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Technical Progress Report

THE EFFECT OF SURFACE TENSION ON THE
SINTERING ROLE OF METAL ALLOYS

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and the
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INTRODUCTION

In the year subsequent to the last progress report, there have been two areas of investigation. The initial program on the effect of oxygen on the sintering rates of silver was completed. This final stage of work consisted of the completion of the experimental aspects of the study involving the determination of the exact dependence of sintering rates in three different atmospheres at two different temperatures. Additionally, considerable effort was expended in the analysis of the experimental data and the development of a logical and rational explanation of the results.

The second area of study was that described in the proposal for the present year's work. The basic premise of this study is that the sintering rates of various solid solution alloys, for which the surface tension values are known, would be determined. These data would then be analyzed so that the rate controlling material transport mechanisms could be found. As of this date, this work is still in its early stages.

RESULTS

The final results of the study on the effect of oxygen on the sintering kinetics of silver are given in the paper based on this work. This paper is included as an appendix to this report; it has been submitted to the Transactions of the Metallurgical Society of AIME. Also included is a copy of the abstract of this work which has been submitted for presentation at the 1968 Annual AIME meeting.

Without repeating what is given in this paper, it should be noted that: (1) the interpretation of the experimental data was based strongly on published information on the dependence of the surface diffusivity of silver on oxygen content; this was not contemplated in the original proposal for this study; (2) it appears that this is the first study to come to the conclusion that shrinkage of a compact during sintering under certain conditions (low green densities at high temperatures) can be controlled by surface diffusion material transport; (3) for those cases without sufficient interconnected porosity (high green densities) at 932°C and for all green densities studied at 714°C the rate controlling material transport mechanism is either volume or grain boundary diffusion but not plastic deformation by slip.

No final results have been obtained on the present research study on solid solution alloys. Some time was spent on surveying the literature in order to find an alloy system for which the dependence of surface tension of the solid alloys on alloy content was known. The system decided upon is the copper-antimony one. The appropriate composition-surface tension data are given in the paper by Inman, et al⁽¹⁾. Based on this work three compositions were chosen for study as given in Table I with the appropriate surface tension values. Spherical atomized

powders with approximately these compositions (see Table I) were purchased from the Federal Mogul Company.

Considerable effort has been spent on developing procedures to insure the chemical homogeneity and purity of these alloys at the sintering temperatures. This work has involved metallographic examination of the as-received powders which indicated a substantial degree of antimony segregation. Various heat treatments are being developed, as well as modifications in the procedures used during sintering in the dilatometer, to insure the elimination of such segregation and surface oxidation.

The use of spherical powder presents some problems with respect to compaction. It is difficult to obtain sufficient green strength over a wide green density range. However, the advantage of using such powder is that more detailed examination of the sintered compacts can be made. This work will include measurements of the changes in neck size, pore size and pore shape. It is hoped that by using carefully selected size powders and interpreting such measurements on the basis of new analyses (work in its final stages at Northwestern University by Dr. D. L. Johnson but not yet published), additional conclusions on the mechanisms of sintering may be made.

REFERENCE

1. M. C. Inman, D. McLean and H. R. Tipler, "Interfacial Free Energy of Copper-Antimony Alloys," Proc. Royal Soc., A-273, pp. 538-557, 1963.

TABLE I COMPOSITIONS AND SURFACE TENSIONS OF MATERIALS				
Wt. % Cu		Wt. % Sb		Surface Tension ^(a) (ergs/cm ²)
Nominal	Actual	Nominal	Actual	
100.00	99.79	0.00	0.005	1745 ^(b)
99.5	99.18	0.5	0.45	1000 ^(c)
98.5	98.37	1.5	1.32	900 ^(c)
(a) values for 950°C from ref. (1) (b) average value for pure copper (c) interpolated from actual data				