35th International Conference
on Production Engineering

# ICPE 2013

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Faculty of Mechanical and Civil Engineering in Kraljevo

# ANALYSIS OF MACHINING STRATEGIES USING COMMERCIAL CAD/CAM SOFTWARE

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***Abstract:*** *The choice of CAD/CAM software has a profound effect on efficiency, and therefore cost of production. Commercial CAD/CAM softwares have possibility to choose of machining strategies. The paper presents the analysis of the strategy of machining of the same part to define criteria by which to be exercised in selecting the most most adequately optimization strategy and a comparison of a given software with previous versions.*

***Key words****: CNC machining*

## 1. INTRODUCTION

Machine parts with free form surfaces often appear in the engineering practice as a result of functional and aesthetic requirements. The machining of such parts is mostly done by milling. Precision and surface quality and productivity mainly depends of tool path which designed the main task of CNC machining. Due to the increasing competition in the market, it is crucial reduced processing time and cost without sacrificing the quality of the machine part. Machining of the free form surfaces is timed and expensive process, and the process of finishing may represent up to 75% of the total cost of machining. In the case of this machining it is necessarily use a CAD/CAM software how to the surface defined analytically, on the ground that generate the appropriate tool path. As one of the criteria for the selection of machining strategies might be cutting forces, with the aim for minimizing the machining time without violate required tolerances and quality of machined parts. Special attention represent machining with ball mills. Ball mill is not the best choice because they are changing the machining parameters, and there are times when the cutting speed is zero, which is reflected in the cutting process and surface quality [4].

Fig. 1 shows the 3D models of the parts on which examples will make an analysis of the election strategy of machining. To create CAD models and to create NC code it is used a software package Creo Parametric 2.0. The upper part is used for analytes machining strategy, while the other two used for comparison with the previous version of the software. The analysis includes only 3–axial machining.

## 2. DEFINING THE PROBLEM

If we analyze the geometry of the parts, and taking into account that the machining performed ball mill is easy to see where the problems occur, or that places can not be machined. In fact, if the want to machined a sharp edge at that location will remain the fillet radius of the cutter. For convenience this is shown on Fig. 2 where we have shown details which can be occurs an machining error. Detail marked with A can not be machined with cutter larger than 10 mm because the holes diameter is equal 10 mm, and detail marked B is unable to machining with ball mill.

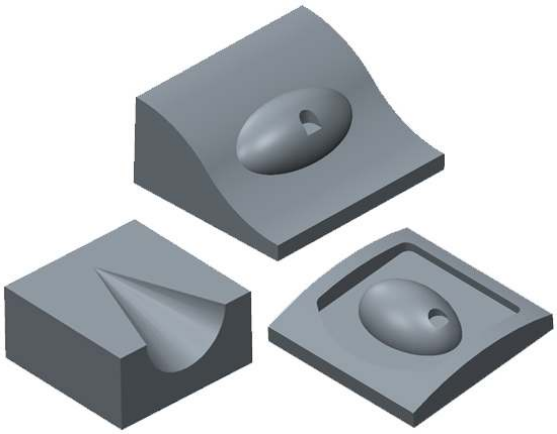


*Fig. 1. 3D models of parts that are used for analysis of strategy selection process*

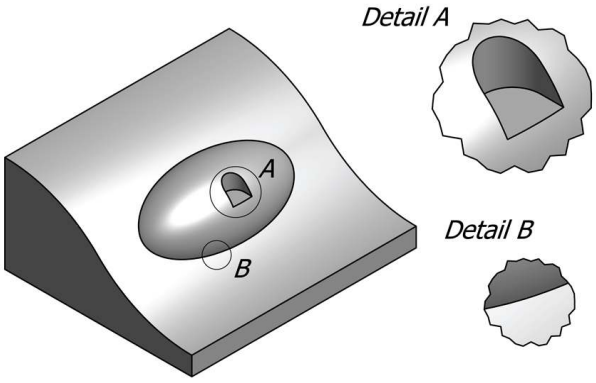


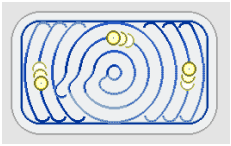
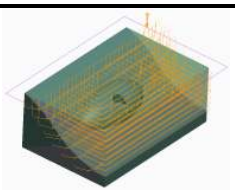
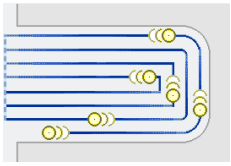
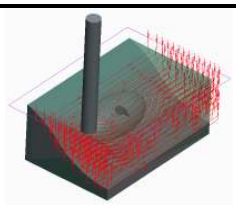
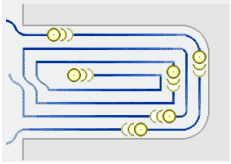
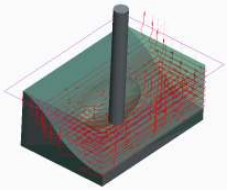
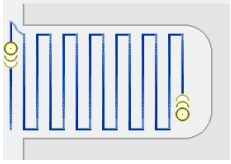
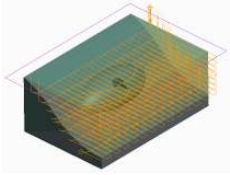
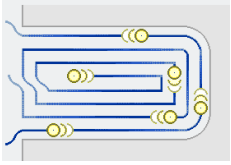
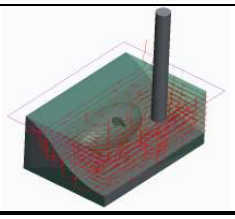
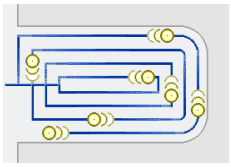
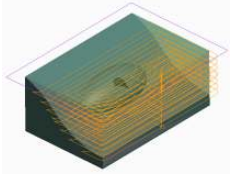

