A Look at Dispersion Strengthening by Powder Metallurgy Methods

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Since the stimulating discovery of aluminum oxide dispersion strengthened aluminum, S.A.P., by Irmann[1], an alloy which showed unusual high temperature strength far in excess of that achievable by conventional aluminum alloys, many other metallic systems have now been investigated in sufficient detail [2-6] to indicate that most metallic systems are capable of being strengthened by an ultra-fine dispersion of a hard insoluble phase.

It has further been demonstrated that powder metallurgy techniques offer by far the greatest promise and flexibility in preparing such dispersion strengthening alloys.

STRUCTURAL PARAMETERS

Based on the work which has been done in oxide dispersion strengthened systems involving primarily aluminum, copper and nickel, a number of structural parameters have now been examined adequately to be able to list them as the major factors which control the properties of such alloys. They are the following:

1. A fine interparticle spacing—In SAP-type alloys containing of the order of 12 volume percent of oxide, the interparticle spacing is approximately 0.3 micron. In internally oxidized copper-aluminum alloys, for a 3.5 volume percent Al_2O_3 composition, the interparticle spacing is also about 0.3 micron. In a 1 micron copper-10 volume percent Al_2O_3 alloy, the inter-particle spacing was about 1 micron. In a 2 to 5 micron nickel-9 volume percent aluminum oxide alloy, prepared by mechanical mixing of powders, the interparticle spacing was at least 2 microns. The resultant strengthening in the latter two alloys was good, but was relatively poor when compared to the strengthening achieved with the SAP alloy or the internally oxidized copper-aluminum oxide alloy. Fig. 1 shows the relationship between the stress for 10, 100, and 1000 hours life at 1500° F. versus the interparticle spacing for a series of nickel-aluminum oxide alloys[3] with increasing