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CHAPTER 63

PROPERTIES OF METALS AT LOW TEMPERATURES

Tensile Strength, Ductility, Notch Bar Impact, Nonferrous Alloys, Steels, Tests, Selection of Materials, Specifications, Physical Constants

THIS chapter describes how low temperatures affect the properties of pure metals and commercial alloys and also the criteria used for selecting metals for low temperature applications or metals subjected to low temperature environments.

Few general deductions can be made except that with decrease in temperature there is an increase in hardness, strength and modulus of elasticity. The effect of low temperatures on ductility and toughness varies considerably among the metals and alloys; the ductility of some metals increases with decrease in temperature, while others show increase in ductility to some limiting low temperature followed by a decrease at lower temperatures, and still others show decrease in toughness and ductility as the temperature is decreased below that normally encountered in the atmosphere.

TENSILE STRENGTH

In Fig. 1 the relation of tensile strength to temperature is shown for metals generally selected for structural components. It will be noted that the slope of the curves indicating increase in strength with decrease in temperature, varies among the different metals.

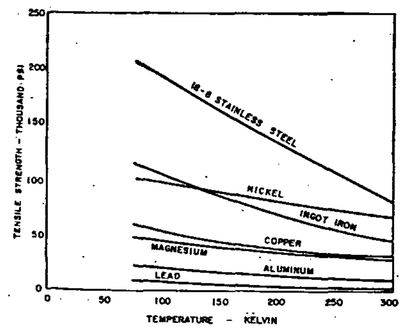

Fig. 1 .... Relation of Temperature to Tensile Strength of Several Metals[1]

Tensile strength, however, is not a particularly good criterion for determining the suitability of a material for low temperature service as most failures result from embrittlement. Ductility values obtained from the static tensile test may give some clue to the degree of embrittlement, but the notched bar impact test is generally preferred as it is considered to give a better indication of how the material performs under dynamic loading, and the reaction to complex multi-directional stress.

DUCTILITY

Ductility, as measured by percentage of elongation in the tensile test, is shown in relation to temperature for several of the frequently used metals (Fig. 2). Of particular note are the curves for copper, nickel, aluminum, and lead which show that ductility of all these metals increase as the temperature is lowered. The three metals iron, zinc, and magnesium show a decided decrease in ductility with decrease in temperature, and at the temperature of liquid air, all of these metals rupture with little plastic deformation, even when tested under static loading.

NOTCH BAR IMPACT

When these metals are compared on the basis of notched bar impact properties, the same trends may be noted, although the order of magnitude may differ appreciably from that when comparison was made on basis of ductility. For instance, lead has a high order of ductility when determined by the static tensile test, but the resistance to impact is

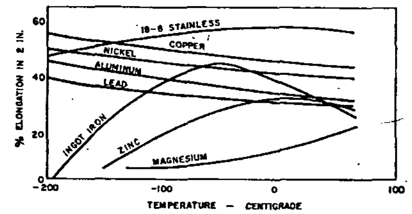

Fig. 2 .... Relation of Temperature to Elongation of Several Metals[2]