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APPLICATION OF STEP-NC PROTOCOL FOR MILLING ON MACHINE TOOLS THAT USE FANUC-SIEMENS-LINUXCNC CONTROL SYSTEM

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Abstract: *This paper presents a method for the application of STEP-NC protocol for milling on machine tools that have Fanuc, Siemens, or LinuxCNC control systems. The programming method used ISO 10303-238 (AP-238) standard for programming CNC machine tools. Application and validation of an indirect programming method according to STEP-NC protocol are performed using available CNC machine tools with different control systems.*

Keywords: *STEP-NC, programming, virtual machine, control system*

1. INTRODUCTION

This paper discusses the possibility of application STEP-NC protocol for milling machine tools that have different control units. In this regard, the application of an indirect programming method based on the new standard ISO 10303-238 (AP-238) known as STEP-NC (Standard for Product Model Data Exchange for Numerical Control) is considered [1-4].

The article presents research results on the application of a new programming method in actual production conditions, whereby machining process based on complete technology-based according to the STEP-NC standard is achieved. The aim is to show the possibilities of application and realization in cases when it is necessary to take over and realize the technology of machining a part, which was prepared based on of STEP-NC standard (ISO 10303-238) [3-5].

In today's real production conditions, machine tools which can read only G-code files are dominant. In this regard, the most common application of the STEP-NC protocol is indirect, so that STEP-NC programs are translated into G-code using a developed translator. This level is indirect programming based on STEP-NC [1-7].

2. OUTLINE OF THE CONCEPT OF STEP-NC PROTOCOL APPLICATION

The STEP-NC standard has been developed to challenge the standardization of the exchange of product data along the manufacturing digital chain (CAD-CAPP-CAM-CNC), which includes simulation, optimization, and convert or export code capabilities [1], Fig. 1. The digital thread for manufacturing in this paper considered various CNC machine tools with the different control units.

The STEP-NC provides a comprehensive model of the manufacturing technology. It is object and feature-oriented and describes the machining operations executed on the workpiece, and not machine-dependent axis motions. It will be running on different machine tools or controllers [8].

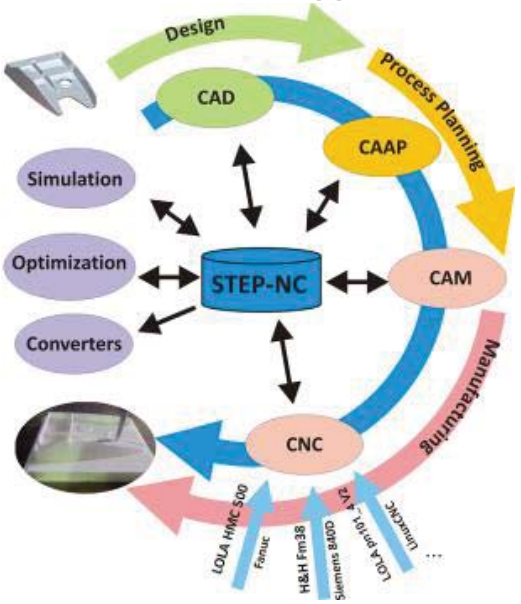

Figure 1. Digital chains based on STEP-NC

If the part machining technology is based on the STEP-NC protocol, and the available machines can only execute G-code, there must be that there are appropriate translators or converters that will be able to convert the STEP-NC program into corresponding G-code.

For now, for most users, this new method of programming based on STEP-NC cannot be completely used with all the benefits provided by STEP-NC [1]. This paper presents the possibilities of applying for the native STEP-NC program, post-processing or converting STEP-NC program into G-code and executing on the different machine tool which is only able to interpret-only G-code files, Fig. 2. This application scenario is realistic, for most users, and can be realized in three ways. The first way is using CLF, exported from STEP-NC file, which is specifically imported into the available CAD/CAM system and post-processed for the selected machine tool. This approach is used when users have already developed a postprocessor in CAD/CAM system. CAD system takes reference model and workpiece in STEP format and CL File. Verification of material removal is done in a CAD/CAM system in the module (NC Check). CAD/CAM system uses configured postprocessor to generate G-code for the available CNC machine tools [1,5], Fig. 2.

