Class: 1st
Subject: Engineering Materials
Lecturer: M.Sc Murtadha Mohsen Al-Masoudy
E-mail: Murtadha_Almasoody@mustaqbal-college.edu.iq

Non-Ferrous Alloys

Introduction

Nonferrous alloys (i.e., alloys of elements other than iron) include, but are not limited to, alloys based on Aluminium, Copper, Nickel, Cobalt, Zinc, precious (expensive) metals (such as Pt, Au, Ag, Pd), and other metals (e.g., Nb, Ta, W). We will briefly explore the properties and applications of Cu, and Al alloys in load-bearing applications.

In many applications, weight is a critical factor. To relate the strength of the material to its weight, a specific strength, or strength-to-weight ratio, is defined:

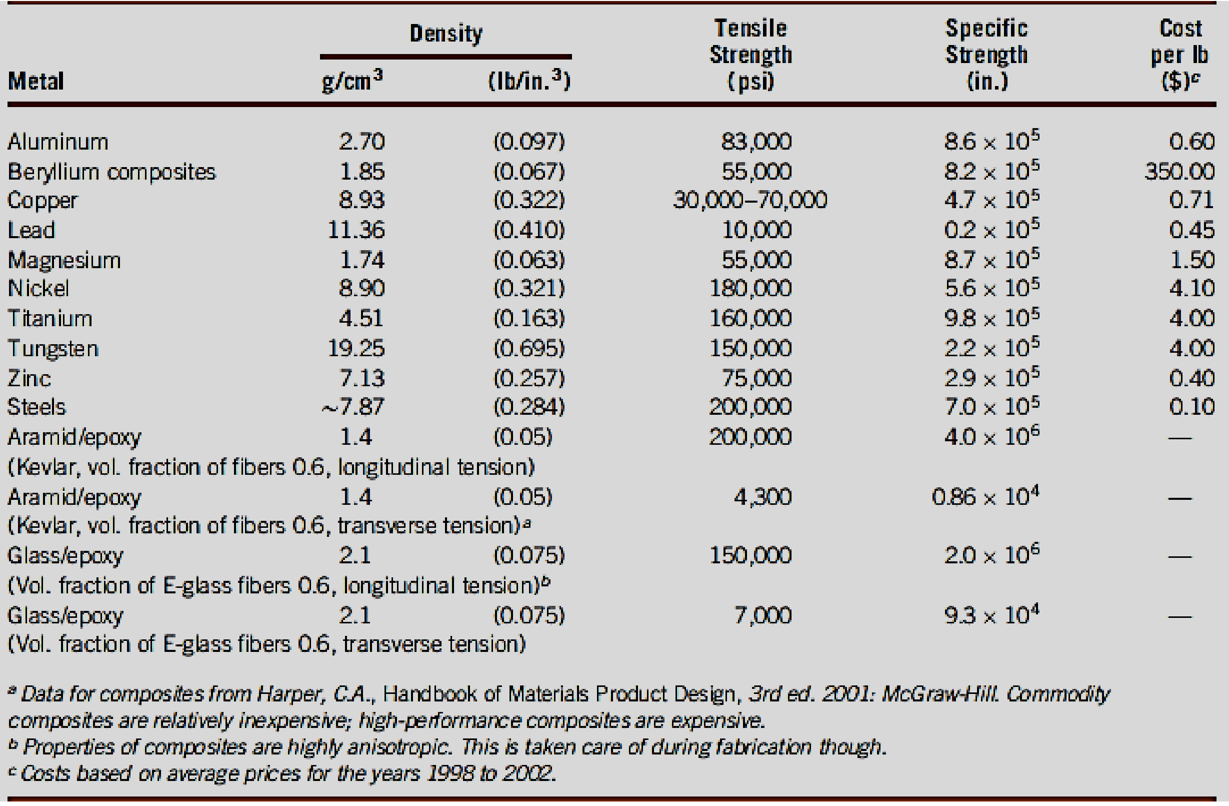
$$\text{Specific strength} = \frac{\text{strength}}{\text{density}}$$

Table.1 compares the specific strength of steel, some high-strength nonferrous alloys, and polymer-matrix composites. Note that these are just examples of properties and these should not be used for design purposes. The actual values for any given family of alloy will vary.

Another factor to consider in designing with nonferrous metals is their cost, which also varies considerably. Table 1 gives the approximate price of different materials. One should note, however, that the price of the material is only a small portion of the cost of a part. Fabrication and finishing, not to mention marketing and distribution, often contribute much more to the overall cost of a part.

Composites based on carbon and other fibers also have significant advantages with respect to their specific strength. However, their properties could be anisotropic and the temperature at which they can be used is limited. In practice, to overcome the anisotropy, composites are often made in many layers. The directions of fibers are changed in different layers so as to minimize the anisotropy in properties.

Table.1 Specific strength and cost of nonferrous alloys, steels, and polymer composites.



Metal	Density g/cm^3	Density (lb/in.^{3})	Tensile Strength (psi)	Specific Strength (in.)	Cost per lb ($)[c]
Aluminum	2.70	(0.097)	83,000	8.6×10^5	0.60
Beryllium composites	1.85	(0.067)	55,000	8.2×10^5	350.00
Copper	8.93	(0.322)	30,000–70,000	4.7×10^5	0.71
Lead	11.36	(0.410)	10,000	0.2×10^5	0.45
Magnesium	1.74	(0.063)	55,000	8.7×10^5	1.50
Nickel	8.90	(0.321)	180,000	5.6×10^5	4.10
Titanium	4.51	(0.163)	160,000	9.8×10^5	4.00
Tungsten	19.25	(0.695)	150,000	2.2×10^5	4.00
Zinc	7.13	(0.257)	75,000	2.9×10^5	0.40
Steels	~7.87	(0.284)	200,000	7.0×10^5	0.10
Aramid/epoxy (Kevlar, vol. fraction of fibers 0.6, longitudinal tension)	1.4	(0.05)	200,000	4.0×10^6	—
Aramid/epoxy (Kevlar, vol. fraction of fibers 0.6, transverse tension)[a]	1.4	(0.05)	4,300	0.86×10^4	—
Glass/epoxy (Vol. fraction of E-glass fibers 0.6, longitudinal tension)[b]	2.1	(0.075)	150,000	2.0×10^6	—
Glass/epoxy (Vol. fraction of E-glass fibers 0.6, transverse tension)	2.1	(0.075)	7,000	9.3×10^4	—

[a] *Data for composites from Harper, C.A.,* Handbook of Materials Product Design, *3rd ed. 2001: McGraw-Hill. Commodity composites are relatively inexpensive; high-performance composites are expensive.*
[b] *Properties of composites are highly anisotropic. This is taken care of during fabrication though.*
[c] *Costs based on average prices for the years 1998 to 2002.*