

APPLICATION OF THE STEP-NC STANDARD ISO 10303 AP238 FOR TURNING OPERATIONS

Abstract: The paper considers the possibility of applying a new programming method according to the STEP-NC standard for turning operations. The programming method in this paper is based on the STEP-NC standard ISO 10303 AP238. In order to verify the programming method, a virtual CNC lathe is configured that can interpret STEP-NC programs. Virtual lathe is integrated with software STEP-NC Machine. The method for obtaining the STEP-NC program is proposed, as well as the possibility for the current application of such programs, on the current machine tool control unit that interpret G-code, using the export option of STEP-NC Machine.

Key words: STEP-NC, programming, simulation, turning operations, CNC lathe

1. INTRODUCTION

For more than half a century, programming of CNC machine tools is based on G-code, according to ISO 6983 standard. This standard, commonly known as G and M codes, focuses on programming the path of the cutter centre location with respect to the machine axes, rather than the machining task with respect to a part [1].

Programs in G code address directly the individual axes of the machine, so it is necessary to use postprocessors for each control unit and the kinematics of the machine in particular. It is necessary to prepare the tool path for each type of CNC machine tools individually using appropriate postprocessor. It requires large number of different postprocessor for each type of machine tool. Therefore, programs for CNC machine tools in G-code do not include any useful information about the product, such as data about the geometric primitives of the model, tolerances, material properties, setting up fixture, and other information created during the design and planning of manufacturing technology. All of this information will disappear when postprocessing tool path into G code [2]. In this case, information flow is one-way, from CAD/CAM to a CNC machine tool, Figure 1a.

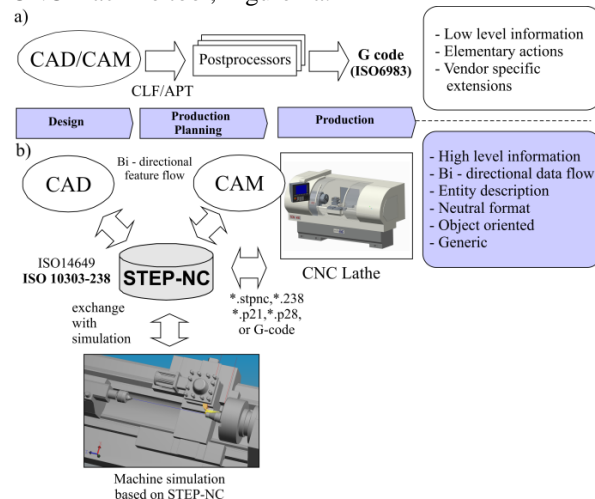


Fig. 1. Current ISO 6983 and new STEP-NC interface for programming CNC lathes

Today a new standard, informally known as STEP-NC (Standard for Product Model Data Exchange for Numerical Control), is being used as the basis for development of the next generation of CNC controller [3-6]. This new standard is ISO 14649 and ISO 10303 AP 238. STEP-NC is a new interface that has been developed for exchange of information between CAD/CAM systems and CNC controllers. Its object oriented design and the use of data elements of the widely disseminated STEP standard support comprehensive bi-directional data exchange whilst using common databases [7], Figure 1b.

Benefits of using STEP-NC are: (i) providing new opportunities to support high level information from design to CNC controller; (ii) the STEP-NC data interface is a neutral data description; (iii) bi-directional information flow; (iv) STEP-NC is independent from the machine tool vendor; (v) higher quality of information on the shop floor; (vi) STEP-NC programs in XML formats can be used for information transfer and enable Web based manufacturing or e-manufacturing.

However, classical programming in the G code is still current and dominant, while the object programming using STEP-NC standards has not been introduced to the full extent so far, and both of these programming methods exist parallel, as illustrated in Figure 1.

There are plenty of results for the application of STEP-NC standards for turning operations [1,8-10] and all are generally based on ISO14649 standard. This paper aims to explore the application of new STEP-NC standard ISO10303-AP238 for programming CNC lathes i.e. for CNC machining of turned parts to enable data exchange of manufacturing rich information from CAD/CAM to CNC.

2. STEP-NC FOR PROGRAMMING CNC LATHES

This section provides a literature review of the STEP-NC compliant research focused on turning operations.

