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Part Manufacturing "Secondary Shaft" by Cross-Wedge Rolling Method

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Abstract: In this research, the comparison of technological processes of forging manufacturing "Secondary shaft" on universal equipment and on a cross-wedge rolling mill is made. The advantages of the forgings manufacturing by the cross-wedge rolling method and the essence of the rolling process of the "Secondary shaft" are considered.

Key words: Secondary shaft, cross-wedge rolling, essence, forging, manufacturing, universal equipment

INTRODUCTION

In the production of shafts and axles in the conditions of mass and large-scale production, various methods of pressure metal process in gare currently used, since, they give the products increased mechanical properties, provide high productivity and efficient use of metal. A special method among them is Cross-Wedge Rolling (CWR) (Kozhevnikova, 2010). From other processes it is favorably distinguished by a high coefficient of metal use (0.8-0.98), possibility of complete automation of the process, the maximum approximation of the rolled part to the profile of the final product, wide technological possibilities, high tool stability, low noise level and lack of vibratory sources. Hot cross-wedge rolling, frome conomic point of view, significantly exceeds stamping on hammers, presses, forging machines.

Let's consider in more detail the advantages of the cross-wedge rolling method for example by comparing the process of part manufacturing "Secondary shaft" on the universal equipment and on the cross-wedge rolling mill.

The technological process of partmanufacturing "Secondary shaft" on the universal equipment is shown in Fig. 1.

For manufacturingthe "Secondary shaft", steel 20 CrNiMn is used which has the following composition: Fe 95%; Cu up to 0.3%; Cr 0.6-0.9%; P up to 0.025%; S up to 0.025%; Ni 2.75-3.15; Mn 0.3-0.6%; Si 0.17-0.37%; C 0.17-0.24%.

The cylindrical billet, heated in the inductor is firstly rolled on the roll forging in two junctions. This semifinished product is conveyed on a belt conveyor to a universal crank press where it is stamped firstly in a draft transition then in a finishing crane. After that, the forgings are conveyed on the transporter to the edging press where the excess metal is cut off and straighten. Despite a relatively simple and well known process for years, it has a number of significant disadvantages:

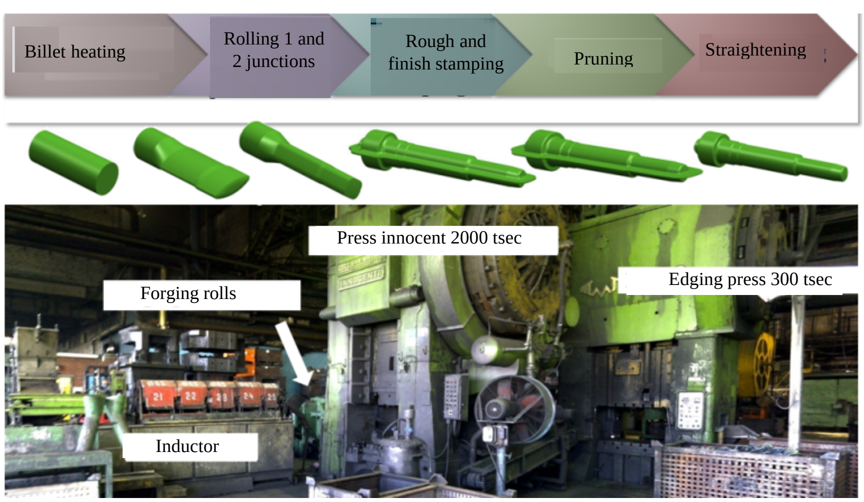

Fig. 1: Part manufacturing "Secondary shaft" on universal equipment

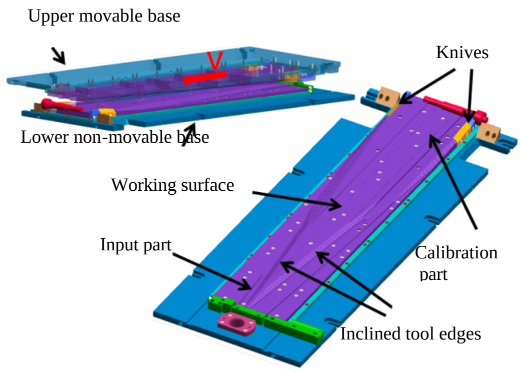

Fig. 2: Equipment for cross-wedging rolling

- With open stamping on a universal press, a part of the metal is consumed on a burr
- Large allowances and machining allowances are assigned to the forgings
- The full cycle of stamping requires manufacturing 4 types of rigging for different equipment as well as its adjustment and if required, repair
- High probability of a defect due to a large number of processing

