DEDICATED CNC MILLING STRATEGIES FOR COMPLEX SURFACES

Assoc. Prof. Ph.D. Eng. Adrian BUT[1], [1]Politehnica University of Timisoara, Mechanical Faculty, Materials andManufacturing Engineering Department, ROMANIA, adrian.but@upt.ro
Eng.Cristian POPESCU [2], EVOPART Company, Timisoara, ROMANIA, cristian.popescu@evopart.ro
Lect. Ph.D. Eng Lucian GAL[3] AUREL VLAICU" University of Arad, ROMANIA, lucian.gal@gmail.com

Abstract:*The parts for the aerospace sector are complex, varied models, with above average hardness, heat treated, resistant to humidity and variable stress. Comparison the "old planes "with the "new planes", we saw the dramatically reducing the aluminium components and was replace with more components from titanium. This mean that we have high cutting temperature in manufacturing area, high stress close to the edge, tendency to deflection of the cutting tools, adhesion, and welding materials on the cutting edge.*
To control all these negative influences, we need dedicated cutting tools, with high cutting parameters and innovative milling strategies.
The paper presents applications and processing solutions of some components from the aerospace sector, with advanced processing strategies, with the advantages and specific cases analysed.

Keywords: CNC machine tools, CAM applications

1. Introduction

To manufacturing parts in aerospace sector requires advanced CNC machines tool, high-performance cutting tools, versatile clamping systems, innovative processing strategies.

Here, the interconnection between these factors is capital, and each component contributes to manufacturing the complex part and to obtaining high accuracy.

Knowing in detail the influence of these factors and the interconnections between them, lead to the desired results. It is specified that if one of them does not exist or is not treated correspondingly, the performance of the piece will be affected.

2. The state of art

Therefore, five-axis machining centers are used to process a part with a single clamping, essential for obtaining high precision requirements. (Fig 1.)

The advantages of processing on these types of machines are:

- Possibility to machine several sides of a shape while reducing the number of manipulations of raw material
- Ability to machine complex shapes without compromising the manufacturing time
- Use of shorter tools allow a more precise machining and surface finishing improved
- Increased productivity

Possible use of new machining strategies [2]

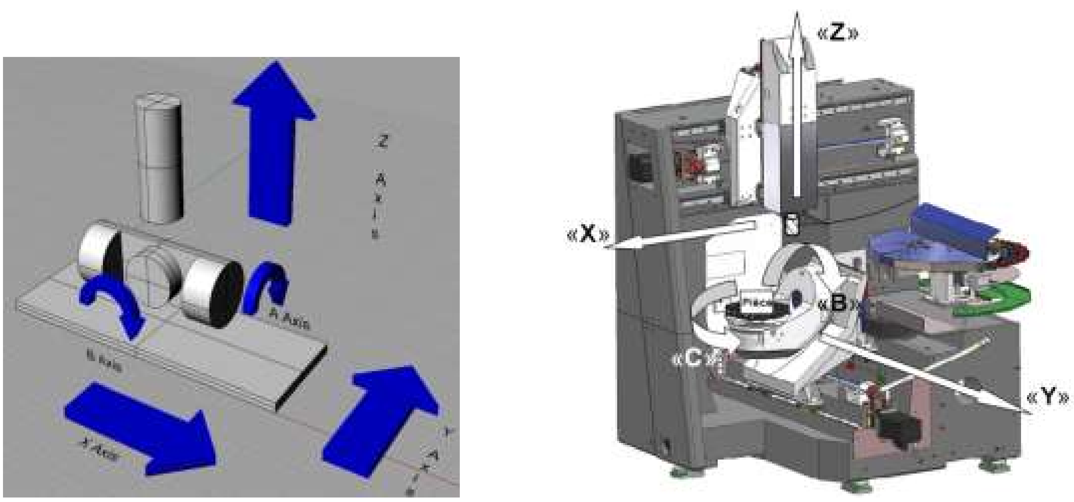


Fig. 1 Five axis machine tools

The present paper comes with the confirmation and practical validation of some of the newest and most efficient processing strategies.

