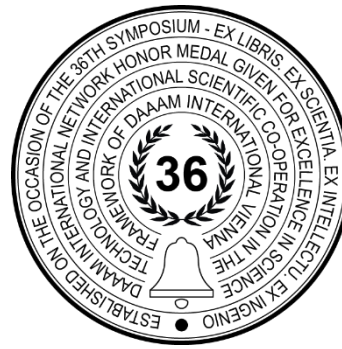


APPLICATION OF TEMPLATES IN A CAM SYSTEM FOR GEOMETRICALLY SIMILAR COMPONENTS

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Abstract

The paper addresses the application of templates in CAM systems for the development of technological operations on geometrically similar components. The introduction outlines the potential of templates as a tool for standardisation and acceleration of the programming process in environments such as Fusion 360 and SolidCAM. Subsequently, the procedure for creating templates from individual operations and their application in the machining of further similar components is described. The study demonstrates that, given sufficient similarity of parts, templates enable a significant reduction in production preparation time and the elimination of repetitive steps. The findings confirm that the principal advantages of templates lie in repeatability and efficiency, while their limitation may arise from restricted applicability to components or stock of differing geometries.

Keywords: CAM; template; geometric similarity; technological similarity

1. Introduction

Research in the field of CAM technologies has historically focused on a variety of topics, such as surface quality achieved using copy tools in CAM milling [1], [2], [3] or ground tools [4], the influence of different CAM strategies [5], wear of copy tools used in CAM [6], issues related to multi-axis milling [7], [8], and the application of additional energy sources, such as ultrasonic-assisted CAM machining [9], [10].

Contemporary CAM (Computer-Aided Manufacturing) systems no longer limit themselves to the generation of toolpaths alone but increasingly offer capabilities for process standardisation and automation. One of the tools that supports this trend is templates. In practice, templates allow proven machining settings to be saved and reused—such as tool definitions, feed rates, speeds, or entire sequences of operations [11], [12].

The advantage of this approach is that a CNC programmer does not need to repeat the same steps for every new workpiece. Instead, a prepared template is loaded, which sets the fundamental parameters and provides a consistent, verified workflow. This reduces production preparation time, minimises the risk of errors, and improves both the quality and reproducibility of results [13], [14].

The use of templates has been adopted in several professional solutions: Fusion 360 supports rapid application of CAM workflows through saved setups [13]; SolidCAM distinguishes between “operation templates” and more complex “process templates” [12]; and Siemens NX provides Manufacturing Templates to initialise the entire manufacturing process [14]. Further research indicates that systematic use of templates—such as the Automatic CAM Programming Using Machining Templates (ACPUT) methodology—can lead to significant time and cost savings in the creation of manufacturing programs [15].

An article published by Tebis presents the experience of a user implementing CAD templates with direct integration into CAM processes. The main idea is that all critical parameters—from workpiece geometry through orientation to fixturing—can be prepared directly in the CAD environment. These parameters are then automatically transferred to the CAM module, eliminating the need for repeated data entry. The author emphasises that this approach significantly accelerates programming, reduces errors, and increases consistency of manufacturing procedures, highlighting the importance of templates as a tool for automation and more efficient CAD–CAM integration [16].

An article published by Bantam Tools focuses on the use of CAM templates in Fusion 360 as a means of streamlining CNC programming. The author reports that template implementation allows standardisation of the machining operation creation process, resulting in higher productivity and a reduction in programming errors [13]. The described procedure involves multiple steps: first, a prepared CAM template is imported into Fusion 360; next, a new setup is created defining the workpiece parameters, and a specific template is selected. The template automatically predefines the technological parameters of machining, such as cut depth or feed rate. Users, however, can adjust these settings to meet specific requirements. The outcome is an NC program in the form of G-code, ready to be sent to the CNC machine [13].

