Textures and Microstructures, 1991, Vols 14–18, pp. 1135–1140
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COMPARISON OF SIMULATED AND EXPERIMENTAL DEFORMATION TEXTURES FOR BCC METALS

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1. Materials

Two low carbon steels (non oriented electrical steels) have been used in this study. Table I sums up the conditions of cold rolling. For all specimens (before and after cold rolling) complete O.D.F.s have been determined by using X-rays pole figure data and the quadratic method /1/.

Starting material	Rolling conditions	Final material
Steel 1 after hot rolling (St1hot)	65% reduction cold rolling in previous RD	Steel 1 cold rolled (St1RD)
Steel 1 after hot rolling (St1hot)	65% reduction cold rolling in previous TD	Steel 1 cold rolled (St1TD)
Steel 2 after hot rolling (St2hot)	65% reduction cold rolling in previous RD	Steel 2 cold rolled (St2RD)

Table I : Nomenclature of the used materials.

Steel 1 after hot rolling exhibits a well defined deformation texture whereas steel 2 has a very weak texture (nearly random) after hot rolling.

2. Used models of plastic deformation and scheme of the comparison

The simulations of cold rolling have been done by using the Taylor-Bishop-Hill model under various conditions (FC = full constrained, RC lath = relaxed constrained assuming lath shape of the grains, RC pancake = relaxed constrained assuming pancake shape /2/, LAP = Los Alamos Plasticity code /3/) and a visco-plastic self consistent model (referred as VPSC in the following) already described in the literature /4,5/.The two families of slip systems {110} <111> and {112} <111> have been used in all the cases with the same critical shear stress.

A calculation starts with a set of about 400 orientations the weights of which have been deduced from the continuous O.D.F. of the starting material (St1hot or St2hot). The result of a simulation is then also a set of orientations with corresponding weights. It can be transformed into a continuous O.D.F. by setting on each one a gaussian peak ($\varnothing_0$ = 8° in our case) and by using a series expansion (up to lmax = 34 in our case).

This discretization of the start O.D.F. and, to a lesser extent, the reconstruction of the continuous end O.D.F. lead to a loss of power of resolution and thus makes a truly quantitative comparison with the corresponding experimental texture difficult. Nevertheless the comparison of the internal structure of the O.D.F.'s (relative weights of the several texture components) remains meaningfull.

3. Results and discussion

Figures 1, 2 and 3 show three selected sections of the experimental and calculated O.D.F.s. corresponding to the three cold rolled steels. As it can be seen in the experimental O.D.F.s the sharpness varies greatly according to the steel considered and the direction of rolling.
In figure 1 and 3 one recognizes that Taylor FC and to a lesser extent LAP (which starts with full constrained conditions and uses relaxation when the deformation increases) give the more unrealistic predictions. On the contrary Taylor RC pancake and VPSC models lead to O.D.F.'s which are in better accordance with the experimental ones with a slight 'advantage' for the VPSC model in the case of St1TD and St2RD specimens when considering the relative weights of the peaks.

