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Processing of a Part Such as a Composite Bearing Housing on a Milling Machine With a Digital Control Program

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Abstract. In the era of the industrial revolution of ndustry 4.0, the Republic of Kazakhstan is rapidly introducing automated robots and digital control programs in many of its production facilities. In this context, special attention is paid to modern technologies, and AKIRA SEIKI milling machines with FANUC control software stand out as advanced technologies in this process. They are becoming the most popular in the CIS countries due to the economic efficiency and intellectual support of the Taiwanese manufacturer.

Practical aspects of constructing CNC milling machines and their practical use are presented in this article. Particular attention is paid to the functionality of milling machines using the example of processing such a part as a composite bearing housing. In addition, the process of writing processing operation codes in the CIMKO computer program is described. The code is provided with brief descriptions to help you understand the compiled workpiece processing operations.

With the growing need for efficiency and precision in production, many companies and industrial plants in the Republic of Kazakhstan are considering AKIRA SEIKI milling machines with FANUC control software as a major investment. These machines not only provide high productivity, but also help automate complex technological processes. CIMKO, among other things, allows the development and optimization of machining code, which complements the efficiency and accuracy of the machines.

Keywords: CNC, CIMKO, dump truck, bearing, CAM system, industry 4.0, milling, processing tools.

Introduction

Enhancing the productivity of machine-based manufacturing can be accomplished by employing cutting-edge machinery and tools capable of implementing resource-efficient technologies on a large scale. These approaches are particularly pertinent in the manufacturing of intricate components [1].

In recent decades, the new stage of the industrial revolution - Industry 4.0 - has been paying close attention to new technologies and production automation, and great changes are taking place in the world. This concept involves the integration of advanced technologies such as the Internet, artificial intelligence, automation and cloud computing into production and economic processes. Since the Republic of Kazakhstan is a country striving for modern development, it is among the countries that pay deep attention to the implementation of the principles of Industry 4.0 in various areas of their economy [2].

One of the main areas where Kazakhstan seeks to implement the concept of Industry 4.0 is the manufacturing industry. Modern automation and robotics technologies can significantly increase the efficiency of production processes, reduce labor costs and improve product quality. An example is the automotive industry, where automated assembly lines and robots speed up production and reduce the likelihood of errors.

Industry 4.0 - a new stage of industrial and economic development - is based on the introduction of advanced technologies into production processes. Among the main components of this concept are CNC machines. These advanced devices, which enable automation and flexibility in production, play an important role in the successful implementation of Industry 4.0.

CNC machines are a combination of mechanical systems and electronics that allow high-precision programming and control of material processing. The use of CNC machines is becoming a key factor in achieving the goals of Industry 4.0:

- flexibility and automation of production;
- productivity increase;
- monitoring and data collection;
- integration with other technologies;
- training and development of personnel;
- economic impact.

Goal of the work **-** implement processing of a part such as a composite bearing housing using a CNC system. The processing will be carried out on a Taiwanese Akira Seiki Oi-MF milling machine equipped with a Japanese numerical control program (FANUC).

1. Methodology

The Akira Seiki Oi-MF is a high-tech CNC router that comes with many impressive features and capabilities. This machine (Figure 1) is a perfect combination of mechanical design, electronics and software to ensure high productivity and quality processing.

