Study on the application of CAM techniques on CNC lathes with Y axis and driven tools

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Abstract. CNC lathes with Y axes and driven tools are machine-tools with complex kinematic. Using CAM techniques to program these machines is a cumbersome process and could easily lead to collisions. Collisions may occur not only between tools and workpiece but also between the mobile elements of the CNC lathe. While CAM software package can identify the first type of collisions, for the second type supplementary measures must be taken. This work presents the build of a kinematic model of such a CNC lathe and how can the CAM techniques be improved by using this model.

1. Introduction
Nowadays machining processes require more and more complex CNC machine-tools. 3-axis milling machine centers are gradually replaced by 5-axis ones [1, 2].

5-axis machining can be performed on 3-axis CNC machine-tools by adding supplementary modules, such as rotary-tilting tables [3, 4] or even additional linear axis [5]. Adding supplementary modules could increase the machining errors, by means of additional deviations, situation which has addressed in [6].

Reconfigurable machine-tools have been seen as a solution for increasing both the machining capabilities and the flexibility of technological equipment [7, 8] but there quite few industrial implementations of them.

Increasing the number of machine axes by adding supplementary modules (during or post-fabrication) lead to a more complicated kinematic of the machine and consequently increases the probability of collisions occurrence. Avoiding the collisions, not only between tools and workpiece, but also between moving machine elements and modules was targeted in the literature [9].

Modern CAM software packages are able to identify such collisions for multi-axes machine tools but require kinematic models of the CNC machines to fulfill this task. Few kinematic models of the most common CNC machine on the market are available as standard in the libraries of the software, but most of them have to be built by the users [10].

CNC lathes, normally fitted with X and Z axes, were also considered for increasing their machining capabilities. Modern structures of lathe-milling machines, obtained by fitting normal CNC lathes with Y axis and driven tools [11, 12] are now offered as standard by most of major CNC machine-tools manufacturers.

This work presents some aspects of building a kinematic model of such lathe-milling machine and how this model was used for applying CAM techniques in machining.
2. GENOS L-300E-MY lathe-milling machine

GENOS L-300E-MY lathe-milling machine is a multitasking CNC lathe, equipped with driven tools and fitted with a supplementary Y-axis (which is normally not present in normal CNC lathes). Driven tools enable the machine to perform also milling operations, besides the normal turning operations. The machine is built by GENOS, a subsidiary of the well-known OKUMA company.

The machine is marketed by its manufacturer as a “simple multitasking machine with superior cost and performance”. Indeed, it allows the user to perform a variety of machining operations, by combining turning and milling capabilities.

3. Kinematic model

As stated before, the complex kinematic of the machine-tool requires the use of a kinematic model to be used in conjunction with CAM software. Because the machine is not very common on the market, it is not present in the standard libraries of the CAM software packages.

The first step in building the kinematic model was to build the 3D geometric model of the machine-tool, as an assembly. The disk was rather difficult because neither GENOS, not OKUMA provide information about such model. There are companies on the market (HAAS) which provide such kind of 3D model for each manufactured machine-tool.

Consequently, the information for building the 3D geometric model has to be taken on-site, from the physical machine-tool (figure 1 and figure 2).

After retrieving all geometric and functional information from the machine, the 3D geometric model presented in figure 3 and 4 was built and saved in .igs format.
To build the kinematic model, the 3D geometric model was divided into the following blocks:

- Machine frame / X, Y, Z and C axes (each one separately) / turret axis / tailstock / pinole center / jaws of the holding device form C axis.

After this division, a special software was used to build the kinematic model, by defining degrees of freedoms and kinematic dependencies (parent-child type) for each above mentioned block.

Finally, the kinematic model was saved as a .xml file.

The flowchart of building the kinematic model of the machine is presented in figure 5.

**Figure 5. Flowchart of building the kinematic model of the machine-tool.**

4. **Machining a test part**

To test the proposed kinematic model, a complex part (a screw from the structure of a hydraulic pump) was machined.

The machining process was performed at Sonnek Engineering company, form Șura Mică, Sibiu county. The programming and machining processes were supervised by engineers from the company. Figure 6 presents some machined parts, while figures 7 and 8 presents screenshots from the simulated machining proces (rough milling operation).
5. Conclusion
Multitasking CNC machine-tools, which provide the user increased flexibility and machining capabilities are used increasingly in modern machining processes. Of course, modern CAD/CAM techniques have to be used to program these machines in order to obtain error-free CNC programs.

Using CAM software allows the user to simulate the relative movements between tools and machined parts in order to avoid collisions. However, when machine-tools with complex kinematic and structure are used, the collisions may also occur between moving machine elements (linear slides and/or rotary tables), a scenario which CAM software packages cannot take into consideration without supplementary information. This information may be provided by building a kinematic model of the CNC machine-tool used during the machining process.

This work presented the process of building a kinematic model for a GENOS L-300E-MY lathe-milling machine, which was further successfully tested by machining a complex part.

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