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COMPARISON OF CREATING TECHNOLOGICAL OPERATIONS BASED ON SIMILARITY IN CAM SOFTWARE

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Abstract

The article will examine the comparison of creating simple operations based on the similarity of two parts in CAM software, specifically SolidCAM, MasterCAM, and Fusion 360. The introduction presents two similar parts. In the following sections, the article summarises and explains how operations can be created in each CAM software based on similarity. The principle of creating an operation for a similar part in SolidCAM and Fusion 360 is done through templates. The template is created from the operation for the first part. Then, when inserted into the program for a similar part, the necessary elements are edited, and the operation is created. In MasterCAM, a similar operation must be manually modified, where the principle lies in editing the elements directly within the created operation. The next step, of the research will involve comparing with more complex and intricate parts.

Keywords: CAM; part similarity; technological operation; CAM software

1. Introduction

Computer-Aided Manufacturing (CAM) software converts Computer-Aided Design (CAD) models into information that can be used by shop floor machines. This type of software helps engineering companies optimize the process of transforming raw materials and components into finished products [1]. CAM involves the use of engineers and programmers in manufacturing or prototyping components and products, either with or without the aid of CAD [2]. CAM refers to the use of software to control machine tools and automate specific manufacturing processes. It is a type of manufacturing automation process known as programmable automation. CAM is one of a series of steps that include modelling the design in CAD software. Next, Computer-Aided Engineering (CAE) tools analyse and validate the product design, and only then is the product ready for the manufacturing phase [3], [10]. The most common technological method in CAM is milling, which is divided into 3- to 5-axis milling [4].

The manufacturing phase begins when the 3D model of the product is imported into CAM software. This model contains vector graphic information defining the product's geometry and properties. However, the 3D model alone is not

sufficient for manufacturing. Accordingly, CAM software requires the user to provide additional information, such as the machine, available tools, materials, post-processor, maximum supported feed rate, supported acceleration and deceleration rates, and the machine's work cycle [3].

By combining all this information, the software determines the required cutting/tool path, feed rate, and cutting speed. It can also simulate the machining/manufacturing process depending on the software's capabilities. This allows the user to identify errors in aspects such as the generated tool path [3].

Finally, the post-processor generates CNC programs. These include lines of code documenting all these steps, tool paths, and other manufacturing information, such as tool definition and height above the workpiece. This NC code is compliant with the machine's conventions, meaning it cannot be universally deployed across all machines. Post-processors are not agnostic; rather, they are customized and fine-tuned for use with specific machines. Therefore, a custom post-processor for your device needs to be installed whenever CAM software is set up [3].

Once generated, the programs are transferred to the machine's control unit, which then directs its operations and tool movements. Simply put, the machine relies on these programs to create the geometric features on the part [3].

The integration of CAM software in the manufacturing process offers many advantages that streamline operations, improve accuracy, and increase overall productivity. CAM software is designed to enhance machining efficiency. It also helps eliminate human errors, thus reducing time spent on adjustments. The level of precision and consistency that can be achieved is difficult to compare with manual machine programming. It allows the replication of parts with complex geometries and tight tolerances, ensuring consistently high-quality output [8], [11].

In the industry, most new product designs are derived by partially modifying existing products. It is very rare that completely new products need to be designed from scratch. If everything were new, it would be time- and cost-intensive. Therefore, in many cases, designers aim to use existing product data during the design process of a new product. Today, most mechanical designers use feature-based 3D modelling systems. In this system, new models can be easily created by modifying some constraints of existing models instead of completely redesigning them [9].

Based on this idea, it can be argued that such an approach could also be applied to CAM programming, thus partially automating the creation of certain technological operations when creating a new CAM program for similar parts. This would increase the productivity of creating CAM programs and reduce the time required to create a new CAM program for a similar part. The current state in the field of creating technological procedures for CNC machines is oriented either to the creation of CAM paths using various techniques [11], [12] or to the interconnection and integration of CAD/CAM/CAPP systems [13], [14], [15].

