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ADAPTATION OF LIQUID ROCKET ENGINE SHELL MANUFACTURING TECHNOLOGY TO MODERN CAPABILITIES OF CAD-CAM SYSTEMS AND 5-AXIS COORDINATE CNC MACHINES

In my study I have described and substantiated:

1. The planing process using a special cutting tool on a 5-coordinate CNC machine for machining spiral surfaces of liquid engines shells has been proposed for the first time.

2. The principles of programming 5-axis CNC machines [1] for planing using modern CAM-systems [2] have been developed for the first time.

3. A mathematical model of increasing the accuracy of the control program on a CNC machine for processing the spiral surfaces of the shells of liquid rocket engines [3] has been obtained for the first time.

4. CAM-modelling of the cutting process to obtain the results of machining accuracy has been carried out.

The practical significance of the results described in the article:

1. Methods of programming 5-axis CNC machines for processing spiral surfaces of shells of liquid rocket engines by milling and planing methods were created and introduced into production.

2. Planing technology using a 5-axis CNC machine and a special cutting tool was introduced.

3. A system for measuring and analysing the shells of liquid jet engines has been introduced into production.

4. A system for correction of the control program of a CNC machine tool has been created and implemented to increase the accuracy of processing the spiral surfaces of the shells of liquid rocket engines.

Theoretical and practical achievements of the work were implemented at the following enterprises: State Enterprise “Production Association Yuzhny Machine-Building plant named after A.M. Makarov” (YUZHMASH), State Enterprise “Yuzhnoye State Design Office named after M.K. Yangel” (YUZHNOYE SDO).

The main body analyses the problems of manufacturing shells of liquid rocket engines in modern production, methods of their manufacture and control, substantiation and adaptation of the method of modelling the planing process for processing spiral surfaces of shells of liquid rocket engines. The method of programming 5-coordinate CNC machines for the planing process is described. The technique of control of accuracy at modelling of process of planing is offered.

Technologically, the classical manufacturing of a liquid rocket engine body can be divided into two stages. The first stage is external and internal turning of the nozzle geometry. The second stage is the milling of spiral surfaces (the so-called fins – the cooling channels of the shell).

One of the technological features of the second stage of production is the introduction of a special tool instead of a milling cutter.

In this case, the cutting process is more like turning or even planing than milling although all 5 coordinates of the CNC machine are used simultaneously. To program such a process, you also need to perform special actions.

The main problem with modelling the planing process in modern CAM systems is the lack of a planing operation as such. Therefore, it was decided to obtain a planing simulation process by adapting the existing 5-axis milling operation.

First, we need to justify the choice of the cutting method. For a typical case, this process requires calculating the economic component – that is, which cutting method will make our shell the cheapest without losing quality. But in this paper, we will consider the methodology for switching to multi-axis planing because it is not a standard method in modern production.

In a CAM system, the planing operation is calculated as a 5-axis milling operation, but the following features should be taken into account: planing tool geometry, workpiece and tool materials, tool control point, and kinematic capabilities of the CNC machine.

The adaptation of machine and postprocessor parameters in NX must be performed according to the machine data sheet, indicating the machine's limitations and all kinematic features and taking them into account. This will help to avoid additional errors and mistakes when developing the control on a CNC machine. One of the most important points here is to disable the machine's locking during the working movement (cutting process) without tool rotation, in our case, the planing tool. This requires an additional M-command in the postprocessor and in the machine logic.

Optimizing the control and verifying the result are perhaps some of the most important steps. Without optimization of the control using the planing process, a lot of rejects can be produced in the manufacture of the radial pressure vessel shell. This is due to the influence of the accuracy of modelling the shell itself on the accuracy of the control by the working bodies of the CNC machine when manufacturing fins (of rather complex geometry) by planing.

The result of an unoptimized control can be a deformation of the geometry of the fins or the wall of the shell itself.

The mathematical model of increase of accuracy of processing of spiral surfaces of covers of liquid rocket engines is developed, experimental researches on field samples with use of mathematical model are considered, methods of modelling and programming of the planing process for processing spiral surfaces of liquid rocket engines covers have been developed. The results of using the above-mentioned methods in production have been considered.

In the general conclusions recommendations of practical use of the developed methods and results are offered and results of theoretical and experimental researches are summarized.

References:

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