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► To cite this version:

D. Bouvard, M. C. Cheynet. Densification behaviour of metal powders at high temperature. *Revue de Physique Appliquée*, 1988, 23 (4), pp.701-701. 10.1051/rphysap:01988002304070100 . jpa-00245857

HAL Id: jpa-00245857

<https://hal.science/jpa-00245857>

Submitted on 1 Jan 1988

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DENSIFICATION BEHAVIOUR OF METAL POWDERS AT HIGH TEMPERATURE

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INTRODUCTION

Hot pressing is a technique used increasingly to densify hard to work metal and ceramic powders. However the mechanisms of densification have just started being realistically analysed and modelled (1). The main impediment to significant advancement seems to be the lack of suitable experimental results, which require indeed heavy testing programs.

In this paper we present the results of such a program realized on a powder superalloy and an analytical model for the densification of monosized spherical particles under isotropic pressure.

EXPERIMENTAL WORK (2)

A great number of interrupted hot isostatic pressing tests was performed on two particle size distributions of argon atomized nickel base superalloy René 95 powder at different temperatures. The partially densified specimens were analysed from two points of view :

- Bulk density measures permitted to estimate the densification rate as a function of relative density for each condition of temperature and particle size distribution.

- Microscopic observations showed in particular that the morphological and microstructural changes of the particles depend on their initial structure. When most of the dendritic particles remain in their initial shape and structure, all the others are largely deformed and recrystallized during the densification. We observed also that, in the tested conditions, interparticle diffusion is not significant up to 95% of density, at least.

These results permitted to explain the difference in densification rate between the two lots of powder and provided valuable information for a theoretical description of the compaction.

MODELLING OF DENSIFICATION (3)

We consider a random arrangement of monosized spherical particles submitted to an external isotropic pressure. The constituent material is incompressible and deforms by power

law creep. We do not take account of the diffusion-related mechanisms that have often little effect on the densification, except for high densities.

We introduce "internal parameters" characterizing the particle deformation, as for example the interparticle contact area and the interparticle force. These parameters are supposed to be random variables, since they take different values within the material.

An equation describing the deformation of two contacting spheres is assumed and general relations between the internal parameters and the macroscopic parameters, which are the external pressure and the relative density, are displayed. Then, after an estimation of the statistical distribution of the random variables, an analytical expression of the densification rate is proposed.

The comparison of the densification rate determined for the René 95 powder with the prediction of the model is rather satisfactory, although the real particle size distribution does not agree with the hypothesis of the model.

CONCLUSION

These results are a first step towards a complete, realistic modelling of powder densification, that is expected to be directly usable for the selection of the main process parameters from the macro- and microscopic properties of the powder.

The present subjects of investigation concern the introduction of morphological and microstructural characteristics of the material in the model and the influence of deviatoric stresses on the densification rate.

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