The article will compare the creation of technological operations based on certain similarities between two parts and then compare them in the CAM software SolidCAM, MasterCAM, and Fusion 360. The pairs of parts are created with dimensional similarities, meaning the features are the same but have different dimensions. Creating specific operations based on similarity can help accelerate the process of generating CAM programs for complex parts, meaning efficient creation of new programs in CAM software. This article aims to explain the principle and establish the foundation for further potential research in the area of automated CAM program generation. The research will be limited to a simple part, basic operations, and three CAM software programs.

In Fig. 1, you can see the dimensional differences between Part 1 (orange) and Part 2 (grey). To compare, two operations will be created: face milling and rough pocketing.

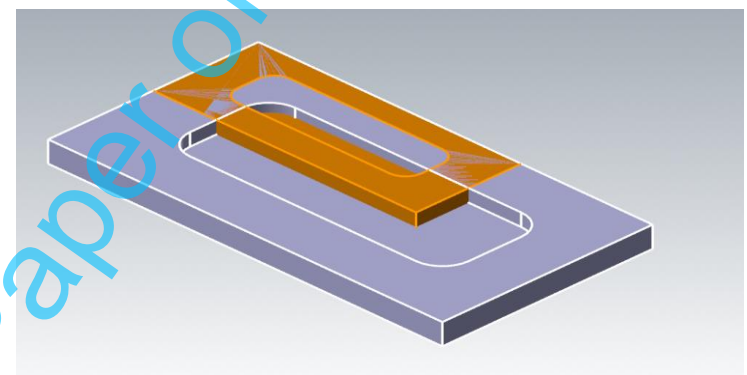


Fig. 1. Part 1 (orange) and Part 2 (grey)

The basic method of our research is analysis and similarity. In this contribution, we want to point out the possibility of applying the well-known technological statement: "Similar parts are produced by a similar technological procedure", which was presented by prominent personalities such as Prof. A.P. Sokolovskij and further developed by Prof. J. Békés. This rule was stated for the so-called conventional machining technologies. Our hypothesis is to apply this rule when designing technological procedures using CAM software. In the first step of our research (and in this post), we focused on the analysis of several CAM software, as offered by software tools for creating NC paths and how they fulfil the mentioned technological rule.

2. SolidCAM

The principle of creating operations based on similarity in SolidCAM is as follows. After creating the CAM program, it is necessary to create templates from the operations. When creating a new CAM program for a new part that is similar, the operations are created from these templates, where various parameters of the operations are already defined, and adjustments are made, such as the machining boundaries, machining depth, and so on.

For Part 1, operations were created, from which templates were generated, as shown in Fig. 2, where the operations 'Face Roughing' and 'Pocket Roughing' are displayed. In the face milling operation, all parameters remain the same, with only the face being adjusted. After all the preparatory steps, such as defining the zero point and the stock material, the CAM program creation follows. The process will differ from that of a new part because a template has been created, which will be used to generate the face milling operation.