From a practical perspective, the article emphasises that using CAM templates in Fusion 360 contributes to the acceleration and standardisation of the manufacturing process, while simultaneously reducing the likelihood of errors during the configuration of individual operations [13]. A contribution from the Autodesk University conference focuses on optimising repetitive workflows using templates in a CAM environment. The authors present a methodology for identifying the most frequently performed operations and subsequently creating templates to automate them. This approach reduces the time required to prepare NC programs and increases the uniformity of the resulting processes. The text highlights the benefits of templates, particularly for industrial enterprises handling large volumes of similar components and seeking to accelerate production preparation [11].

The official Siemens website introduces Solid Edge CAM Pro, which includes built-in templates designed to streamline the programming of machining operations. The software emphasises an intuitive interface and modularity, while templates simplify parameter setting and standardise repetitive procedures. The text highlights that the use of templates reduces operational complexity, speeds up NC code generation, and contributes to more accurate and stable production [17].

Based on previous research, it has been found that the process of creating operations based on similarity is very similar in both SolidCAM and Fusion 360. Initially, an operation is created for the first part and then saved as a template. This template is subsequently applied when creating operations for additional parts, significantly reducing the time required to prepare similar operations. The fundamental principle is therefore the use of templates [18]. Figure 1 shows Part 1. Machining operations for this part will be created using templates, which will then be applied to Parts 2 and 3. For clarity, surfaces/features that are similar (or different) are highlighted in red. The potential application of templates will be examined on the surfaces marked in red.

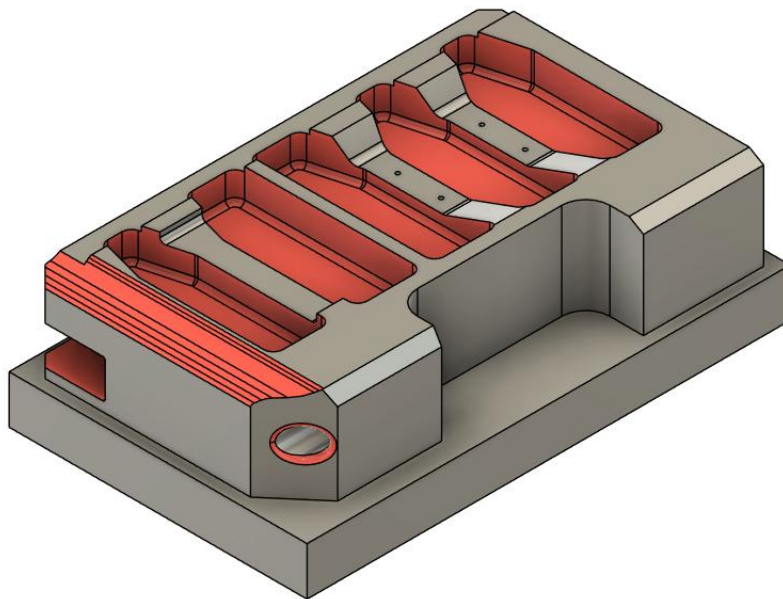


Fig. 1. Part 1

Figures 2 and 3 show similar components on which the application, advantages, and limitations of templates will be investigated across five different types of operations in the CAD/CAM software Fusion 360. In this study, it is not necessary to consider the machine, fixturing, workpiece material, cutting parameters, machining time, or other such factors, as they do not influence the aspects under investigation. Conversely, attention must be paid to the strategy employed, the tool diameter and type, and the stock material prior to milling. These parameters are critical for the creation of templates for the respective operations.

