Classical and Modern Methods of Manufacturing on CNC Milling Centers

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Abstract. The milling operation is widely used and the results are directly influenced by the milling strategies adopted. The paper presents two processing methods: one classical and one actual, both methods with wide industrial applications. Was made the comparison of these methods in manufacturing, are presented the results that were obtained on a real application. Knowing the milling processes, the new strategies developed by the CAM software, bring more substantial results and efficiency in manufacturing process.

1. Introduction

More milling strategies was developed by the Computer Aided Manufacturing (CAM) software's with the target to reduce the time of manufacturing and to upgrade the surface quality.

Some of this new milling strategies are:

1.1. "Helical Finish"

The Helical Milling strategy is especially useful for milling all around steep cavities or cores, especially in manufacturing the electrodes. (Fig.1)

The benefits using this strategy are: higher surface quality and a shorter machining time when we have more complicate surfaces to manufacturing. (Fig. 2)

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Figure 1 Helical Finish

Figure 2 5X Multi-Blade
1.2. "5X Multi-Blade"
5X Multi-Blade milling strategy is a dedicate application for programming of multi-blade parts for aerospace area, and is recommend for 5X-continuous milling applications for: roughing, finish floor and finish walls. (Fig.2)
The benefits of this milling strategy are:
- Fast and simple programming
- Safe, high quality tool path
- Finish surface quality

1.3. "Prevent waterfall"
New capabilities for better results when machining near a surface’s edge:

![Figure 3. Prevent waterfall strategy](image)

Air extension is smooth and have a natural extension of the tool path outside the part in all directions. (Fig.3)
The benefits are: extensions, along path, extra passes.

1.4. Rough "VoluMill"
Is a new strategy for ultra high volume removal and generate high speed machining (HSM) all-rounded tool-path to maintain constant material removal rate.
This milling strategy consider updated stock, take in consideration the holder of the cutting tools and is execute between layers.

![Figure 4. "VoluMill" strategy](image)
2. State of art
Regarding the "Volumill" strategy (Fig.4) in the article was presented the comparison with the classical milling method - "Z constant" milling strategy.

Was manufacturing one part with a geometry not so complicated but with some sharp shapes with narrow channels and with sudden changes of direction (Fig.5)

![Figure 5. The part what was manufacturing](image)

The NC programs were generated by the CAM software who use the cutting tools parameters what was recommended by the cutting tool catalogue.

The raw part is made from steel C45 with the dimensions 100 x 100 x 50 mm and the thickness what will be manufacturing is 5 mm and was use one end mill cutting tools 10 mm diameter with four teeth.

2.1. Constant Z milling strategy
The thickness (15 mm) was divided in 3 constant passes, so the $a_p$ will be 5 mm and the radial engagement will be 60% from the cutting tool diameter: $a_e=6$ mm. Starting with this technical informations we will have:

![Figure 6. Axial and radial engagements](image)
The cutting speed of the tool will be $V_c = 135 \text{ m/min}$ and the feed per tooth is $f_z = 0.027 \text{ mm/tooth}$, and we will use cooling liquid. (Fig.7)

The trajectory of the cutting tool is present in (Fig.8)

In Fig.9 we can see the chip that is around the cutting tool what affect the life of the cutting tool and the surface quality of the part.
2.2. The Volumill strategy
The same raw part was manufacturing with "Volumill strategy". Now all the thickness 15mm will be manufacturing in one single pass: \( a_p = 15 \) mm and the radial engagement is \( 10\% / D_c \). The value is \( a_e = 1 \) mm. (Fig.10)

![Image of the Volumill strategy interface](image1)

**Figure 10.** Axial and radial engagement

The radial engagement is small, the cutting tools trajectory are tangents, the chip volume is minimal so will be possible to use higher cutting parameters: spindle speed 9708 rpm. and the feed per tooth is 0.1 mm (Fig. 11).

![Image of the cutting tool parameters and processing time](image2)

**Figure 11.** The cutting tool parameters and the processing time
The cutting tool is very short time in contact with the material, the heating transfer is very low, so isn't necessary to use cooling - the chips are not coloured. (Fig.13.)

**Figure** 12. The cutting tool trajectories in CAM

**Figure** 13. The cutting tool and the chips

3. **Conclusions**

After the tests we conclude that "Volumill" is much more productive, the quality of the surface is much better and the cutting tool live was increase.

**Figure** 14. The manufacturing time

**Figure** 15. The chip volume diagram

The time of manufacturing using the "Z constant" strategy was 9 minutes and 13 seconds (Fig.14) in comparison with "Volumill" strategy when was 4 minutes and 31 seconds and the quantities of the chips evacuation is three times more. (Fig.15) This experimental test data's show us a high productivity and using the all highest cutting parameters of the tool demonstrate the productivity of this new "Volumill" milling strategy.

4. **References**

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