Plastic working is being increasingly used as a method of processing sintered P/M per-
forms. One blank shaping technique, possessing a number of advantages, is radial deforma-
tion [1]. Using the radial deformation process, it is possible, e.g., to produce long cy-
lindrical parts with an even longitudinal density distribution, which would be virtually im-
possible to achieve by axial working. Up to now, however, the radial working process has
received insufficient investigation, which is delaying its adoption on an industrial scale.

In this article an examination is made of the radial compression of a two-layer hollow
porous cylinder by an external pressure and its expansion by an internal pressure. Such a
formulation of the problem makes it possible to allow for the densification (or density loss)
characteristics of initially dissimilar powder blanks - dissimilar in starting density distri-
bution, mechanical properties, and compositions of materials - and also to model the pheno-
mena occurring during the deformation of two-layer porous bimetallic parts of complex con-
figuration (Fig. 1).

To solve this problem, we will use the same mathematical model as in [2]. It is based
on the theory of plasticity of a porous solid [3, 4]. All boundary value problems are solved
by the finite element method. Boundary conditins are the same as in [2]. Apart from this,
at the interface between the layers the condition of equality of radial stresses and velo-
cities must be satisfied.

Let us consider compression by an external pressure. We assume that the material of
the cylinder is uniform, the initial accumulated plastic strain is equal to zero, and only
the starting porosities of the layers $\theta_1$ and $\theta_2$ differ (the subscripts 2 and 1 refer to the
outer and inner layers, respectively). It is found that, at $\theta_1 > \theta_2$, as the radius decreases
from b to a, the rate of radial displacement referred to the rate of deformation ($v_r/v_{def}$)
grows. At the point of contact between the layers a curve of the rate of displacement clearly
shows a break, and the intensity of growth of the rate falls, which may be attributed to an
increase in porosity. At $\theta_1 < \theta_2$, in the part between $r_0$ and a the rate $v_r/v_{def}$ grows with
decreasing radius. In the part from b to $r_0$ two cases are possible. As the outer layer
undergoes compression on the stronger inner layer, there is a tendency for the rate of radial
displacement to fall with decreasing radius. On the other hand, as is shown above, the rate
can also grow, and it is the relative magnitudes of $\theta_1$ and $\theta_2$ that determine which effect
will predominate. When these two quantities differ only slightly, the rate in the part b-$r_0$
grows, although the growth is less intense than it is in the inner layer. With increasing
difference between $\theta_1$ and $\theta_2$, the quantity $v_r/v_{def}$ decreases, the decrease being the more
rapid the greater the difference in porosity between the layers.

As the degree of radial deformation rises, the rate of displacement of the inside
cylinder surface grows. Its magnitude is influenced by the relative densities of the layers
and also by the position of the interface, which is characterized by the size of the radius
$r_0$. An increase in the thickness of the inner layer brings about a decrease in the rate of
displacement of the free inside surface at $\theta_2 < \theta_1$ and to its increase at $\theta_2 > \theta_1$.

This character of velocity field distribution means that, when the degree of deformation
rises, the inside cylinder radius $a$ and the radius $r_0$ decrease. At any given $\theta_1$, $a$ and $r_0$
decrease more rapidly when the porosity of the outer layer is lower. The effect of the loca-
tion of the interface $r_0$ on the inside radius manifests itself as follows: At $\theta_1 < \theta_2$ an
increase in $r_0$ brings about a more rapid change in $a$, and at $\theta_1 > \theta_2$, a slower change in $a$.

Let us examine the character of the densification process. The intensity of densifica-
tion of the outer layer relative to the inner depends on their starting densities. If the
porosity of the inner layer is less that that of the outer, then the densification of the outer layer is more rapid. When \( \theta_1 > \theta_2 \), the reverse is true. At any given starting value of \( \theta_1 \), the rate of densification of the inner layer growth with decreasing starting value of \( \theta_2 \) (Fig. 2). With decreasing starting value of \( \theta_1 \), the densification of the outer layer increases in intensity (Fig. 3).

The densification of the inner and outer layers is affected also by the position of the interface \( r_0 \). The rate of porosity reduction in the inner layer grows with increasing \( r_0 \) at \( \theta_1 < \theta_2 \) and falls at \( \theta_1 > \theta_2 \). With increasing \( r_0 \) the rate of densification of the outer layer grows when \( \theta_1 < \theta_2 \) and falls when \( \theta_1 > \theta_2 \). To simplify analysis, mean values of porosity of the layers are used. Within each layer its porosity grows with increasing radius.

The distribution of the accumulated strain of the solid phase \( \Gamma_0 \) is uneven. With increasing radius, \( \Gamma_0 \) increases.

Let us examine the stressed state of the solid. All stresses are compressive. The stresses \( \sigma_z \), \( \sigma_r \), and \( \sigma_\theta \) and the hydrostatic pressure \( P \) grow in absolute value when the radius increases from \( a \) to \( b \). Values of \( \sigma_r \) are discontinuous. At \( r = r_0 \) there is a break in the curve of \( \sigma_r \). At \( \theta_1 > \theta_2 \), in the part from \( r_0 \) to be the radial stress changes more rapidly than it does in the part from \( a \) to \( r_0 \), and \( \theta_1 < \theta_2 \) it changes less rapidly. The stresses \( \sigma_z \) and \( \sigma_\theta \) and also the pressure \( P \) have discontinuities at the layer contact point \( (r = r_0) \). As the radius increases from \( a \) to \( b \), at the layer contact point the stresses grow in absolute value at \( \theta_1 > \theta_2 \) and fall at \( \theta_1 < \theta_2 \).

The porosity of the outer layer affects the external pressure \( \sigma_r \): With increasing \( \theta_2 \), the compression pressure falls. At constant \( \theta_2 \), an increase in \( \theta_1 \), too, brings about a fall in \( \sigma_r \).