Description

Image

Caption

1. Organ pipes are made of tin or of a tin - lead alloy. 2. Close-up of the material. © Håkan Svensson (Xauxa) at en.wikipedia - (CC BY-SA 3.0)

The material

Tin (symbol Sn) has been know to man since at least 3500 BC. The discovery that copper alloyed with tin to give bronze, greatly improving the mechanical properties, launched the Bronze age. In 1800 Napoleon offered prize of 12,000 francs for a method for preserving food for his armies. The tin can (steel coated with tin), which revolutionise the storage and preservation of foodstuffs and liquids, was invented in 1810, ironically by an Englishman; the first commercial canning factory opened just 3 years later.

Composition (summary)

Tin, Sn.

General properties

Density		7.26e3	-	7.27e3	kg/m^3
Price	*	17	-	18	USD/kg
Date first used		-3500			

Mechanical properties

Young's modulus		41	-	45	GPa
Shear modulus		14	-	18	GPa
Bulk modulus		38	-	46	GPa
Poisson's ratio		0.325	-	0.335	
Yield strength (elastic limit)		7	-	15	MPa
Tensile strength		11	-	18	MPa
Compressive strength		7	-	15	MPa
Elongation		55	-	75	% strain
Hardness - Vickers		3	-	5	HV
Fatigue strength at 10^7 cycles	*	4	-	9	MPa

Fracture toughness	* 15	-	30	MPa.m^0.5
Mechanical loss coefficient (tan delta)	* 0.015	-	0.045	

Thermal properties

Melting point	230	-	232	°C
Maximum service temperature	* 90	-	100	°C
Minimum service temperature	0	-	13.2	°C
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	60	-	61.5	W/m.°C
Specific heat capacity	216	-	228	J/kg.°C
Thermal expansion coefficient	22.5	-	23.5	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	10	-	12	µohm.cm

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	Yes

Processability

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

Durability: water and aqueous solutions

Water (fresh)	Excellent
Water (salt)	Excellent
Soils, acidic (peat)	Excellent
Soils, alkaline (clay)	Excellent
Wine	Acceptable

Durability: acids

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

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

Durability: alkalis

Sodium hydroxide (10%)	Limited use
Sodium hydroxide (60%)	Limited use

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Limited use
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	Acceptable
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable
O2 (oxygen gas)	Limited use

Sulfur dioxide (gas)	Excellent			

Durability: built environments

Industrial atmosphere	Excellent
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Acceptable
Tolerance up to 250 C (482 F)	Unacceptable
Tolerance up to 450 C (842 F)	Unacceptable
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	3.07e5	tonne/yr
Reserves, principal component	5.6e6	tonne

Primary material production: energy, CO2 and water

Embodied energy, primary production	*	216	-	238	MJ/kg
CO2 footprint, primary production	*	12.5	-	13.8	kg/kg
Water usage	*	1.04e4	-	1.15e4	l/kg

Material processing: energy

Casting energy	*	5.42	-	5.99	MJ/kg
Extrusion, foil rolling energy	*	0.463	-	0.512	MJ/kg
Rough rolling, forging energy	*	0.374	-	0.413	MJ/kg
Wire drawing energy	*	0.952	-	1.05	MJ/kg
Metal powder forming energy	*	4.12	-	4.55	MJ/kg
Vaporization energy	*	2.39e3	-	2.64e3	MJ/kg
Coarse machining energy (per unit wt removed)	*	0.488	-	0.54	MJ/kg
Fine machining energy (per unit wt removed)	*	0.608	-	0.672	MJ/kg
Grinding energy (per unit wt removed)	*	0.742	-	0.82	MJ/kg
Non-conventional machining energy (per unit wt removed)		23.9	-	26.4	MJ/kg

Material processing: CO2 footprint

Casting CO2	*	0.407	-	0.45	kg/kg

Extrusion, foil rolling CO_2	* 0.0347	-	0.0384	kg/kg
Rough rolling, forging CO_2	* 0.028	-	0.031	kg/kg
Wire drawing CO_2	* 0.0714	-	0.0789	kg/kg
Metal powder forming CO_2	* 0.33	-	0.364	kg/kg
Vaporization CO_2	* 179	-	198	kg/kg
Coarse machining CO_2 (per unit wt removed)	* 0.0366	-	0.0405	kg/kg
Fine machining CO_2 (per unit wt removed)	* 0.0456	-	0.0504	kg/kg
Grinding CO_2 (per unit wt removed)	* 0.0556	-	0.0615	kg/kg
Non-conventional machining CO_2 (per unit wt removed	1.79	-	1.98	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✔			
Embodied energy, recycling	* 35.7	-	39.4	MJ/kg
CO_2 footprint, recycling	* 2.8	-	3.1	kg/kg
Recycle fraction in current supply	5.5	-	6.5	%
Downcycle	✔			
Combust for energy recovery	✖			
Landfill	✔			
Biodegrade	✖			
Toxicity rating	Non-toxic			
A renewable resource?	✖			

Environmental notes

Tin(II) salts can be poisonous by ingestion and other routes, and there is evidence that tin can have experimental carcinogenic and human mutagenic effects. Some organo-tin compounds are very toxic.

Supporting information

Technical notes

Tin is extracted by the reduction of cassiterite, SnO_2, with carbon. At normal temperatures tin is metallic ("white" tin), but below 13.2 C it transforms (slowly) to non-metallic gray tin -- a problem known as "tin pest" when tin is used at low temperatures.

Typical uses

Tin is used in pure form in storage tanks for pharmaceutical chemical solutions, as electrodes of capacitors, and fuse wire and as organ pipes (though usually alloyed with some lead). Its most important applications, however, are as a coating on steel sheet ("tin plate") and as an alloying element in bronze, pewter and solder. Its salts are used as polymer additives, for antifouling paints, and to produce a transparent, conducting coating on glass.

Further reading

Eco data from Hammond, G. and Jones, C. (2006) "Inventory of carbon and energy (ICE), Dept. of Mechanical Engineering, University of Bath, UK

Links

Reference

ProcessUniverse

Producers