Fig. 1. - Assembling an Akira Seiki machine with Fanuc control software

One of the main features of the Akira Seiki Oi-MF is its precise mechanical system. Modern components and advanced technologies ensure high stability and precision of machine movement. This is especially important when performing complex machining operations that require minimal deviation from specified parameters. The base of the machine (Fig. 1) is placed on the bed as shown, the first of which is to install the bed on a 40 cm concrete field, the side of which is limited by vibration, and after installing the bed, its mechanisms are cleaned with kerosene from solid oils that have been smeared by the manufacturer in to protect the frame from rust during transportation of the machine. The machine column is installed on a completely cleaned bed (Fig. 1). The column tray is secured to the frame with a torque wrench, maintaining a known torque using M24 screws. After securing the column to the frame, a turret is installed in the secured column (Fig. 1). The turret is designed for 28 tools and has tool mounting points. After installing the turret, the hydraulic and pneumatic hoses of the machine are tightened and the machine frame is assembled, as shown in Fig. 1, c. The spacer between the frames is sealed with sealant to prevent cooling water from spilling outside the machine, and then fixed with screws. When assembling the machine frame, an electrical cabinet is also installed. When all the elements shown in the diagram are installed, the last thing to install is the machine door and the conveyor carrying the coolant and processed material (chips), as well as the coolant tank [3] and [4].

Computer numerical control (CNC) machines are central to the modern manufacturing world. One of the most widespread and innovative manufacturers of such machines is Fanuc. Fanuc machine programming is based on the use of G-codes and M-codes, which allows precise control of geometric operations and auxiliary functions of the machine. G-codes, or geometric codes, are commands that tell a machine how to move and perform operations in three-dimensional space. These codes define various actions such as moving the X, Y, and Z axes, setting the feedrate, and rapid traverse. For example, the G00 command means rapid motion, which allows the tool to move quickly between points without cutting the material. The G01 and G02 codes define linear and rotary motions respectively, allowing the machine to perform various types of machining. M codes, or auxiliary function codes, control various aspects of machine operation, including spindle rotation, cooling, lubrication, and other auxiliary operations. For example, command M03 rotates the spindle to the right, and M08 turns on the cooling system. These codes allow programmers to precisely control the operating conditions of the machine according to the requirements of the material being processed.

Programming a Fanuc machine begins by creating a program text file containing a sequence of G-codes and M-codes. The programmer determines tool movements, feed rates, tool types, and other parameters required to complete the machining task. This file is then downloaded to the device's digital controller [5] and [6].

It is important to understand that programming Fanuc machines requires precision and attention to detail. A small error in the code can cause the tool to move incorrectly or even cause damage to the machine and workpiece. Therefore, programmers must have a deep understanding of G-codes and M-codes, as well as the specifications of the specific Fanuc machine they are working on.

Fig. 2. - The main Fanuc unit for controlling the Akira Seiki milling machine

When processing any product, a processing program is written for it. CAM (computer-aided manufacturing) software systems such as MasterCAM, SolidCAM, PowerMILL are used in mechanical engineering to write machining programs. CAM programming is the process of creating machining programs that optimize manufacturing operations on CNC machines. This eliminates the need to manually enter each G-code and M-code, reducing the likelihood of errors and simplifying the programming process. Instead, the programmer works with a CAD model of the part and creates a CAM program that automatically generates the G-codes and M-codes needed for machining.

Advantages of CAM programming in mechanical engineering:

CAM programs allow you to achieve high precision machining of parts. Once a program is created, it can be reused on the same parts, ensuring product consistency.

CAM software can optimize workflows and select the best tools and feed rates to speed up production processes.

Transferring complex calculations and code generation to the CAM system reduces the likelihood of errors associated with manual code entry.

If there are changes to the part design, the CAM program can be easily adapted without having to rewrite all the code by hand.

CAM programming programs for CNC machining are of great importance to modern industry. They increase accuracy, repeatability, optimize production and reduce the risk of errors. Despite the challenges, CAM programming remains a key factor in manufacturing improvement and product quality.

2. Results and discussion

The above sketch shows the processing coordinates, including the dimensions of the workpiece. Processing coordinates simplify the compilation of program code, which is written during the processing of the product. The drawing was made in the AutoCAD program, the code for the machine will be written in the CIMKO program, and the initial simulation is written in the same program. The point (X0;Y0) shown in the drawing is the starting point of the product on this machine. That is, the program is written in accordance with these starting points.

Before writing any program, it is advisable to plan the processing operation completely in advance. That is, planning the types of operations and processing modes used during processing, as well as the types of tools required in accordance with these modes, helps the technologist to prevent many errors. Let's plan the operations performed when processing the product shown in Figure 3.

