Description

Image

Caption

Medium carbon steel is the material of cheap tools. Low alloy steels are much superior and only a little more expensive -- quality tools are low alloy. © Granta Design

The material

Medium carbon steel (0.25-0.7% carbon) hardens when quenched - a quality that gives great control over properties. "Hardenability" measures the degree to which it can be hardened in thick sections; plain carbon steels have poor hardenability - additional alloying elements are used to increase it (see Low alloy steels). Medium carbon steels are used on an enormous scale for railroad tracks; there are many other lower-volume applications.

Composition (summary)

Fe/0.3 - 0.7%C

General properties

Density		487	-	493	lb/ft^3
Price	*	0.29	-	0.349	USD/lb
Date first used		1610			

Mechanical properties

Young's modulus		29	-	31.3	10^6 psi
Shear modulus		11.2	-	12.3	10^6 psi
Bulk modulus		22.9	-	24.7	10^6 psi
Poisson's ratio		0.285	-	0.295	
Yield strength (elastic limit)		44.2	-	131	ksi
Tensile strength		59.5	-	174	ksi
Compressive strength		44.2	-	255	ksi
Elongation		4	-	39	% strain
Hardness - Vickers		120	-	565	HV
Fatigue strength at 10^7 cycles	*	33.2	-	87	ksi

Fracture toughness	*	10.9	-	83.7	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	2.2e-4	-	0.00119	

Thermal properties

Melting point		2.52e3	-	2.76e3	°F
Maximum service temperature	*	698	-	788	°F
Minimum service temperature	*	-90.7	-	-27.7	°F
Thermal conductor or insulator?		Good conductor			
Thermal conductivity		26	-	31.8	BTU.ft/h.ft^2.F
Specific heat capacity		0.105	-	0.124	BTU/lb.°F
Thermal expansion coefficient		5.56	-	7.78	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Good conductor			
Electrical resistivity		15	-	22	µohm.cm

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

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

Durability: water and aqueous solutions

Water (fresh)	Acceptable
Water (salt)	Limited use
Soils, acidic (peat)	Acceptable
Soils, alkaline (clay)	Acceptable
Wine	Unacceptable

Durability: acids

Acetic acid (10%)	Limited use
Acetic acid (glacial)	Unacceptable
Citric acid (10%)	Unacceptable
Hydrochloric acid (10%)	Unacceptable
Hydrochloric acid (36%)	Unacceptable

Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Unacceptable
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Unacceptable
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Unacceptable
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

Sodium hydroxide (10%)	Excellent
Sodium hydroxide (60%)	Acceptable

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Excellent
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Excellent
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Limited use
Acetone	Excellent
Ethyl alcohol (ethanol)	Acceptable
Ethylene glycol	Acceptable
Formaldehyde (40%)	Unacceptable
Glycerol	Excellent
Methyl alcohol (methanol)	Acceptable

Durability: halogens and gases

Chlorine gas (dry)	Acceptable
Fluorine (gas)	Excellent
O2 (oxygen gas)	Limited use

Sulfur dioxide (gas)	Acceptable

Durability: built environments

Industrial atmosphere	Limited use
Rural atmosphere	Acceptable
Marine atmosphere	Limited use
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Excellent
Tolerance up to 450 C (842 F)	Acceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Geo-economic data for principal component

Annual world production, principal component	2.26e9	ton/yr
Reserves, principal component	1.57e11	I. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	*	2.72e3	-	3.01e3	kcal/lb
CO2 footprint, primary production	*	1.72	-	1.9	lb/lb
Water usage	*	5.22	-	5.78	gal(US)/lb
Eco-indicator 95		86			millipoints/kg
Eco-indicator 99		106			millipoints/kg

Material processing: energy

Casting energy	*	1.18e3	-	1.31e3	kcal/lb
Extrusion, foil rolling energy	*	644	-	712	kcal/lb
Rough rolling, forging energy	*	337	-	373	kcal/lb
Wire drawing energy	*	2.33e3	-	2.58e3	kcal/lb
Metal powder forming energy	*	3.89e3	-	4.63e3	kcal/lb
Vaporization energy	*	1.18e6	-	1.3e6	kcal/lb
Coarse machining energy (per unit wt removed)	*	97.4	-	108	kcal/lb
Fine machining energy (per unit wt removed)	*	511	-	564	kcal/lb
Grinding energy (per unit wt removed)	*	971	-	1.07e3	kcal/lb
Non-conventional machining energy (per unit wt removed)		1.18e4	-	1.3e4	kcal/lb

Material processing: CO2 footprint

Casting CO2	* 0.819	-	0.906	lb/lb
Extrusion, foil rolling CO2	* 0.446	-	0.492	lb/lb
Rough rolling, forging CO2	* 0.233	-	0.258	lb/lb
Wire drawing CO2	* 1.61	-	1.78	lb/lb
Metal powder forming CO2	* 2.87	-	3.42	lb/lb
Vaporization CO2	* 815	-	901	lb/lb
Coarse machining CO2 (per unit wt removed)	* 0.0674	-	0.0745	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.354	-	0.391	lb/lb
Grinding CO2 (per unit wt removed)	* 0.672	-	0.743	lb/lb
Non-conventional machining CO2 (per unit wt removed	8.15	-	9.01	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✔			
Embodied energy, recycling	* 754	-	833	kcal/lb
CO2 footprint, recycling	* 0.547	-	0.605	lb/lb
Recycle fraction in current supply	40	-	44	%
Downcycle	✔			
Combust for energy recovery	✘			
Landfill	✔			
Biodegrade	✘			
Toxicity rating	Non-toxic			
A renewable resource?	✘			

Environmental notes

The production energy of steel is comparatively low - per unit weight, about a half that of polymers; per unit volume, though, twice as much. Carbon steels are easy to recycle, and the energy to do so is small.

