COMPARISON OF PROGRAMMING PRODUCTION OF THIN WALLED PARTS USING DIFFERENT CAM SYSTEMS

MICHALIK PETER, ZAJAC JOZEF, HATALA MICHAL, DUPLAK JAN, MITAL DUSAN

Technical University in Kosice with seat in Presov
Faculty of Manufacturing Technologies
Presov, Slovak Republic

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e-mail: peter.michalik@tuke.sk

The article deals with comparing the programming of production of thin-walled parts using CAM software. Were evaluated by the number of clicks buttons and the amount of time during which the G codes generated. One side parts has been produced by the program generated by CAD applications Creo Parametric 2.0 and the other side part using Autodesk Inventor Professional HSM PRO 2016 was made on CNC vertical machining centre Pinnacle VMC 650 S.

KEYWORDS

thin-walled parts, CAM software, NC program, CNC machining centre

1 INTRODUCTION

Today are used the following ways of programming are used for the preparation of CNC programs:

- teach programming,
- manual programming by the help of ISO G codes,
- automatic programming using programming languages,
- automatic programming using CAD/CAM systems,
- shop floor programming,
- macro programming [Kral 2008],
- step programming [Fabian 2014]

The mode of the program production for a concrete component is affected by:

- the shape of a component itself,
- hardware and software design level for programming,
- operator's prior experience and skills [Balog 2016],
- the type of the control system of a CNC machine, the technical equipment of a CNC machine [Michalik 2010].

Popma used in the field of high-speed machining Computer Aided Process Planning for high-speed milling of thin-walled. This approach and concepts have been implemented into software, based on an existing feature based, knowledge-based CAPP package. The core steps of planning volumes to remove, how to machine them, and in which order, have been automated in a knowledge based way. Also supplementary software utilities and functionality have been implemented. From evaluation of the resulting application for industrial practice, the automatic determination of the machining sequence for thin-walled geometry and the improved overview of the process plan were considered great benefits [Popma 2010].

Computer-aided manufacturing (CAM) is use of computer software to control machine tools and related machinery in the manufacturing of workpieces. Most machining progresses through four stages, each of which is implemented by a variety of basic and sophisticated strategies, depending on the material and the software available

The 8 largest CAM software products and companies, by vendor revenues in year 2015 are, sorted alphabetically:

- Autodesk Inventor CAM HSM PRO
- BobCAD-CAM
- CATIA from Dassault Systèmes
- CSoft
- Cimatron from Cimatron group
- Dynavista from Nihon Unisys
- Edgecam from Planit
- Esprit from DP Technoogy
- HyperMill from Open Mind
- Mastercam from CNC Software
- NX (Unigraphics) from Siemens PLM Software
- Powermill from Delcam
- Creo from PTC
- SolidCAM from SolidCAM
- Space E from NTTD
- SurfCAM from Surfware
- TopCAM from Missler
- Tebis from Tebis AG
- VisiCAM from Vero
- VisualMILL from MecSoft
- Vericut from CGtech
- WorkNC from Sescoi [Michalik 2012].

The stages are:

Roughing: This process begins with raw stock, known as billet, and cuts it very roughly to shape of the final model. In milling, the result often gives the appearance of terraces, because the strategy has taken advantage of the ability to cut the model horizontally. Common strategies are zig-zag clearing, offset clearing, and plunge roughing, rest-roughing.

Semi-finishing: This process begins with a roughed part that unevenly approximates the model and cuts to within a fixed offset distance from the model. The semi-finishing pass must leave a small amount of material so the tool can cut accurately while finishing, but not so little that the tool and material deflect instead of shearing. Common strategies are raster passes, waterline passes, constant step-over passes, pencil milling.

Finishing: Finishing involves a slow pass across the material in very fine steps to produce the finished part. In finishing, the step between one pass and another is knowledge compilation, and achieved good results. Feed rates are low and spindle speeds are raised to produce an accurate surface.

