STUDY REGARDING THE INFLUENCE OF TECHNOLOGICAL PARAMETERS IN MILLING PROCESS OF COMPLEX SURFACES

Authors: ***Mihaela Iuliana MUREŞAN, Marian BORZAN, Adrian TRIF,***
Email: ***Mihaela.MURESAN@tcm.utcluj.ro, Marian.Borzan@tcm.utcluj.ro, adrian.trif@tcm.utcluj.ro***

Abstract:

This paper studies theoretical influence of technological parameters on precision processing of complex surfaces: geometric parameters of tool, choosing the condition of cutting and others parameters witch has to be considered in Micro milling.

1. INTRODUCTION

Due to development of science and technology, marked requires more complex pieces with regular curve surfaces or asymmetrical surfaces. To realize those types of surfaces a CNC machine is needed with a high precision and it has to be taking count of a series of factors that affect the accuracy of the piece, factors witch will be related in this paper.

In technology that refers at cutting processes a very good knowledge of technological parameters is necessary. If technological parameters are correctly chosen will result the next advantages: high accuracy of the piece, a smaller ware of tool and machine system which leads at economical advantages. The biggest problem that appears processing complex surfaces is reaching the required roughness. So, are presented certain parameters like geometrical parameters of the tool and others that has to be known in milling operation.

2. CHOOSING PARAMETERS

Currently has developed a variety of mills capable of running various types of cutting operations. Mills presented in this paper (figure 1) for processing complex surfaces are those which are used in Micro and Mini cutting operations. They have different dimensions regarding type of cutting operation starting from a diameter of d_1=0,2mm and a radius of R=0,1mm.

The part material may have hardness up to 66 HRC and tool feed, depending of material, can be between 80 mm/min and 7500mm/min. Using this mills can be reached a high geometrical complexity and a good flexibility of working material.

Fig. 1 *Mini and Macro types of mills, [2]*

Typical applications for these Micro and Mini milling cutters are, for example, the production of moulding tools, spray-injection moulds, coining and extrusion dies for mass production, graphite and copper electrodes, or the high-precision surface structuring of macroscopic components and the direct production of micro-mechanical components in small and medium series production. [2]

2.1 Choosing tool parameters

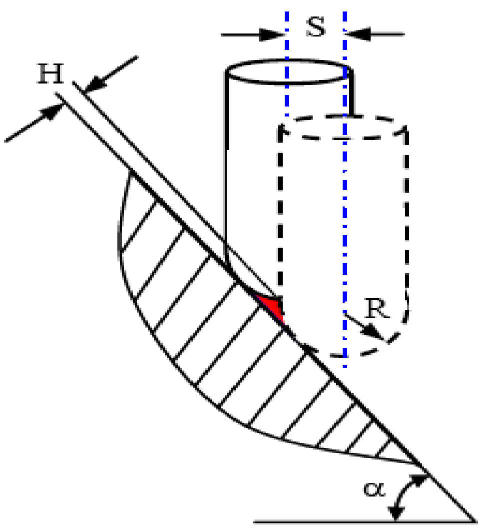
The processing parameters of complex surfaces includes: knowing the cutting distance between two certain points, tolerances, cutting depth, feed speed. This parameters depends of tool type. At such small dimensions mill has to be chosen carefully and also it's geometrical parameters. To obtain the desired form of the piece, beside the geometrical form of cutter, the dimensions of mills have a major importance.

To improve tool rigidity it has a tapered face that makes a bind between the active part of cutting tool and it's shank and to evoid premature ware of tool and obtain better quality of surface the condition of tool producer given in tool catalog has to be respected.

