THEORY AND TECHNOLOGY OF THE COMPONENT FORMATION PROCESS

MECHANISM OF THE DEFORMATION OF METAL POWDERS DURING ROLLING IN THE LOWER PART OF THE FEED REGION

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In our previous work [1], it was established by experiment that, during the rolling of metal powders, an appreciable nonuniformity of transverse and longitudinal strains arises in the lower part of the feed region. This nonuniformity is due to the fact that, while the strain along the height—which is determined by the geometry of the tool, i.e., the rolls—grows, in the feed region the metal powder being rolled experiences very little densification.

In the determination of possible causes of the nonuniformity of transverse and longitudinal strains, it is necessary to bear in mind that powder rolling is always performed at feed angles exceeding the angle of active drawing of the powder into the deformation zone. In such a case, rolling takes place under specific conditions, involving the appearance, in the deformation zone, of tensile forces acting along the deformation zone.

The tensile stress acting in the region of the deformation zone under consideration is set up as a result of the action of the normal contact stress on the material being rolled. In a horizontal section located at a certain height and characterized by an angle \( \varphi = \alpha_t \), the resultant of the elementary forces acts horizontally in the direction of the rolls (Fig. 1). Because of this, the region of the material being rolled above the horizontal section characterized by the central angle \( \varphi = \alpha_t \) is nonself-locking. This region is acted upon by the vertical ejecting force \( F_x - T_x \), and it is this force that brings about the tensile stress in the section \( h_t \). This stress attains values at which a limiting state is set up in the region, and the longitudinal strain in it sharply increases. In many cases, for example, in the rolling of aluminum and Kh18N15Cr-Ni stainless steel powders, at high relative strip densities the region of the deformation zone under examination becomes severely stretched. This weakens the adhesion of the powder to the rolls and reduces the active frictional forces drawing the powder being deformed into the deformation zone. Experiments have shown that, under these conditions, the rolling process becomes "unstable" and slipping occurs.

As has been shown by Vydrin [2], the condition under which stretching can occur in the deformation zone is described by the expression

\[
2(F_x - T_x) > \sigma_s h_t,
\]

where \( F_x \) and \( T_x \) are, respectively, the vertical projections of the normal pressure and the frictional force, \( \sigma_s \) is the yield stress of the powder body, and \( h_t \) is the length of the section in which tensile stresses arise.

The frictional force and the normal pressure, as well as their projections on the rolling axis, can be found from the following self-evident relationships:

\[
T = \tau R (\sigma_s - \sigma_t); \quad F = \rho R (\sigma_s - \sigma_t),
\]

where \( T \) and \( F \) are, respectively, the frictional force and the normal pressure, \( \tau \) is the mean value of the tangential stresses at the roll–powder contact, \( \rho \) the mean value of the normal contact stresses, \( R \) the roll radius, \( \sigma_s \) the angle of active drawing of the powder into the deformation zone, and \( \sigma_t \) the central angle characterizing the position of the section in which tensile stresses are operative;

Fig. 1. Diagrammatic representation of forces causing extension of powder bodies during rolling.

Fig. 2. Extension curves for powder bodies being rolled at coefficients of external friction of $f = 0.1$ (solid lines) and $f = 0.2$ (dotted lines).