*Fig. 2. Places that can not be machined with chosen tool and strategy.*

As the problem is defined, it is now to analyse capabilities of the chosen CAM software. There will be variations of machining strategy and also the tool diameter. It is necessary to mention that is not impossible to machining given part as required, but it's suggested analysis of ball mill and 3–axial machining so that the analysis is limited to this case of machining.

## 3. ANALYSIS OF MACHINING STRATEGY

Here is an analysis of the strategy of machining for machine part from Fig. 2, using the software package Creo Parametric 2.0. Given software has a choice of machining strategies, such as volume milling, trajectory milling, rounghing, surface milling, holemaking, etc. For a start will be made rounghing that will work by end mill with 12mm diameter with diferent machining strategies. Table 1 shows the different machining strategies with drawings of scan type and machining times. Parameters for this analysis was: cut feed 80mm/min, step over 5mm, max_step_depth 5mm, spindle_speed 1000 o/min. Appendix for finishing was 0.5 mm.

*Table 1. Variation of roughing strategies*

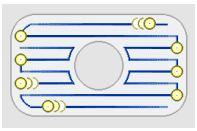
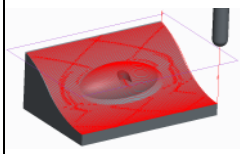
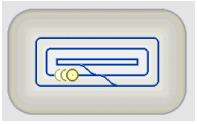
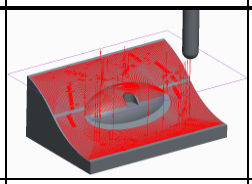
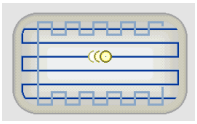
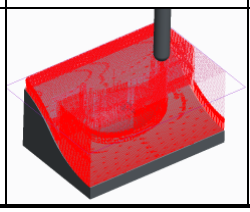
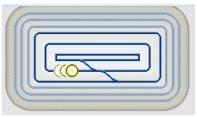
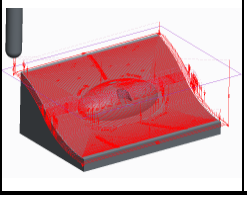
| N$^0$ | Scan type | Toolpath | Time [min] | N$^0$ | Scan type | Toolpath | Time [min] |
|---|---|---|---|---|---|---|---|
| 1 |  constant_load |  | 263.65 | 4 |  follow_contour |  | 285.52 |
| 2 |  maintain_cut_dir |  | 143.87 | 5 |  type_3 |  | 177.60 |
| 3 |  maintain_cut_type |  | 146.73 | 6 |  type_spiral |  | 149.77 |

Based on the data from Table 1 can be clearly seen that with the same tool and cutting parameters, we obtain different machining times for different machining strategies. Analyzing the roughting of machine part can be concluded.

- Selecting the strategy of constant cutting force (N$^0$1) obtained greater machining time.
- Selection strategy follow_contuour (N$^0$4) get something smaller machining time, but higher than the minimum time because the tool after one pass must be drawn to the retract planeand after that must further re-pass the contour.
- Also, the choice of strategy type_3 (N$^0$5) where cutter movement is parallel to a plane of the coordinate system of the machine gets bigger machining time than minimum time. because after the tool pass of mentioned planes tool must eventually pass the whole contour.
- The shortest machining time is obtained by selecting a strategy maintain_cut_dir (N$^0$2) that follows the cut direction where no case as in the previous strategy that the tool finally pass the whole contour because he did it in the first pass.
- The other two strategies (N$^0$3 and N$^0$6) provide a bit larger machining time than the minimum time.

For fine machining strategy it is used a method of SURFACE MILLING (N$^0$1) and the FINISHING (N$^0$2–4) with a variation of machining strategies. The results are shown in Table 2 where can see the tool path obtained with processing times. Parameters for this analysis was: cut feed 80mm/min, step over 0.5mm, spindle_speed 1200 o/min. The tool was in all cases ball mill with 10mm diameter.
Looking at the results shown in Table 2 may be conclude the following: Depending on what's the criteria for machining, that is what we claim as our objective. If for example the request is the minimum machining time would then be chosen strategies numbered N$^0$1. The difference between this strategy and the other three (N$^0$2–4) is that because surface miling strategy requires hand-selected area that we want to machining, while in the finishing strategy overhang software to calculate the tool path based on defined mill window. Choice of strategy surface milling in parts with many surfaces can lead to difficulties for manual selecting surfaces that we want to machining.