These are:

1. High depth of cut
2. Finish profiling
3. Thin wall

3. Dynamic Milling

Is a relative new milling strategies where the axial depth of cut is very high -could be the same as the all the cutting length of the tool, and a very small radial depth 10-20% of a end mill cutting tool.[3]. In different CAM software's have different name: Dynamic milling in MASTERCAM-software, Volumill in CIMATRON software, I-machining-in SOLIDCAM software. Ideal for prismatic parts and complex 3D. Uses the principle of trochoidal machining. (Fig. 2)

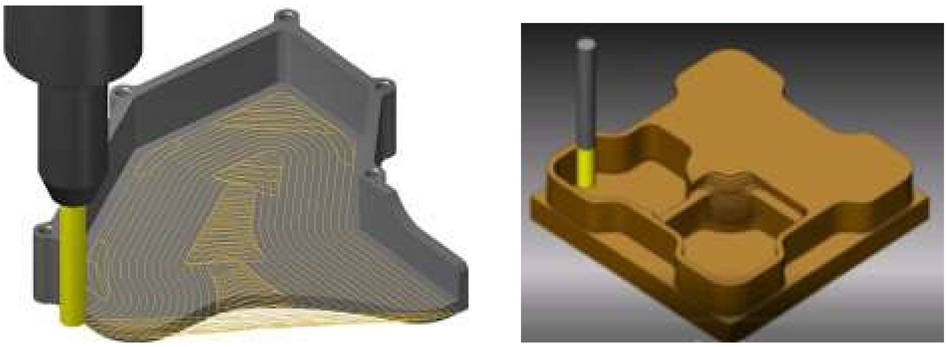


Fig. 2. Dynamic milling

Using this milling strategy, the milling machines are more productive than ever:

Companies increase their performance up to 200% on average and up to 400% in maximum.

-Maintain life tool time.
-Strong grip axial passes.
-Speed ahead.

-Preserve machine axes.
-It can be used with any material, including the hardest metals.

4. Finish profiling

Finishing can be split into the following categories 2D finishing using the flank of the end mill to generate the profile - large depths of cut can be taken [5].

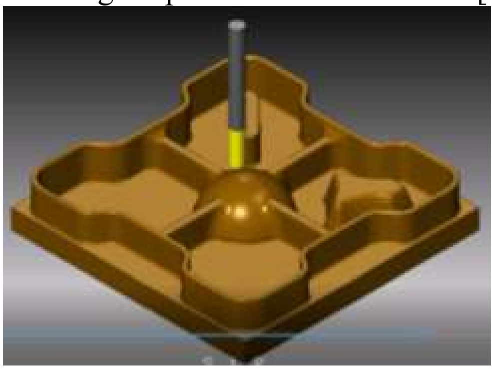


Fig.3. 3D finishing

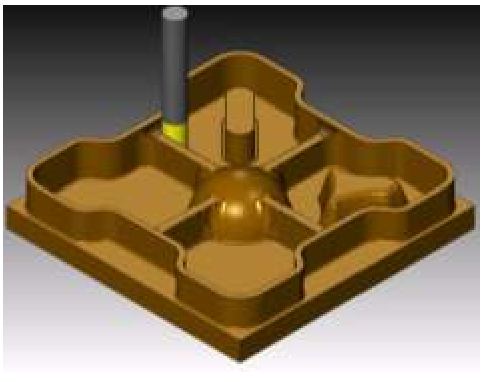
3D finishing(Fig.3):
- the component form is generated with successive passes to produce the profile using the radius on the end mill – ball or bull nose;
- small stepovers are taken to scan the surface making this the most time consuming method

5. Thin wall and Thin base

This milling strategies are often used in aerospace frame structural parts. (Fig. 4, Fig 5)

5.1Thin wall (Fig. 4)

- Limit radial cut a_e to 20% D_c
- Max a_p 100% D_c.
- Large programming radii to prevent increase in arc of engagement in corners.
- Finish both sides same time with stepover[8]
-



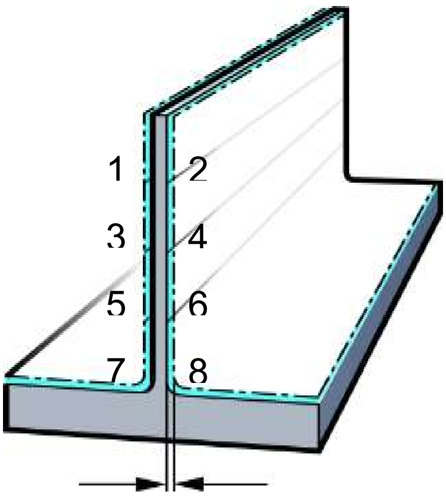


Fig. 4. Thin wall

• Chip formation effects the direction of the cutting forces

1.climb milling - pulling the material

2.conventional milling - pushing the material

• In practical terms, conventional milling will normally have the tendency of cutting undersize whereas climb milling leaves more material on.