Contour milling: In milling applications on hardware with five or more axes, a separate finishing process called contouring can be performed. Instead of stepping down in fine-grained increments to approximate a surface, the workpiece is rotated to make the cutting surfaces of the tool tangent to the ideal part features. This produces an excellent surface finish with high dimensional accuracy. The first commercial applications of CAM was realized decades before. It was in large companies in the automotive and aerospace industries, for example UNISURF in 1971 at Renault for car body design and tooling. The output from the CAM software is usually a simple text file of G-code, sometimes few thousands of commands long, that is then transferred to a machine tool using a distributed numerical control (DNC) program3. The 10 largest CAM software products and companies, by vendor revenues in year 2015 are, sorted alphabetically: BOBCAD-CAM from BobCAD-CAM, CATIA from Dassault Systèmes, CAM-Tool from C & G Systems, Cimatron from Cimatron group, Dynavista from Nihon Unisys, Edgecam from Planit, Esprit from DP Technoogy, HyperMill from Open Mind, Mastercam from CNC Software, NX (Unigraphics) from Siemens PLM Software, Powermill from Delcam, Creo from PTC product, Autodesk Inventor Professional HSM PRO, SolidCAM from SolidCAM, Space E from NTTD, SurfCAM from Surfware, TopCAM from Missler, Tebis from Tebis AG, VisiCAM from Vero, VisualMILL from MecSoft, Vericut from CGtech, WorkNC from Sescoiand WCam2K from Ravelli [Michalik 2013].

Moldovan et.al analyzed and manufactured by CAD/CAM-technologies standardized, accurate production of dental restorations out of high strength materials (zirconia). The three-dimensional internal fit of CAD/CAM-manufactured zirconia copings was evaluated in vitro to verify the realizability of this aim. The analysis was based on ceramic master dies of prepared teeth and corresponding virtual CAD surfaces. Five copings per die were manufactured with two different CAD/CAM-technologies: milling and grinding. The internal fit was determined by a threedimensional replica technique by optical digitization and computer-assisted analysis. Mean internal gaps were 134/84 µm for molar and 93/69 µm for premolar copings (milling/grinding) using a digitizable silicone for the replicas representing the cement space. They were statistically significant regarding tooth and CAD/CAM-system. All zirconia copings showed an internal accuracy of fit where the gap widths ranged within the current clinical recommendations. However, there still is room for improvement and further standardization of CAD/CAM-technologies [Moldovan 2011].

Giannetopoulos et. al investigated and compared the marginal integrity of ceramic copings constructed with the CEREC3 and the EVEREST system employing three different margin angle designs and explore to what extent these CAD/CAM machines can produce acute marginal angles creating restorations with acceptable margins. Materials and methods: Three brass models were prepared with a different marginal finish line. Ten restorations were produced for each finishing line and CAD/CAM system, respectively. The results of this study indicated that the introduction of a marginal angle of the restoration increases the potential for marginal chipping. Different CAD/CAM systems which employ different milling processes produce restorations with different amount of marginal chipping, although this only became apparent for a marginal angle of a 60 [Giannetopoulos 2010]