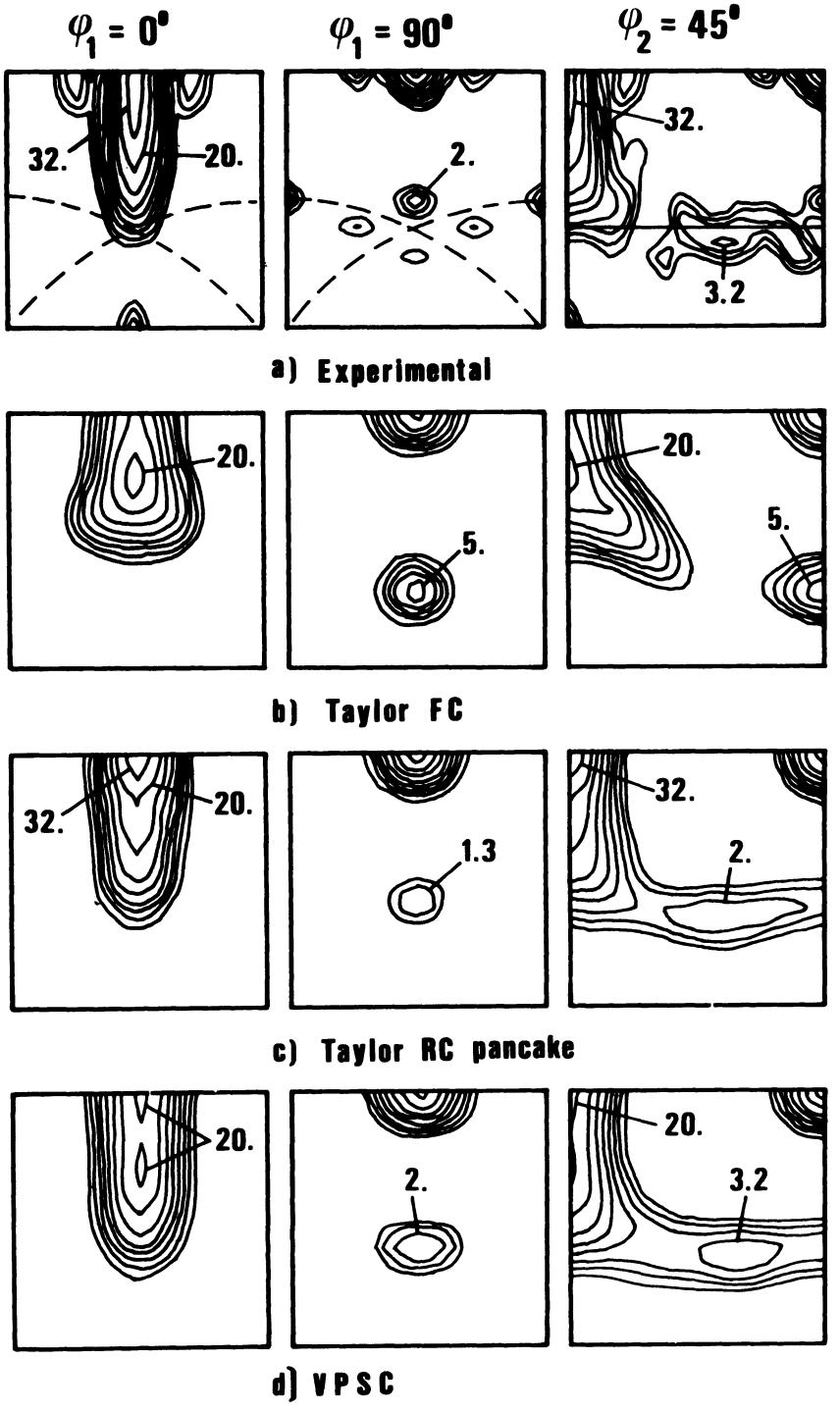

Fig. 1 : Experimental and calculated O.D.F.s of St1RD

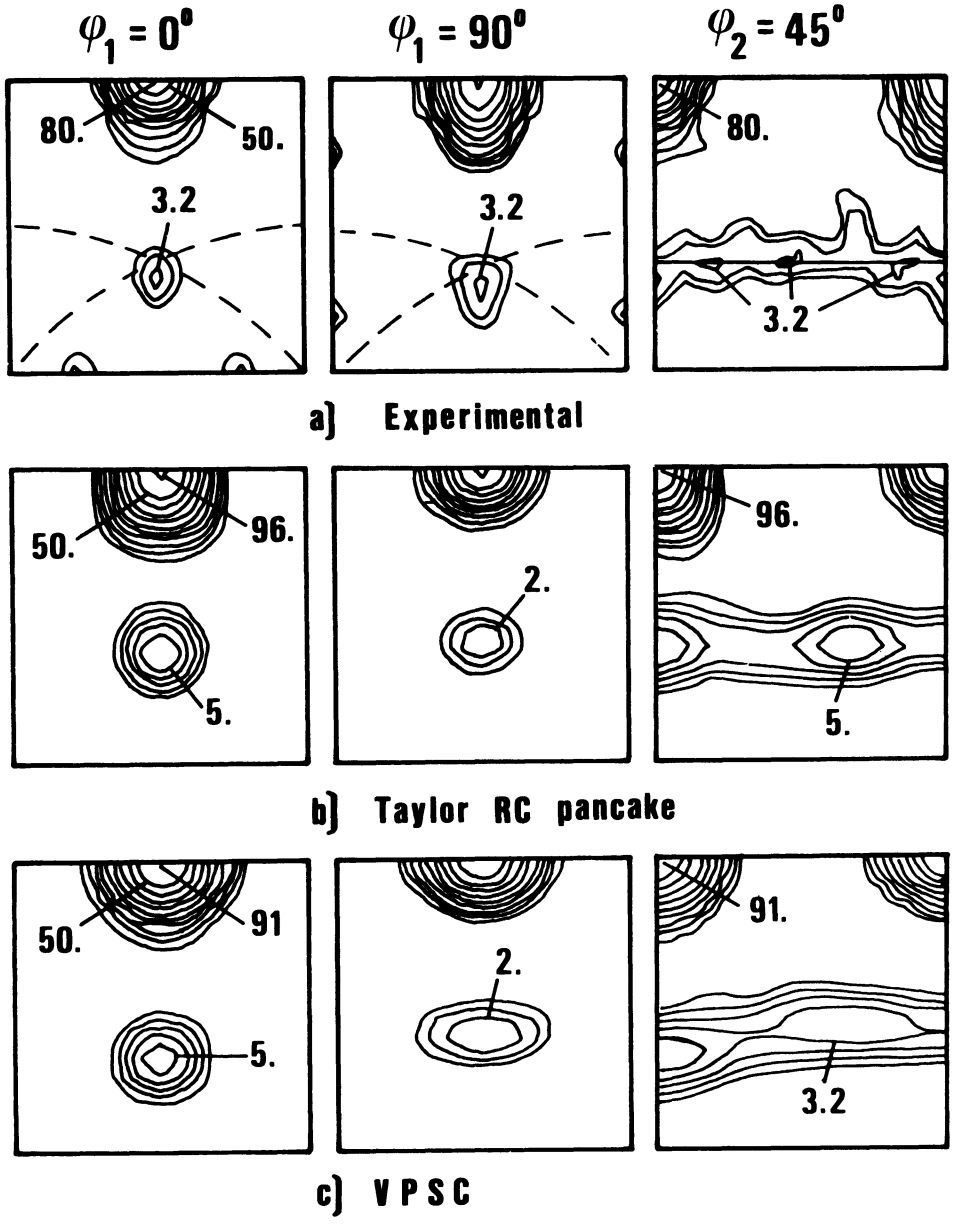

Fig. 2 : Experimental and calculated O.D.F.s of St1TD

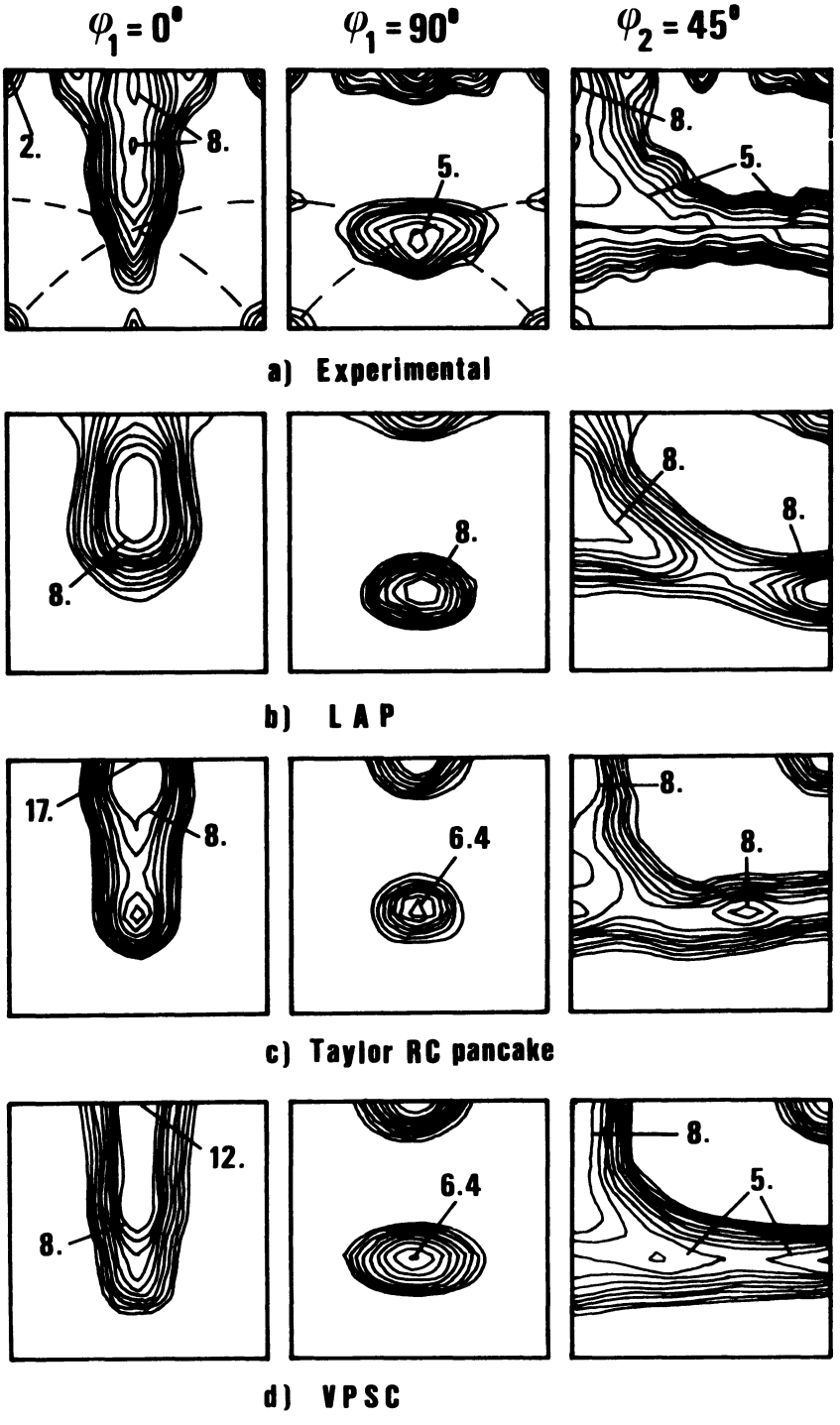

Fig. 3 : Experimental and calculated O.D.F.s of St2RD

Some calculations have been done including a hardening law in the VPSC model : the obtained textures do not show significant deviations and the conclusion was that the hardening is not important in the texture evolution of these steels.
Optical micrographs show that the grains are approximately equiaxed in the steels after hot rolling (especially in St2hot). This implies that the use of the RC pancake model can not be justified by a shape argument. On the contrary the VPSC starts the calculation by assuming an isotropic shape of the grains. Both models give then satisfactory results in terms of texture evolution for different reasons. By considering the slip activity in the VPSC model it appears that the mean number of activated slip systems varies from 3.2 up to 4. when the deformation increases from 0 up to 1. The similarity in the results of both models (Taylor RC pancake and VPSC) is then due to the fact that both consider about the same number of slips systems which is likely to be a good representation of the reality as it is demonstrated by the predicted textures. This number of slip systems is artificially imposed in the Taylor RC pankake (there is no shape argument for this relaxation) wheareas it results 'naturally' from the VPSC model.

References

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