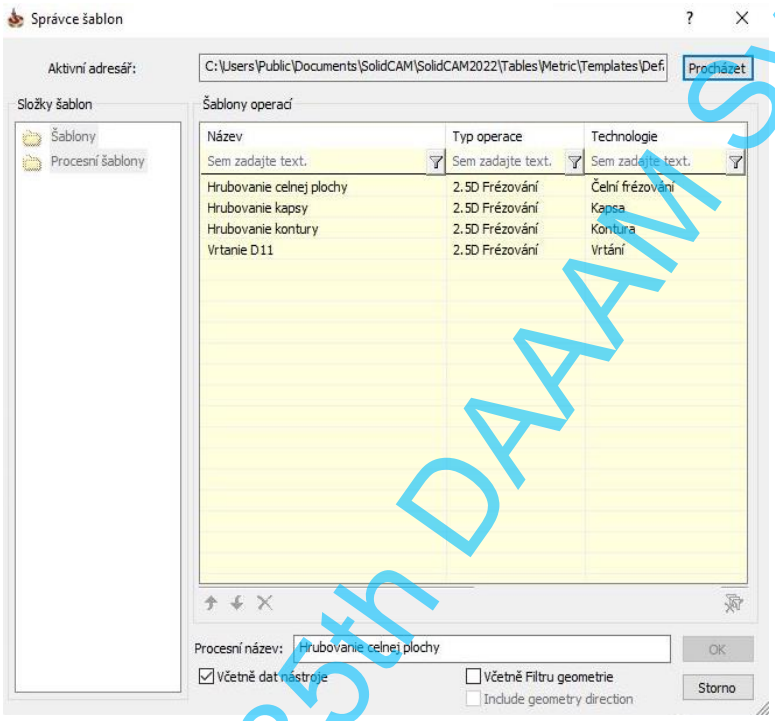


Fig. 2. Creation of a Template in SolidCAM

In Fig. 3, there is a dialogue box that appears after adding the template. In this window, as seen in Fig. 3, you can fill in parameters such as the machining curve or the Z coordinates for the surface and machining depth. For this operation, no additional input is needed, as the face milling operation takes the largest dimension of the part, meaning it is automatically calculated. The operation needs to be recalculated, and then the toolpaths are generated.

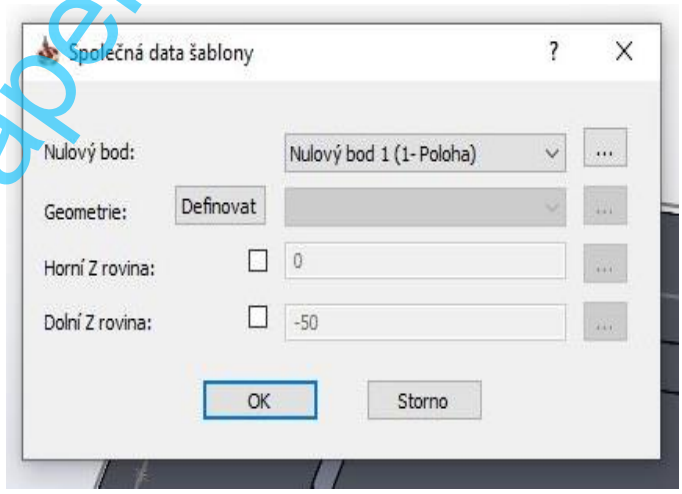


Fig. 3. Adding a Template in SolidCAM

For the pocket roughing operation, the procedure is the same. The change occurs when selecting a new curve, as shown in Fig. 4. In this operation, it is necessary to define a new machining curve in the dialogue box shown in Fig. 3.

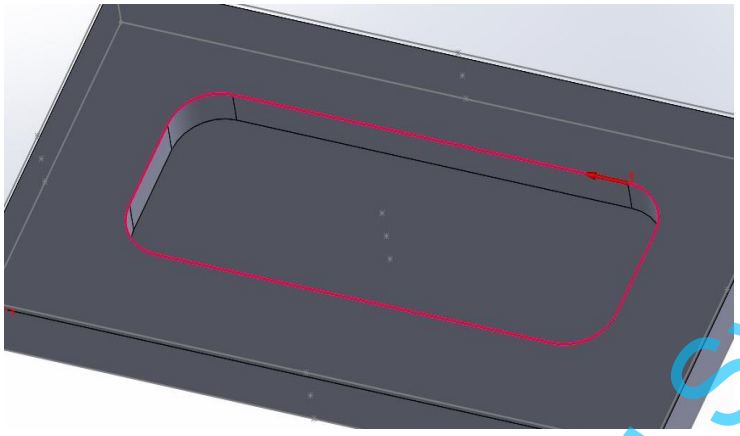


Fig. 4. Selecting the Machining Curve in SolidCAM

The surface coordinate remains the same, meaning that the thickness of Part 2 is the same as that of Part 1. The other difference is in the depth of this pocket. In the dialogue box, it is necessary to check the depth box, which will then highlight the box to the right with three dots. You need to click on this box and then select the pocket depth on the 3D model (red dot in Fig. 5), which represents the value Z-30 mm, as shown in Fig. 5.