2.2 Choosing step distance

The step distance is the distance between adjacent two feeds, the step-distance ***S*** is shown in the figure 2. The step-distance is an important parameter, which relates with the cutting load and the machining efficiency of the machining tool and the surface quality of the work piece. The step-distance is larger, the time of the feed is less, and the machining time is shorter. But the cutting load is increscent. With the big sphere butt mill, it will lead that the residual height ***H*** is increasing after machining. The influence of the ***H*** on the surface roughness is very obvious. So, in the rough machining, the S should be bigger; in the precision machining, the ***S*** may be smaller. [1]

Generally, three methods (the rate of the tool diameter, the constant and the variable) are used to confirm the step-distance. To the machining of the steep surface, the choice of the step-distance depends on the accuracy of the machined surface. [1]



S – step-distance
H – residual height
R – radius of sphere mill
α – lean angle of the steepest surface

Fig. 2 *Cut steep surface condition, [1]* Influence of tool radius and step distance can be obtain with relation, [1] :

$$H = R - \frac{\sqrt{4R^2(\cos\alpha)^2 - S}}{2\cos\alpha} \quad (1)$$

From figure 3 we can see, when the ladder step-distance is adopted, the surface roughness is larger, and when the surface step-distance is adopted, the surface roughness is smaller and the surface step-distance can make the residual height to keep consistent approximately with different slope. [1]

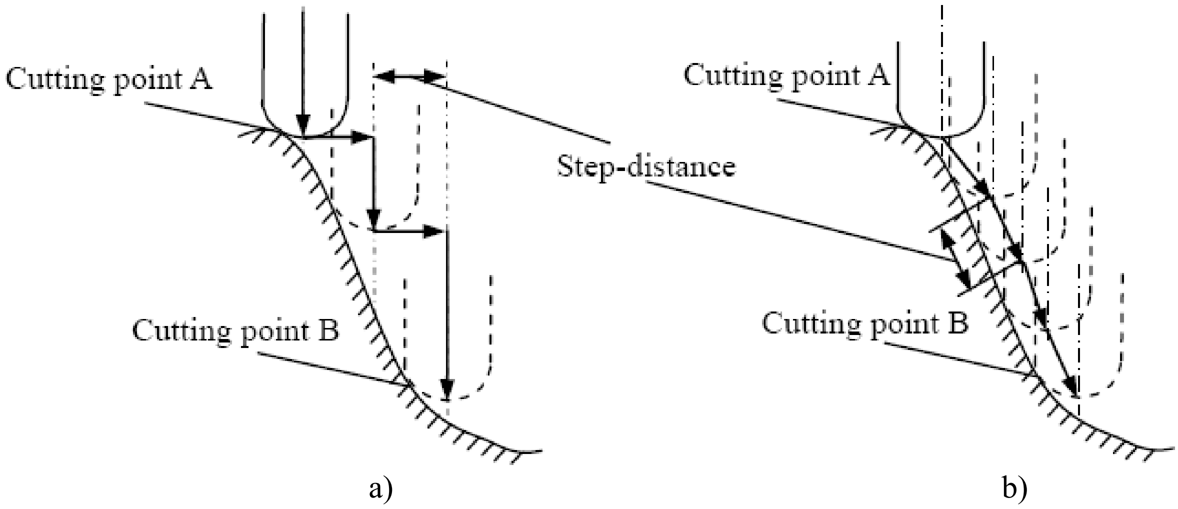


Fig. 3 *a) roughing process*
b) finishing process, [1]

It is indicated that in roughing process the to use ladder steps and for finishing process cutting tool should fallow surface contour.

2.3 Choosing cutting depth

The depth of the steps in the Z axis during roughing will affect the quantity of material left for finishing, but larger steps in the Z axis leave more material for finishing and smaller steps in the Z axis leave less material to be removed during your finish cut.

