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PREDNOSTI VISOKO PRODUKTIVNIH PROCESA OBRADE (CAM/HSM) PREZENTIRANI PRIMJEROM PROIZVODNJE ISPUNJAVANJU JEZGRE-PLOČA ZA KUĆIŠTE BUŠILICE
THE ADVANTAGES OF HIGHLY PRODUCTIVE MACHINING PROCESSES (CAM/HSM) REPRESENTED THROUGH THE PRODUCTION OF THE INFUSING CORE-PLATE FOR DRILL HOUSING

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Sažetak: *Suvremeni dizajn, posebno za proizvode za masovnu primjenu, postaju sve više sofisticirani što značajno otežava izradu alata za proizvodnju njihovih komponenti. Životni vijek takvih proizvoda stalno se smanjuje, što ograničava vrijeme razvoja i izgradnje alat. Osim toga, veća produktivnost, uža tolerancijska polja proizvodnosti, veći broj radnih sati do kvara, te smanjenje potrošnje energije traže se od alata, što dovodi do pojma konkurentnog inženjerstva. Kako bi se proizvodio alat u najkraćem roku, potrebno je koristiti suvremene obradne procese. Suvremene strategije, koje vode do maksimalne produktivnosti, poznate su kao HSM - High Speed Machining proces [3]. U ovom radu, HSM predstavlja strojnu obradu sa brzinom rezanja (oko* 1800 m/min*), i visokim brojevima okretaja (do* 40.000 o/min*), velika brzina pomoćnih kretanja i plića dubina reza. Ova tehnologija korištena je u procesu proizvodnje i ispunjavanju jezgrene-ploče (Aluminijska slitina) za smještaj akumulatora bušenja u okviru programa SolidWorks i programskog modula za stvaranje konačnog programskog koda za SolidCam upravljanje CNC strojem.*

Ključne riječi:
- natjecateljsko inženjerstvo
- obrada pri visokim brzinama
- ispunjavanje jezgre-kućišta
- SolidWorks/SolidCAM

Abstract: *Contemporary design, especially of products for mass application, becomes more sophisticated which significantly complicates the construction of tools for production of their components. The life span of such products is constantly decreasing, which limits the period of time for tool development and construction. Additionally, higher productivity, narrower production field tolerance, higher number of working hours until failure and reduction of energy consumption are required from the tools, leading to the notion of competitive engineering. In order to produce a tool for the shortest time period, you need to use contemporary machining processes. Contemporary strategies, which lead to maximum productivity elevation, are known as HSM – High Speed Machining process [3]. In this work, HSM represents machining with cutting speed (about* 1800 m/min*), and high revolution numbers (up to* 40 000 RPM*), high speed of auxiliary movement and shallower cutting depth. This technology was used during the production process of infusing core-plate (Aluminum alloy) for the battery drill housing within the framework of SolidWorks program and its program module for creating of the final program code for CNC machine SolidCam management.*

Keywords:
- competitive engineering
- High Speed Machining, HSM
- infusing core-plate
- SolidWorks/SolidCAM

1. INTRODUCTION

The research of HSM highly productive machining processes states that these machining technologies produce machined surfaces of considerable quality and production accuracy. Exceeding critical cutting speed leads to changes in chip formation; where instead of plastic material-chip flowing, local material shearing-rupturing occurs. This reduces the amount of the heat generated in the cutting area. Namely, 98 % of the amount of the heat generated is eliminated through chips leaving the machining object and tool cold. The coldness directly affects the quality of the machined surface and narrows the production field tolerance. Basically, the machining process occurs out of the area of vibration (Figure 1). [3]

