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PLASTIC FLOW AND STRUCTURAL MORPHOLOGY OF TWO PHASE MATERIALS

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Up to now, the microheterogeneous material plastic modelling developed on the basis of explicit or implicit very strong hypotheses concerning the space distribution of the constituent phases. Thus, uniform strain assumption of the Taylor model is equivalent (from a statistical point of view) to a parallel connection of the phases with respect to exterior loading, whereas the uniform stress assumption of the static model is equivalent to a series connection, and the self-consistent scheme makes a peculiar hypothesis of disorder. None of the existing models can take an arbitrary phase spatial distribution into account ; the only experimental information that is used is the phase volume fraction which leads, at best, to upper and lower bounds for the overall plastic behaviour.

In order to check the influence of the phase morphology on the overall plastic behaviour of materials, and to determine the pertinent parameters, a study of the plasticity of a two-phase material is now in progress. This material is an iron/silver aggregate elaborated by hot isostatic pressing in all proportion of iron and silver ; it shows a good macrohomogeneity and neither a morphological texture nor a crystallographic one.

1 - Yielding behaviour

Classically, pure iron plasticizes heterogeneously by propagation of Lüders bands whereas in the same conditions, silver plasticizes homogeneously without any front propagation. These different behaviours give rise to different stress/strain curves (Fig 1) ; the Lüders band phenomenon is associated with an upper yield point followed by a more or less flat plateau corres-

Fig 1 Experimental and model stress strain curves at different phase concentrations.

ponding to the band propagation ; the homogeneous behaviour of silver gives a smooth transition from the elastic to the plastic regime.

In the case of the two-phase materials, different behaviours can be associated with different concentration ranges ;

- from 100% to 85% Fe : Ag and Fe plasticize together by Lüders band propagation,

- from 85% to 70% Fe : Ag plasticizes first homogeneously, then deformation goes on by band propagation,

- less than 70% Fe : homogeneous deformation without band propagation ; Fe plasticizes later when its concentration is weaker but deformation traces can be observed at all concentrations.

Thus, a strong influence of the phase concentration on the yielding conditions can be observed. It can be quite naturally conjectured that this concentration effect is in fact a morphological effect, and a more precise study of the influence of morphology at fixed concentration is now in progress.

2 - Plastic flow behaviour

As can be checked micrographically and by electrical resistivity measurements (Fig 2), iron particles are mainly included in the silver matrix (experimental measurements consistent with Hashin - Shtrikman lower bound). Therefore a three-phase model based on a composite sphere in an equivalent homogeneous medium (fig 1) allows, in some measure to take into better account the actual phase arrangement. Nevertheless this type of model can't describe the heterogeneous inception of plastic flow.

Fig 2 Electrical resistivity vs phase concentration. Experimental curve and predicted bounds.