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EFFECT OF CAM SYSTEMS INTEGRATION INTO PRECISE PRODUCTION OF TOLERATED GROOVES

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ABSTRACT

The issue of precision groove milling is constantly addressed in manufacturing companies focused on the production of components for every type of industry. In this area, companies face implementation problems, explore the efficiency of production or the possibility of integrating CAM systems in the area. The integration of CAM systems is an attribute that is increasingly being considered precisely because of the rapid development of digitization. In conjunction with other attributes, which include accuracy, speed, productivity, and the ability to respond to change in practice, the integration of CAM systems becomes a deciding existential factor in the company. This article focuses on the impact of the integration of CAM systems in the manufacturing of tolerated grooves. It provides a general overview of several systems in determining the same production parameters. The conclusion brings a general description of the achieved results and their summary. This research was supported by research grant VEGA 1/0080/20 and KEGA 014TUKE-4/2020.

Keywords: CAM systems, Integration, Precision manufacturing, Milling, Tolerated grooves.

INTRODUCTION

The need to use CAD / CAM systems is explained by the competitive environment, which depends on the flexibility, speed, accuracy, and efficiency of the subsystems. The primary application of CAD / CAM systems is in the field of production, research, and development, but also in other branches of the engineering industry (Michalik, Zajac, Duplák, & Pivovarnik, 2012). CAM can be understood in two ways - as a specific software, but also as an overall view of computer support in production. CAM can therefore include a wide range of machinery, transport, measuring, control, and auxiliary equipment, which is controlled by a computer during production (Panda, Dyadyura, & Grabko, 2018). CAM technology, together with CAD technology, can eliminate the differences between these two separate activities of a manufacturing company by integrating the pre-production and production stages. In the technical community, the term CAM is known mainly as a type of software (Ivanov, & Zajac, 2018). The concept of CAM, understood as software, includes much fewer functions compared to the concept of CAM as an in-house department. From a software point of view, CAM systems can also be supplied as educational applications (Perea-Lowery, Minja, Lassila, Ramakrishnaiah, & Vallittu, 2021). These serve to acquaint students with the principles of the process of creating NC programs. These educational applications usually have limitations preventing the use of data from the given applications in industrial practice (Longstaff, Fletcher, Parkinson, & Myers, 2013).

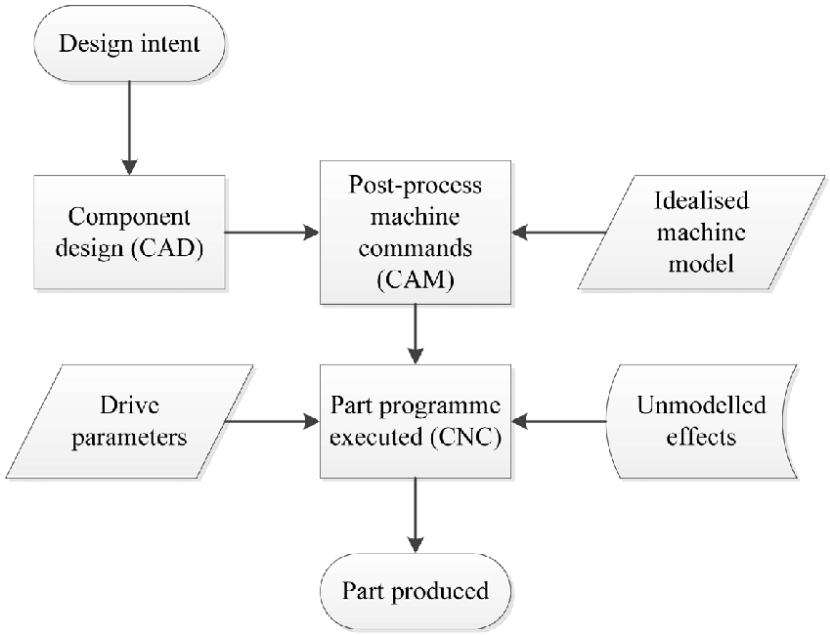

Figure 1. Basic CAD/CAM flow chart (Longstaff et al., 2013).

