FORMING ELLIPTICAL BOTTOMS WITH A VARIABLE CLAMPING FORCE

V. P. Luk'yanov, E. D. Gorokhov, L. V. Obrushnikov, and V. I. Tal'vinskii

In chemical and petroleum engineering much use is made of convex elliptical bottoms up to 4000 mm in diameter. In large scale and mass production the most promising method of producing them is forming on hydraulic presses. However, despite much production experience in forming, defects of the bottoms are often found (corrugations, bulging, localized thinning of the wall, fissures, etc.). This may be explained primarily by the fact that existing production operations are inadequate and the conditions of the forming operation are not the optimum.

In [1] it is shown that in forming thin walled elliptical bottoms with an insufficient force for clamping the flange portion of the blank the formation of folds occurs only at a definite value of the relative travel of the punch h/a (h is the value of the operating stroke of the punch and a is half of the internal diameter of the bottom), dependent primarily on the ratio D_b/S_0, where D_b and S_0 are the diameter and thickness of the original blank.

It has been experimentally established (Fig. 1) that in cold forming of comparatively thin walled elliptical bottoms (D_b/S_0 > 100) the folds appear on the portion of the blank free from contact with the die and only with further movement of the punch do they appear on the flange portion under the clamping ring. In forming less thin-walled bottoms (75 < D_b/S_0 < 100) folds appear on the flanged portion, and in forming

![Fig. 1](image1.png)

**Fig. 1.** Curves characterizing the moment of the start of formation of folds: 1) on the portion of the blank free from contact with the die; 2) on the flange portion of the blank.

![Fig. 2](image2.png)

**Fig. 2.** Change in the minimum necessary clamping force q providing the production of elliptical bottoms without corrugations and bulging in relation to the ratio h/a.

Translated from Khimichesko Neftyanoe Mashinostroenie, No. 4, pp. 28-29, April, 1976.
Fig. 3. Plan of the equipment for forming bottoms with a variable clamping force on a 2000 ton hydraulic press.

Fig. 4. Relationship of the minimum necessary clamping force $q$ to the ratio $D_b/S_0$ of the blank in forming bottoms in the hot condition.

bottoms with the ratio $D_b/S_0 < 75$ folds generally do not appear. In forming bottoms with the ratio $D_b/S_0 \approx 100$ folds are formed simultaneously on the portions of the blank free from contact with the die and in the flange with $h/a \approx 0.43$.

In subsequent forming the folds appearing on the portion free from contact with the die form bulges on the spherical surface of the bottom which are located, as a rule, in the zone close to the transition to the cylindrical portion of the bottom. In subsequent forming the folds formed in the flanged portion of the blank frequently form corrugations located in the cylindrical portion of the bottom.

With an increase in the clamping force the loss of rigidity of the blank (formation of folds) starts at a later moment in the drawing process, in other words, with greater values of $h/a$. As experiments have shown, the optimum clamping force preventing the formation of folds is a variable value and increases with an increase in the relative travel of the punch (Fig. 2).

The use of a clamping force which is variable during the forming of elliptical bottoms makes it possible under production conditions to not only prevent the formation of folds but also to substantially reduce thinning of the walls of the bottoms. As a result a project was developed in the All-Union Scientific-Research Institute of Chemical and Petroleum Apparatus in Volgograd to modernize the 2000 ton hydraulic press of Salavatsk Machine Construction Plant for forming bottoms from 2200 to 3600 mm in diam. The modernization of the press included the development of special equipment providing the creation of a variable clamping force by the use of automatic control systems (feeler mechanisms). The equipment (Fig. 3) consists of a regulating valve 1 controlled by the push rod and the actuating straight edge 2, which is fastened to the rod 3 which moves with the inner punch 4. For a significant reduction in the forces from the weight of the moveable portions of the clamping ring 5 (their weight is 140 tons) and the possibility of creating in this way the optimum clamping force for the bottoms being formed, the pump 7 and the safety valve 8 were added.

Before the start of the drawing operation the pump is turned on and the liquid, passing through the safety valve into the raising cylinders 6 of the clamping ring, create a specific pressure on it balancing the weight of the moveable portions. With lowering of the inner punch the actuating straight edge comes in contact with the push rod of the valve and automatically changes the liquid pressure in the hydraulic cylinders which, in turn, leads to a change in the clamping force on the flange portion of the blank. By changing the shape of the actuating straight edge it is possible to obtain practically any form of change in the clamping force.