Cross-wedge rolling is performed in an instrument, having inclined edges, located at an angle to the plane of rotation (Titov and Kokorin, 2013) (Fig. 2). In the rolling process, these edges cause the excess metal to move, arising when the tool is inserted into the billet, i.e., promote the redistribution of metal along the axis of the billet.

MATERIALS AND METHODS

Part manufacturing "Secondary shaft" on the rolling mill is carried out as follows in Fig. 3: the billet is fed into the working area and is located across the tool input parts. The upper tool is given translational motion and the input parts of both instruments are inserted into the billet from opposite sides, cause it to rotate and form an circumferential groove. After that, the circumferential groove is expanded by rolling the metal with the inclined faces of the tool and excess metal volumes are moved axially, profiling and elongation of the billet. At the final stage, the profile is calibrated and the excess metal is trimmed.

The main parameters of cross-wedge rolling are the reduction rate and the geometric parameters of the tool. The degree of reduction is determined in accordance with the following expression:

$$\delta = \frac{D}{d} \tag{1}$$

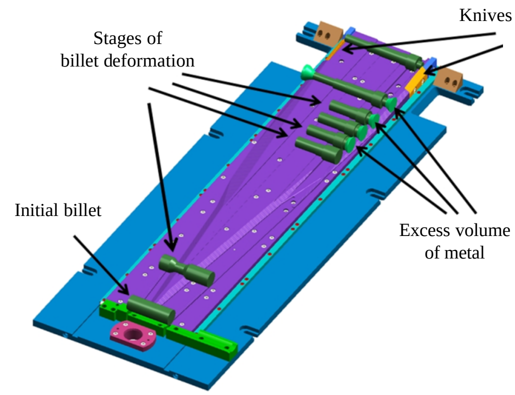

Fig. 3: Process of part manufacturing

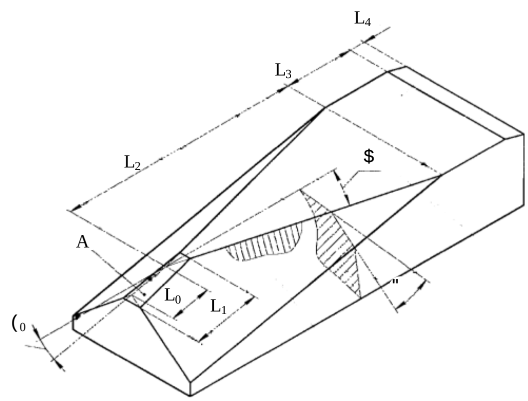

Fig. 4: Wedge inputing area

Where:
D = Initial diameter of the billet
d = Diameter of rolled rod

The length of the input area of the double-sided wedge (Fig. 4) is determined in accordance with following expression (Klushin and Rudovich, 2010):

$$L_1 = \frac{D-d+2\Delta}{2tg\alpha \cdot tg\beta} \tag{2}$$

where, Δ is depth of penetration the input area into the billet, mm. The angle of raisingtheinput area and the width of the contacting area are determined in accordance with the following expressions:

$$tg\gamma_0 = tg\alpha \cdot tg\beta \tag{3}$$

$$S = \frac{2\Delta}{tg\alpha} \tag{4}$$

The length of the deforming area is determined by the following expression:

$$L_2 = \frac{l}{tg\beta} \quad (5)$$

where, l is length of the rolled billet. The length of the calibration part is given by:

$$L_3 = (1 \div 2)\pi r_k D \quad (6)$$

where, r_k = 0.438+0.0016 β-0.08. (δ-1) rolling radius.