MATERIAL AND METHODS

Today, CAM software is necessarily used in practice to produce precise grooves. There are several CAM software on the market, which differ from each other in various advantages and disadvantages, price and other aspects. In the described experiment, three CAM software selected based on professional experience were tested: HSMWorks, CAMWorks, and SURFCAM.

The tools that were used for milling the given grooves were selected based on suitable technological properties of the tool from the tool library of the tool shop from practice. The initial cutting conditions were chosen for the average values from the manufacturers' catalogues and gradually higher values were set for feeds and cutting speeds in cooperation with the operator of the machining centre and a team of CAD / CAM specialists from practice. The following basic conditions were determined for the implementation of the experiment:

- maintaining the functionality of the groove according to the specified production documentation
- the possibility of achieving a minimum production time
- broad-spectrum implementation for various production machines
- use of available data on the tools used
- ensuring the economic efficiency of the production process

Based on the above-defined practical conditions, simulation models were compiled, in which the individual geometric paths were compared, in which the geometric conditions were preserved in each tested CAM software, ie the depth of cut ap and the lateral overlap of the tool ae. Cutting speeds v_c and feed rates f were also maintained for each groove tested.

There are two grooves on the part in question. One is on the smaller diameter of the part - a semi-closed recessed groove that can be machined with 2-person technology (2D groove). The second groove is on the larger diameter of the part. It is a closed through groove, while its production requires turning the lathe spindle (groove 4D).

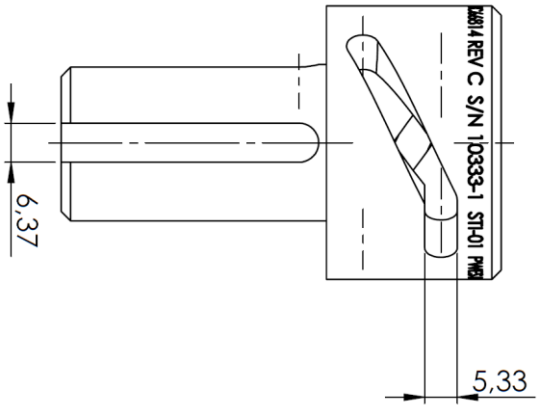

Figure 2. Schematic interpretation of groove.

There are two pairs of identical grooves on the part. One pair of grooves can be milled with 2-axis technology and one pair with 4-axis technology. A lathe with driven tools is therefore the most suitable variant to produce this part, as it allows you to turn the external shape of the part and mill a 4-axis groove in one clamping. to carry out the experiment, the mod shown in the following figure was recovered.

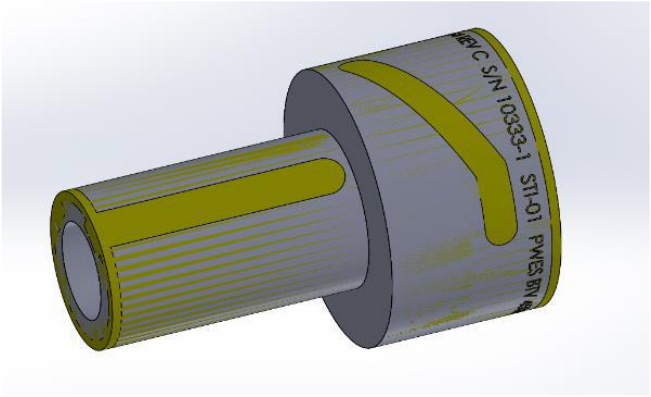

Figure 3. Model for HSM.

RESULTS AND DISCUSSION

After creating the model, the first experiment was implemented in the HSMWorks program. Although the grooves are milled, the possibility of turning with driven tools is implemented, which allows the use of the fourth axis without having to program using multiple axis operations. In the first case, the HSMWorks program produced a groove using the "Groove" strategy. However, this strategy lacks side-step editing, which orients the path to the centre of the groove. After consultation with practice, the 2D "Pocket" strategy (roughing operations) and the 2D "contour" strategy (finishing operations) were identified as the most efficient and simplest choice for 2D groove production.