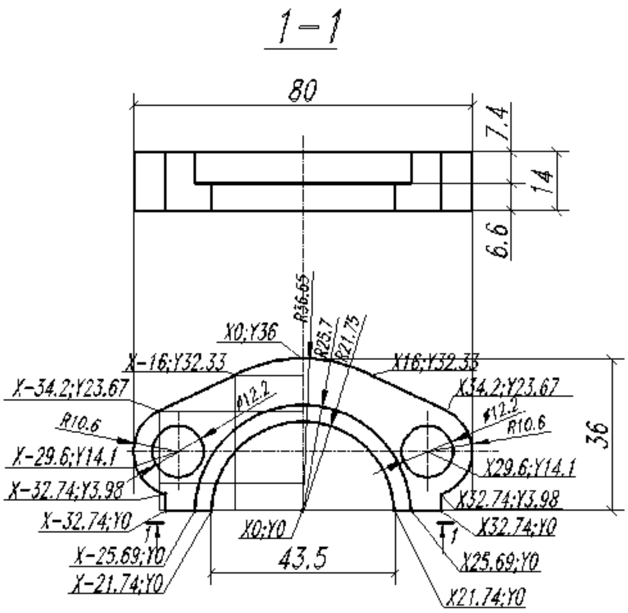

Fig. 3. - Sketch of a component type of compound bearing housing

The plan started with the selection of the required workpiece, if we select the workpiece, then the dimensions of the workpiece will be 90x50x30mm, because for the machining work, we will clamp the workpiece on a support (vice) by 5 mm, and grind another 5. mm on top of it with an end mill (Figure 4).

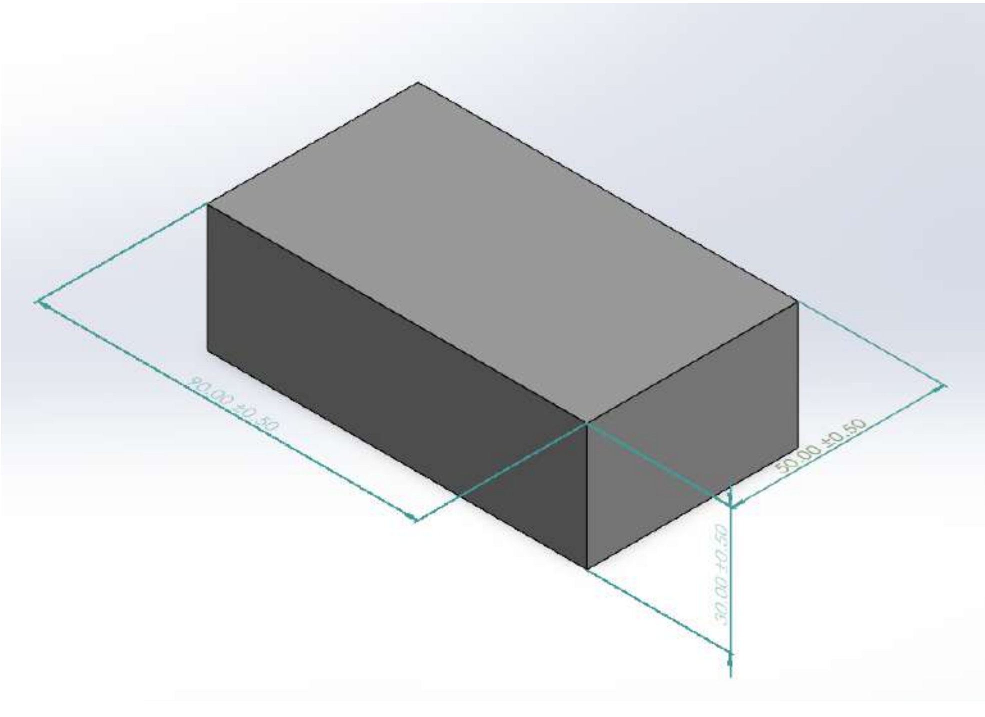

Fig. 4. - 3D model of the workpiece

We will leave an allowance of 2.5 mm at the edges for finishing the contour of the workpiece. According to the plan, processing this workpiece will require 3 main operations (Figure 5):

- milling the upper surface (required tool – end mill ∅50 mm);
- contour milling with an end mill (end mill ∅16 mm);
- drilling holes (required tools ∅14 mm).