One of the first systems based on the STEP standard related to the machining of rotational parts by turning is the STEPTurn system [1,8]. The STEPTurn has been developed by researchers from the Institute for Control Engineering of Machine Tools and Manufacturing Units at the University of Stuttgart (ISW), Germany. This system is a CAPP system bridging the gap between CAD and CAM and it reads geometry data firstly from a STEP AP203 Part 21 file and displays the part geometry and performs normal process-planning tasks such as feature recognition and Workingstep sequencing in order to generate a STEP-NC physical file [1].

The other such system, TurnSTEP is developed by a mutual participation of researchers from the national research laboratory for STEP-NC technologies POSTECH (Korea) and from ISW University in Stuttgart. The TurnSTEP is to be fully compliant with ISO 14649 and suitable for e-manufacturing. In terms of turning machining, TurnSTEP is one of the earliest systems to have been developed for compliance with STEP-NC and supported by XML schema [1].

The G2STEP system has been designed based on design and functional considerations developed by researchers from the National Research Laboratory for STEP-NC, POSTECH, South Korea together with a researcher from the EPFL, Switzerland and is based on the ISO 14649 data model, the ARM model and instruction schema on G-code based on the FANUC0 series. The main proposal for G2STEP is to generate a STEP-NC part program from a G-code program with additional information related to real machining that is easily generated by skilled operators [1].

If we focus on turning operations, only three proposed systems are available, STEPTurn, TurnSTEP and G2STEP. For e-manufacturing, STEPTurn leads in this aspect due to the capability of internet file transfer. The TurnSTEP clearly defines the number of set-ups as either one set-up or two set-ups dependent on the independent machine format. The output of this system can be in text and XML file formats. As reported TurnSTEP is at a prototype stage and the implementation of another part, which is intelligent and autonomous is still under development [1].

3. TURNING MACHINE SIMULATION BASED ON STEP-NC

Today, a small number of machines can directly interpret the STEP-NC program. In this regard, for the direct verification of the STEP-NC program, it is advantageous to use virtual machines that can work in the STEP-NC Machine environment.

This section demonstrates how to configure a virtual CNC lathe, with a possibility of machining simulations when the machine working using the STEP-NC program according to ISO 10303 AP238.

Configured virtual CNC Lathe is able to interpret the STEP-NC program in the software STEP-NC Machine environment. To load the configured machine in the STEP-NC Machine, it is necessary to follow the next procedure:

- 1) Prepare a CAD model of the CNC lathe in available CAD/CAM system [11];
- 2) Store the prepared model of CNC lathe in STEP format (AP203, AP214 or AP224);
- 3) Prepare XML file, with description basic information about machine;
- 4) Save XML and STEP file in folder ... / Machine;
- 5) Run the STEP-NC Machine and load the configured CNC Lathe from the drop down menu Machine Tool.

Basic information for machine in XML file includes: (i) machine name, (ii) control algorithm, (iii) name of the STEP file machine, (iv) description of the machine base structure, which is stationary, (v) description of tool side structure, (vi) defining placement location for tool, (vii) description of workpiece side structure, (viii) defining placement location for workpiece, (ix) description of NC axes and their feeds.

An example of the XML file fragment for configured 2-axis CNC lathe (TCN410), with comments and illustrations is given in Fig. 2.

ST Viewer

tcn_410_step_asm.stp

```

<machine name="TCN 410 Lathe" description="TCN 410 Lathe"
algorithm="3-axis">
<default file="tcn_410_step_asm.stp" />
<geometry shape_eid="2866" />
<geometry shape_eid="9304" />
<geometry shape_eid="29601" />
<geometry shape_eid="10474" />
<geometry shape_eid="10036" />
...
<chain target="tool">
<axis name="z" min="-250" max="450">
<geometry shape_eid="4118" />
<geometry shape_eid="27626" />
</axis>
<axis name="x" min="-150" max="100">
<geometry shape_eid="4436" />
</axis>
<axis name="y" min="0" max="0">
<geometry shape_eid="6179" />
<geometry shape_eid="11653" />
<geometry shape_eid="12247" />
<geometry shape_eid="12840" />
<geometry shape_eid="13434" />
...
</axis>
<placement shape_eid="6179">
<location component="z" face_eid="5308" />
<location component="xy" face_eid="6129" />
</placement>
</chain>
<chain target="workpiece">
<placement location="0 0 25" />
</chain>
</machine>

