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SHORT COMMUNICATION

Authors' Reply to Comments on the Determination of Wire Textures

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The preceding comment by J. Kajamaa touches a problem of quite general importance in texture analysis, that is, the problem of the statistical symmetry (specimen symmetry) of an orientation distribution function which expresses itself in the symmetry of the pole figures.[1] The specimen symmetry is clearly to be distinguished from the crystal symmetry which shows up in the inverse pole figures. Both these symmetries together make up the symmetry in the three-dimensional orientation space. This problem has been treated recently by Baker[2] in a quite general way.

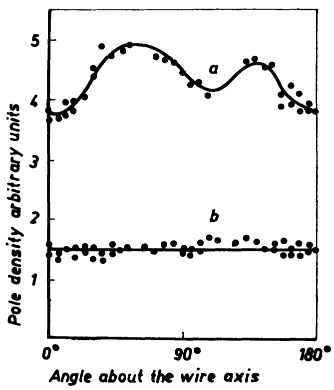

FIGURE 1 Reflected neutron intensity, (220)-pole figure, perpendicular to the wire axis, a = extruded and recrystallized rod, b = cold drawn wire used for texture determination.

Looked upon from the view point of mathematical texture representation[3] both these symmetries are equivalent (right-hand and left-hand symmetry respectively of the orientation distribution function). There is, however, an important difference between them as far as the possible deviations from the ideal symmetry are concerned. In the majority of texture problems investigated thus far the crystal symmetry was out of question. Possible deviations from the ideal symmetry due to different kinds of crystal lattice defects usually are so small that they are far below the limit of detectability by texture methods. Thus crystal symmetry, in most cases, may be looked upon as "mathematically" fulfilled. (Of course, there are certain special texture problems in which a detectable deviation from an otherwise grossly fulfilled crystal symmetry may be of some importance).

On the other hand, the specimen symmetry is imposed upon the orientation distribution function only by force of the symmetry of the external conditions under which the texture was formed. This symmetry in many cases is but a gross approximation of the real situation. Hence the specimen symmetry is much more liable to be violated than the crystal symmetry. Textures in metals usually originate from the combined action of two types of processes, namely, crystallization and deformation processes each of which is prone to a specific reason for symmetry deviations. In crystallization and recrystallization processes, too low a number of crystals may be the limiting factor. In this case the specimen symmetry will be fulfilled only within the margin of the statistical reliability according to the number of crystals involved. In deformation processes, on the other hand, the local deformation state may definitely deviate from the externally imposed one even on a scale larger than the grain size. That is to say, the plastic flow field may exhibit a certain amount of turbulence, thus giving rise to statistical fluctuations in the texture. Due to either of these causes, fluctuations in texture may occur which after deformation may be stretched out in a rather long part of the specimen, for example, a drawn wire. If, as is usual in texture analysis, only small specimens are used, then symmetry deviations beyond the limit of experimental error may be detected. They will, however, be cancelled out if a lot of specimens taken from different parts of the material are investigated. Whether or not deviations of this kind should be taken into consideration depends on the purpose of the investigation. Of course, they are significant if physical properties of that very part of the material are concerned. If, on the other hand, the results were to be compared with a theory describing the mean plastic flow behaviour as, for example, the Taylor theory, then it is not only justified but even desirable to eliminate such deviations by taking appropriate mean values. Such was the purpose in our paper on the texture of aluminium wires. Of course, this does not exclude that, in an advanced state of the theory, the deviations from the mean flow behaviour may become subject of the investigations.

There is still another more trivial cause of symmetry deviations in textures which was mentioned in Kajamaa's comment. It occurs if the material, during its history, passes through a process of different symmetry. Of course, this process, for example wire *rolling*, will imprint its symmetry on the texture in this state. During the following processes, for example wire *drawing*, the texture will be modified by the new symmetry, but after the first steps it will not yet have attained this symmetry. In this state the material has a "memory" for its history. Textures of this type are very complex and usually are inhomogeneous. Thus after rolling and subsequent drawing, the texture of a wire will be inhomogeneously distributed over the cross-section. And according to the combined action of the two different symmetries, the texture will not only depend on the radius but also on the angle about the wire axis. (Figures 1a and b of the preceding comment certainly do not meet the real situation in this state insofar as they imply a homogeneous distribution of the texture over the cross-section of the wire). Hence for a rigorous treatment of this complex texture it would not be sufficient to decompose the wire into coaxial cylinders, as it was done in our investigation. Rather, it would be necessary to decompose it into a bundle of parallel filaments. The measurement of the integrated texture (over the cross-section) as carried out by Kajamaa in his thesis[4] gives of course some valuable first information, but it is by no means sufficient in order to understand such a complex and inhomogeneous texture state in a material. Hence the "accurate and complete determination of the whole texture including all types of textures in the material" as claimed by Kajamaa in his comment really would lead to a formidable experimental task if it were taken seriously.

It has been proved repeatedly[5] that after large plastic deformations ($> 95\%$ reduction) the texture is independent of the orientation or orientation distribution of the starting material. Hence a drawn wire will lose its memory of the lower symmetry rolling process after high enough a drawing reduction, and will assume an axial symmetry.

The wires used in our investigation had been extruded and recrystallized and subsequently cold drawn. Both of these deformation processes are axisymmetric. After extrusion and recrystallization a certain amount of memory of a preceeding lower symmetry state was present, as is to be seen in Figure 1 curve a. After cold drawing, however, curve b, the material had forgotten the period of its past, and proved axisymmetric within the limit of experimental error. It was in this state that the texture measurements described in our paper were carried out. Hence the statements in Kajamaa's comment, valuable as they may be by themselves, do not really touch the investigations described in our paper.

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