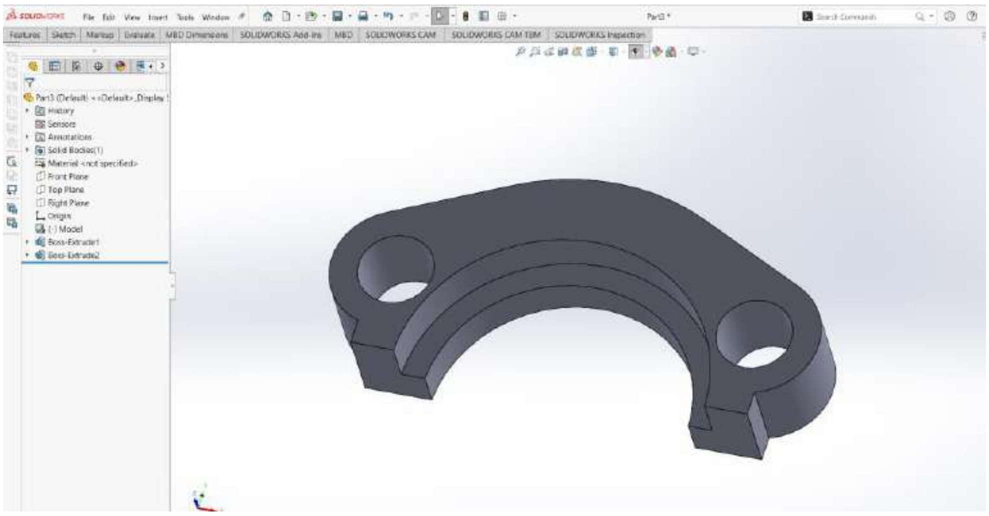

Fig. 5. - 3D model of the finished part

Having previously planned the writing of the program, we write the necessary program in the CIMKO program and check the correctness of the program. The CIMKO program is cheaper compared to other CAM system programs, since it only shows code visualization with program functions. Other programs in the CAM system supply the first visual processing with the most necessary information from the drawn 3D model, that is, from the type of tool used to the cutting modes of the machining tools, and automatically prepare their own program for the required tool accordingly. These programs are very suitable for processing complex products, but due to their high price, are not economically feasible for use in small-scale production unless multi-batch processes are available. Therefore, it is useful to write the code and check its visualization in the CIMKO program.

If we consider the program written above, then «O0007» in the first line is the name of the program, in the code system «O0001 - O7999» is considered a list of programs written by the operator or can be changed by the operator, and «O8000 - O9999» is written by the service personnel during setup program code whose settings cannot be changed by the operator (Figure 6).