The number of cutting layers must be confirmed by the steep degree of the machining surface appropriately. Figure 4 shows the dividing of the cutting range and the adopting of the different depth of cut in different range. [1]

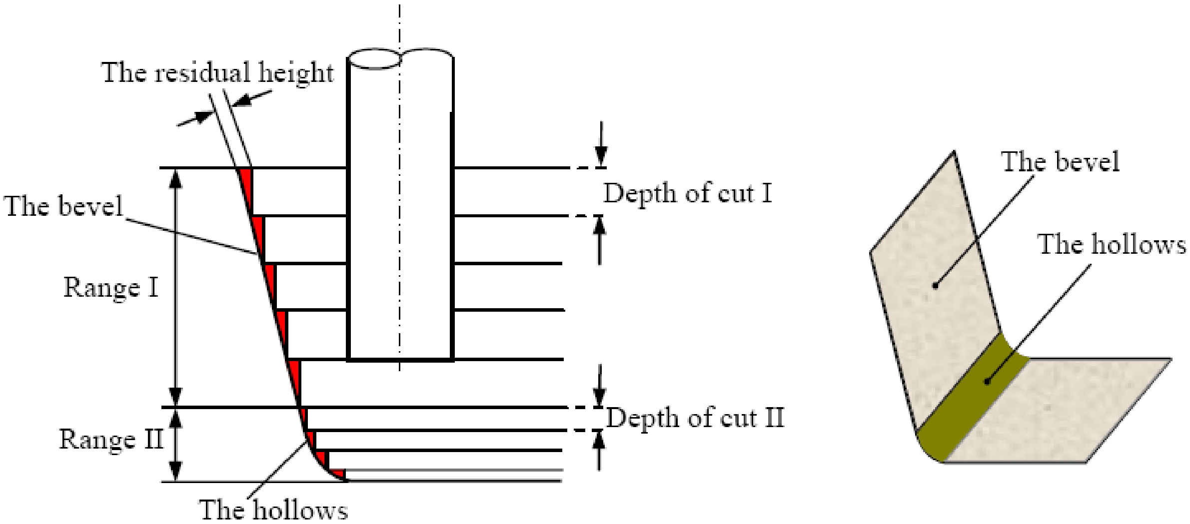


Fig. 4 *Surface division and setting depth of cut with flat-end mill [1]*

Depth of cut in the range II must be smaller than in the range I, and then the surface residual height in different part is consistent. So we can obtain the conclusion: when choosing the depth of cut, if the surface is steeper, the depth of cut is larger, and if the surface is flatter, the depth of cut is smaller. It aims to make the residual surface height to keep and satisfy the requirement of the machining accuracy. [1]

