OPTIMIZATION OF THE TECHNOLOGICAL PROCESS OF PRODUCTION OF A HOUSING PART BASED ON THE USE OF CNC MACHINES

Butovsky Petr Mikhailovich,
t.f.f.d., Associate Professor Tashkent Institute of Textile and Light Industry

Narmatov Elmurod Avazovich,
t.f.f.d., Associate Professor Tashkent Institute of Textile and Light Industry

Saifullaeva Kamola Fakhrddin kizi
Student, Tashkent Institute of Textile and Light Industry

Muminova Iroda Sobir kizi
Student

Abstract
The article is devoted to the development of a rational technological process for manufacturing the housing of a hydraulic distributor using CNC (computer numerical control) machines. The main objectives of the study are to reduce the manufacturing cost of the part and increase labor productivity.

Keywords: Technological process, hydraulic booster housing, technological route, mechanical processing of parts, technological cost.

Introduction

Mechanical engineering is a key industry. Today, it is extremely important to ensure high quality of mechanisms for their competitiveness, which requires careful design and technological preparation of production at the design stage.

Due to the growth of production rates and the transition to the release of new products, there is a need to reduce the time it takes to bring products to market and ensure high product quality at all stages of the life cycle. When designing and manufacturing molds, the possibility of errors is not completely excluded.

To a certain extent, the number of errors in design can be reduced by using libraries of previously created products, although finding solutions also takes time. Currently, mold design is a long and labor-intensive process that is being automated in order to reduce the number of errors and design time, as well as improve the quality of molds and, as a result, the products themselves.

In this regard, there is a need to develop scientifically based recommendations for optimizing individual stages of design and technological preparation for the production of products based on modeling information flows and the use of CAD/CAM systems. This paper presents recommendations for optimizing individual stages of design and technological preparation for the production of products. The purpose of introducing new information technologies is to increase the efficiency of production preparation processes and timely provision of data to the production planning system in reducing the time for project development and improving the quality of manufactured products.

The most important achievement of scientific and technological progress is the comprehensive automation of industrial production. [1]. In connection with the creation and use of flexible production complexes for mechanical cutting, machines with numerical control (CNC) acquire special significance. (Fig. 1.)

Fig.1.Machine tools with numerical control

The precision of machining on CNC machines is ensured by the high precision of the machines themselves. Complete machining of parts on such machines requires fewer setups, which allows for a reduction in the time for setup and reinstallation of the part by an average of 30% and a reduction in the cost of inter-machine transportation. [2].

CNC machining provides a significant increase in productivity - up to 20-30%. One of the key elements of such machines is the hydraulic distributor, which controls the start, change of direction and stop of the flow of working fluid in various systems of mechanisms, including the supply of lubricating and cooling agents and the distribution of lubricant between the mating parts.

The hydraulic distributor housing is a part of a simple geometric shape, but has many channels for the passage of liquid, which are deep holes of small diameter. This creates certain difficulties in their processing.

Improving the efficiency of production of the hydraulic distributor housing is the key objective of this study. The main goal is to reduce the cost of manufacturing this part and at the same time increase productivity, as well as improve the reliability of the technological process. To achieve this goal, the following tasks were set: reducing costs for the original workpiece, developing a rational technological process for mechanical processing of the housing, designing the necessary tooling. [3,4].

Currently, hydraulic distributor housings are made of deformable aluminum alloy AMg61 (1561), the blank is a rolled rectangular section. This type of blank provides a low material utilization factor - only 0.423. The author proposed to use a forged forging with a blind hole as a blank, which will increase the KIM to 0.81. Also, this type of blank will reduce the labor intensity of further mechanical processing.

The developed technological route assumes the use of a CNC machining center of the FS65MF3 type. Machining of body parts on such machines has a number of significant advantages:

- Increased productivity by reducing auxiliary and machine time;
- Elimination of preliminary manual marking work;
- High precision processing without the use of jigs, which simplifies and reduces the cost of tooling and reduces the time required for production preparation;
- Possibility of complex processing in one or several setups, which reduces the time of setup and reinstallation of the part, as well as inter-machine transportation.