```

XML representation of CNC lathe TCN410

Fig. 2. STEP and *.XML representation of CNC Lathe TCN410 for machining simulation in STEP-NC Machine environment

In order to correctly create the XML file structure and the description of the assembly components that are loaded in the CNC lathe machine model for the needs of simulation, the software ST Viewer is also used to define geometry *shape_eid* for each part and *face_eid* for corresponding surfaces. Three elementary entities can be distinguished in a structure: machine stationary components, chain target-tool and chain target –workpiece. Movable sliders are placed here on the side of the tool for moving along X and Z axes. The third axis must be also defined since the algorithm for 3-axis serial kinematics is used. Moving along the third Y axis does not exist, because it is the CNC lathe with two control axes, and consequently Y axis define with movement $min=0, max=0$.

Placement location for the workpiece is defined with respect to a specific coordinate system of the CNC lathe from the *tcn_410_step_asm.stp* file, Fig.2. This coordinate system is a zero point, and it can be moved along the Z axis.

Virtual CNC lathe does not need to include all existing components of the original model, so the

virtual model is simpler and it is more easily and quickly loaded. For the case of the CNC lathe TCN410, because of the better visibility of working area and simpler model, the cabin of the machine was not include in model of virtual machine.

Thus prepared virtual CNC lathe is loaded in the STEP-NC Machine environment, where it will appear as a new machine in a dropdown menu of *Machine Tool*, Fig. 3. In the STEP-NC Machine environment, there have not been any CNC lathes up to now.

Upon selecting the machine from the menu, it is loaded in the STEP-NC Machine environment and can execute STEP-NC programs. This is of importance for training in a new method of programming, because it is now possible to check STEP-NC programs by simulating work on a virtual machine.

Virtual simulation allows off-line programming with verification and testing on a remote site without machine engagement. Working in the virtual environment is also suitable for training and education in programming especially if you do not have CNC lathe which has interpret STEP-NC programs directly.

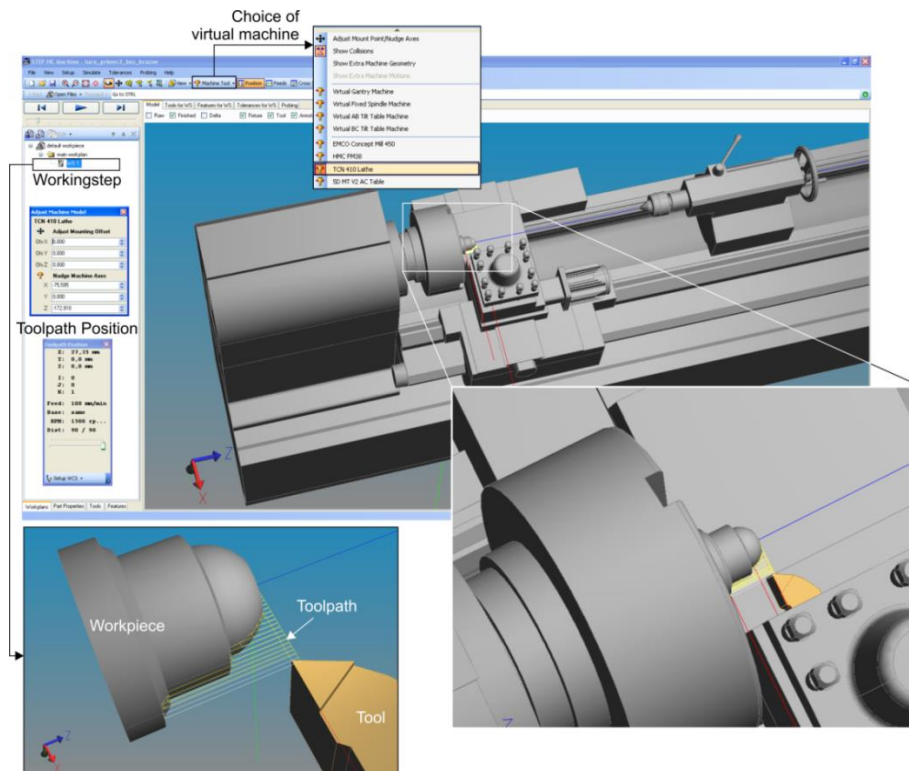


Fig. 3. Virtual CNC Lathe TCN410 in STEP-NC Machine

4. PROPOSED STEP-NC PROGRAMMING METHOD FOR TURNING OPERATIONS

To practice a new programming method in the case of turning operations, it is currently not possible to load the machine from the STEP-NC Machine software because CNC lathe does not exist, but it is therefore possible to configure and integrate own virtual CNC lathe machine into the software, as shown in Chapter 3. This chapter proposes the method by which to prepare its own STEP-NC program for turning operations, based on ISO 10303 AP238, using the manufacturing technology in the available CAD/CAM system. For the selected machining process, it is necessary to prepare

technology.