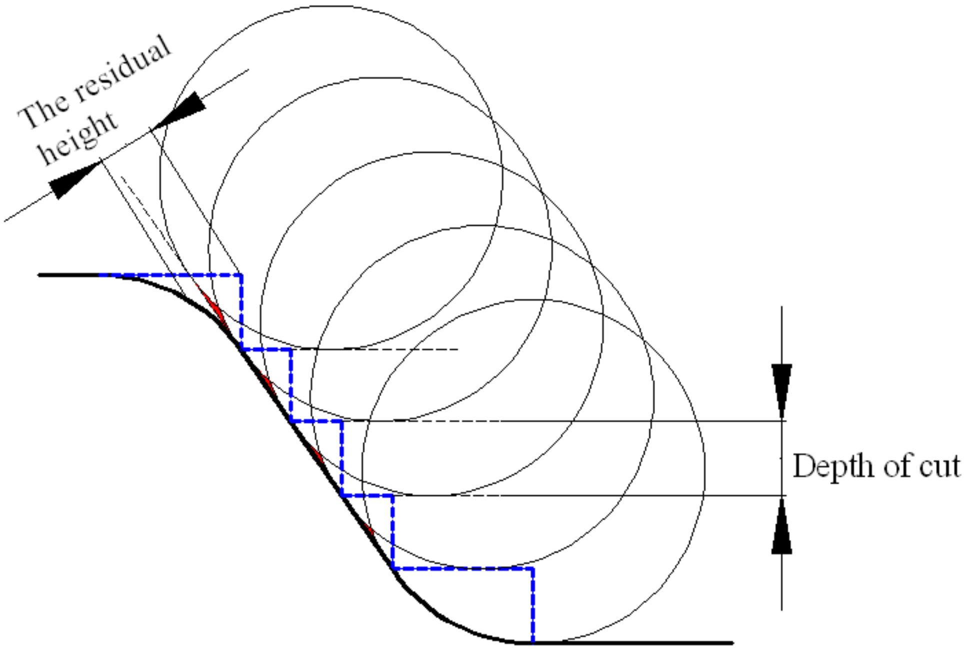


Fig. 5 *Surface division and setting depth of cut with ball-end mill*

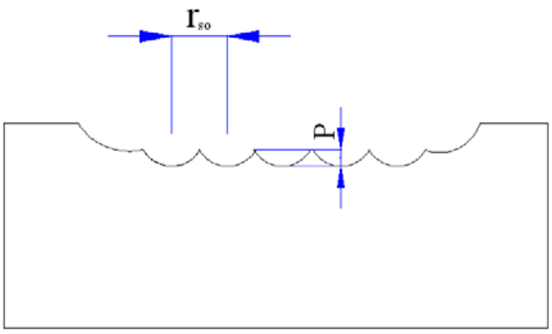
We observe that using a flat end-mill the residual height and the number of cutting cycle times are bigger and cutting depth has different values, it has to be chosen smaller steps because leaves less material to be removed during finish cut. But using a ball-end mill the depth of cut has the same value, the roughness is smaller and because of its geometrical shape the accuracy of surface is better.

To produce an excellent quality surface, a finish tool path will be created using a ball-end mill. A ball-end mill is used specifically because of its spherical shape. This shape allows it to move over all surfaces and cut at any point around the sphere. For example, think of a ball bearing placed in a bowl. You can roll the ball over any part of the bowl and it will make contact with the surface in different points around the sphere. The point of contact is called the tangent point.

A very important parameter witch influences the accuracy of surface is radial step-over and this is the distance between centrelines of successive parallel cuts. When the radial step-over is increased, the cusp height will increase, [3].

A cusp height of 0.00076 to 0.00127 mm will produce a very fine finish. Since the cusp height is controlled by the radial step-over and the tool diameter, the following formula can be used to calculate the cusp height on a flat surface, [3]:

$$P = \frac{d_1}{2} - \frac{\sqrt{d_1^{\,2} + r_{so}^{\,2}}}{4} \tag{2}$$



d_1- tool diameter
r_{so} - radial step-over
P – cusp height

Fig. 6 *Cusp height on a flat surface*

From recent researches it has discovered that in Micro-milling process the surface roughness is not proportional with the cutting feed per tooth. If a bigger depth of cut is chosen that increase the force acting on the tool body resulting in the flexure produced by axial compression.

Taking into consideration that the step-distance has a constant value and the diameter of tool is changed, therefore radius has different values, we tried to follow the changes occurred on residual height.