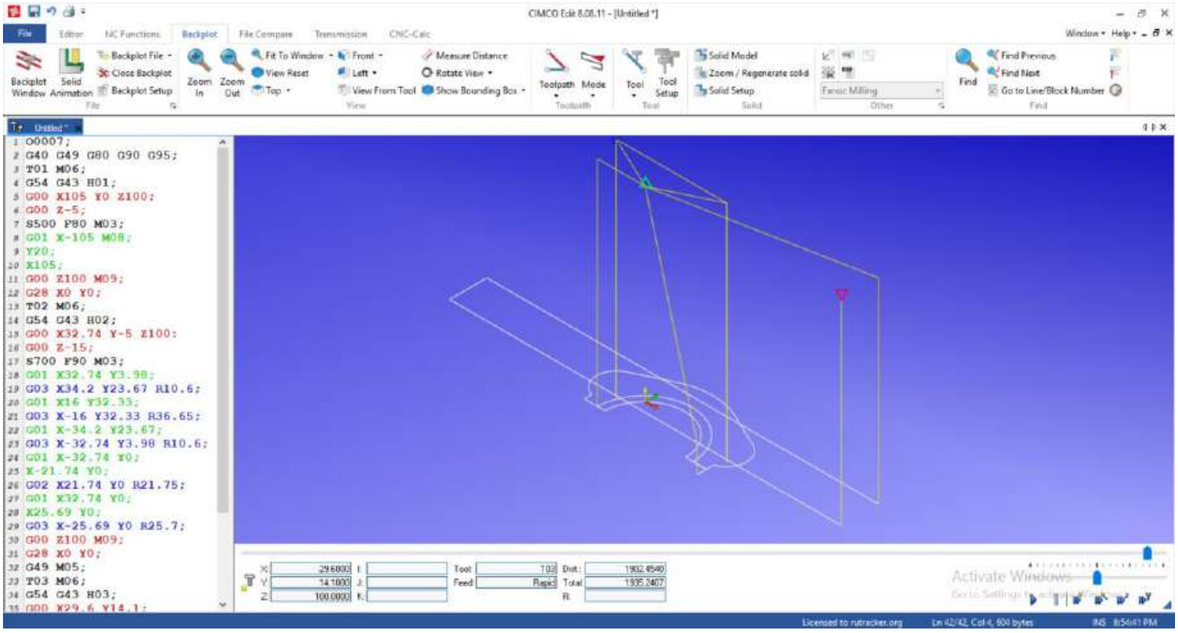

Fig. 6. - Processing codes for a CNC machine written in the CIMKO program

The G40 G49 G80 G90 commands on the second line are commands that reset the lever settings to their original state, recording the command system as a precaution to erase commands that were not erased in previous operations. T01 is the serial number of the tools in the turret, and command M06 is the command to change the spindle to another tool (Figure 7).

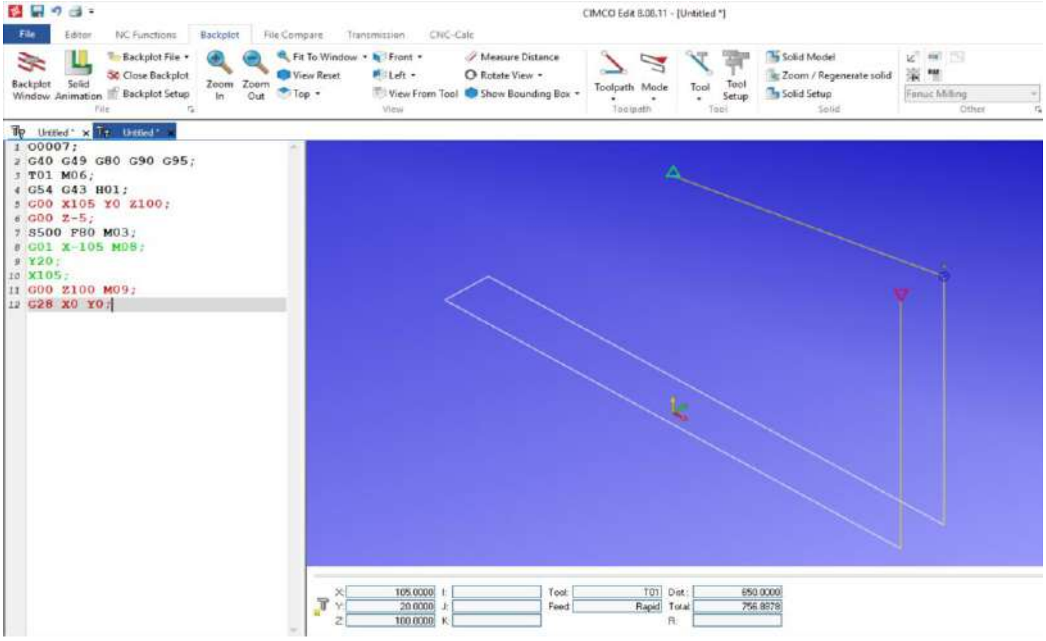

Fig. 7. - Codes for processing a product with a side mill (end mill)