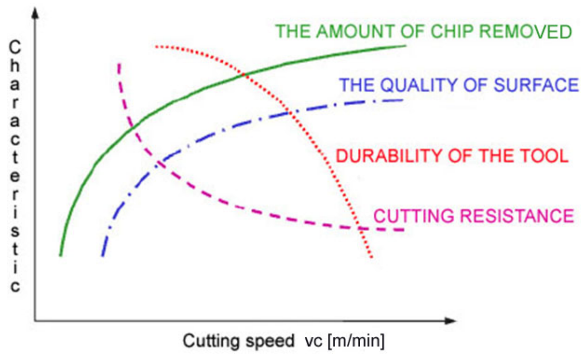

Figure 1. Characteristics of High Speed Machining HSM

2. PLANNING OF MACHINING TECHNOLOGY IN SolidCAM MODULE

2.1. Advantages of HSM machining

The high cutting speed enables the increase of auxiliary movement speed up to 10 times. The possibility of machining with tools of smaller diameter of shallower cutting depth and milling width achieves considerably higher productivity. In addition, machining with shallower cutting depth and working with small diameter milling cutters enables the elimination of semifinal machining, i.e. enables the elimination of certain super-fine machining processes (grinding, smoothing …), with a final machining process. The elimination of additional grinding and smoothing preserves the geometry of the . basic CAD model. The resistance occurring during cutting is reduced at higher speeds, at the same time the clamping force with which the object is held is also reduced. This enables the machining of a thin-walled object with higher precision. In the case of high hardness materials, the need for electro-scouring is eliminated. HS strategies according to 3-axis milling strategies allow the selection of parameters such as ways of entry and exit tools from the material, smoothes the path at the point of the sharp change of direction and eliminates air-cutting.

2.2. Disadvantages of HSM machining

High cutting speeds call for higher maintenance costs, especially with high speed spindle. The total energy consumption is elevated. The work recess due to high productivity considerably influences the production costs elevation.

2.3. Properties of the machine, tools and technical properties of modeling plate

As the preparation object for infusing core-plate for drill housing we used modeling plate – SikaBlock ®M160 (Table 1), tested for controlling the program designed for 4-axis CNC milling machine HAAS VF-4 type. The model also served for design-analysis study, because the exterior housing of the drill is in question, for which appearance is crucial.

Table 1. Technical properties of modeling plate SikaBlock® M160

Physical characteristics (approximate values)			
Sika Block® M160			
Density	ISO 845	g/cm³	0.16
Strength in bending	ISO 178	MPa	3.6
Jung modules	ISO 604	Mpa	70
Compressive strength	ISO 178	Mpa	2.3
Temperature range of application		ºC	– 80 do +130
Coefficient of linear thermal expansion	DIN 53 752	K^{-1}	60e-006

The HAAS VF-4 CNC milling machine provides an MS revolution speed of 10000 ^{o}/min (spindle speed =10000 ^{o}/min), speed of auxiliary movement of 3000 mm/min (feed rate = 3000 mm/min). During plate machining, we have used the End and Ball hard metal (HM) tool of the German manufacturer of the Orion group Hahn-Kolb (Figure 3).

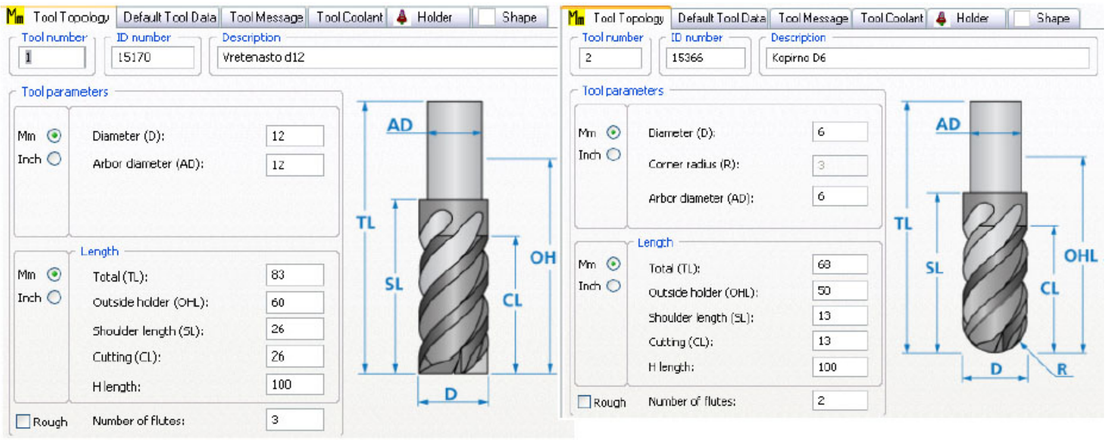

Figure 3. Geometrical parameters of tools

2.4. Defining of general "Manufacturing" parameters

The creation of the final controlling (.tap) file for the management of the CNC machine calls for the defining of general parameters: machine type, striction utensil, working coordinate system (working '0') and 'retract' plane, i.e. tool clearance plane after the completion of one sequence. The schematic representation of the algorithm sequence of planning machining technology and creation of final controlling file is shown through the structural scheme (Figure 4).