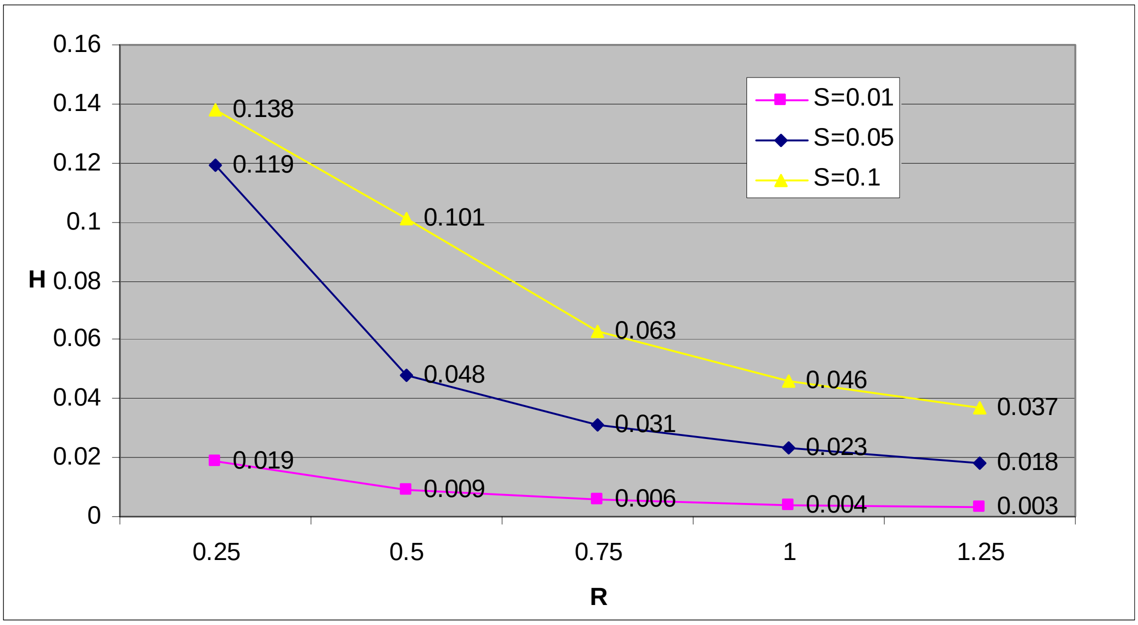


Fig. 7 *Influence on residual height when radius has different values*

The influence on residual height changing the step-distance and considering that radius has same values; cases are presented in diagram from figure 8.

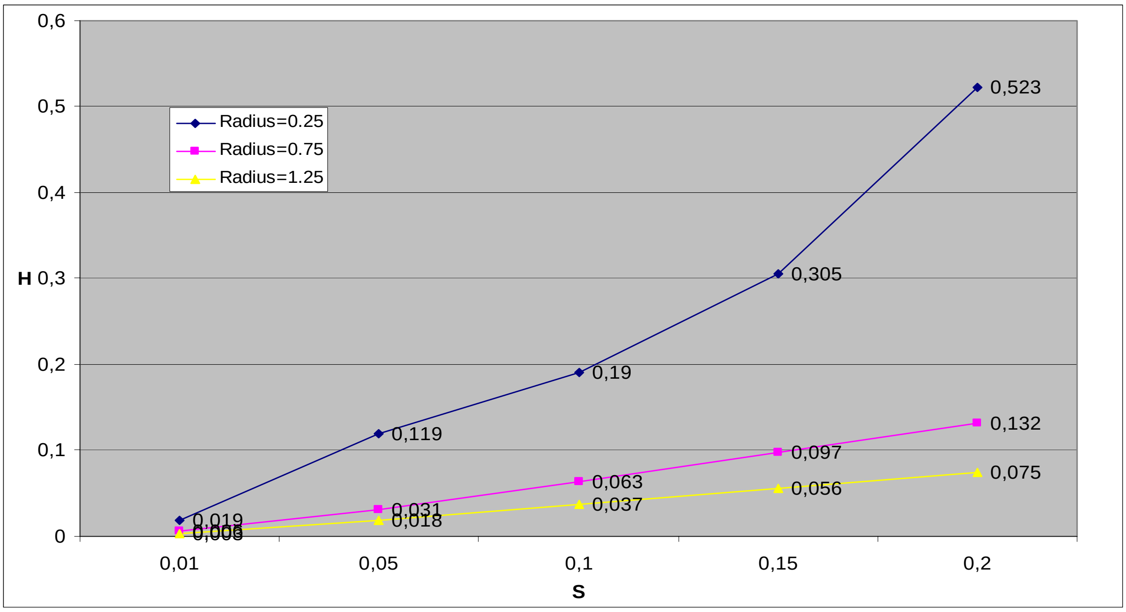


Fig. 8 *Influence on residual height when step-distance has different values*

The influence on residual height changing the lean angle of the steepest surface and considering that radius has deferent's values; cases are presented in diagram from figure 9.

