Cast iron, ductile (nodular)

Description

Image

Caption

Ductile or malleable cast irons are used for heavily loaded parts such as gears and automotive suspension components.

The material

The foundations of modern industrial society are set, so to speak, in cast iron: it is the material that made the industrial revolution possible. Today it holds a second honor: that of being the cheapest of all engineering metals. Cast iron contains at least 2% carbon -- most have 3 to 4% -- and from 1-3% silicon. The carbon makes the iron very fluid when molten, allowing it to be cast to intricate shapes. There are five classes of cast iron: gray, white, ductile (or nodular), malleable and alloy; details are given under Design Guidelines, below. The two that are most used are gray and ductile. This record is for ductile cast iron.

Composition (summary)

Fe/3.2-4.1%C/1.8-2.8%Si/<0.8%Mn/<0.1%P/<0.03%S

General properties

Density	440	-	453	lb/ft^3
Price	* 0.245	-	0.272	USD/lb
Date first used	1948			

Mechanical properties

Young's modulus	23.9	-	26.1	10^6 psi
Shear modulus	9.28	-	10.3	10^6 psi
Bulk modulus	17.3	-	19.9	10^6 psi
Poisson's ratio	0.26	-	0.28	
Yield strength (elastic limit)	36.3	-	98.6	ksi
Tensile strength	59.5	-	120	ksi
Compressive strength	36.3	-	115	ksi
Elongation	3	-	18	% strain
Hardness - Vickers	115	-	320	HV
Fatigue strength at 10^7 cycles	26.1	-	47.9	ksi
Fracture toughness	20	-	49.1	ksi.in^0.5
Mechanical loss coefficient (tan delta)	0.002	-	0.009	

Thermal properties

Melting point	2.07e3	-	2.28e3	°F
Maximum service temperature	662	-	842	°F
Minimum service temperature	-145	-	-36.7	°F

Thermal conductor or insulator?	Good conductor			
Thermal conductivity	16.8	-	25.4	BTU.ft/h.ft^2.F
Specific heat capacity	0.11	-	0.118	BTU/lb.°F
Thermal expansion coefficient	5.56	-	6.94	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	49	-	56	µohm.cm

Optical properties

Transparency	Opaque

Processability

Castability	5			
Formability	1	-	2	
Machinability	4			
Weldability	1			
Solder/brazability	1	-	2	

Eco properties

Embodied energy, primary production	* 1.95e3	-	2.38e3	kcal/lb
CO2 footprint, primary production	* 1.7	-	1.8	lb/lb
Recycle	✓			

Supporting information

Design guidelines

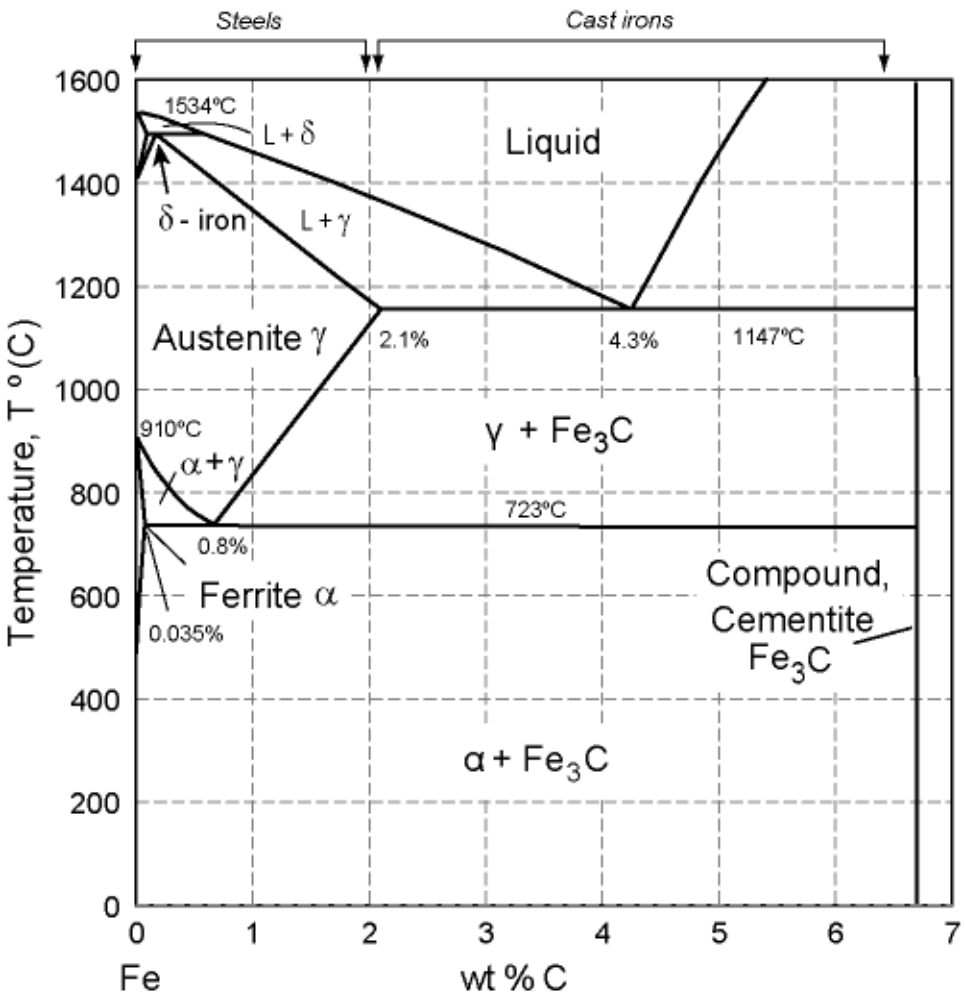
There are five kinds of cast iron. Gray cast iron machines easily, damps vibration well, is relatively brittle and has low tensile strength; it is the material of automotive cylinder blocks, exhaust manifolds, break disks and drums, gears and flywheels. White cast iron, made by chill casting to give a high cooling rate at the surface, is much harder than gray; it is used when wear resistance is wanted, as in rolls for rolling mills, blades for crushers and mixers. Nodular (ductile) cast iron contains additions that cause the flakes of graphite that are present in gray iron to spherodize, giving higher toughness and strength but at the loss of damping-ability; it is used for crank shafts and heavy duty gears. Malleable cast iron, made by heat-treating white cast iron, is ductile and easily machined; it is used for heavy-duty parts of cars, trucks, and railway rolling stock. Finally, alloy cast irons contain up to 35% of chromium or nickel; they are corrosion resistant and have high strength, but are much more expensive.

Technical notes

There is no single systematic numbering system for cast irons. The UNS and the AISI systems are widely used, particularly in the US. Ductile cast irons are generally described using the ASTM system, a set of three numbers separated by colons, like this: ASTM 60:40:18. The first number is the tensile strength in ksi, the second is the yield strength in ksi and the third is the elongation in % (to convert ksi to MPa, multiply by 6.89).More information on designations and equivalent grades can be found on the Granta Design website at www.grantadesign.com/designations

Phase diagram

Cast iron, ductile (nodular)



Phase diagram description

Grey cast irons are based on iron (Fe) with 3 - 4.1% carbon (C), for which this is the phase diagram. Ductile cast irons have small additions of magnesium or cerium that cause the graphite to form spherical nodules rather than flakes.

Typical uses

Brake discs and drums; bearings; camshafts; cylinder liners; piston rings; machine tool structural parts; engine blocks, gears, crankshafts; heavy-duty gear cases; pipe joints; pump casings; components in rock crushers.

Links

Reference

ProcessUniverse

Producers