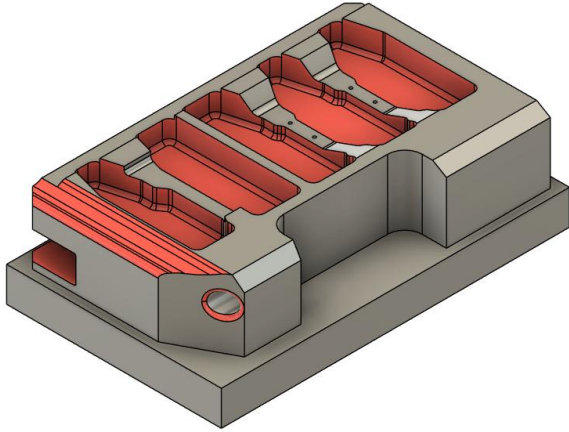


Fig. 2. Part 2

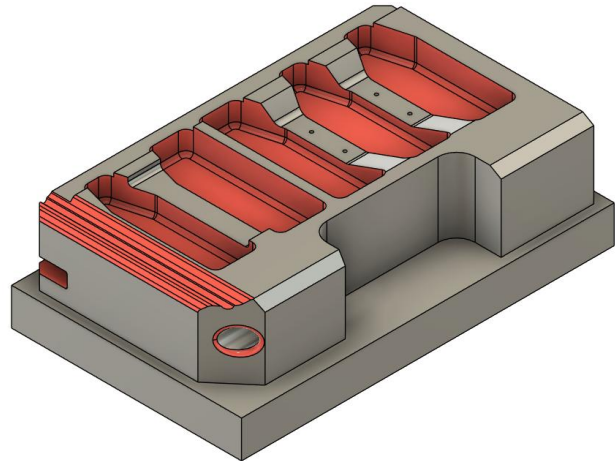


Fig. 3. Part 3

2. Creation of templates from operations

In this section, the basic operations for milling the sample component will be created. The stock for roughing the pockets from above includes a 5 mm allowance on the walls and the bottom, as illustrated in Figure 4 (the stock is shown in green). This operation accounts for these allowances, thereby eliminating air milling. The operation for roughing the pocket walls from above is performed using dynamic milling along the full length of the tool's cutting edge. A solid tool with a 16 mm diameter will be used. The machining boundaries are defined by five curves representing the pocket walls, selected directly from the model. The milling depth is set to reach the start of the corner radius at the bottom (i.e., 60 mm), and the radial step-over of the tool is set to 1.6 mm.

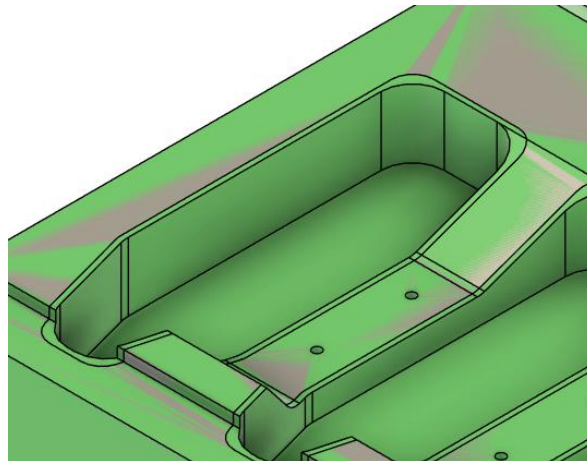


Fig. 4. Stock for the pockets from above

The operation for milling the pocket bottoms and R10 radii is performed as 3D roughing, taking into account the stock and the previous operation. A high-feed tool with a 25 mm diameter will be used, with an axial step-down of 0.6 mm and a radial step-over of 15 mm for bottom milling. The machining boundaries are identical to the previous operation, defined by the five curves representing the pocket walls. The milling depth extends from the start of the radius to the flat bottom of the pocket (i.e., 10 mm). Figure 5 shows the stock for the contoured surface. Next, the contoured surface on the model will be milled. A 1 mm allowance is applied to this surface, following its shape. The selected operation accounts for the stock and previous operations, and therefore only the contoured surface will be machined. The contoured surface will be finished using a 20 mm diameter ball-end mill, with a downward step of 0.3 mm. Toolpaths will be generated from one side to the other in both directions.