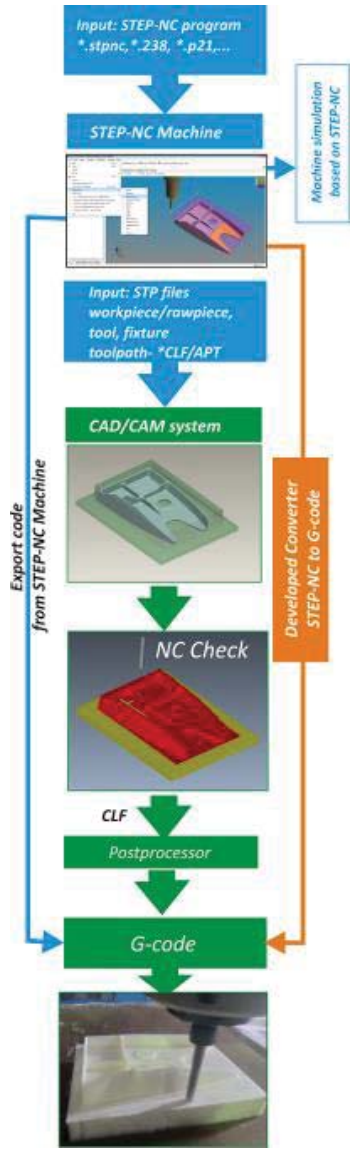

Figure 2. Outline of the concept for the application of STEP-NC protocol on CNC machine tools that are only able to read G-code

The second way uses an export code option of STEP-NC Machine which can directly export STEP-NC program into G-code from the available control units, offered by software (Fanuc, Siemens, Okuma, Haas, etc.), Fig. 3.

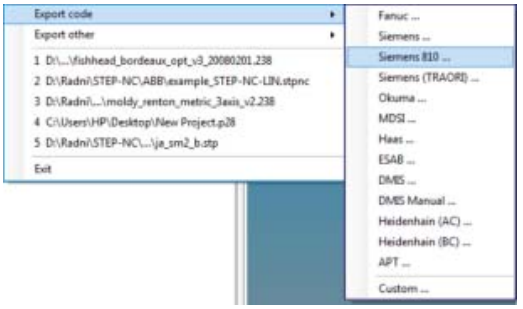

Figure 3. Exporting of code from STEP-NC Machine

The third way is parsing the STEP-NC file and converted into G-code using developed converters [1].

3. MACHINE SIMULATION BASED ON STEP-NC

STEP-NC Machine can display and simulate the machining process within a STEP-NC file, including the simulation of virtual machine tools, and it can be extended as needed to simulate the kinematic of new machines. Thus, the STEP-NC Machine environment allows configuring its own virtual CNC machine tools. In this way, it is possible to perform a simulation of STEP-NC based technology [1].

This is important to gain insight into the proposed technology and prepare adequate technological documentation for machining on machines that perform only G-code. Also, the possibility of configuring your own machines enables verification of toolpath by the virtual machine, before converting STEP-NC file into G-code.

For the machine tools considered in this paper (LOLA HMC 500, H&H FM38, and LOLA pn101_4 V2), the appropriate virtual machines were configured and integrated into the licensed STEP-NC Machine software. A detailed procedure for configuring new machine tools in STEP-NC machines is given in [9].

For the considered configured virtual machines, a machining simulation was performed based on the original STEP-NC file, Fishhead [10], which is shown in Fig. 4.

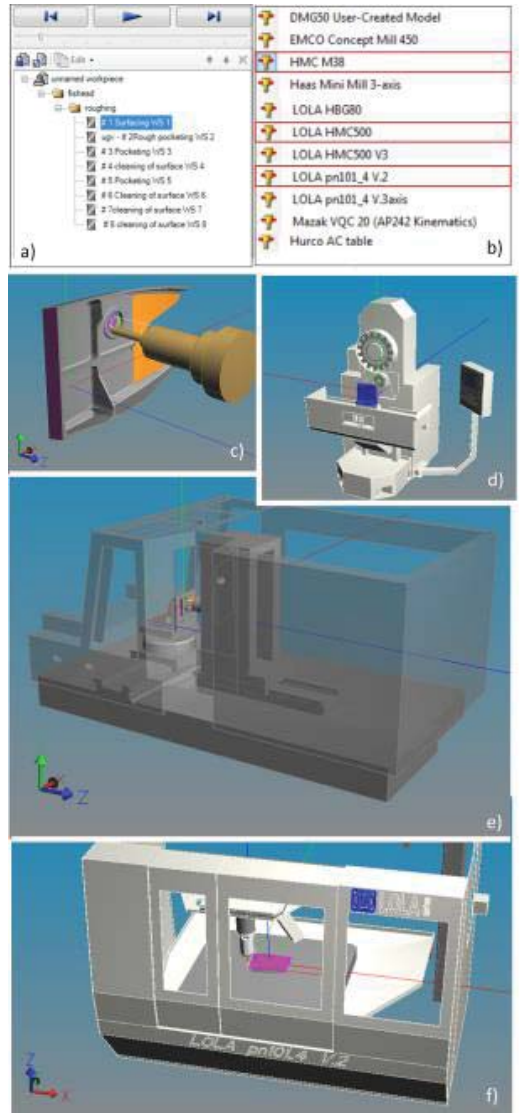

Figure 4. Machine simulation based on STEP-NC

Based on the insights of the performed simulations on three different machines, it is evident that an identical STEP-NC program is executed. Since machines that execute the G-code are used in this case, it is necessary to prepare for the conversion of the STEP-NC program into the G-code, according to one of the ways proposed in Fig. 2.