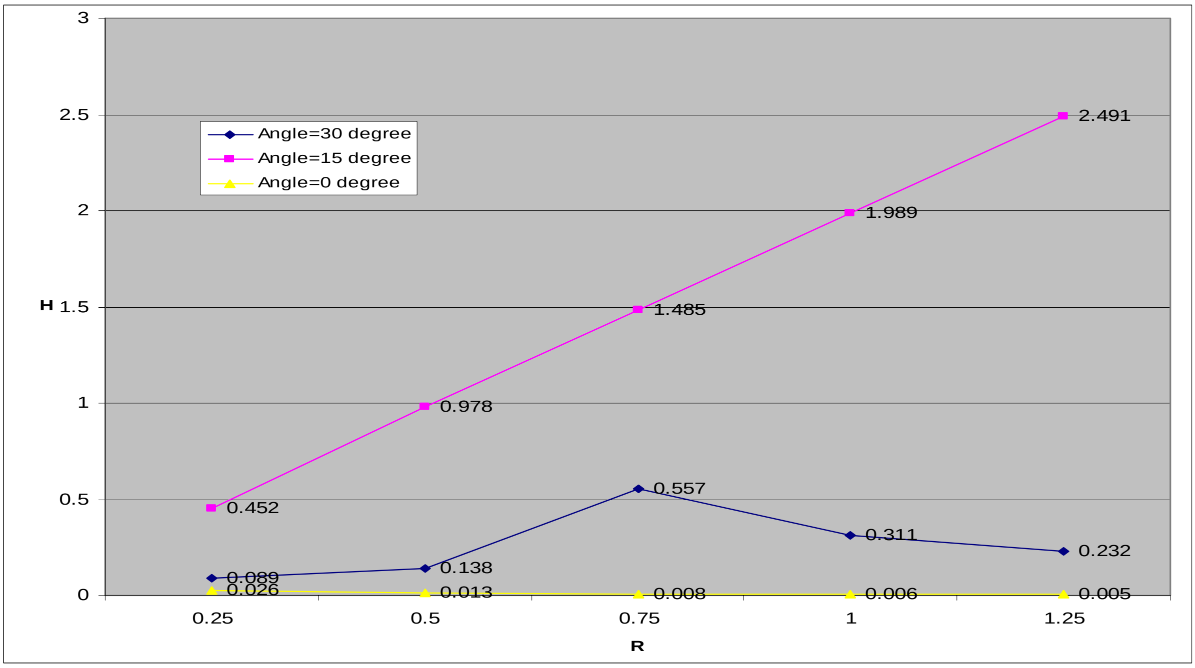


Fig. 9 *Influence on residual height when angle has different values*

2.4 Tolerances influence

Tolerance has an important role in achieving the desired accuracy and roughness of surfaces, but surface roughness depends largely on the steps-distances. Because of mill deviation on piece surface appear negative and positive tolerances which determine the allowable dimensions.

The tolerance is smaller the surface of the part is smoother. So, the negative and positive tolerance determines the accuracy of the part surface and it affects the surface roughness too. But, its influence on the surface roughness is not as remarkable as the step-distance. [1]

3. CONCLUSIONS

In conclusion, from those three diagram, the next information are obtained:

- for a good roughness of surface is indicated a tool with a big radius;
- if the step-distance is small the surface roughness is better;
- the lean angle of surface has to be correlated with tool radius for a good surface accuracy.

Taking into consideration in milling process the facts presented above the results will be positive, achieving a good quality of processed piece and a better tool ware resistance. To be considered that a ball end-mill gives better rezults regarding surface accuracy than flat end-mill.

Advantages of cutting with these Micro mills are:

- these have a good productivity because of the high speed cutting;
- these not requires the use of cutting fluid, which leads to lower costs.

References

[1] CHEN, M., J., LIANG, Y., C., SUN, Y., Z., GUO, W., X. AND ZONG, W., J. *Research of the Technological Parameters Influencing on the Surface Quality of Micro Complex Surface, Key Engineering Materials Vols.* 291-292 (2005) pages 513-518.

[2] www.emuge-franken.com

[3] http://www.haascnc.com/solutions_3D.asp