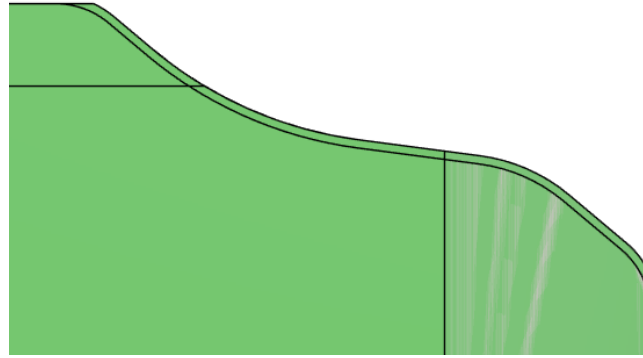


Fig. 5. Stock for the contoured surface

The stock for the fillet is defined by the previously drilled D55 hole (Figure 6). The R10 fillet on the D55 hole is finished using a 20 mm diameter ball-end mill. The downward step is set to 0.3 mm, and the toolpaths are generated in a top-down spiral.

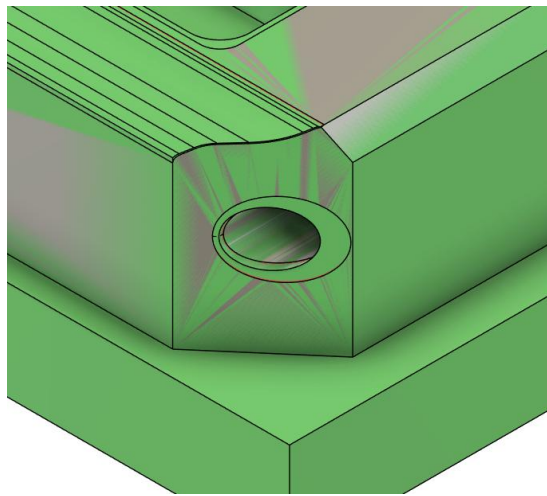


Fig. 6. Stock for the R10 fillet on the D55 hole

Figure 7 shows the stock for the slot. The operation will be created using a 2D contour. This operation does not take the stock or previous operations into account, but instead follows the defined curve. A high-feed mill with a 52 mm diameter will be used, with an axial step of 0.8 mm.

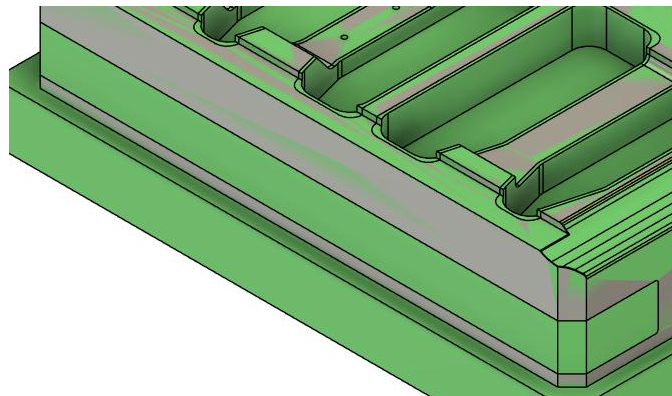


Fig. 7. Stock for the slot

After creating the program, templates will be generated from each operation. By right-clicking on a created operation, a menu will expand, providing the option “Save as Template” (Figure 8a). Upon selecting this option, a pop-up window appears, as shown in Figure 8b, where the template name is entered and the folder in which the template will be saved is specified. Clicking “Save” stores the template, and this process is repeated for all operations.