4. CONVERTER FROM STEP-NC TO G-CODE

In our research presented in papers [11,12] is described an Indirect programming method, based on standard ISO 10303–238, which is used the own developed converters. These converters are employed for translating the exported STEP-NC *.p21 file into (i) G-code, or (ii) robot programming language.

These converters can be used for both industrial robots and machine tools with appropriate customization of the program output format, where for this paper only the part that converts the STEP-NC program to G-code for CNC machine tools is used, Fig. 5.

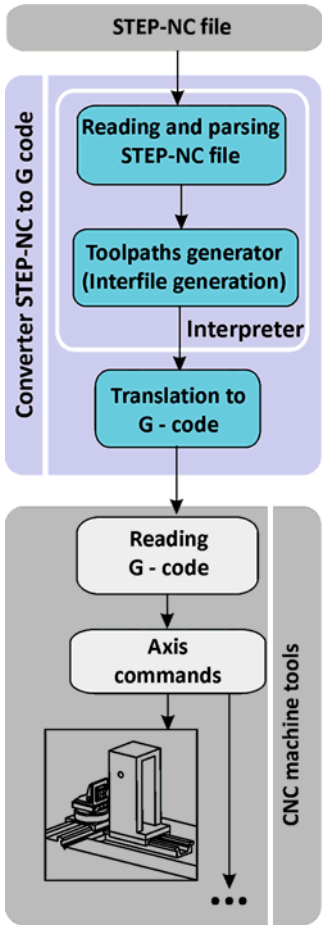

Figure 5. Developed converter for machine tools

The complete procedure of STEP-NC program conversion to G -code or robot language can be seen in [11,12]. This procedure should involve a STEP-NC program interpreter and its translation into an appropriate language. Main activities during translation STEP-NC program are: (i) reading and parsing P21 file, (ii) toolpath generator (Interfile generation), (iii) translation to G-code, (iv) toolpath simulation of generated G-code, and (v) execution of the program on the real CNC machine tool.

5. APPLICATION OF STEP-NC PROTOCOL IN REAL PRODUCTION CONDITIONS

Machining experiments related to the machining of original STEP-NC file, from STEP Tools [10], machining of part Fishhead was performed.

The considered example of the original STEP-NC file is Fishhead, and for this example, the STEP-NC file (ISO10303-238) is translated into the G-code and then it was machined on three different machines, with three different control systems: (i) LOLA HMC 500, Fanuc (FME-BG), (ii) 3 axis vertical milling machine with parallel kinematics LOLA pn101_4 V2, LinuxCNC (FME-BG), and (iii) CNC Horizontal machining center, H&H FM38 Siemens 840D (FTN-NS), Fig. 6.

For machining Fishhead on LOLA HMC 500 with Fanuc, the control unit is used the possibility of applying the available CAD / CAM system in which there is a configured postprocessor for this machine was used. From STEP-NC is used exported CLF, and STEP files of the workpiece, which is imported in CAD/CAM system were used available postprocessor for generating G-code.

For machining Fishhead on 3-axes vertical milling machine with parallel kinematics LOLA pn101_4 V2 with LinuxCNC control system used developed converter [11] from STEP-NC to G-code.

For machining Fishead on CNC Horizontal machining center, H&H FM38 with Siemens 840D control unit is used export code option of software STEP-NC Machine. In this way, it is possible to export the program directly from the STEP-NC program to the G-code for different control units, with Siemens being selected here in this case.

The obtained G-codes were in all three cases machined in laboratory real production conditions on selected machines. A soft material, Styrofoam and wood, was used for machining.

Figure 6. Machining experiments on three different machines

The performed machining experiments confirmed the accuracy of translating the STEP-NC program into G-code by achieving correct machining of the original Fishhead part.

6. CONCLUSION

The paper shows the possibility of applying the exchange of machining technology based on the STEP-NC file for machine tools that have different control units. Verification was performed by processing the original STEP-NC file according to ISO10303-238 on available machines, whereby the STEP-NC file was converted to G-code.

For now, the application of STEP-NC-based programming methods is limited and is applied mainly at the first indirect level that applies to machines that can only execute G-code.

The future works includes the further development of converters for specific G-code, as well as the transition to the level of direct interpreted STEP-NC programming where axis command is directly executed from STEP-NC file. In order to fully realize this concept, the development of a STEP-NC compliant control unit is crucial.

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