G54 in the next line G43 command H01 G54 – selection of the workpiece coordinate system, G43 – setting tool length compensation by positive or negative offset, H01 – correction of the deviation of the selected tool, that is, if the processing tool is worn out, the digital tool handle makes corrections to improve the accuracy of machining operations . The G00 and G01 commands are the commands that provide the movement of the side cutter, and the direction of these commands is determined by the X,Y,Z coordinate.

After the first operation is completed, the spindle is moved to the starting point (safe point for tool change) by command G28 X0 Y0, and the next end mill is selected at this point by command T02 M06 (Figure 8).

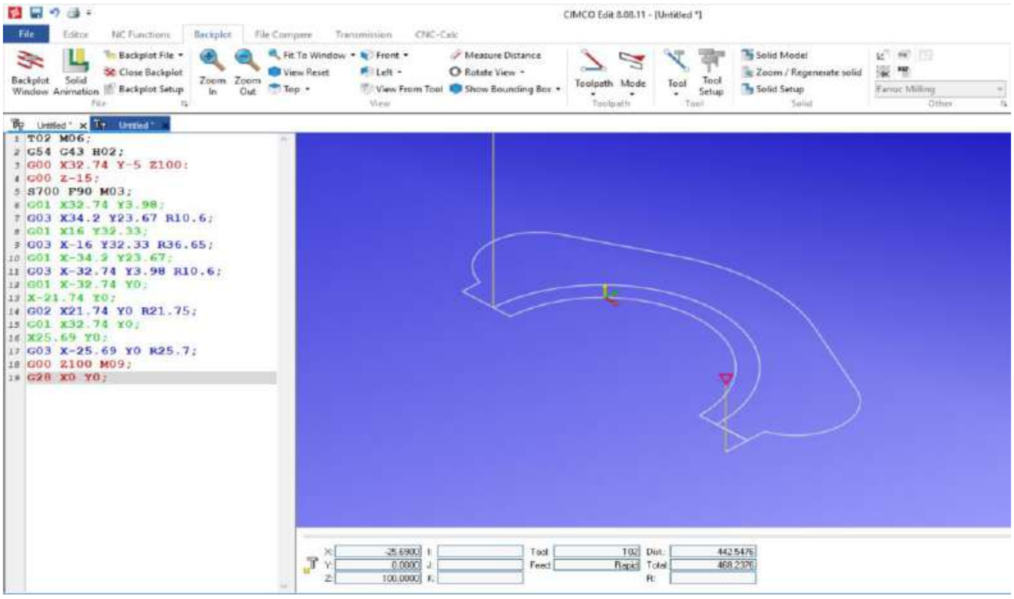

Fig. 8. - Product contour machining codes (finger cutter)

The main difference between the commands for this operation is the G02 and G03 commands. These commands provide movement along the contour of the device along a trajectory specified by radius R (Figure 9).