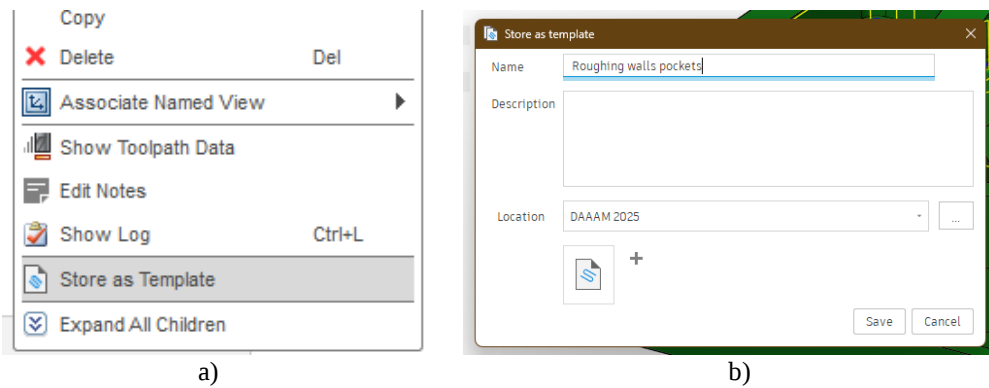


Fig. 8. a) List of options, b) Saving the template

Next, in the template library (Figure 9), the operations are selected sequentially, and any necessary minor adjustments are made. Adding a template to a new CAM program involves selecting the desired operation and then clicking the corresponding icon (indicated by the red arrow), which adds the operation to the operation tree.

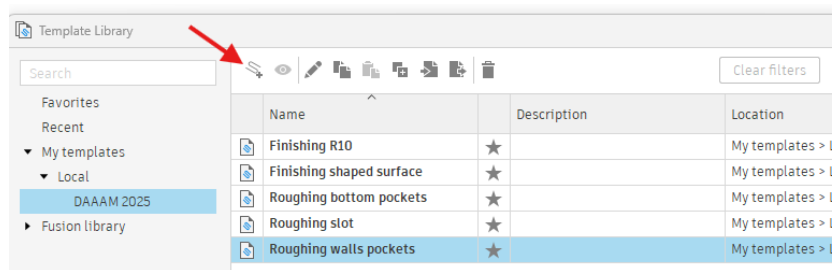


Fig. 9. Template Library

3. Creating a Program for Part 2 Using Templates

Compared to Part 1, the differences are as follows. The pockets have a different shape, while the depth and stock remain the same. The contoured surface has a different profile. The side hole has a diameter of D60, a different position, and the fillet on the wall is at a different angle. The dimensions of the front slot are unchanged. For the operations “Roughing Walls Pockets,” “Roughing Bottom Pockets,” “Finishing Shaped Surface,” and “Roughing Slot,” it is necessary to adjust and select new machining curves according to the Part 2 model. In the “Finishing R10” operation, the new fillet surface on the D60 hole must be selected. Figure 10 shows an example comparison of the machining curves for the “Roughing Walls Pockets” operation. In this way, all operations are updated.

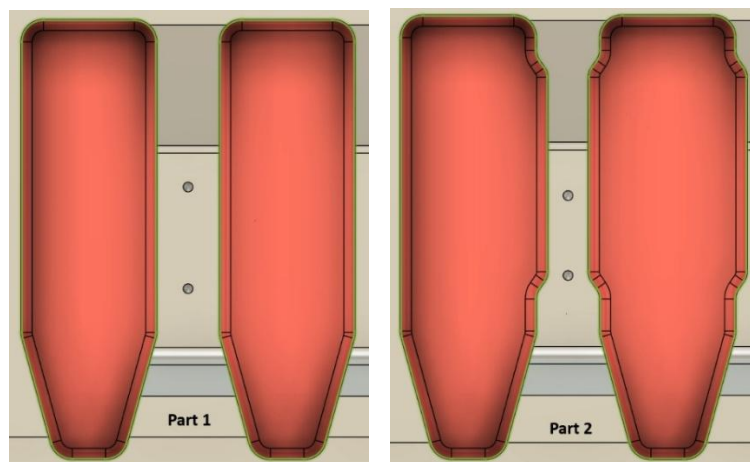


Fig. 10. Comparison of Pocket Machining Curves for Part 1 and Part 2

In each of the operations created using templates, the same tools, operation parameters (radial and axial step-over), machining planes (rapid, safe, top, and bottom), as well as entry, transition, and exit paths, are used. All these parameters are identical to those in Part 1.

For Part 2, it was possible to apply a template to each operation, and after adjusting the machining curves and surfaces, the operations were fully functional. Although the pockets have a different shape, the stock principle remains the same, and therefore the machining allowances are identical. The contoured surface has a different profile, but the machining principle remains unchanged, allowing the template to be used for this operation as well. Although there are several differences in the R10 fillet on the side hole, these do not affect the functionality or applicability of the template, so it can also be used in this case. A comparison of these two operations is shown in Figure 11. The front slot is completely identical to that in Part 1. The advantage of using templates lies in the speed of creating the operations. This approach eliminates certain repetitive tasks and saves time for operations that require more careful consideration. As seen in this case, it is necessary that the components are similar. Likewise, the operation created using the template must be correctly designed, as any errors would be replicated across subsequent components.