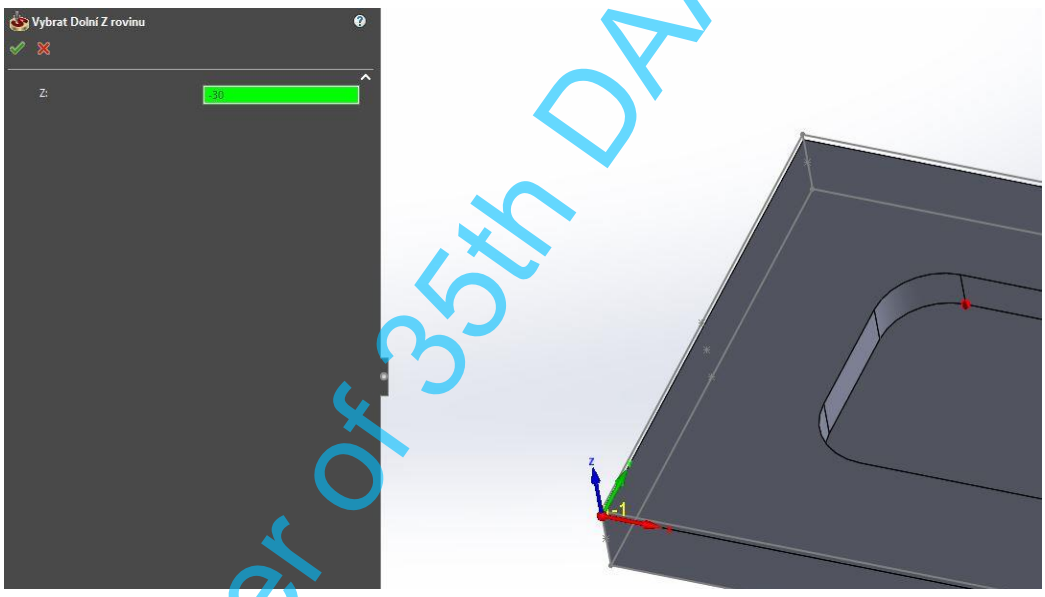


Fig. 5. Pocket Depth in SolidCAM

The next steps are the same as for the previous operation, which means recalculating the operation and then generating the toolpaths.

3. MasterCAM

The principle of creating operations based on similarity in MasterCAM differs from that in SolidCAM and Fusion 360. The principle is as follows: For simple 2D operations, most parameters remain the same for similar parts. In cases of dimensional similarity, the boundary curve, which defines the machining limits or machining depth, often changes.

After creating both operations for Part 1, Part 2 is inserted into the program. First, it is necessary to align Part 2 to one of the 4 corners, as shown in Fig. 1. Then, the stock for Part 2 is adjusted. The operations are still created for Part 1.

The face milling operation will be adjusted first. The tool remains the same, so there is no need to edit it. For the face milling operation, only the curve defining the area to be milled will be adjusted. Fig. 6 shows the selection of the new curve. The other parameters remain as defined for in Part 1. This operation is then regenerated, and the toolpaths are generated for Part 2.

