Rolling of fibrous materials is a new fabrication process offering considerable promise for the manufacture of porous metal sheets and various metal sections. Below are presented the results of an experimental investigation of pressures and torques in the axial hot rolling of a fibrous material. The starting materials used in this work were smooth Kh18N10T steel* filter nets Nos. 24, 60, and 90 made in accordance with GOST 3187-65 standard. The choice of such a range of filter net numbers made it possible to study the effects of the number of sheets in the compact (n), reduction (εN) porosity (Π), and net spacing on the warp (S_a) upon the pressure and torque in axial hot rolling. The rolling temperature was 1150-1200°C.

The relative reduction of a porous net compact, with allowance for negative wire tolerances, was determined with the formula [1]

$$\varepsilon_N = \frac{k \cdot n \left( d_a + 2d_e \right) - h_r}{k \cdot n \left( d_a + 2d_e \right)} \cdot 100\%,$$

where k is a correction factor allowing for the true thickness of the starting net (k = 0.9-0.92), n the number of net layers in the compact, d_a the metal net warp diameter, d_e the metal net weft diameter, and h_r the thickness of the rolled material.

An experimental study was made, using a strain measurement technique described in [2], of the full pressure and rolling torque required for the complete or partial elimination of compact porosity. The mean contact pressure was calculated with the expression

$$P_m = \frac{P_\Sigma}{F},$$

where P_Σ is the pressure exerted by the metal on the rolls and F the horizontal projection of the area of contact between the metal and a roll. In the case of rolling of a net compact, the true area of contact between the porous material and the tool is the sum of all points of contact between the outer net layers and the rolls. In this work, the variation of the area of the contact points over the deformation zone was not considered. Contact area determinations were made in the same way as in the rolling of a bulk material.

Curves of contact pressure as a function of reduction and porosity, P_m vs εN and P_m vs Π, for specimens from smooth filter nets No. 60 at n = 4, 8, and 12 are shown in Fig. 1. The porosity of the material was determined with the expression

$$\Pi = \frac{\rho_b - \rho_p}{\rho_b} \cdot 100\%,$$

where ρ_b and ρ_p are the densities of the bulk and porous materials, respectively.

* A Ti-stabilized 18% Cr-10% Ni stainless steel. – Translator.


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Fig. 1. Variation of contact pressure with reduction and porosity for specimens from smooth filter nets No. 60: 1) \( p_m \) vs \( \varepsilon_N \) at \( n = 8 \) and 12; 2) \( p_m \) vs \( \varepsilon_N \) at \( n = 4 \); 3-5) \( p_m \) vs \( \varepsilon_N \) at \( n = 4, 8, \) and 12, respectively.

Fig. 2. Variation of contact pressure with reduction for specimens from smooth filter nets at \( n = 8 \): 1-3) \( p_m \) vs \( \varepsilon_N \) for nets Nos. 90, 60, and 24, respectively (\( s_a = 0.32, 0.56, \) and 0.8, respectively).

Fig. 3. Effects of relative reduction and number of net layers on radius coefficient of equivalent metal pressure on rolls in rolling of smooth filter nets No. 60: 1-3) \( \psi \) vs \( \varepsilon_N \) at \( n = 12, 8, \) and 4, respectively.

Fig. 4. Effects of deformation zone shape and number of net layers on radius coefficient of equivalent metal pressure on rolls in rolling of smooth filter nets No. 60: 1-3) \( \psi \) vs \( l/h_m \) at \( n = 4, 8, \) and 12, respectively.

The experimental relationships obtained show that, irrespective of the number of net layers, the contact pressure is negligible over the reduction range 0-35% and the porosity range 35-60%. This reduction range is characterized by elastic-plastic bending of the warp and weft wires and small plastic strains at the net joints, which means that the fibrous material undergoes plastic deformation accompanied by intense filling of the voids. The rise in contact pressure observed in the reduction range 35-60% and the porosity range 35-10% is attributable to increased plastic deformation of the weft and warp wires and a marked decrease in the porosity of the material brought about by rolling. The dependence of the mean pressure on the number of net layers is presumably due to differences in the character of internal friction between the individual net layers in the compact.

To determine the effect of net spacing on the warp upon the contact pressure, rolling experiments were carried out on eight-layer specimens assembled from smooth filter nets Nos. 24, 60, and 90. Experimentally constructed curves of contact pressure for the various net numbers are shown in Fig. 2. Metal nets Nos. 60 and 90, which have the same starting porosity but different spacings on the warp, are characterized by different intensities of contact pressure buildup. The reason for this is that each type of smooth filter net has a different length of deformation zone \([1]\). Decreasing the net spacing on the warp reduces the lengths of the structural and structural-plastic deformation zones.

From the theory of rolling of bulk metal, it is known that the rolling torque necessary for plastic deformation can be found with the formula

\[
M = 2\psi P x l,
\]