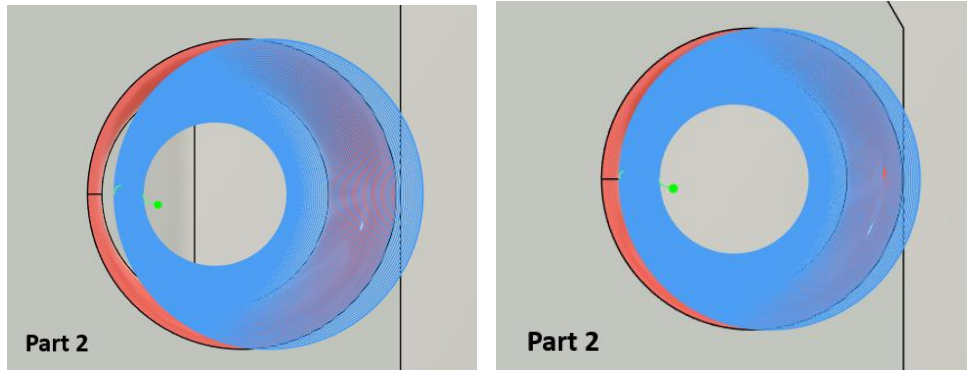


Fig. 11. Comparison of Toolpaths for the Fillet in Part 1 and Part 2

4. Creating a Program for Part 3 Using Templates

Compared to Part 1, the differences are as follows. The pockets have the same shape and depth, but the stock is different; in this case, the stock is solid. The contoured surface has a different profile. The side hole and fillet are identical, while the dimensions of the front slot differ.

In the “Roughing Walls Pockets” operation, it is possible to use a template; however, the stock from which the machining originates in Part 1 is different. In Part 1, a 5 mm allowance on the walls and bottom is considered, so only this remaining material is machined, whereas in Part 3 machining starts from solid material. A comparison of the stock for this operation is shown in Figure 12 (stock is shown in green). The template was functional when inserted into the program, but in this case, it would be advisable to consider whether a more efficient machining strategy could be employed. Therefore, it can be stated that, although the template is functional, it is not suitable from a technological process perspective, as a different stock is involved compared to Part 1.

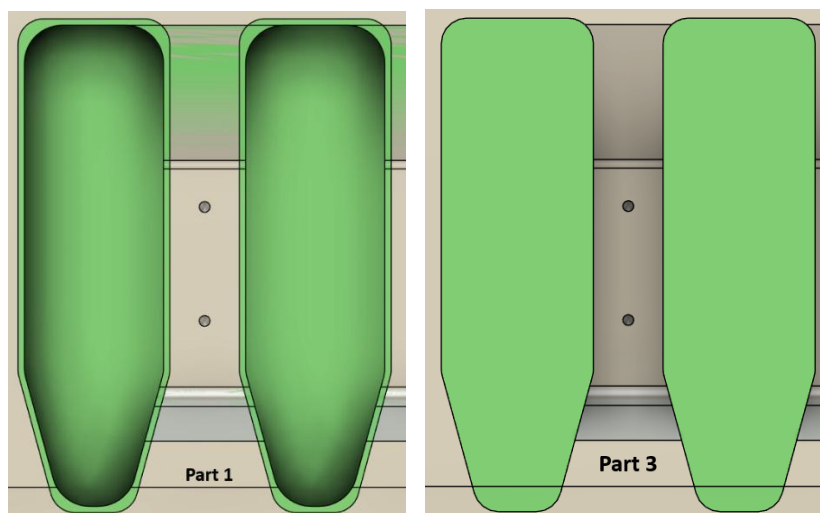


Fig. 12. Comparison of Pocket Machining Stock for Part 1 and Part 3

Figure 13 shows a comparison of the machined contoured surface for Part 1 and Part 3. A template was also used to create the “Finishing Shaped Surface” operation. In Figure 13 (left, shown in green), the entire machined contoured surface can be seen. In Figure 13 (right), certain areas of the surface (shown in white) remain unmachined.

