, offshore oil installations, underwater cables and pipes.

Links

Reference

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