2 COMPONENT

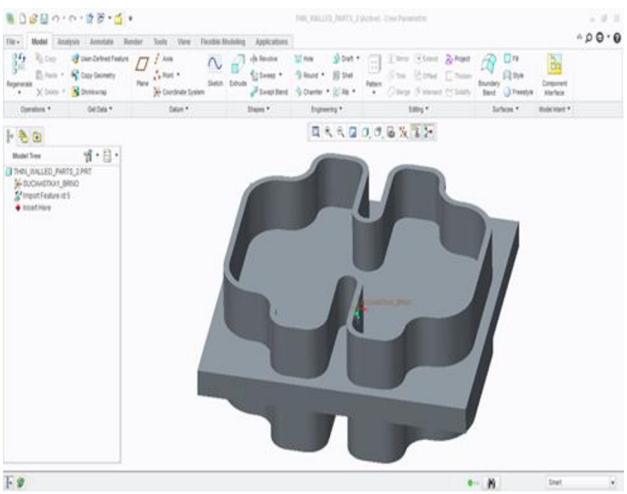

Figure 1. Modeling in graphical environment Creo Parametric 2.0

CAD model of part was created using software Creo Parametric 2.0, with use of features like Extrude, Removal Extrude, Round, Edge Chamfer (Fig. 1) [Novak-Marcincin 2014].

Modeling in Autodesk Inventor Professional 2016 (Fig. 2) would be realized with use of same features and operations [Fabian 2014].

CAD model of part was saved in STEP (*.stp) format. Environments of different CAM software solutions are showed on further figures. They present Inventor Professional HSM (Fig.3).

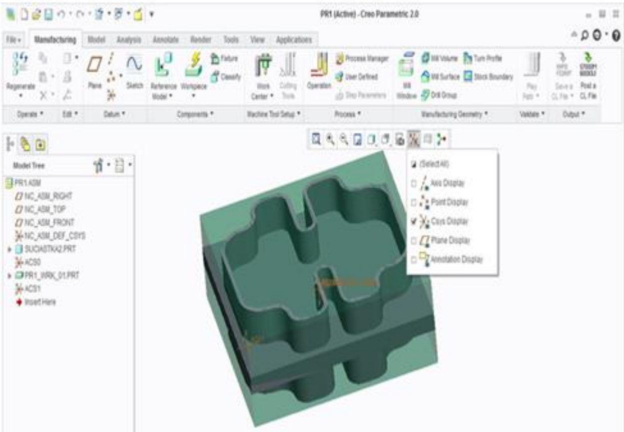

Figure 2. Choice machine origin in Creo Parametric 2.0

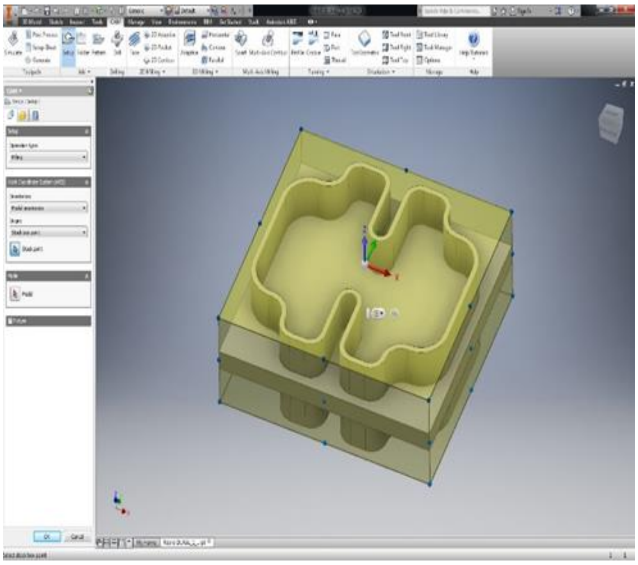

Figure 3. Choice machine origin in Autodesk Inventor Professional HSM PRO 2016

3 COMPARISON AND EVALUATION OF CREATING OF CNC PROGRAMS WITH USE OF DIFFERENT CAM SOFTWARE

Prior to comparison of creation of CNC programs in environment of different software solution it is necessary to determine the categories and values that will be observed, measured and compared in order to make the final result objective and true.

With this paper following values were selected for evaluation purposes:

- Number of mouse clicks while programming the particular operations,
- Time necessary for programs creation and completion of particular technological operations.

3.1 Number of mouse clicks while programming the particular technological operations

While setting particular technological operations and cutting conditions it is necessary to use the mouse clicks many times for selecting of actions, orders. Figure 4 provides information on total click amount for selected technological operations.

