ADVANCED METHODS FOR USE OF NUMERICAL CONTROL COMPUTER AIDED FOR OPTIMIZATION OF BEARING RINGS SURFACE PROCESSING

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Abstract - In the bearing industry precision of bearings ring manufacturing is a determining factor in the quality of the finished product. From this point of view, integration of processing machines with CNC numerical command was a necessity and brought important contributions in optimizing the manufacturing of the bearing rings.

This paper describes in detail the stages of design and manufacturing of bearing rings on a CNC machine tool. In the stages of design CAD and production CAM on numerical controlled lathes are presented and analyzed the process parameters that may influence product quality. Manufacturing of the bearing rings on CNC machine tools is justified by the performance and flexibility criteria, that lead to increasing of productivity in the conditions of assurance high level standards of accuracy.

Keywords: CAD/CAM, CNC Lathe Machining, bearing rings.

1. Introduction

Because bearings are used in a wide range of applications, they must have a number of specific properties for each area of use, such as: to provide good sealing, to operate properly at high temperatures, to provide a accurate rotation movement, to be silent, to have increased durability in condition of lowest dimensions, to operate at high and very high speeds etc.

Technological evolution and especially manufacturing technologies evolution is a key factor in meeting the requirements of quality and precision rolling surfaces. However, this technological evolution involves at the same time increasing the demands related to accuracy and reliability of the bearing mechanisms, aiming to obtain bearings with reduced size, having a longer lifetime and which operate at very high speeds and high temperatures.

In general, small bearings rings are made of pipe or bar by turning to obtain a product in raw form.

After turning, the bearing rings are heat treated by oil quenching process at 820°C, followed by cooling and high reheating, achieving a hardness value in the range of 58-65HRC.

To obtain the accuracy required to ensure the operation of the bearings within the parameters, active surface of the bearing rings finishing is done by grinding.

For small bearings with inner diameter up to 25 mm, processing through removal of material by turning is considered the most economical meeting requirements of all imposed technological standards [1].

Bearings industry is in continuous evolution and specific particularities of this industry, respectively manufacturing a variety of products in large series, in compliance with strict accuracy standards and as low as possible execution times, has imposed integrating the computerized numerically controlled machine tools (CNC) in the production chain.

Now, as for any other technological product, conditions relating to functional, reliability and costs imposed standards of bearings have increased, requiring manufacturing process optimization through the implementation of new technologies. Continuous evolution of the CNC machines and related processes, led in greater flexibility for rapid adaptation to the specific conditions of production without great effort, besides increasing productivity in bearing industry with compliance with quality standards.

2. Manufacturing of Bearing Rings by Turning

Integrated CAD/CAM systems have been developed and imposed in the past years achieving and combining the two adjacent and at the same time complementary components:
- constructive design component (the proper design) - CAD (Computer Aided Design);
- technological design (manufacturing) - CAM (Computer Aided Manufacturing).

To realise a virtual prototype, CAD module generates models (graphical representations of the
object to be processed) and knowledge (information relating to the manufacturing process necessary for CAM module).

To draw a 2D profile of bearing ring, we use the Sketcher application of Mechanical Design module, from the Start menu. This module enables creating, editing the elements of a sketches and applying constraints between their components. With the help of its tools are quick obtained profiles used as supports for 3D bodies, model analysis, highlighting that is one symmetrically part, represented in Figure 1-a.

Drawing can be done using the options from Geometry toolbar, using the Sketcher tool, all elements can be constrained to each other through the dimensional or geometric constraints. Shaft option (Figure 1-b) allows to generate solid bodies of revolution by rotating a 2D profile around an axis created in the same sketch. [2] [3] [4] [5] [6].

To define and organize numerical control programs dedicated for processing the parts whose geometry is represented by 3D models, we need CAM module that uses the manufacturing techniques of machine tools, using 2 up to 5 axes, having a post processor engine that allows covering the entire manufacturing process, from generating tool path to the NC program.

For the design of manufacturing process of bearing ring whose modelling was realised previously, was chosen turning processing module with the Lathe Machining NC Manufacturing application, from Start menu, Figure 2.

![Figure 1. 3D module – Bearing ring: a - Sketch tool; b – Shaft tool](image1)

![Figure 2. Lathe Machining application](image2)
Using the **Part Operation.1** option, from browser, opens the window **Part Operation**. Choosing the icon **Machine** will be displayed the dialog window **Machine Editor**, figure 3.

Then will be selected **Horizontal Lathe Machine** icon, corresponding to a normal lathe.