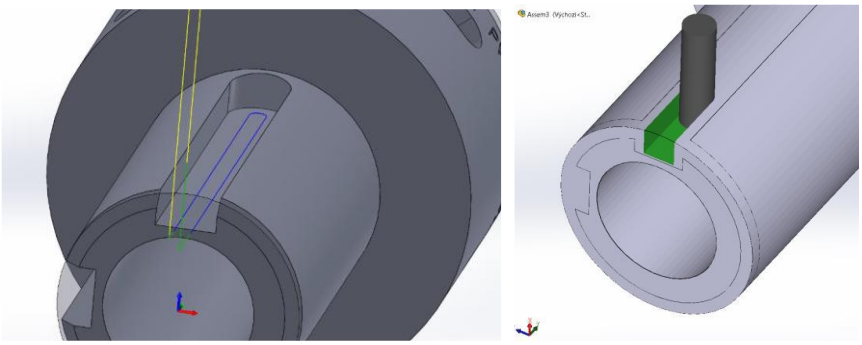

Figure 4. Tool path creation (left) and simulation (right) of 2D groove in HSMWorks.

In the next step, the production of a 4D groove located on a larger component diameter will be simulated. A 3-axis pocketing strategy will be used for roughing operations, which can also move in the fourth axis. To guarantee the correct machining of the part, a negative allowance of 1 mm is defined at the bottom of the groove during the last axial passes of the cutter. Before starting the roughing of the 4D groove, two holes are drilled into the groove, which will be situated at the radiuses of the groove so that there is sufficient allowance for finishing on all walls. These holes are necessary for the correct and safe passage of the roughing cutter in the groove. A 3D contour finishing strategy is applied to complete the groove.

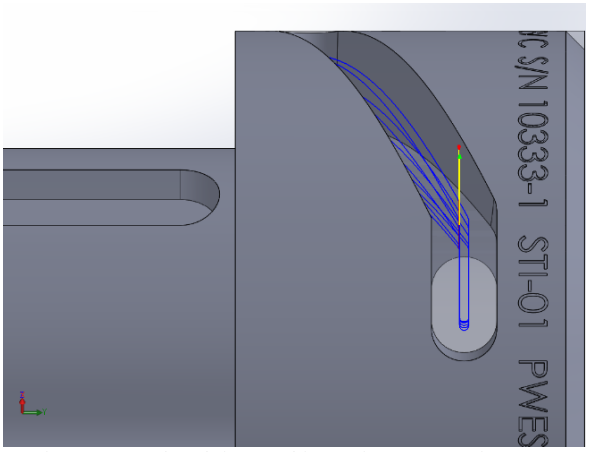

Figure 5. Tool path in roughing of 4D groove in HSM.

In the second experiment, the grooves were made in Surfcam. After positioning the part model and its semi-finished product, the machine on which the part will be manufactured is defined. In this, Surfcam differs from most current CAM software because the machine on which the component will be programmed is preselected, but with other CAM software, selecting a postprocessor is one of the last steps. After selecting the machine, the creation of departments follows. The departments in Surfcam have the task of pre-preparing a 3D model of a part for creating tracks.

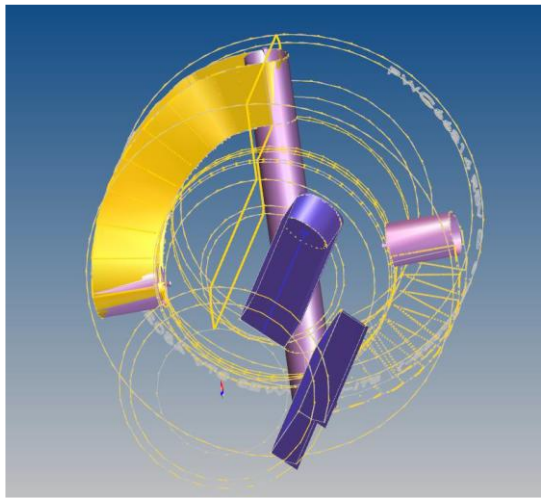

Figure 6. Created shapes of grooves milling- Surfcam.

Based on the compiled shapes, the necessary attributes for 2D milling were created using the Profiling strategy. In the given program, the experiment was also carried out with the same type of cutter, while the finishing passes were carried out in the same way as in the previous experiment - one transition to the full height of the groove.