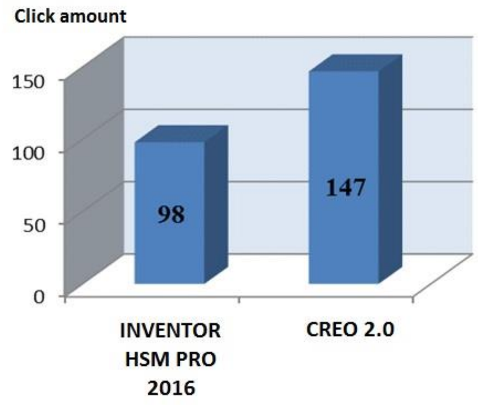

Figure 4. Total click number for necessary for creation of CNC program

For measuring of click count there were the same conditions set in all programs, for example also the initial clicks for software starting and environment getting ready were counted as well as clicks for creation and saving of part model.

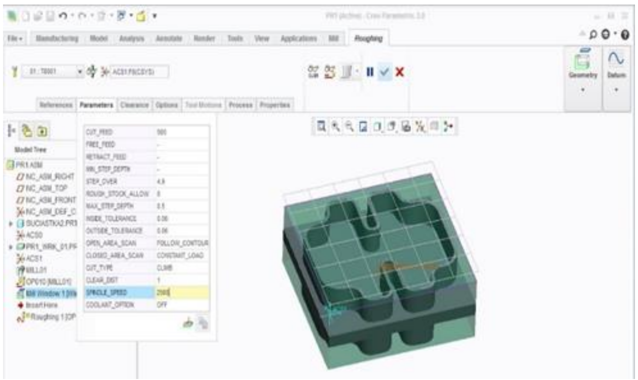

Figure 5. Cutting parameters selection in Creo Parametric 2.0

Following figures shows the selection of technological parameters of manufacturing and also selection of tools in different CAM software and play path process with CL data Creo Parametric 2.0 (Fig.5), Autodesk Inventor HSM 2016 (Fig.6).

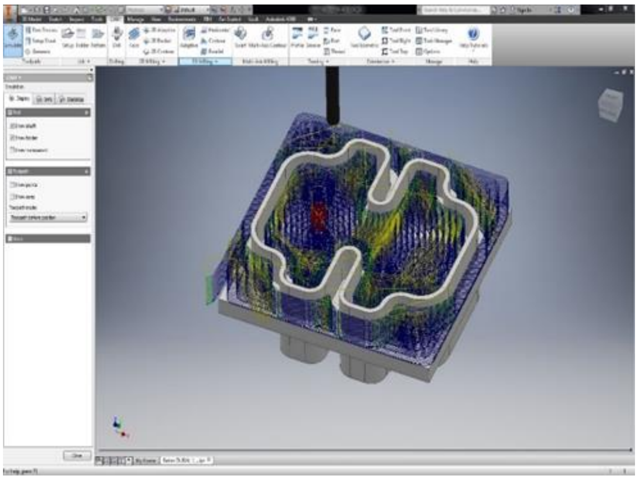

Figure 6. Play path in Autodesk Inventor Professional HSM PRO 2016

3.2 Time of model creation

Measuring was started with first click on the icon of the program and stopped with complete and usable NC program created. Time measuring was realized between first and last mouse click (Fig. 7).

Figure 9 shows total time necessary for part programming in seconds. Shortest time of model creation was measured for Autodesk Inventor HSM PRO 2016 thanks to low number of necessary clicks. Second place took Creo Parametric 2.0, where the program creation took almost 6 minutes mainly because of complicated use of working windows

After generating of CL data and handling them with postprocessor (Fig. 8) they were inserted to control program of CNC vertical center Pinnacle VMC 650-S using ceramic cutting plates [Cep 2010], following manufacturing itself (Fig. 9). . Manufactured a thin walled component is see (Fig. 10).

