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CREEP OF ALLOYS RESEARCH

Technical Progress Report
to July 1, 1952

by
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1.

The following investigations are in progress at the present time:

1. Effects of Cobalt and of Iron on the Plastic Properties of Nickel -

Tensile and creep properties of a series of binary nickel alloys with cobalt and with iron have been studied. These alloys are characterized by having the solute and solvent atoms of essentially equal size and having the same gaseous state electron configuration except for the d-levels. Since the atomic radii are similar, the magnitude of the strain center - dislocation interaction which is prevelantly held to be the major factor in solid solution hardening, is reduced to a minimum. Consequently, differences in properties may be attributed to changes in d-level electron interaction.

Three different alloy compositions in the solid solution range have been prepared and tested for each binary system. Tensile tests at 30°C and 700°C have been made on each alloy; precise determinations of the lattice parameters have also been made at each of these temperatures.

It has been found that the addition of cobalt up to ~ 9 atomic percent has no significant strengthening effect on nickel. The properties of the nickel-iron alloys vary in a regular manner, the strength increasing with increasing iron content. Similarly, the lattice parameter of nickel, while almost unaffected by cobalt, is considerably increased by the addition of iron to nickel.

Results to date indicate that d-level electron interactions have very slight influence on plastic properties. However, a series of tensile tests at various temperatures are now in progress to determine whether there is a discontinuity in the region of the Curie Temperature. The electrical restivity of these alloys is also now being measured. This work will be reported as soon as these tests are completed.

2. Effects of Solid Solution Alloying on the Creep Parameter of Nickel -

Four series of solid solution nickel alloys have been prepared and the effects of these alloy additions on creep resistance has been determined at 700°C. It has been found that excellent correlation exists between the amount of alloy addition and the values of the creep parameters A and b. The shape of the creep curve is described by the relationship

$$\epsilon - \epsilon_0 = A t^b$$

where

ϵ = Total true strain

ϵ_0 = Instantaneous true strain at zero time

t = Time

A, b = Constants

Values of b increase linearly with atomic percent alloy addition while $\log A$ decreases linearly with alloy content. This work is now being prepared for publication as a technical report.

3. Determination of the Effects of Stress and Temperature on the Values of Creep Parameters - Considerable work has been done on the $\frac{1}{2}$ At % W nickel alloy to determine the specific effects of stress and temperature on the shape of the creep curve. Within the high and intermediate temperature and stress ranges (650°C to 800°C and 4200 PSI to 9200 PSI), it appears that A varies exponentially with the reciprocal of the absolute temperature and as a power term with stress. The precise manner in which b varies is not clear at the present time, but stress does not now appear to have a very large influence on this quantity. Thus, for the limited cases examined, we may express the creep curve as

$$\epsilon - \epsilon_0 = C e^{-Q_{RT}} t^b \sigma^n$$

Investigators elsewhere have found that a similar expression may be used for describing the creep curve, but they have noted that the value of "b" changes

when low values of stress or temperature are used. The investigations in this laboratory will now be extended to include tests at lower stresses and temperatures. Additional ingots of pure Ni have also been cast which will be used to make parallel studies on this material.

4. Studies on Recovery - In order to provide data which may be useful in better understanding the basic factors involved in the creep phenomena, a program is being initiated to determine the recovery characteristics of all the alloys investigated to date. Activation energies will be measured for the recovery process and these energies will be compared with data obtained for creep and diffusion.

5. Nickel - Chromium Alloys - Work by numerous investigators has demonstrated the influence of surface condition on creep rate. It has been previously shown that the oxide film on nickel has a profound effect on this property. Consequently, it may be expected that the oxidation characteristics of the elements added to nickel will influence the creep strength of the resulting alloys.

In an effort to evaluate this factor, a series of nickel-chromium alloys have been prepared. It is generally believed that it is the tightly adhering, stable oxide surface which results when chromium is added that is the principle factor in imparting excellent high temperature properties to alloys. Therefore, creep tests will be made on these alloys in air and in a helium atmosphere to determine the influence of the oxide surface on creep resistance. Thus it is expected that it will be possible to separate the alloying effect due to surface condition from the one produced by atom size and bonding.

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