Preparation of the STEP-NC program for turning operations involves the first preparation of the necessary geometric information about the workpiece and tool, in the STEP format. It is then necessary to prepare the tool path in the available CAD/CAM system in CLF/APT format. For this approach of programming, the PTC Creo environment was used.

Figure 4 shows the procedure with the basic order of events for the preparation of the STEP-NC program. Procedure starts in the CAD/CAM system and ends in the STEP-NC Machine software. For the considered case of turning operation, the machining technology was prepared in the CAD/CAM system. Model of

workpiece and tool in STEP format and toolpath in CLF/APT format were exported from CAD/CAM system and loaded into the STEP-NC Machine software, where all this information is integrated into a single STEP-NC program.

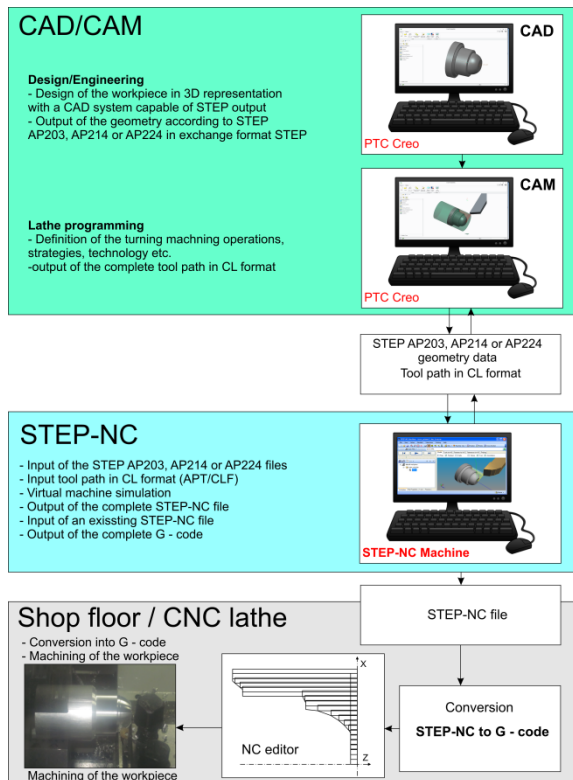


Fig. 4. Turning process chain based on STEP-NC

The generated STEP-NC program can be simulated in the STEP-NC Machine environment on the configured virtual CNC lathe (TCN410), Figure 3. In order to enable the workpiece to be machined on most of the available CNC lathes that are controlled using the G-code, the STEP-NC program so obtained can be converted into G-code using the Exoprt option of the STEP-NC Machine software, or using own program translator. For now, this is just a preparation for a new programming method, with a lot of constraints, but which can be applied to existing CNC lathes.

5. CONCLUSION

Promotion and dissemination of a new programming method are usually performed on hybrid machining systems. These machines are typically programmed with the G code, but also have the ability to convert, in some way, a program prepared by programming using STEP-NC standard. In this paper the STEP-NC Machine software is used for converting the STEP-NC program directly into the G code.

The method proposed in this paper is one of the possible ways of preparation for the new method of programming using the STEP-NC standard ISO 10303 AP238. Configured and integrated virtual CNC lathe, which running by the STEP-NC program in the STEP-NC Machine environment, is aimed at practicing for the future implementation of a new programming method.

6. REFERENCES

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Authors: Assoc. Prof. Sasa Zivanovic, Assist. Prof. Nikola Slavkovic, University of Belgrade, Faculty of Mechanical Engineering, Production Engineering Department, Kraljice Marije 16, 11120 Belgrade, Serbia, Phone.: +381 11 33-02-423, Fax: +381 11 33-70-364.

E-mail: szivanovic@mas.bg.ac.rs ;
nslavkovic@mas.bg.ac.rs ;

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