PAPER NO. 69

FOUNDING PROPERTIES OF NON-FERROUS LIQUID METALS(*)

Manjit Singh and
Rajendra Kumar,
National Metallurgical
Laboratory, Jamshedpur.

The paper evaluates the important physical properties such as viscosity, surface tension and density and volume contraction on solidification of some non-ferrous liquid metals and alloys, interms of the liquid state structure.

Viscosity

The temperature dependence of viscosity of monomeric liquids follows an Arrhenius type of rate process equation, but metallic solutions depart from the relationship due to the presence of solute-or-solvent-rich clusters in the liquid solutions. The viscosity isotherms show minima at the eutectic compositions and maxima at compositions corresponding to intermetallic compounds in solid state. The latter observation suggests that a strong atomic interaction is still retained on melting, but true melt features become prominent through randomization of atoms in the clusters at higher temperatures. The liquid state viscosity bears approximately a linear relationship with the atomic concentration in solid solution type of systems.

Surface Tension

It is shown that the magnitude of surface tension is governed by interatomic cohesion. If melting point, atomic volume or atomic numbers of metals are taken as cohesion indices, the surface tension of pure metals (dynes/cm) numerically approximately corresponds to their melting points (^{o}C); is inversely proportional to the atomic volume or a periodic function of atomic number.

(*) Paper for presentation at the Symposium on "Recent Developments in Non-ferrous Metals' Technology"- 4th to 7th December, 1968, Jamshedpur.

The solid solution alloys exhibit a smooth often linear variation with composition, or slight negative deviations from additivity. Eutectic systems appear to give: (i) smooth composition dependence of surface tension; (ii) minimum at the eutectic composition close to the liquidus temperature. In systems with intermetallic compounds in the solid state, a discontinuity is observed in surface tension in the liquid state corresponding to intermetallic compound composition, indicating that the dissociation of the compound is incomplete on melting. The discontinuity may exhibit minima, maxima or an inflexion depending on the compound being (i) surface active to the alloy constituents, (ii) not surface active to the alloy constituents, (iii) surface active to only one of the alloy constituents.

Density: Volume Change

Most metals undergo volume expansion on melting of the order of about 3-4%. Atomic volume in liquid state is also a periodic function of atomic number as in the solid state. Exceptional behaviour is, however, shown by bismuth, antimony, gallium, silicon etc. which show contraction on melting due to the tendency towards closer packing in the liquid state. Since there is no solute-solvent interaction in ideal solutions, the density of the alloys bears a linear relationship. Density measurements for liquid alloys show that the linear relationship is not obeyed and most of the liquid alloys show small deviations about 1-5%.

The volume changes on mixing are dependent upon the type of alloy system. They are very small and usually positive for eutectic systems. In compound containing systems the volume changes are generally negative, the maximum negative value corresponding to the compound composition.

Other properties of the liquid state are also discussed.