In this case, the tool cannot reach these areas because the tool diameter is too large. Therefore, it is not advisable to use the template to create this operation, as the operation is not fully functional and does not machine the entire surface.

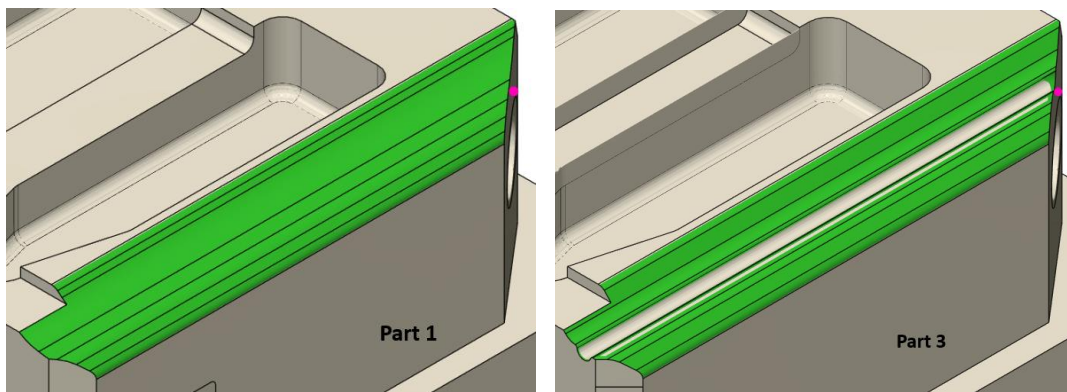


Fig. 13. Comparison of Machined Contoured Surface for Part 1 and Part 3

Figure 14 shows that the width of the front slot differs, being narrower in Part 3 compared to Part 1. It was not possible to use the template because the slot is smaller, and a 52 mm diameter tool is too large to machine the slot. This means that, in this case, the template cannot be used to create the operation.



Fig. 14. Comparison of the Front Slot for Part 1 and Part 3

5. Conclusion

The conducted research confirmed that the use of templates in CAM programming enables faster and more standardised creation of operations for geometrically similar components. The results obtained in Fusion 360 demonstrated that the reuse of properly designed templates allows the CAM programmer to eliminate repetitive tasks and achieve a high level of process repeatability. Compared to manual programming, the preparation time of operations was significantly reduced. The study further showed that the functionality of templates strongly depends on the degree of geometric and technological similarity of the parts. While in the case of the second component all operations created using templates were fully functional, certain limitations were observed for the third component due to differences in the stock material. These findings are consistent with the conclusions of Kowalski et al., who also emphasised that the efficiency of automatic CAM programming based on templates rapidly decreases when the required level of similarity is not achieved. In comparison with the observations of Bantam Tools and Autodesk University, which focused primarily on increasing productivity through automation, this study extends the discussion by identifying specific situations where template-based programming no longer provides advantages. Similarly, as pointed out by Tebis and Siemens, who highlight the importance of integrating data between CAD and CAM, the results of this work underline the necessity of evaluating the technological context — particularly the stock definition, tool accessibility, and strategy compatibility — before applying templates.

The research question — to what extent can templates be effectively applied in CAM systems for geometrically similar components — has been answered by confirming that templates are highly effective when geometric similarity, machining strategy, and technological context remain consistent. Conversely, when greater deviations occur, templates lose their functionality and require manual adjustments. In conclusion, templates represent a valuable tool for improving repeatability, quality, and time efficiency in CAM programming. Their correct use, however, requires careful evaluation of geometric similarity and machining conditions. A potential next step could involve examining a more complex component in terms of template applicability, as well as analysing the technological process of such a component directly within the CAM software environment.

6. Acknowledgments

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