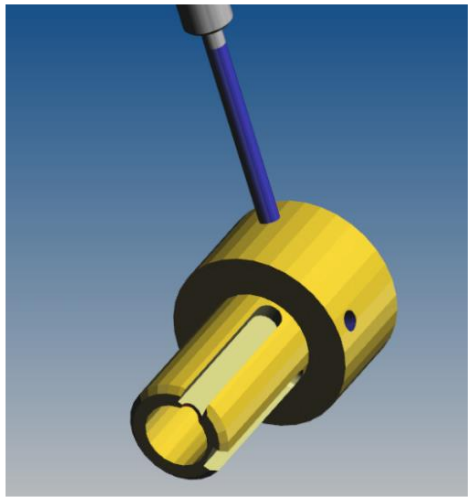

Figure 7. Drilling of auxiliary holes during the manufacturing of grooves – Surfcam.

After drilling the auxiliary holes, roughing of the 4D groove is performed. This takes place under the same cutting conditions and with the same tool. However, with this 4D groove, Surfcam does not allow roughing of the groove by conventional roughing methods. Therefore, the "Groove" strategy has become the most effective roughing option, but it will leave more allowances on the groove walls. Finishing operations are the same as for HSM.

In the third experiment, after stabilizing the model, determining the zero point and other inputs, we switch to automatic element recognition. It's about the same function as in Surfcam under the departments function.

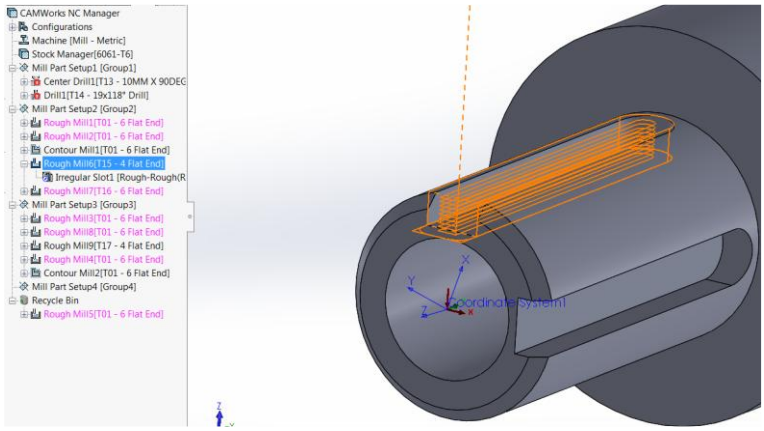

Figure 8. Selection from suggested operations for 2D groove - CAMWorks.

After selecting and generating the most advantageous path, its modification will start. Additions, cutting conditions and other inputs are adjusted to be the same as in the previous two experiments. As with the creation of a CAM model for 2D groove machining, the procedure is also used for CAM modelling of a 4D groove. It is also necessary to drill auxiliary holes and keep the allowances correctly.

Based on the performed experiments, production times were achieved, which are presented in the following table.

Table 1. Results of experiment.

Milling strategy	HSMWorks	Surfcam	CAMWorks
2D groove – roughing	1 min 40 sec	1 min 40 sec	1 min 39 sec
2D groove – finishing	29 sec	30 sec	29 sec
4D groove – roughing	4 min 20 sec	4 min 41 sec	4 min 32 sec
4D groove – finishing	35 sec	32 sec	34 sec
Total production time	7 min 4 sec	7 min 23 sec	7 min 14 sec

Based on the table above, the shortest machining time was achieved by implementing the HSMWorks program, which was caused by the individual implemented machining strategies.

CONCLUSIONS

Nowadays, automation, shortening production times, and increasing even complex components in the shortest possible time with the required participation and surface accuracy, which are used by CNC machine tools. Of course, this is closely related to the use of CAD / CAM systems, which are used to prepare data and CNC programs. Presented article was focused on effect of CAM systems integration into precise production of tolerated grooves. The results of CAM systems showed that they are approximately at the same level and each of the tested software has its strengths and weaknesses. The choice of CAM software based on the efficiency of groove milling is only important in series or large-scale production.

ACKNOWLEDGEMENT

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