

Benefits of Cold Plane Finishing

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Abstract—For cylindrical and annular workpieces, a method is proposed for increasing the precision obtained in cold deformation on the basis of plane finishing. Modeling results are presented. The stress–strain state of the workpiece in upsetting is determined.

Keywords: forging, plastic deformation, bulk stamping, precision, plane finishing, stress–strain state, simulation, QForm

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Characteristics of steel and alloys such as the impact strength, plasticity, and strength and hence the performance of the corresponding parts depend on the fibrous structure formed as a result of plastic deformation in stamping. As a rule, these properties are higher in the direction of the fibers. This is especially important for parts operating under large static and dynamic loads (levers, gears, shafts, axles, etc.). Therefore, in stamping, the fibrous structure must not be disrupted in subsequent cutting of the forgings. Finishing of forgings after hot bulk stamping may be used to that end, with accompanying decrease in the resources required.

Finishing not only retains the fibrous structure formed by bulk stamping but also ensures precise dimensions and shape of the forging. Options include bulk or plane finishing and hot or cold finishing [1]. Before finishing, scale and dirt are carefully removed from the forging. No defects deeper than 0.1–0.2 mm are permitted at the surface to be finished.

Cold finishing ensures tolerances from 0.1–0.25 mm for regular precision to 0.05–0.15 mm for high precision. Cutting of the finished surfaces is not permissible.

One factor preventing the wide use of plane finishing in manufacturing is the nonplanarity and increased roughness of the surfaces obtained.

To understand defect formation in finishing, we use QForm software for simulation of the stress–strain state and contact stress in the cold upsetting of cylindrical and annular workpieces with small strain.

In Fig. 1, we show the stress–strain state in the finishing of a cylindrical workpiece with a plane end, obtained after upsetting by 1 (a), 2 (b), and 3 mm (c). On account of the lower stress at the center of the stand and the greater elastic deformation at its periph-

ery, the end surfaces of the forging are somewhat distorted. Convexity of height up to 0.5 mm is seen.

To eliminate this defect, the use of two-part stamps was proposed for the finishing of the end surfaces of circular workpieces in [2]. The elastic modulus is different in the peripheral and central sections by a factor of 1.2–1.6. This range may be ensured if the central part is manufactured from tool steel whose macrostructure is perpendicular to the inset axis. Since the peripheral section is less pliable, the central convexity of the surface is considerably reduced, and there is no need for repeated finishing.

The surface quality may also be improved by creating a specific shape in stamping. For example, a complex surface was created in stamping in [3]. After cleaning, the forgings are subjected to plane finishing, in which the metal from the convex zone is displaced to the periphery. In other words, a plane end is formed, with the required radius at its junction with the lateral surface.

QForm simulation is also used to determine how the initial shape of the surface affects the finishing forces and the quality of the final forging. In Figs. 1–3, we show the distribution of the stress in cylindrical workpieces with plane, convex (radius $R = 1.5$ mm), and concave ($R = 1.5$ mm) end surfaces, respectively, after upsetting by 1 (a), 2 (b), and 3 mm (c). In 3-mm upsetting, the surface becomes plane in all the samples. In 2-mm upsetting, the sample with a concave central surface retains a depression, while a projection is formed in the zone adjacent to the end. In the case of samples with a complex end, the lateral contour is uniform, with little evidence of barrel shape.

The finishing force P (MN) is plotted against the tool displacement L (mm) in Fig. 4. In the initial stage, P is 25–30% greater for the sample with a plane