A numerical method is proposed for calculating the strain during hot open-die forming of porous preforms. With this model the density distribution in various stamping zones at any stage of the process can be estimated as a function of the preform size and the geometry of the empty die. The optimal parameters for the process can be chosen on the basis of the results.
Fig. 1. Computational diagram of the stamping process.

Fig. 2. Variation of the running density of the material in zones I (1), II (2), and III (3) and of the flash (4) as a function of the axial strain H.

It is assumed that the thermal effects and inertial forces can be ignored. In view of the symmetry of the deformable preform about the coordinate axes, the calculations were done for half of its cross section.

The boundary conditions for the velocity components $v_z$ and $v_r$ are

$$
\begin{align*}
  v_z|_{z=h} &= -v_0; \quad v_r = 0; \\
  v_z|_{z=0} &= 0; \quad v_r|_{r=0} = 0; \\
  v_z|_{z=H} &= -v_0
\end{align*}
$$

(1)

respectively, in zones I, II, and III (Fig. 1). Here $v_0$ is the velocity of the top half-die.

Assuming that the velocities are linear functions of the coordinates $r$ and $z$, with allowance for (1) we take the following expressions that describe the field of the flow velocities of the material:

$$
\begin{align*}
  \text{zone I - } v_z &= -v_0 \frac{z}{H}; \quad v_r = 0; \\
  \text{zone II - } v_z &= -v_0 \frac{z}{H}; \quad v_r = \frac{v_0}{h} a_1 \nu; \\
  \text{zone III - } v_z &= -v_0 \frac{h}{h}; \quad v_r = \frac{v_0}{h} R_0 a_1 \nu \left(1 + a_2 \frac{r - R_0}{R_1} \right)
\end{align*}
$$

(2)

Here $a_1$ and $a_2$ are variable parameters and $\nu$ is Poisson's ratio, the value of which can be expressed, in accordance with [7], in terms of the running porosity $\Theta$ of the preform:

$$
\nu = \frac{2 - 3\Theta}{4 - 3\Theta}
$$

(3)

The strain rate tensor components associated with the rate of flow of the material by the relations

$$
\begin{align*}
  e_z &= \frac{\partial v_z}{\partial z}; \quad e_r = \frac{\partial v_r}{\partial r}; \quad e_\phi = \frac{v_r}{r}
\end{align*}
$$

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