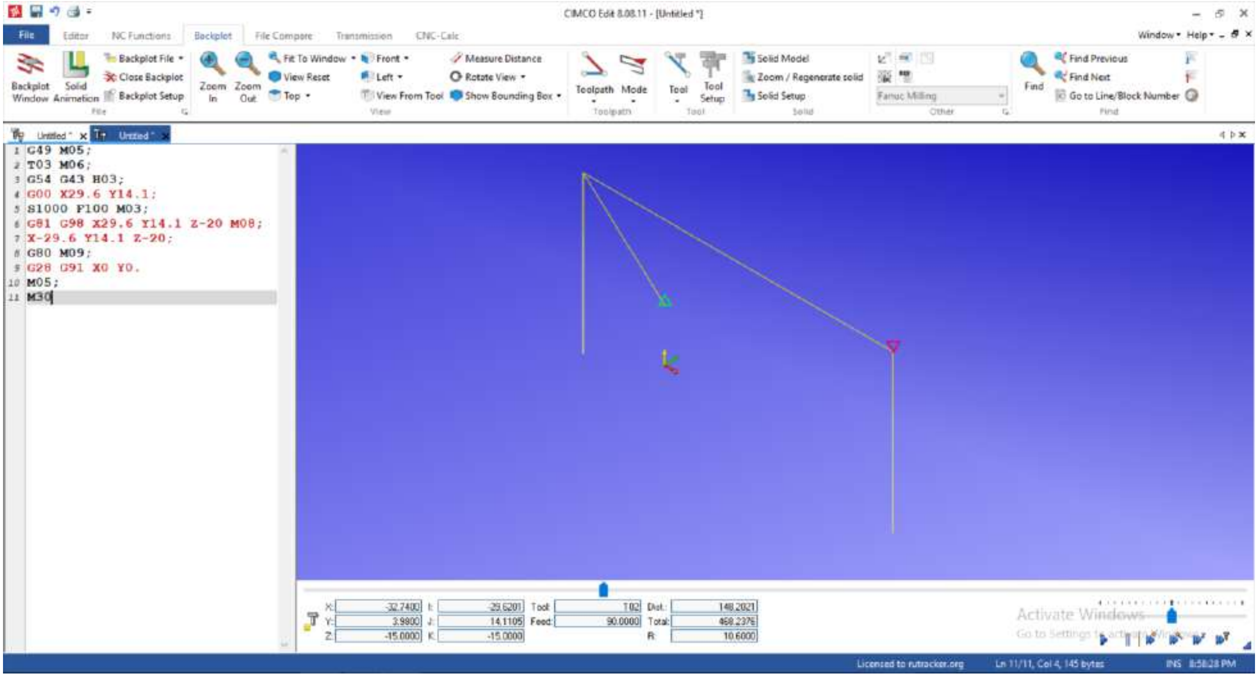

Fig. 9. - Processing codes for drilling holes in the product

The drilling operation code, like the machining operation codes above, after replacing the device, when the device arrives at the machining point at a certain safe height, after entering the spindle rotation modes using the S1000 F100 M03 command, the drilling code is written using the G81 G98 command. After recording the main drilling codes, the coordinates of the holes being machined are entered. After the holes are machined, the spindle will move to the reference point. Then the spindle is stopped through the M05 command, and the operation code is completed through the M30 command.

The code written in the CIMKO program is loaded via media into the machine control processor. After loading the program onto the machine, the workpiece is mounted on the clamp, the zero point of each tool relative to the workpiece is determined, and composition deviations are entered into the machine's CPU (Figure 10, a).

a) b)

Fig. 10. - The process of processing a workpiece on a milling machine

After the written program is entered on the machine and the zero points of the devices are determined, the operation of the codes according to the written program at a certain safe distance from the workpiece is first checked. Only after passing this check will the program start and the machine will begin processing the workpiece. During the processing of the workpiece, the movement of the tool is controlled, as shown on the screen (Fig. 10, b) in the control center of the FANUC machine. Processing operations are carried out using the commands for turning on the coolant (TCJ) M08 and turning off M09. (Fig. 10, b) the reason is that coolants are an important process in preventing overheating and tool failure.

Conclusions

During the work on the AKIRA SEIKI machine in the Japanese FANUC control system, work was carried out to process a Sketch of a part such as a composite bearing housing. During the article, the structure of the machine was discussed and a brief information about its activities was given. In order to carry out the machining operation, first of all, a plan was drawn up, according to which the operation codes were written in the CIMKO program, the correctness of the code written by the simulation was checked and installed on the machine.

As a result of the work, a sketch of a part such as a composite bearing housing was made on a milling machine. An image of the finished product is shown (Figure 11).

Fig. 11. - The result of processing the product on a milling machine

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