splitting or delamination in the plane of the sheet if the testing speed is rapid enough and the testing temperature is low enough. This occurs because the thickness of the above-mentioned (100)[011] pancake-shaped layer shrinks three to four times more than the thickness of the adjacent (111) matrix. Also, the induced tensile force in the thickness direction acting upon the (100) plane of the (100)[011] component, which is the cleavage plane of bcc materials, can cause splitting in thick sections because the constraint imposed by thick sections prevents roping from occurring. The detail analysis will be the subject for this writer's next paper. Should the thickness of the (100)[011] component remain equal to the through thickness of the sheet, delamination would not occur in any mechanical test and roping would not be corrugated in appearance; instead, it would appear as alternate variations in thickness or grooving.

1. R. N. Wright: *Met. Trans.*, 1972, vol. 3, p. 83.
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Author's Reply

ROGER N. WRIGHT

H-C. Chao was the first to demonstrate conclusively a correlation between the roping phenomenon and a texture mix[1] and, thus, his commentary is most welcome. Nonetheless, the arguments set forth in Fig. 1 of his discussion seem self-contradictory. The r-value calculations, *per se*, are accurate and consistent with the previous work.[1-3] The problem lies in the overall (111)[11$\bar{2}$] matrix deformation implicit in Fig. 1(*b*). It appears in the Figure that the matrix material at the ends of the slot is somehow not deforming when, in fact, it would be experiencing the same E_y as the matrix material at the sides of the slot. Moreover, it is of course the strain of the matrix material at the slot ends which controls Gap_f. In short, the entire sheet of (111)[11$\bar{2}$] material should be decreasing in width with tensile straining and the slot must *decrease* in width with the matrix sheet. This behavior has been discussed quantitatively in previous work[3,4] and is fundamental to the plastic buckling model.

Now the slot-end matrix material constraint shown in Fig. 1(*b*) could be produced by tensile grip effects. However, such constraints should not be present in the tensile gage section proper and not as *general* behavior in sheet forming operations.

The statement that the (100)[011] material consists of thin bands with thicknesses well below that of the sheet is interesting, but unsubstantiated. In any case, all that is required for the buckling mechanism is that certain through-the-thickness "bands" or sections be relatively rich in (100)[011] texture in comparison to a matrix relatively rich in (111)[11$\bar{2}$] texture (or a similar texture such as (111)[0$\bar{1}$1]). The longitudinal strain at which buckling ensues will depend on how pronounced the texture variation is, as discussed previously.[3]

The remarks concerning delamination and cleavage are, again, very interesting. Hopefully, well defined evidence for the cause-effect relationships will be forthcoming in future publications.

The plastic buckling model was set forth as a specific mechanical explanation for roping. Unlike other models, it is consistent with the observed texture mixes *and* with the undulating or corrugated morphology. To be sure, the buckling model may well oversimplify the physical behavior. Nonetheless, quantitative projections show it to be consistent with observed ratios of corrugation width to sheet thickness,[3] with observations on the minimum rolling direction strain needed for buckling,[3] and with the effects of tensile axis variation.[4]

1. H-C Chao: *ASM Trans. Quart.*, 1967, vol. 60, p. 37.
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Difficulty of Coarsening of Silica Inclusions in Slowly and Rapidly Solidified Iron

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Inclusions, known to be detrimental to mechanical properties, have, for example, an especially strong effect on the ductility of rolled products in the short transverse direction. Four variables describe inclusion behavior in fracture: volume fraction, shape, size, and nature of the inclusions. It is known that the volume fraction of inclusions should be minimized for good ductility. Although the shape factor is not well understood, spheres are preferable to angular inclusions to minimize stress concentrations. The nature of the inclusion may effect the type of crack that forms at the inclusion site during fracture. Brower and Singh[1] have shown that spherical FeO inclusions in iron exhibit both internal cracks and matrix-inclusion interface decohesion. SiO_2 inclusions in iron, however, exhibit only matrix-inclusion decohesion. Since cracks are associated with inclusions during deformation, larger inclusions result in larger cracks and lower ductility.

This work is concerned with the control of inclusion size. Large inclusions may result either during inclusion formation and matrix solidification or dur-

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