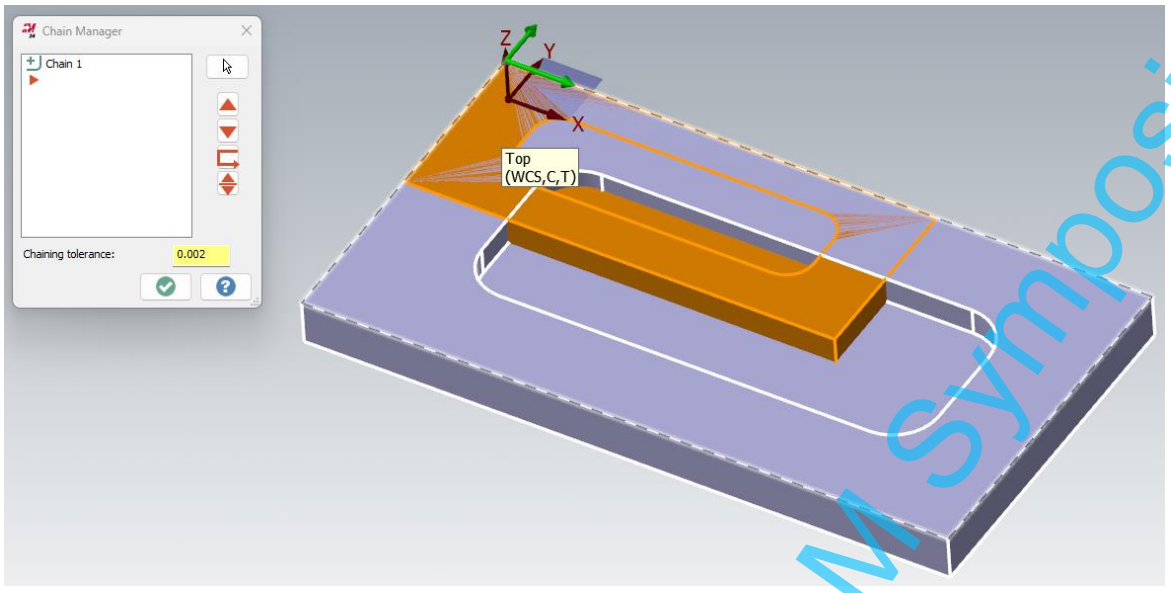


Fig. 6. Selecting the Curve in MasterCAM

The next operation to be adjusted is pocket milling. As with the previous operation, the tool and other parameters will remain the same as for Part 1, so no changes are necessary. A new machining boundary will be defined, similar to the previous operation, meaning a new curve will be marked. Another parameter that differs is the pocket depth. Fig. 7 shows the selection of the machining depth for Part 2. The pocket in Part 1 was milled to a depth of 20 mm. In the highlighted window, it can be seen that the pocket has a depth of 30 mm.

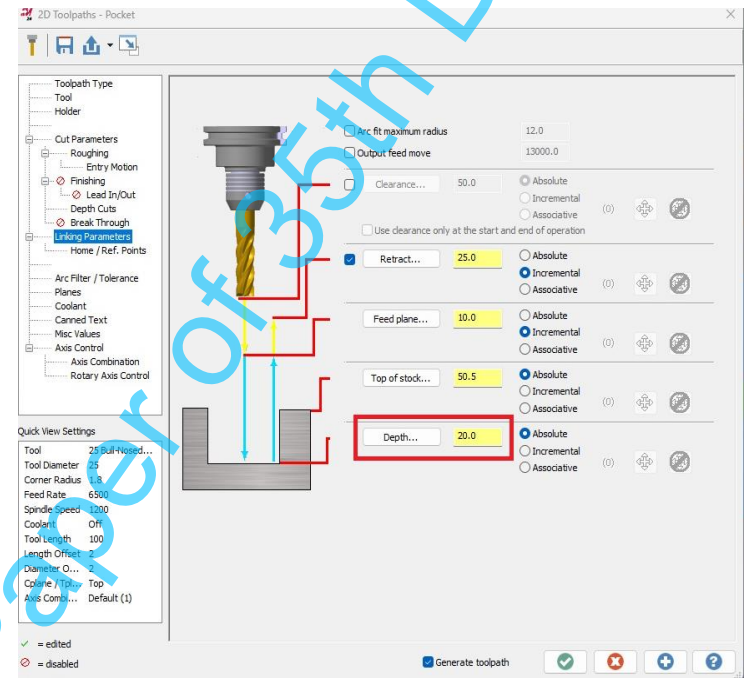
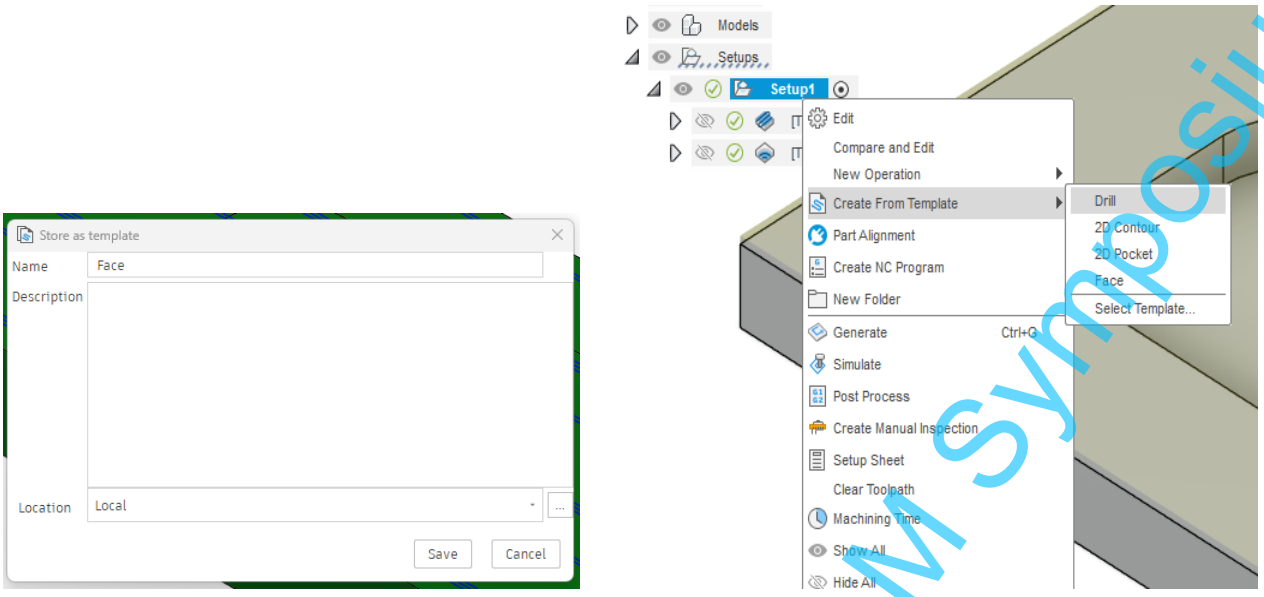


