The processes of metal powder molding have been analyzed theoretically by many authors, most of whom, however, have failed to take into account the effect of load application rate on the character of the stressed state generated in the material being pressed. Yet it is known that high loading rates create specific deformation conditions leading, in particular, to a marked reduction in transverse pressure [1, 2]. As the load application rate is raised, it becomes possible to dispense with the die in the pressing of metal powders.

In the present work, a qualitative analysis is given of the plane stressed state pattern in powder materials subjected to high-rate deformation processes, which should enable certain aspects of such processes to be evaluated in a general form.

We start with the following system of equations:

$$
\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} = \gamma \frac{\partial^2 U_x}{\partial t^2}; \tag{1}
$$

$$
\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} = \gamma \frac{\partial^2 U_y}{\partial t^2}; \tag{2}
$$

$$
\frac{1}{4} (\alpha_x - \alpha_y)^2 + \varphi \tau_{xy}^2 = \frac{\sin^2 \varphi}{4} (\alpha_x + \alpha_y + 2H)^2; \tag{3}
$$

$$
\frac{\Delta \varphi}{\varphi} = \frac{\partial U_x}{\partial x} + \frac{\partial U_y}{\partial y}; \tag{4}
$$

$$
\frac{\partial U_x}{\partial x} - \frac{\partial U_y}{\partial y} = \ln 2\varphi. \tag{5}
$$

As our investigation is to be concerned primarily with a qualitative analysis of the stressed state pattern, we can assume the displacement components $U_x$ and $U_y$ throughout the whole field to be known and limit ourselves to an examination of Eqs. (1)–(3). Introducing a new variable, we can rewrite these equations as follows:

$$
\frac{\partial \sigma_x}{\partial x} (\sin \varphi + \cos 2\varphi) + \frac{\partial \sigma_y}{\partial y} \sin 2\varphi + 2\sigma \sin \varphi \frac{\partial \varphi}{\partial y} + \left( \sigma \cos \varphi \frac{\partial \delta}{\partial x} - \frac{\partial H}{\partial x} \cos 2\varphi - \frac{\partial H}{\partial y} \sin 2\varphi \right) = \gamma \left( \frac{\partial U_x}{\partial t^2} \cos 2\varphi + \frac{\partial U_y}{\partial t^2} \sin 2\varphi \right) \tag{6}
$$
Equations (6) and (7) constitute a quasilinear system of hyperbolic equations. For this system we can obtain an equivalent system of characteristic equations, enabling us to construct, as shown in [3], the solution of a Cauchy problem in the GH region. At the same time, the solution of this problem can be conveniently employed for carrying out a qualitative analysis of the stressed state characteristics of materials subjected to deformation at high rates. As the object is to determine some qualitative regularities of such a process, we can make the task easier by solving the problem for the following simplifying conditions which do not otherwise significantly affect the analysis:

1) the starting noncharacteristic line is taken to be the y axis on which the front of a plane shock wave is located;
2) the medium has constant properties over its whole cross section;
3) the velocity field will be taken to be known (i.e., $U_x$ and $U_y$ over the whole cross section are known);
4) the process is considered at a fixed specific instant of time, without taking into account the displacement of the maximum stress front within the material or the elastic aftereffect.

As a consequence of the limitations adopted, we have

$$\frac{\partial \varphi}{\partial x} = \frac{\partial \varphi}{\partial y} = \frac{\partial H}{\partial x} = \frac{\partial H}{\partial y} = 0; \quad \frac{\partial U_y}{\partial t} = \frac{\partial V_y}{\partial t} + V_x \frac{\partial V_y}{\partial x} + V_y \frac{\partial V_y}{\partial y} = 0$$

(at the boundary, the wave is plane) and

$$\frac{\partial U_x}{\partial t} = \frac{\partial V_x}{\partial t} + V_x \frac{\partial V_y}{\partial x} + V_y \frac{\partial V_y}{\partial y} = \frac{\partial V_x}{\partial t} + V_x \frac{\partial V_x}{\partial y},$$

where $V_x$ and $V_y$ are the components of the rate of travel of the material being deformed.

The problem can be conveniently solved by the method of numerical integration. The equations, in finite-difference form, of the characteristics of the system composed of Eqs. (6) and (7) for some sought point M, with allowance for the conditions listed above, will be [3, 4]

$$y_M - y_1 = \tan (\varphi_1 + \mu) (x_M - x_1); \quad (8)$$

$$y_M - y_2 = \tan (\varphi_2 + \mu) (x_M - x_2); \quad (9)$$

$$\cos \varphi (\sigma_M - \sigma) + 2 \sigma \sin \varphi (\varphi_M - \varphi) + A [\sin 2\varphi_1 (x_M - x_1) - \cos 2\varphi_1 (y_M - y_1)] = 0; \quad (10)$$

$$\cos \varphi (\sigma_M - \sigma) - 2 \sigma \sin \varphi (\varphi_M - \varphi) - A [\sin 2\varphi_2 (x_M - x_2) - \cos 2\varphi_2 (y_M - y_2)] = 0; \quad (11)$$

$$A = \gamma \left( \frac{\partial V_x}{\partial t} + V_x \frac{\partial V_x}{\partial y} \right). \quad (12)$$

At the boundary we have $x_1 = x_2 = \ldots = x_n = 0$, $y_n = y_{n+1} + 1$; $\sigma_1 = \sigma_2 = \ldots = \sigma_n = \sigma = \text{const}$, and $\varphi_1 = \varphi_2 = \ldots = \varphi_n = \varphi = \text{const}$. It is necessary to take into account that, in Eq. (12), $\partial V_x / \partial x < 0$ and $\partial V_x / \partial t < 0$, because the travel is a decelerating one, i.e., its maximum rate is at the upper boundary. For sought points $M_j$, where $j = 1, 2, \ldots, n-1$, we can write

$$x_{M_j} = \frac{1}{\tan (\varphi + \mu) - \tan (\varphi - \mu)}; \quad (13)$$