RESULTS AND DISCUSSION

To calculate the technological process of hot cross-wedge rolling, there is a dependence of the limiting reduction of the billet on the tool parameters, shown in Fig. 5. The region to the left of the curve characterizes a stable process. It is recommended to take the following values of the angles α: when δ≤1,6 α = 30-40° when δ≤1, 6-1.8 α = 25-30° whenδ≤1,8-2,0 α = 20-25^0. when α<20° there is a danger of formation in the billet of axial cavities and when α>40° Spiral scallops are formed on the surface of the product.

The technological process of part manufacturing "Secondary shaft" in the rolling mill is shown in Fig. 6. The cylindrical billet through the mechanism of the loading device enters the inductor where it is heated to 1200°C. Then it is fed into the working zone of the mill where it is deformed, calibrated and cut off. Ready forgings and waste are in different containers. The resulting forging has a higher accuracy, compared with the forgings obtained on a universal press (Rudovich and Klushin, 2005).

Figure 7 shows the micro structure of a the original, b profiled and c finished forging, of the details of "Secondary shaft". When rolling in profiled workpiece (Fig. 7b), ferrite bands and microcracks with a length of 20-30 μm are observed which are crushed by further rolling. In the finished forging (Fig. 7c), microcracks are not detected. The microstructure of the finished forging has a ferrite grain size of 5-6 μm (Rudskoy and Lunev, 2008).

To remove the residual internal stresses after the rolling process as well as to create a full structure of the alloy and to increase the hardness, the detail is subjected to heat processing (tempering, quenching, carburizing). The tensile strength of the finished part is 1410 MPa in stretching and 2100 MPa in compression.

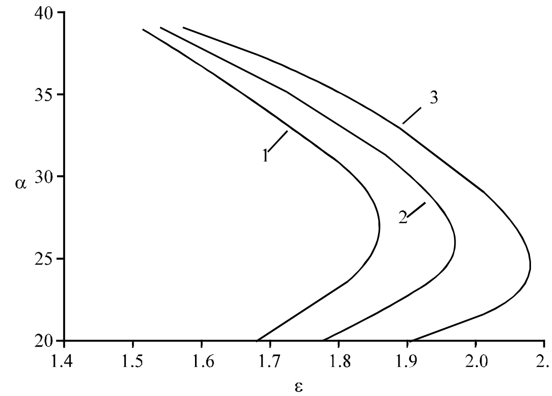

Fig. 5: Dependence of the maximum reduction of the billet on the tool parameters: 1 when β = 5°; 2 when β = 7° 30'; 3 when β = 10°

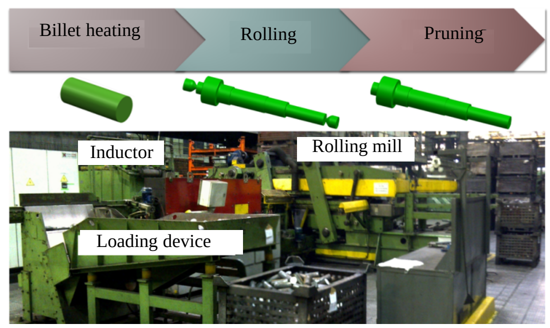

Fig. 6: Part manufacturing "Secondary shaft" in the rolling mill

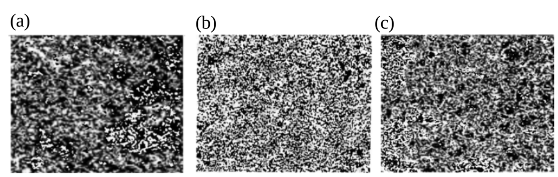

Fig. 7: The microstructure of: a) The original; b) Profiled and c) Finished forging

CONCLUSION

Using the method of cross-wedge rolling in part manufacturing "Secondary shaft" in comparison with forging on universal equipment has the following advantages: the reducing of the technological operations number increases the stability of the process and the quality of the finished parts: there are no microcracks in the finished part, the microstructure of the finished forging has a size of 5-6 μ in ferrite grains, after heat treatment the tensile strength of the finished detail is 1410 MPa in stretching and 2100 MPa in compression.

The number of technological equipment is reduced as a result of which the use of the production area is reduced by 16% and the number of required tools by 75% which reduces the laboriousness of the manufacturing process of both the tooling and the part itself. The material using factor is increased which allows to reduce the rate of metal consumption.

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