Then is checked the correct setting of the machine tools axles, namely cutting movement Z axis and the radial axis X. In Spindle tab, the user specify a point for tool changing, considering the length of the tool and tool holder, part thickness, dimensions and shape of the semi-finished clamping device.

![Figure 3. Machine Editor](image)

Returning to the previous window, **Part Operation**. (Figure 4a), workpiece is selected by clicking **Product or Part** and by clicking **Reference machining axis system** is chosen a system of orthogonal axes belonging to workpiece. The correct orientation of the system is leading to changing the color of the symbols (axes, plans, origin) in green (Figure 4b).

![Figure 4. a - Part Operation ; 4b - Choosing the coordinate axes system of the machine tools](image)

First operation will be a longitudinal turning for roughing. Selecting **Roughing** icon determine adding in the program the **Roughing.1** entity, with the default attached tool. In **Roughing.1** window, the label **Geometry** is default and displays a central icon, used to specify successive semi-finished profile, respectively, piece profile.

For this purpose, **click** on the frontal surfaces, colored in red, of the semi-finished (**Stock area**), respectively of the part (**Part area**), are selected the semi-finished profile (**Stock Element**) and piece profile (**Part Element**). After each selection **click OK** from **Edge Wizard** toolbar.
Then is selected the icon **Strategy** and are setting the working parameters. The operation will be done by clicking the **OK** button from this window. To simulate the tool path for this operation, is used the command **Replay Tool Path**. In the dialog window associated to this command is selected the continuous simulation mode, the tool is positioned in the starting point and starts the simulation process. The tool will move along the calculated path. In the same window are displayed the advance values, basic time and total processing time.

At the end of manufacturing technological process is providing a finishing turning operation (Figure 6). For this purpose, is used the **Finishing profiles** command. In label **Geometry**, click the frontal face of the part icon, colored in red, and on the part model is selected the final profile **Part**. After selection click **OK**.

To view the path of the cutting tool at finishing turning operation (Figure 7), is used the command **Replay Tool Path**. After enabling **Continuous replay mode** icon, the simulation process ca be seen by successively selecting the appropriate buttons.

**Lathe Machining** application allows insertion of other types of operations, using the commands from menu **Insert**, **Lathe Operations** group or the corresponding icons from the toolbar.
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The work session ends by generating an APT source file, to be post-processed for obtaining the control program of NC lathe. In the first phase, the initial setup regarding the type of the lathe and its axis system is verified by doubleclick on the Part Operation icon from the tree structure and finally by opening the Machine Editor window. After this preliminary check, with right-click on the entity Manufacturing Program.1, the context menu is called and successively Manufacturing Program and Generate NC Code can be chosen [7].

3. The Bearing Ring on CNC Lathe Machining

The bearings are generally manufactured in series with various forms and sizes. For each bearings serie, the geometry of processed rings has particularly shape, thickness, angles, radius, etc. These parameters affect the cutting characteristics as the direction of the chip, the size of the cutting forces or the quality of the machined surface.

In addition, the power, rotational speed and depth of cut have an important effect on the cutting process, influencing tool wear, temperature of the piece, the cutting size forces and deformations at the tool-piece contact. The workpiece clamping force is another parameter that may cause deformation of the workpiece. All these elements can introduce errors in the manufacturing process. Taking into account the characteristics of the processed material, cutting tools must have some certain properties: high hardness, a good thermal conductivity, high wear resistance and physical, chemical and thermal stability[8].

The constant improvement of CNC machining centers performances, continuous development of new cutting tools product and also the CAD/CAM software development have increased lately the accuracy of the parts (size, geometry and surface roughness, etc.). Researches in the field of metal cutting processing relate to the three basic elements: the piece quality, cutting tools and CNC machine., Figure 9.
4. Conclusions

Since the industrial market require complex parts with a high level of precision, development of new processing strategies along with new types of cutting tools to facilitate the manufacturing process is necessary.

In order to satisfy these requirements, the CNC machines experienced a progressive evolution in time based on:

- Increased productivity and flexibility achieved by eliminating downtimes like cutting tools load time (development of machine with tools box) and setting time;
- Development of supervision and safety systems;
- Increased dynamic performance (better rigidity, high cutting speed, fast movements with higher precision);
- Multi-axis machines used for development of complex parts.

Currently, due to technological evolution, bearings must operate at high speeds and temperatures imposing the use of materials with superior mechanical properties. Besides these aspects, accuracy standards are increasingly restrictive, imposing major changes of execution process.

The integration of CNC machine in the process of execution of the bearings rings is justified by performance and flexibility characteristics, all the requirements of the processing technology being satisfied.

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