5.2 Thin base (Fig.5)

Take in consideration that the weight restrictions on new aircraft, the base of the pockets is becoming ever thinner.

When the floor of the pocket becomes less than 1:30 of the pocket width or length careful selection of cutter and strategy is required [7].

Part clamped in vice - unsupported base when machining 2nd side

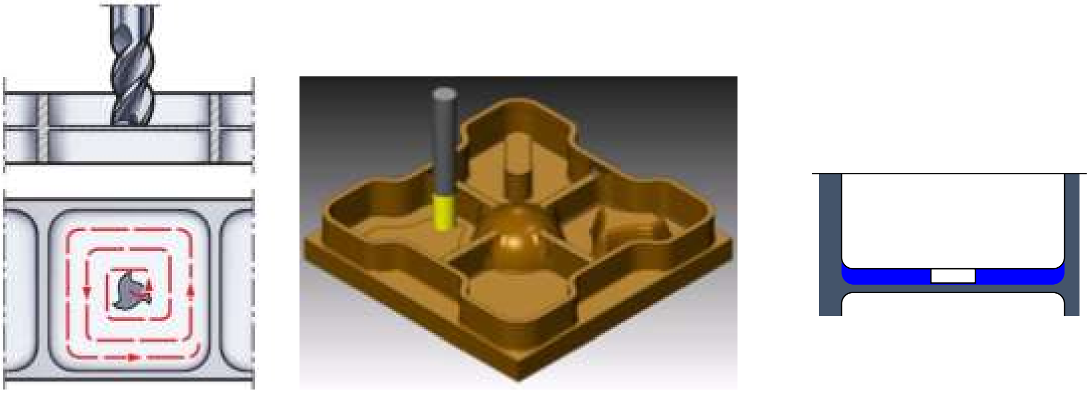


Fig. 5 Thin base

Here could be different milling strategies:

Strategy 1

Indexible inserts – high finishing allowance

4 mm finishing depth to keep base stable.

Spiral morph programming for constant arc of engagement

Strategy 2

• increased finishing depth to keep base stable.
• multiple radial pocket stages
• semi-finishing - Indexible insert.
• finish - monobloc

Fig 6.The part after roughing

The finishing operations regarding sphere in the middle part, was made with one ball nose 12 millimeters diameter milling tool. The direction of trajectories was perpendicular on the trajectories generate with the tool in the "Z constant "strategy. This take a lot of time, but the accuracy in aerospace area is important and the "3D Finishing" milling strategy is often use in many applications.

6.Conclusions:

In the paper was analized a complex part with more aerospace manufacturing applications. The part was divided in four modules (Fig.7).

Fig.7 The final part with the four modules what was analysed.

Was analyse the time manufacturing of the first two modules (1) and (2) (Fig.7. The part from right size (1) was manufacturing with "Z constant "milling strategy and the time of manufacturing was 9 minutes and 13 seconds. (Fig.8.a) The left size, module (2) identical with module (1), was manufacturing with dynamic milling strategy and the time of manufacturing was 4 minutes and 31 seconds. (Fig 8a). Was underline the significant reducing manufacturing time. In (Fig 8.b.) was presented the chip volume diagram.

