The Wear of Noble Metals in Air

THE EFFECT OF CRYSTAL STRUCTURE AND COMPATIBILITY

The most useful generalisations in scientific work often emerge from investigations carried out on a range of materials under closely controlled conditions. Such a study, made at the Massachusetts Institute of Technology, has recently been reported by Drs. N. Ohmae and E. Rabinowicz in a paper based on an earlier ASLE/ASME Conference presentation (*ASLE Trans.*, 1980, **23**, (1), 86–92). These workers used a pin and disc apparatus to determine the friction and wear characteristics of combinations of metals showing a very low tendency to oxide formation. Thus the study included the six platinum group metals with in addition, silver, gold and rhenium, and the testing was carried out at low sliding speeds, to avoid heating effects, in air under unlubricated conditions. Certain of the metals studied find practical application in sliding electric contacts in which the resistance to wear is a particularly important parameter.

The metals used cover a wide range of hardnesses, from gold at 49 to rhodium at 1192 kg/mm^2. The other metallurgical properties considered to be of importance in this study were crystal structure of the metal and compatibility. In this context, pairs of metals showing immiscibility in the molten state are considered to be incompatible, whereas metals with a high degree of mutual solubility even in the solid state are compatible.

From the metal loss during the wear experiments, the Archard wear coefficient k was determined for each metal as follows:

$$V = \frac{kLx}{3p}$$

where V is the volume of wear, L the normal load, x the sliding distance and p the penetration hardness. Thus every test resulted in two k values from the pin and disc materials respectively. Dissimilar metal pairs yielded k_{soft} and k_{hard} values in reasonable agreement with one another. An important generalisation suggested from this novel approach is that an interface may be described in terms of a single wear coefficient, each material wearing by an amount determined by this value and varying inversely as the indentation hardness.

The level of scatter from these experimental results involving noble metals was found to be considerably lower than similar tests involving other metals. This is considered to be due to the absence of perturbing oxide layers and confirms that such metals are particularly suited to determining the laws of wear.

A Contrast with the Cubic Metals

From the analysis of the wear coefficients from over fifty pairs of metals tested, it is concluded that combinations involving the hexagonal metals (ruthenium, rhenium, osmium) or metals showing low compatibilities give low wear rates. It is perhaps unfortunate that the benefits due to the hexagonal structure and incompatibility are not additive, the wear coefficient being independent of degree of compatibility. This contrasts markedly with the cubic noble metals, in which the wear coefficient is shown to be a strong function of the compatibility of the combination.

No success was obtained in attempts to correlate c/a ratios of the hexagonal metals with these experimental findings. For example ruthenium and osmium were found to give very low wear rates compared with earlier results for the Group IV metals, titanium, zirconium and hafnium, even though the c/a ratios are similar.

A practical recommendation from this work is that lower-wearing combinations may be worth considering in slip ring applications, rather than the cubic materials currently used. However, as pointed out in the discussion accompanying the paper, other factors including alloying, lubrication and load need to be taken into account in such circumstances.

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