Cast iron, gray

Description

Image

Caption

1. Cast iron pan. © Evan-Amos at en.wikipedia - Public domain 2. The fluidity of the material allows intricate castings. © John Fernandez

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 gray 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	*	0.204	-	0.227	USD/lb
Date first used		-513			

Mechanical properties

Young's modulus		11.6	-	20	10^6 psi
Shear modulus		4.5	-	8.27	10^6 psi
Bulk modulus		18.9	-	20.3	10^6 psi
Poisson's ratio		0.26	-	0.28	
Yield strength (elastic limit)		20.3	-	60.9	ksi
Tensile strength		20.3	-	65	ksi
Compressive strength		72.5	-	160	ksi
Elongation		0.17	-	0.7	% strain
Hardness - Vickers		90	-	310	HV
Fatigue strength at 10^7 cycles		5.8	-	24.7	ksi
Fracture toughness		9.1	-	21.8	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.01	-	0.04	

Thermal properties

Melting point		2.07e3	-	2.51e3	°F
Maximum service temperature		662	-	842	°F
Minimum service temperature		-238	-	-58	°F

Thermal conductor or insulator?	Good conductor			
Thermal conductivity	23.1	-	41.6	BTU.ft/h.ft^2.F
Specific heat capacity	0.103	-	0.118	BTU/lb.°F
Thermal expansion coefficient	6.11	-	6.94	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	62	-	86	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	* 1.84e3	-	2.28e3	kcal/lb
CO2 footprint, primary production	* 1.65	-	1.75	lb/lb
Recycle	✓			

Supporting information

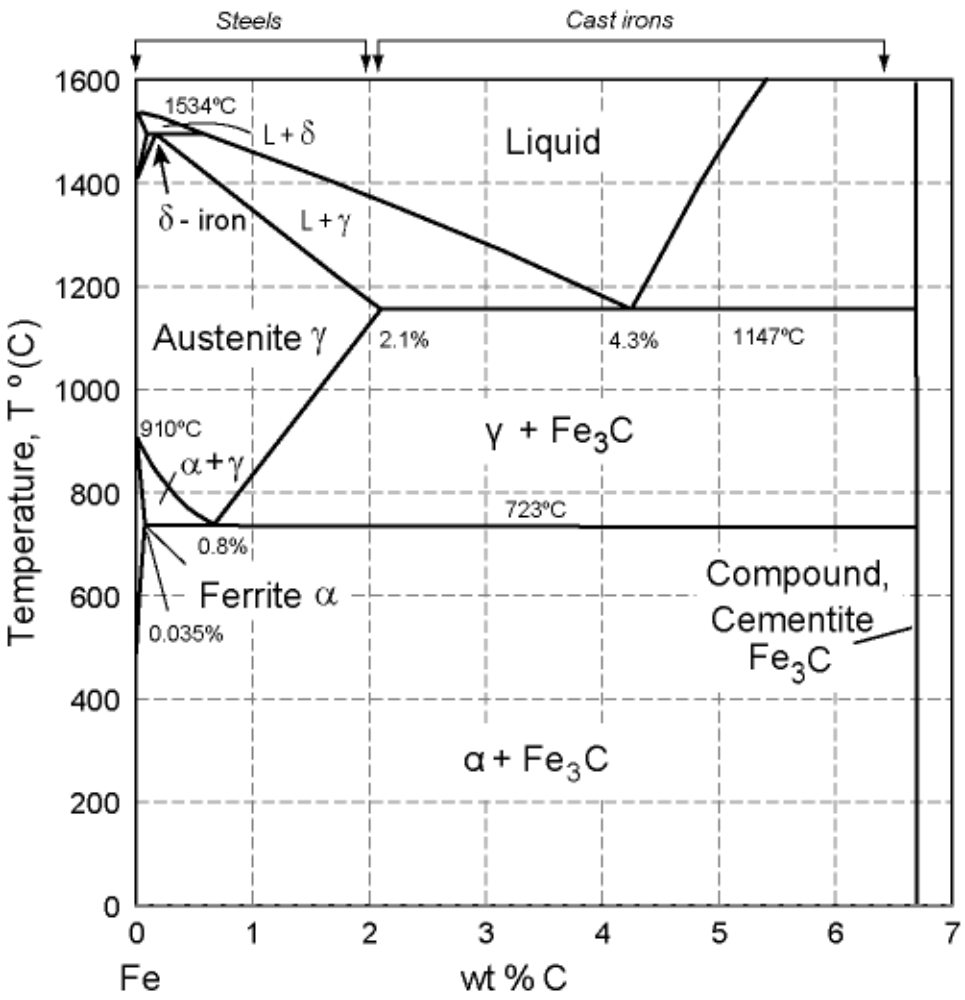
Design guidelines

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. 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

Grey cast irons are based on iron (Fe) with 3 - 4.1% carbon (C), for which this is the phase diagram. Some have additions of silicon and manganese.

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