The developed technological route includes stages of preparatory, mechanical and thermal processing. In this case, the stage of mechanical processing is divided into preliminary and final stages. When designing technological operations, the capabilities of the selected equipment - the IR-500 machine - were taken into account. To ensure the necessary accuracy, clamping force and limitation of the degrees of freedom of the part during processing on this machine, a special device was developed.

According to the designed technological process, the part is processed in several stages. First, processing is performed on universal equipment in order to prepare technological bases. Then the part is processed on a CNC machine. And finally, finishing processing is performed on universal machines to achieve all the requirements of the drawing.

When designing a machining route on CNC machines, the classic principle of dividing mechanical processing into roughing, finishing and finishing stages is followed. However, it is worth noting that the capabilities of modern CNC machines allow for combining roughing and finishing while maintaining high accuracy. [5].

A typical approach to basing box-shaped and case-shaped workpieces on CNC machines of the "machining center" type is installation by plane and two mounting holes. In this case, one hole of the workpiece is installed on a cylindrical pin, and the second on a rhombic pin, depriving the part of six degrees of freedom. [6].

This method of basing is easy to implement. In this case, the basing surfaces (planes and holes) must be processed with high accuracy of dimensions and location, not lower than 7 quality. In addition to basing, we must also take into account the accuracy of positioning of the CNC machine. [7,8].

Now let's look at how it affects the accuracy of hole machining with permissible positioning errors when machining holes on CNC machines. To calculate the permissible positioning error of the tool, we will take:

$$\Delta pos \leq \Delta T / 3 \qquad (1)$$

Where: Δpos - permissible error of tool positioning

ΔT - tolerance on the size of the processed hole

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This ratio is based on the fact that the positioning error must be 3 times smaller than the hole size tolerance to ensure the required accuracy.
To assess the influence of the number of holes processed on the total positioning error:

$$\sum \Delta поз = \sqrt{\Delta поз1^2 + \Delta поз2^2 + \ldots + \Delta позn^2}/n \quad (2)$$

Where: Δpos.∑ - total positioning error
Δpos1, Δpos2, ..., Δposn - positioning errors for each hole
n - number of holes to be machined
This formula shows that with an increase in the number of holes, the total positioning error increases according to the root dependence.
We will take the following calculation for the required accuracy of machine movement along the axes:

$$\Delta st \le \Delta pos / k \quad (3)$$

Where: Δst - the required accuracy of the machine along the axes of movement
Δpos - permissible positioning error
k - safety factor (usually 0.6-0.8)
The last formula sets the requirements for the machine's accuracy based on the permissible error in tool positioning.
Thus, the presented formulas allow us to theoretically estimate the influence of the permissible positioning error, the number of processed holes and the required machine accuracy when designing technological processes for processing parts on CNC machines. But at the same time, when developing a technological route, we must take into account such a sequence so that the error from each processing does not overlap with the accuracy.
The technological route also includes heat treatment. After roughing, annealing is performed to relieve internal stresses. Before finishing and finishing stages, stabilizing aging is performed to prevent warping of the part. For workpieces made of light alloys, aging is natural [9].
The processing of the body of this part includes the following stages:
1. Preparatory stage.
2. Rough mechanical processing (formation of overall planes, main and basic holes for further processing on a CNC machine).
3. Heat treatment (annealing).
4. Finishing mechanical processing (bringing all surfaces to specified parameters).
5. Application of galvanic coating (anodic oxidation in chromic acid).
The developed machining route includes the following operations:

1. Milling of planes.
2. Drilling and boring of technological bases.
3. Processing the part on a machining center.
4. Manual thread cutting.

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5. Hydraulic testing.
6. Metalworking operations (removing burrs, blunting edges).
7. Control operations using special measuring equipment.

Conclusion

A rational technological process was designed, including the development of a special installation and clamping device, which made it possible to eliminate marking operations and increase the reliability of production. The transition from rolled to forged forgings as the initial blank increased the material utilization factor from 0.4 to 0.8, which saved up to 6 kg of material per part and reduced manufacturing costs. Reducing allowances also reduced the volume of mechanical processing, labor intensity, energy costs and wage costs. Economic analysis showed that the annual economic effect from the implementation of the proposed technology could be 135%.

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