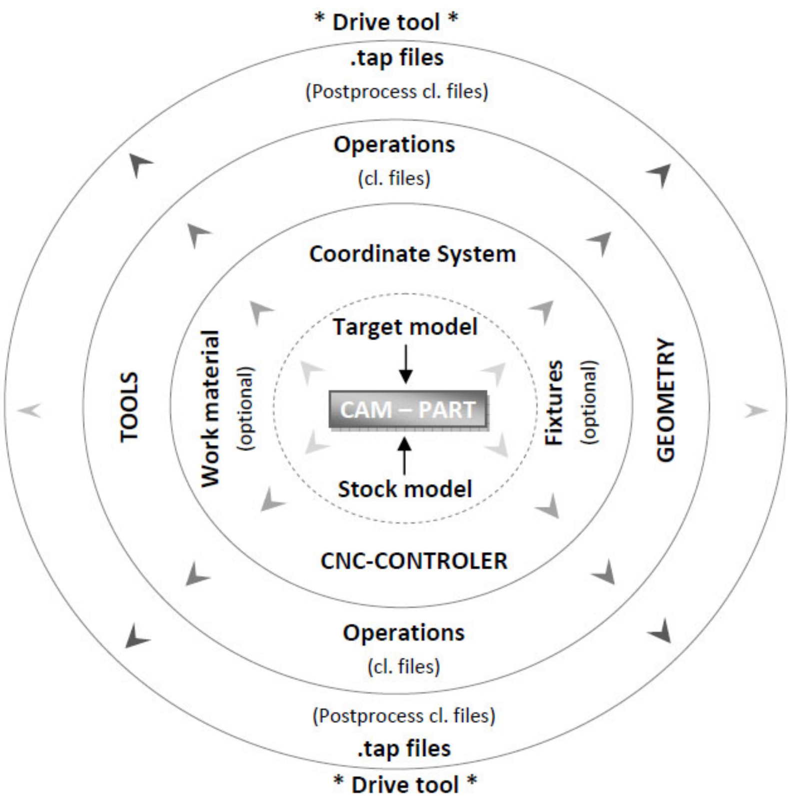

Figure 4. Structural scheme of creating of executive (.tap) file [1]

2.5. Creating of technological milling strategy in five program sequences

The machining of the infusing core-plate is performed during five program sequences (strategies):

- Rough volume milling – removal of a large portion of material “Contour roughing”.
- Fine volume milling – semifinal cleaning machining “Rest roughing”.
- Final fine machining – “Constant Z machining”.
- Final fine machining – “3D constant step over”.
- Final fine machining – “Horizontal machining”.

The first program sequence begins on the object in the shape of a parallelepiped of the dimensions 250 x 190 x 80 mm, each sequence means defining parameters in six obligatory technological phrases, divided into ‘program cards’:

- “Strategy choice”
- “Geometry”.
- “Tool”.
- Object boundary defining in x-y plane – “Constraint boundaries”.
- Direct machining parameter defining – “Passes”.
- Auxiliary machining parameter defining – “Link”.

During rough volume milling, it is important to define the strategy for the connecting of two passes, then defining of horizontal link clearance, as well as defining the parameters for tool entry into the object material with an aim to reduce the cutting resistance in the moment of tool “stabbing”. These parameters are defined in “program cards”: “Strategy” and “Ramping” (Figures 5 and 6).

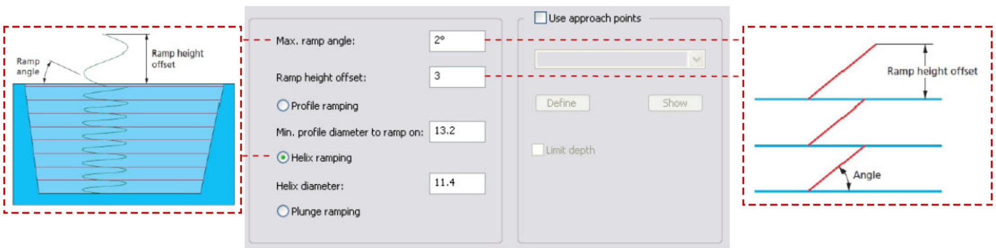

Figure 5. Technological card “Ramping”