Supporting information

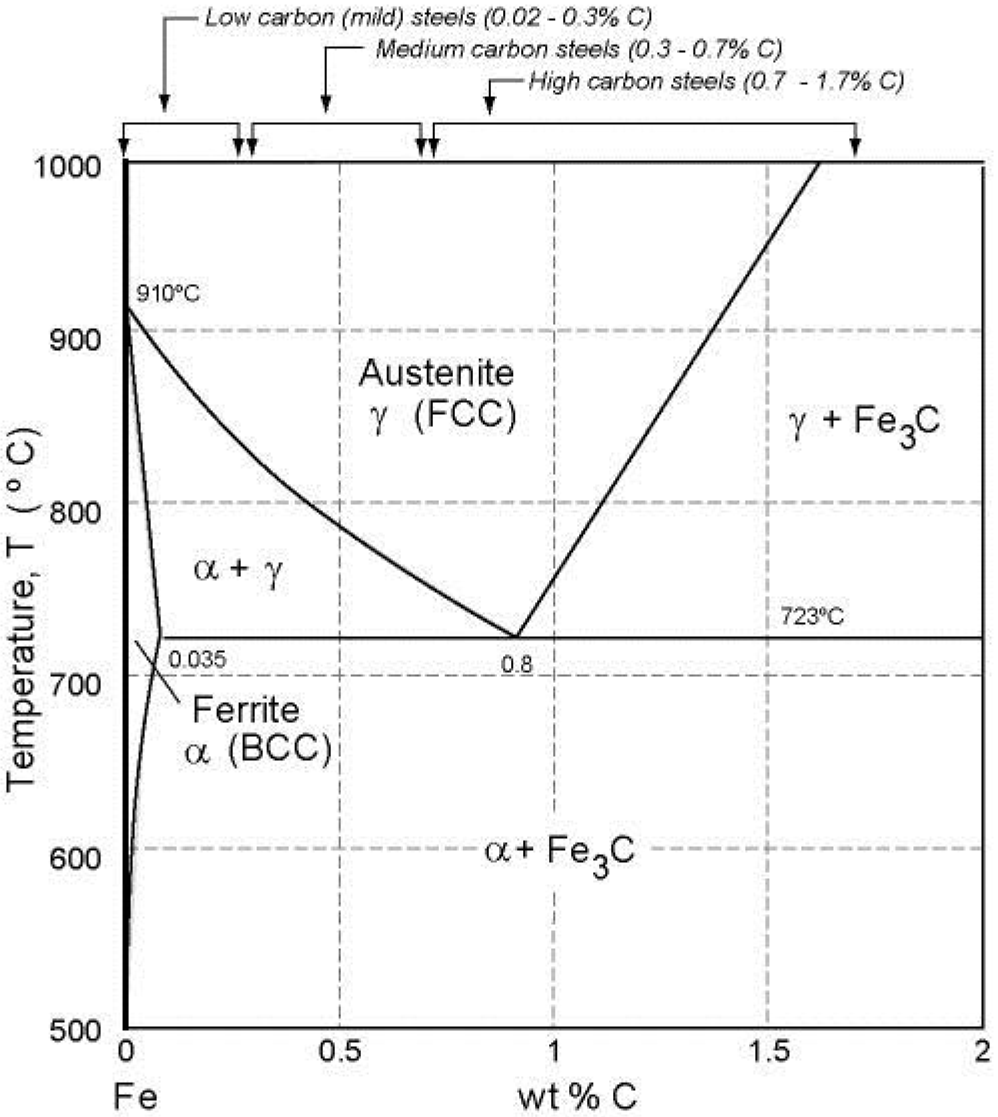
Design guidelines

Hardenability measures the degree to which it can be hardened in thick sections; plain carbon steels have poor hardenability - additional alloying elements are used to increase it (see Low alloy steels).

Technical notes

The two standard classifications for steels, the AISI and the SAE standards, have now been merged. In the SAE-AISI system, each steel has a four-digit code. The first two digits indicate the major alloying elements. The second two give the amount of carbon, in hundredths of a percent. Thus the plain carbon steels have designations starting 10xx, 11xx, 12xx or 14xxx, depending on how much manganese, sulfur and phosphorus they contain. The common low-carbon steels have the designations 1015,1020, 1022, 1117,1118; the common medium carbon steels are 1030,1040, 1050, 1060, 1137, 1141, 1144 and 1340; the common high alloy steels are 1080and 1095. 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

Medium carbon steels are alloys of iron (Fe) with 0.3 - 0.7% carbon (C), for which this is the phase diagram.

Typical uses

General construction, general mechanical engineering, automotive, tools, axles, gears, bearings, cranks, shafts, bells, cams, knives and scissors.

Links

Reference

ProcessUniverse

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