*Table 2. Variation of finishing strategies*

| N⁰ | Scan type | Toolpath | Time [min] | N⁰ | Scan type | Toolpath | Time [min] |
|---|---|---|---|---|---|---|---|
| 1 |  type_3 |  | 241.88 | 3 |  shallow_cuts |  | 241.34 |
| 2 |  straight_cuts |  | 975.22 | 4 |  combined_cuts |  | 393.7 |

## 4. COMPARISON WITH PREVIOUS SOFTWARE VERSION

Analyzing machining of the remaining two parts from Figure 1, which is described in [3] can be concluded: new version of the software allows selection strategy shown in Figure 3, in which the main machining time gets 54.92min which is less than the previous strategy described in [3] for the same machining parameters, which is shown in Table 3.

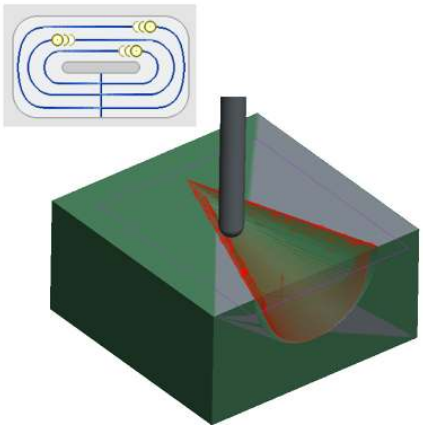
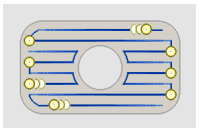
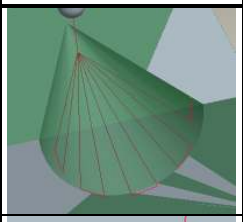
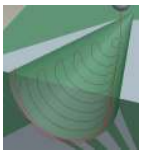
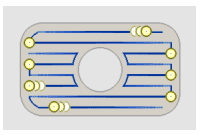
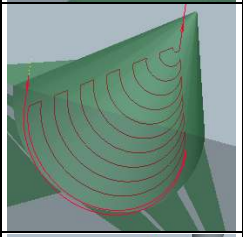
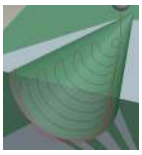
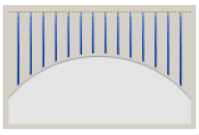
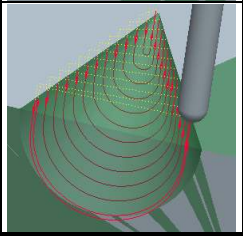


*Fig. 3. The machining strategy and obtained tool path.*

*Table 3. Variation of finishing strategies for part two*

| N⁰ | Scan type | Toolpath | Time [min] | N⁰ | Scan type | Toolpath | Time [min] |
|---|---|---|---|---|---|---|---|
| 1 |  |  | 69.9 | 4 | |  | 55.1 |
| 2 |  |  | 55.4 | 5 | |  | 65.3 |
| 3 |  |  | 129.72 | | | | |

The difference between the strategy $N^0$4 were was used cutter 10mm diameter, and in strategy $N^0$5 cutter 6mm diameter and therefore is greater machining time because the tool diameter is smaller so it takes more time to pass the whole contour. For all strategies parameters was: cut feed 100mm/min, step over 0.5mm, spindle_speed 1000 o/min.
Based on the analysis of machining strategies applied to the third part from Figure 1 has not been a strategy with shorter machining time which was described in [3].

## *5.* CONCLUSION

The paper presents analysis possibilities of CAD/CAM software on the example of machininh three parts. It was analyzed the rough and fine machining. Based on the results of the simulation process, it was concluded that the choice of machining strategy significantly affect the precision of production, and the total machining time. In the selection strategy was necessary to choose a strategy in which the tool does not occur to "cut air" because it increases the total machining time. They are also given different machining times for the tools movement in different directions. When talking about the choice of tools should be noted that this choice greatly affects the precision of machining which implies a degree of match of machined part with predefined etalon, in this case the 3D model. That the greater match is achieved by using a cutter with smaller diameter which leads to a reduction in machining parameters, and therefore increase the total machining time. Therefore it is necessary to analyze part and wherever possible choose a cutter with larger diameter. It should be noted that some disadvantages described in the paper can be avoided by using 5–axis machining.

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[4] T. Chen, S. Zhiliang, A tool path generation strategy for three-axis ball-end milling of free-form surfaces, Journal of Materials Processing Technology, Vol. 208, 1–3, 2008, pp. 259-263

[5] http://creo.ptc.com/