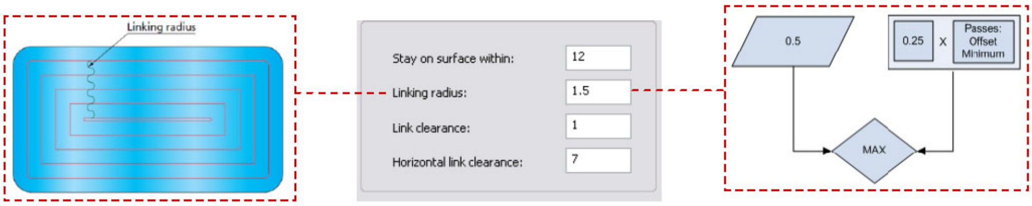

Figure 6. Technological card “Strategy”

The shown parameters have a crucial influence on the main time of the machining sequence “Contour Roughing”, thus they can be considered as key technological parameters in the sense of being the created optimum HS strategies for this sequence. A precise 3D imaging of material removal is enabled through logic of “analytic geometry” of the program option “SolidVerify” (Figure 7).

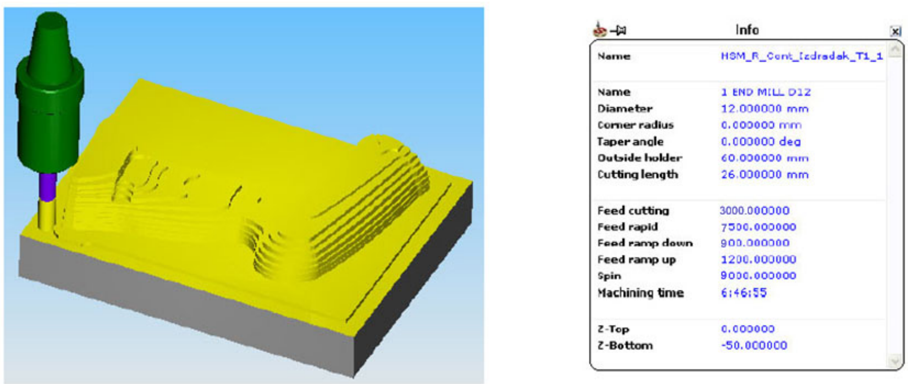

Figure 7. “Solid Verify” displays of material removal and the trajectory of tools of HS strategy “Contour Roughing”

In the sequence of semifinal machining, i.e. material cleaning machining “Rest roughing”, the aim is the machining of areas which the previous tool could not remove due to the diameter. Naturally, the width and depth of the milling are reduced; you have to take care when defining the holder clearance (space between the tool holder and object in order to avoid collision) (Figure 8).

Figure 9 shows the comparative preview of the removed material in “Contour roughing” and “Rest roughing”.

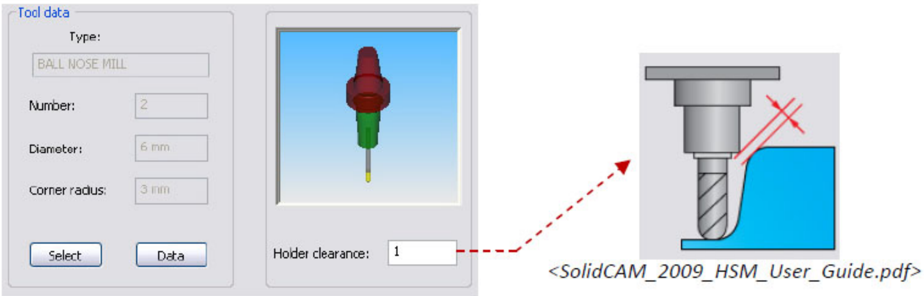

Figure 8. The space between tool holders and object in order to avoid collision

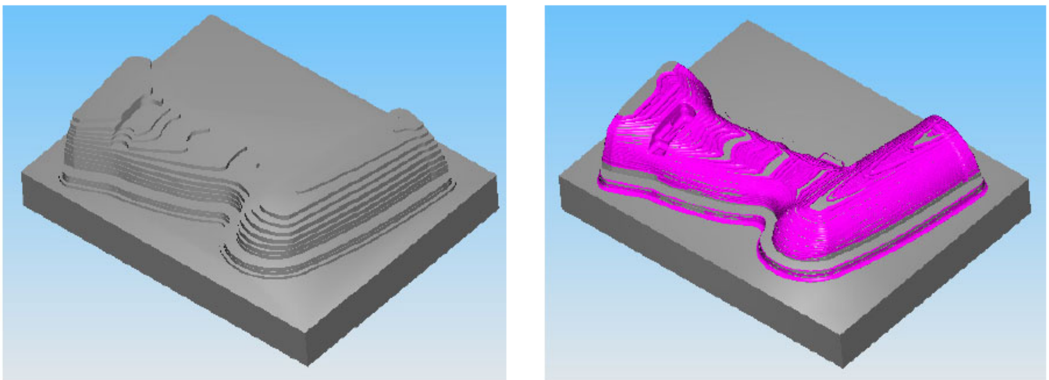

Figure 9. The preview of the removed material and tool trajectory of HS strategy in sequences “Contour roughing” left and “Rest roughing” right

