Design for manufacturing using TEBIS CAM software for milling processing

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Abstract. Complex parts require specific processing. Computer aided manufacturing solutions make their mark and optimize the manufacturing process. Different CAM software’s have different philosophy with different capabilities. TEBIS CAM software brings more facilities and opportunities to manufacturing a complex part. In the paper was presented this capability on real part. It was made the comparison between two different milling strategies: one classical milling strategy- Contour parallel strategy, versus adaptive milling strategy. Was presented the way how was implement the TEBIS CAM software and the results of manufacturing. The time of manufacturing was significantly reduced with 43% using the adaptive milling strategy and the surface accuracy was improved.

1. Introduction

When starting to create a NC technology, one must make an analysis of the input data’s: the CAD model, (materials, technical drawing), the technical characteristics of the CNC machine-tools, the cutting tools, fixtures, in relation to the final goal: accuracy, functionality, time of manufacturing, costs. After that, one must define the technological process: defining the fixtures of the raw part, the operations and the technological phases, the cutting tools parameters, the control systems [1].

![Figure 1. The CNC technological workflow.](Image)
Next step will be the implementation of the workflow in the design, manufacturing and documentation (see figure 1). Sure every CAM, software have somethings what is dedicate for them, something’s that is specific to him, with his advantages and disadvantages.

These details make these CAM programs to be dedicated to some processing and, of course, have some advantages over each other [2].

In this paper it was emphasized the advantages of the TEBIS CAM software with tests and the conclusions what was done after a real test.

2. State of the art

TEBIS is able to provide interfaces to all the common CAD systems (CATIA, SOLID WORKS, NX, CREO, INVENTOR). The powerful connections ensure a smooth, two-way and extremely reliable data transfer. Depending on the format, you can transfer both geometric and structural data, including assemblies and layers.

The TEBIS CAM program interfaces can do:

- Import graphic representation - meshes and boundary curves
- Import structure information - assembly
- Import geometry representations (surfaces, curves, auxiliary elements)
- Import tolerance and notation information
- Export geometry (surfaces, curves, auxiliary elements) in CATIA V5 format

TEBIS provides a seamless, single-window integration and full associatively to the CAD design model. All machining operations are defined, calculated and verified, without leaving the CAD window. With TEBIS CAM-Software, is possible to turn parts built with CAD into G Code for any CNC-Machine.

The big advantages that will give us the TEBIS CAM software are the technological solutions:

- Manufacturing-related CAD preparation functions
- Complete manufacturing knowledge can be stored in the CAM software
- End-to-end programming across all manufacturing types
- High-efficiency roughing
- Outstanding surface qualities
- Long tool life
- Roughing and semi finishing at high feed rates
- The right postprocessors for all types of machines, including robots
- Collision-checked complete programs for simple and complex parts for all 2.5D, 3D turning and 5-axis machining operations
- Optimal machine utilization

The great advantage with TEBIS computer aided manufacturing software:

Because the actual contour of the tool is used for programming, milling areas up to the residual stock are precisely calculated. The real tools can be represented one-to-one in the virtual tool library.

In the paper was analyzed: high-efficiency roughing, roughing and semi finishing at high feed rates and the optimal machine utilization parameters.

In roughing, as much material as possible must be machined as quickly as possible. The entire cutter is often in contact. Therefore, TEBIS uses a variety of options for full-cut handling and for full-cut avoidance. In full-cut handling, feed rates are automatically reduced, or full-cut areas are machined trochoidal.

In full-cut avoidance – so-called adaptive roughing – the path layout is automatically adapted to the geometry without full cuts. Adaptive roughing strategies are especially well suited to components with many cavities. Hard materials can also be machined very effectively using these methods.

In the conventional strategies, tool contact width plays a significant role in the feed rate of the components to be milled. Full-width cuts often cannot be avoided despite constant stepover relative to
the component. The contact load on the tool during material removal increases, especially at edges and on inside contours.

2.1. Contour parallel strategy
Toolpath calculation with the contour parallel strategy can create discontinuous (kinked) toolpaths with critical loads on the tool (figure 2).

![Figure 2. Contour parallel strategy.](image)

![Figure 3. Adaptive strategy.](image)

2.2. Adaptive strategy
The adaptive strategy attempts to specifically correct these discontinuous paths and to achieve maximum tool utilization in material removal using the specified maximum contact (figure 3). The adaptive strategy was specially developed to achieve the greatest tool utilization in material removal without critical loads [3].

![Figure 4. The adaptive milling strategy applied on the test part.](image)

This strategy calculates optimum values for a smooth path that does not exceed the previously specified value of parameter R maximum contact. In particular, complete wrapping of the tool is avoided. This enables utilization of the entire cutting-edge length of the tool without exceeding the loading limits.
A significant advantage of this strategy, in addition to the much higher cutting rate, is the extended tool service life this was the reason to choose adaptive milling strategy (figure 4).

Adaptive roughing strategies can be used to remove large quantities of material in a very short time. But fast machining relies on many factors.

The best way to machine a part depends on the specific geometry, the material and the available tools and machines. This is present in figure 5, where the depth of every teeth was divided in two parts. Technology parameters like cutting data and feed rates must be precisely adjusted to the machining operation.

![Image](a) ![Image](b)

**Figure 5.** The roughing strategy used, a) the upper part of the teeth and b) modality how was generated the inferior surface of the teeth

In this paper it was used another option of the software named “Integrated re-roughing”. This supplemental option "Re-roughing upwards" enables re-machining of residual stock areas from bottom to top with no problems at a lower depth of cut [4].

Another very useful milling strategy what was applied, and test was the “Equidistant strategy”. The “Equidistant strategy” generates NC paths with constant 3D step, the generated milling paths maintain the same distance even in steep surface areas (figure 6).

![Image](a) ![Image](b)

**Figure 6.** The “Equidistant strategy” milling strategy.

Due to the constant 3D step, a high surface quality can be obtained with a single milling process, even in steep areas of the component. Stress on the cutter is reduced [5].

The power of the CAM software is important and the utility of them in multiply the hard work and to elimination of tiring work and the laborious mathematical calculation.

For example, for surface finishing was used a ball mill cutting tool, diameter six mm with two teeth and to obtain a good accuracy was made a step over by 0.2 mm (see figure 7).
3. Conclusions

After the tests we conclude that adaptive milling strategy is much more productive with, the quality of the surface is much better and the cutting tool live was increase. In figure 8 was presented a comparison between the manufacturing time.

![Figure 8. Manufacturing time with contour parallel 2h: 53 min, and time of manufacturing with adaptive strategy is 1h: 41min.](image)

In figure 9 is presented the quantity of the removal chip.

All this information's confirm us that the adaptive milling strategy is much more efficiently who bring more benefits and advantages in comparison with the classical method of manufacturing: cycle time for contour parallel strategy was 2h: 53min and with adaptive strategy it was obtain 1h: 41 min.
The accuracy is significantly better, by adaptive milling strategy it was obtained $R_a = 0.24$ µm in comparison with contour parallel strategy where it was obtained $R_a = 1.97$ µm.

![Figure 9. The chip volume diagram (cm$^3$/min) 13.92 cm$^3$/min-contour parallel and 58.25 cm$^3$/min-adaptive strategy.](image)

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