An experimental study of elasticity in polycrystalline iron

Bevis Hutchinson*[1], Mikael Malmström[2], Anton Jansson[2], and Johan Lönnqvist[2]

[1]Swerim AB – Kista, Sweden
[2]Swerim AB – Sweden

Abstract

Bevis Hutchinson, Mikael Malmström, Anton Jansson, Johan Lönnqvist

Swerim AB

Box 7047, SE-16407 Kista, Sweden

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Elastic properties are a fundamental requirement for many mechanical and physical applications of materials and information about these is widely available for most practical purposes. For isolated crystals there are tensorial descriptions that can be adapted for all loading conditions using parameters describing the anisotropy of the crystals. The situation is less clear when considering the more usual polycrystalline structures where elasticity depends not only on these crystalline parameters but also on their mutual interaction in the composite body. Many models have been proposed in the literature regarding elasticityn in polycrystals but, as far as we know, there has never been a rigorous experimental investigation to test these models.

A correct experimental verification necessitates that the test material corresponds to the conditions on which the models are based and these do not generally apply in readily available materials. The necessary conditions include primarily:

- Completely random texture giving isotropic behaviour
- Equi-axed grains
- A reasonably monotonic distribution of grain sizes
- Grain size that are small in comparison with the material body to minimize the influence of surface relaxations.

It is also desirable to test the observations over a range of different crystalline anisotropy, for example as defined by the Zener ratio 2c44/(c11-c12) for cubic crystals.

We have achieved these intentions by hot isostatic pressing (HIP) pure iron power into a fully dense block and then measuring the velocity of longitudinal (P) elastic waves using laser-ultrasonic equipment together with a Gleeble thermal simulator The measurements

*Speaker

were made at different temperatures between room temperature and 900$\circ$C to vary the crystalline anisotropy. For iron, Zener's ratio varies for 2.42 to 7. 44 over this temperature range. Resulting values are presented and compared with various theoretical models.

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