Final finishing machining of the object (infusing the core-plate) is performed in three sequences, it starts with activation of the “Constant Z machining” sequence with machine sloping areas under 30° – 90°, depending on the object geometry. It is usually combined with the “Constant step over” sequence with machines areas of 0° – 90°. Actually, this is a combined strategy which should be applied in the case of final machining of the plate due to its complicated surface geometry. The key property of these two joined sequences is to provide a constant distance between passes, i.e. sidewise distance measured along the surface of these passes stretch over during machining, regardless of the inclination of the given area. This provides machining of all the areas on the plate model, which are inclined under 10° – 13° alongside other machining parameters defined in the “Passes” card, (Figure 10).

Figure 10. Parameters on the “Passes” technological card for the “Constant step over” sequence

In the end, "Horizontal machining" sequences defines the final machining of the bearing horizontal area of the infusing core-plate. The sequence is defined through movement within the set boundaries of rough machining (Auto-crated box of target geometry) with a clearly defined bearing plane and the fact that bi-directional milling was set (Figure 11).

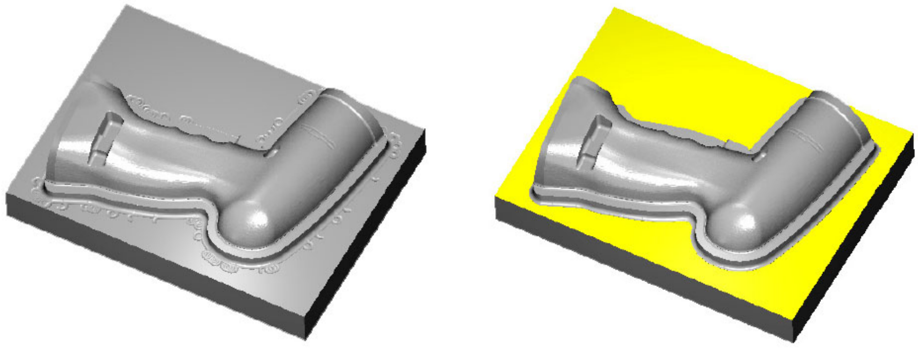

Figure 11. SolidVerify display of the removed material after final "Horizontal machining" sequence

3. CONCLUSION

CMM (Coordinate measuring machine) analysis of the 3D model of the infusing core-plate for drill housing has shown that the technology designed through five joint sequences yielded excellent results, completely within set tolerance boundaries. The total main machining time (tg = 21 min 18 sec) is roughly 10 times shorter than the machining of the identical plate through regimes and sequences which correspond to the strategy for classic 3-Axis milling machine MAHO type 1000 s (tg = 220 min). Worth noticing is the significance of the joint strategy of the final fine machining "Constant Z machining – 3D Constant step over – Horizontal machining", which provides maximum exploitation of the SolidWorks CAM resource module SolidCAM 2009. Since the milling machine on which machining is performed has automatically generated a post-processing code, by choosing the program tool "G code/Generate" we create a direct-final file (.tap file) for CNC machine control, and because of that it is possible to create a control file for each sequence (strategy) or entire HSM operation.

4. LIST OF SYMBOLS

Cutting speed v_c [m/min]
Main spindle revolution number n [^{o}/min]
Main machining time tg [min]
Max. ramp angle – pass tool entry angle [^{o}]
Ramp height offset – tool striating position before the beginning of the working process [mm]
Min. profile diameter ramp – diameter of the tool entry trajectory profile [mm]
Helix diameter – diameter of the helix tool entry trajectory [mm]
Stay on surface within – distance between the final point of the previous pass and the starting point of the following pass [mm]
Linking radius – radius of the curve which connects passes [mm]
Horizontal link clearance– horizontal clearing of the tool while descending into the machining area [mm]
Link clearance – control distance for defining distance connecting [mm]
Holder clearance – safety distance of the tool holder from the object [mm]
Tolerance – border tolerance [mm]
Horizontal step over – milling width per pass [mm]
Vertical step over – milling depth per pass [mm]
Angle – border inclination angles of the object area [^{o}]

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