Figure 7. Total programming time

It may be machining duralumin, Hadfield steel [Fedorko 2011] or composite material [Hutyrova 2013] for various roughness of surface [Miko 2012].

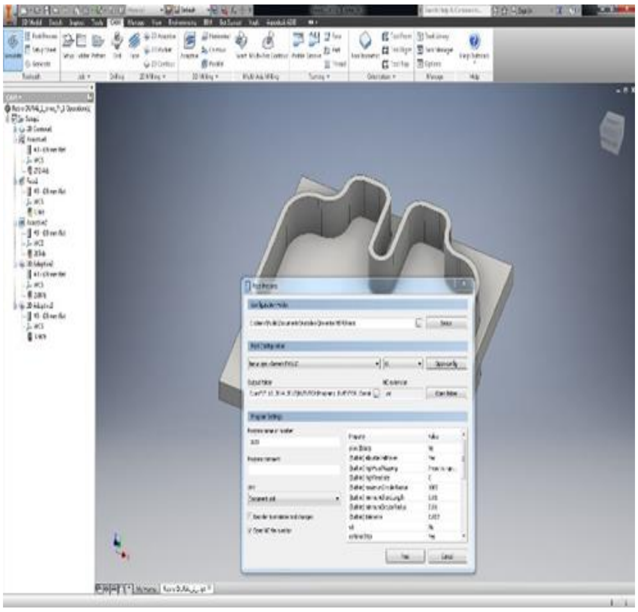

Figure 8. Postprocessing CL data in Autodesk Inventor Professional HSM PRO 2016l

Figure 9. Part manufacturing on CNC machine

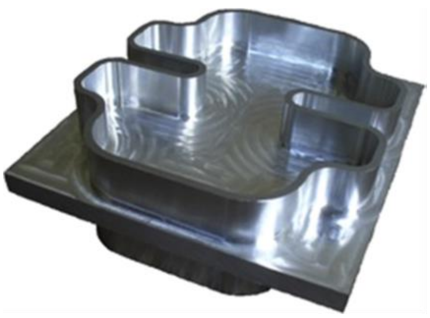

Figure 10. Manufactured thin walled component

4 CONCLUSIONS

For The manufacturing environment is increasingly complex. The need for CAM and PLM tools by the manufacturing engineer, NC programmer or machinist is similar to the need for computer assistance by the pilot of modern aircraft systems. The modern machinery cannot be properly used without this assistance.

Contemporary CAM systems support the full range of machine tools including: turning, 5 axis machining and wire EDM. Today's CAM user can easily generate streamlined tool paths, optimized tool axis tilt for higher feed rates, better tool life and surface finish and optimized Z axis depth cuts as well as driving non-cutting operations such as the specification of probing motions. Program presenting the best solution here can change according to the change of criterion – time, working style, geometrical shape of part. Most suitable seems to be Autodesk Inventor HSM PRO 2016 mainly because of shortest click amount of button and programming time.

This is not the only definition for CAM, but it seems to be the most common. CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. CAM is a subsequent computer-aided process after computer-aided design (CAD) and sometimes computer-aided engineering (CAE) as the model generated in CAD and verified in CAE can present an input into CAM software, which then controls the machine tool.

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CONTACTS:

Doc. Ing. Peter Michalik, PhD., Paed.IGIP
Prof. Ing. Jozef Zajac, PhD.
Doc. Ing. Michal Hatala, PhD.
Ing. Jan Duplak, PhD.
Ing. Dusan Mital, PhD.
Technical University in Kosice with seat in Presov
Faculty of Manufacturing Technologies
Bayerova 1, 080 01, Presov, Slovak Republic
e-mail: peter.michalik@tuke.sk,
e-mail: jozef.zajac@tuke.sk
e-mail: michal.hatala@tuke.sk
e-mail: jan.duplak@tuke.sk
e-mail:dusan.mital@tuke.sk