Fig. 7. Selecting the Machining Depth in MasterCAM

4. Fusion 360

The principle of creating operations based on similarity in Fusion 360 is similar to that in SolidCAM. This means that, just like in SolidCAM, after creating an operation for a representative part, it is necessary to create the operation as a template. Subsequently, when creating a new CAM program, the operation from the template is used. The same parameters of the operation remain unchanged, while some need to be adjusted. Fig. 8 a) shows an example of creating a template from an already created face milling operation.



a) b)

Fig. 8. Creating a Template and an Operation from a Template in Fusion 360
a) Creating a Template, b) Creating an Operation

Fig. 8 b) shows the path to access the created template and subsequently use it when creating a new CAM program. The face milling operation is then automatically recalculated, and the toolpaths are generated.

After adding the template for the pocket roughing operation, it is necessary to select a new machining curve, as shown in Fig. 9. In the next step, it is necessary to directly adjust the milling depth according to the 3D model.

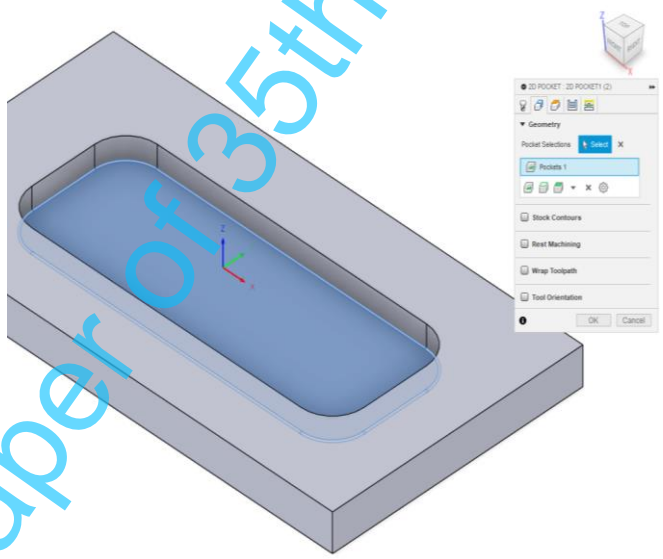


Fig. 9. Selecting the Curve in Fusion 360

5. Conclusion

The article summarizes the comparison of creating simple operations in CAM software. It can be stated that the process and principle of creating operations based on similarity are similar in SolidCAM and Fusion 360. In SolidCAM, an operation is first created for the initial part. This operation is then saved as a template. This template is used to create the operation for the second part, thus reducing the time required to create a similar operation. This means that the principle involves creating templates.

In MasterCAM, the procedure and principle are different. The process is somewhat more labour-intensive and manual, and the principle involves adjusting certain elements of the operations directly during operation editing.

The research identified the process that can be used for creating operations for a simple part based on similarity. Further research would be beneficial to continue comparing with more complex operations or to focus on a more complex part of one CAM software.

6. Acknowledgments

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