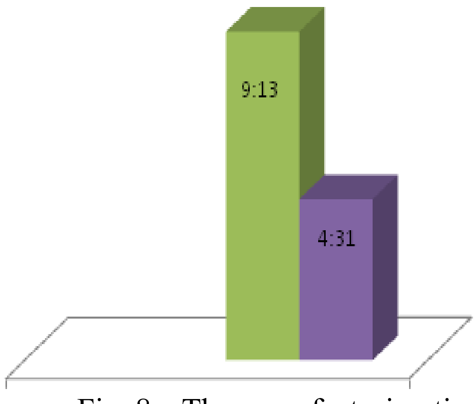


Fig. 8a. The manufacturing time

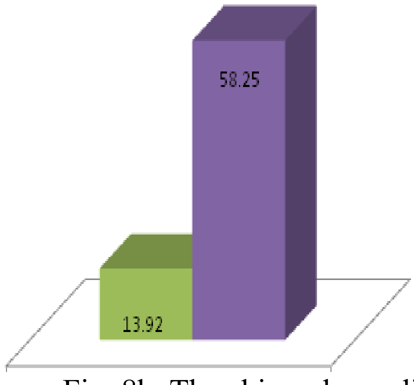


Fig. 8b. The chip volume diagram

Green colour – "Z contour" milling strategy Violet colour -Dynamic milling strategy

In Fig. 9 was presented two "print screens" from the CAM software with the cutting tools parameters: spindle speed n= 9708 rpm, feed per tooth fz =0.1 mm/min, a_p =25 mm and the Volume ill strategy with the time of manufacturing 4 minutes and 31 seconds.

In (Fig. 9) was presented two “print screens” from the CAM software with the cutting tools parameters.

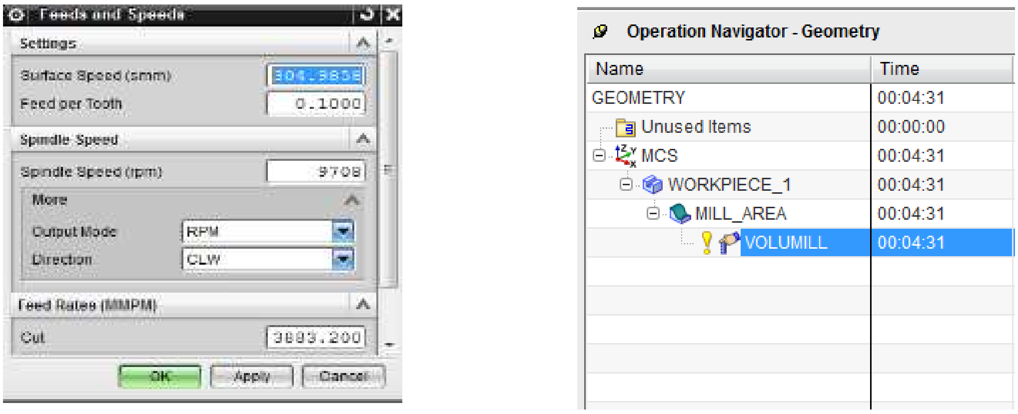


Fig. 9. The cutting tool parameters and the processing time

Regarding the manufacturing of the “thin walls” (Fig.4), was applied the special strategies to manufacturing alternative both sides like in the Fig. 5 to do not have the deformation of the wall. About the “thin base” area was applied the Strategy nr. 2 (Fig. 6) where the finishing surface was made with a monobloc end mill 10 millimetres diameter with 4 flutes cutter tools and the quality, or the part was increase (Fig .7).

The threading operation presented was made with a special tool who replace three cutting tools: drilling, milling and chamfering tools. In this case was used the milling threading operation to underline the steps to manufacturing this three threading’s. - module (3). Take in consideration the supplementary cost of this new threading tools was tested the advantages and disadvantages of this operation.

In module (4) was study the “3D finishing profile”. The roughing area was manufacturing with “trochoidal” milling strategy [8] and the final profile was finished with the “ball nose” milling cutting tools who finished the sphere. Was tested the time of manufacturing, the cutting tool parameters. All this results from module (3) and (4) will be presented on details in another research paper.

References:

[1]. Adrian **BUT** - *Machines and advance manufacturing sistems*, Editura POLITEHNICA Timisoara.- 111 p. ISBN: 978-973-625-949-4

[2]. **KENNETH** R.- WRIGHT-CNC MILLING & TURNING www.cnceducationalservices.com

[3]. What Dynamic Milling can do for you, https://www.canadianmetalworking.com/article/management/what-dynamic-milling-can-do-for-you

[4]. CNC pocket milling, https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/CNC_pocket_milling.html

[5]. *Metal Cutting Technology* Technical guide

[6]. *** *SPINWORKS* -Pokolm cutting tools catalog- 2016

[7]. *** “*Productive Milling Solution*” SANDVIK Coromant

[8]. *** *Training Handbook Metal Cutting Technology* -SANDVIK Coromant