VK6M and VK20 alloys* were chosen for an investigation of the feasibility of producing clad hard-alloy blanks by the die extrusion technique. With rise in the amount of the ductile component, cobalt, in a hard alloy, the strength and toughness of the alloy increase, while its hardness and wear resistance decrease. Thus, VK6M alloy, which is extensively used for the manufacture of cutting tools, possesses high wear resistance and hardness, but low transverse rupture strength $\sigma_{tr}$ and impact strength $\alpha_k$ ($\sigma_{tr} = 130$ kg/mm$^2$, $\alpha_k = 0.2$ kg-m/cm$^2$). VK20 alloy can be successfully employed under impact load conditions, because it surpasses VK6M alloy in both transverse rupture strength ($\sigma_{tr} = 190$ kg/mm$^2$) and impact strength ($\alpha_k = 0.48$ kg-m/cm$^2$), but its wear resistance and hardness are much less.

By pressing a two-layer blank composed of an outer VK6M alloy layer and an inner VK20 layer, it should be possible to obtain a part combining the properties of both alloys. The part can be expected to have a "tough core," whose transverse rupture strength and impact strength are somewhat higher than those of VK6M alloy, while the hardness and wear resistance of the outer layer will be those of the latter alloy.

In the metalworking industry, many methods have been devised for the production of multilayer blanks from various alloys and metals [1, 2]. The process employed in this work consisted in extruding prepressed compacts from VK6M and VK20 hard-alloy mixtures through a die (Fig. 1). The mixtures were prepared for pressing as described in [3]. The VK6M mixture was pressed into rings of 8-10-mm height and 51-mm outside diameter; their inside diameter was chosen depending on the required starting blank parameters. The VK20 mixture was pressed into conventional compacts whose diameter was 0.5 mm smaller than the inside ring diameter, which enabled them to be inserted into the VK6M rings.

The dimensions of the starting compacts were determined from the desired diameters of cylindrical blanks and cladding layer thicknesses, starting from the assumption that the rate of flow of material is constant and that there is no nonuniformity of deformation during extrusion [4]. In such a case, the overall reduction, expressed as the ratio of the cross-sectional area of the compact to the cross-sectional area of the cylindrical blank, is equal to the reduction of each layer:

$$\frac{F}{f} = \frac{F_1}{f_1} = \frac{F_2}{f_2},$$

where $F$ and $f$ are the total cross-sectional areas of the compact and the cylindrical blank, $F_1$ and $f_1$ the cross-sectional

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*WC + 6 and 20% Co, respectively - Publisher.
Thus, with the assumption of constancy of material volume, it is possible to vary within fairly wide limits the ratio of layer thicknesses in the blank by changing the compact dimensions. Table 1 lists the dimensions of some starting compacts for different outside blank diameters and inner layer diameters.

Before the extrusion of blanks, compacts were preheated to 40 ± 3°C and then placed in the extrusion die set, which was also preheated, to the same temperature as the compacts. Blanks were extruded from compacts in a PG-100A hydraulic press at reductions of 98-99.4%.

Nonsteady-state material flow conditions give rise to a nonuniform distribution of layer thicknesses over the length of the resultant cylindrical blank. Subsequently, after the emergence of 150-200 mm of blank material, constant values of outlet velocity (60-80 mm/min) and pressure are attained, enabling uniform inner and outer layers of the desired thickness to be produced. Uniformity of layers in extruded blanks depends chiefly on the rheological characteristics of the mixtures employed. As has been reported in [3], such rheological constants of mixtures as plastic strength and plastic viscosity are mainly determined by their plasticizer content and preheating temperature.

Taking into account the specific surface and cobalt content of the VK6M and VK20 mixtures, the amounts of paraffin wax added to them were 11 and 8.5 wt.%, respectively, resulting in equal values of plastic strength and viscosity. Unless allowance is made for this factor in the extrusion of two mixtures having different rheological characteristics, the required thickness of the cladding layer is not obtained and the duration of nonsteady-state extrusion increases, which reduces the yield of sound blanks. In addition, lamination occurs as a result of nonuniformity of longitudinal deformation during extrusion, which also increases the amount of scrap.