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MILLING PROCESS MANAGEMENT

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Abstract: *Milling process are the most widespread operations among metal machining. The development of this process is due to a large variety of parts configuration, parts dimensions, precision al surface quality and economical efficiency which can be achieved by using this process.*
To reach a high degree of competitively any workshop should have a wide technological base, with performant characteristics. A modern technological base means not necessary a state of the art machines, but it could reach a high performance by using performant cutting tools, combined with a correct technological management and technical knowledge.
Keywords: *metal cutting, milling strategies, milling, HSM, HPM.*

1. INTRODUCTION

Metal machining processes are and it will remain the most widespread types of processes in part machining, despite the development of other technologies like die cast or electro-erosion.

Milling process can achieve:

- High accuracy;
- Good surface quality;
- Wide variety of forms and dimensions;
- Low costs and high removal rates.

The development known by milling process in the past years is due to the competition known by this sector to obtain low production costs. In the 70's the introduction of Computed Numerical Control on milling machines, enlarged the possibility's to manufacture more complex parts faster and cheaper. Also the entire production system had to be reorganized due to the fact that on a single machine tool could be performed several types of operations (e.g. milling, drilling and tapping).

The cutting tools maintained the competition to build more accurate, much faster and more stabile, by developing better materials for the cutting tools, by improving the tools geometry and developing new protective layers for the cutting edges, forcing the machine tools designers to achieve higher feed rates and spindle speeds. Also the CAM software's development improved the process management by using optimum milling strategies and cutting times of designing the tool path.

2. MILLING PROCESS CLASSIFICATION

Dividing the milling process into punctual strategies, specific to every type of application, enlarged the range of products which could be machined by milling, cutting the production times and costs. Tool designers coped with this issue by developing cutting tools with a specific geometry for each milling strategy.

The milling process can be divided into several strategies:

- General milling strategy;
- High Speed Machining (HSM);
- High Productivity Machining (HPM);
- High Feed Machining (HFM);
- Micro Milling.

Each strategy has its own know how, involving cutting process parameters, cutting tool geometry and requires specific machine tool characteristics.

General milling strategy

This strategy is used mainly in single part production on old, classic milling machines. The depth and radial engagement varies from part to part but it is indicated that the cutting tool should be engaged on the entire cutting tool length. The cutting tool material is mostly HSS, but also carbide for finishing operations or inserts millings for roughing operations. The cutting tools length is long covering a large range of diameters. The cutting speeds are low, obtaining a low removal rate.

High speed machining - HSM

High Speed Machining is a strategy which uses a new approach, by using smaller depths of cut which generates less heat in the cutting process, allowing increasing the spindle speeds and therefore - higher feeds.

The cutting tools used for HSM has to be rigid, with a large core diameter, made of sub-micro grain carbide. The geometry is special designed to transmit the heat into the chip and it is coated with special layers to protect the cutting edges.

The machine tools for this strategy have to be very rigid, stable with a powerful control with the machine ways and ball screws need to be able to manage or stand up to the heat generated by high feed rates. The Computed Numerical Command must have the power to read and process the program quickly to determine the sudden trajectory changing and reducing the feed, to avoid shocks and overstressing the guide ways and the ball screws. A binding function of the Computed Numerical Command is the NURBS function – *Non Uniform Rational Basis Spline* which approximates the programmed tool path with the multitude of curbs (fig. 1), providing a smoother path with no shocks.

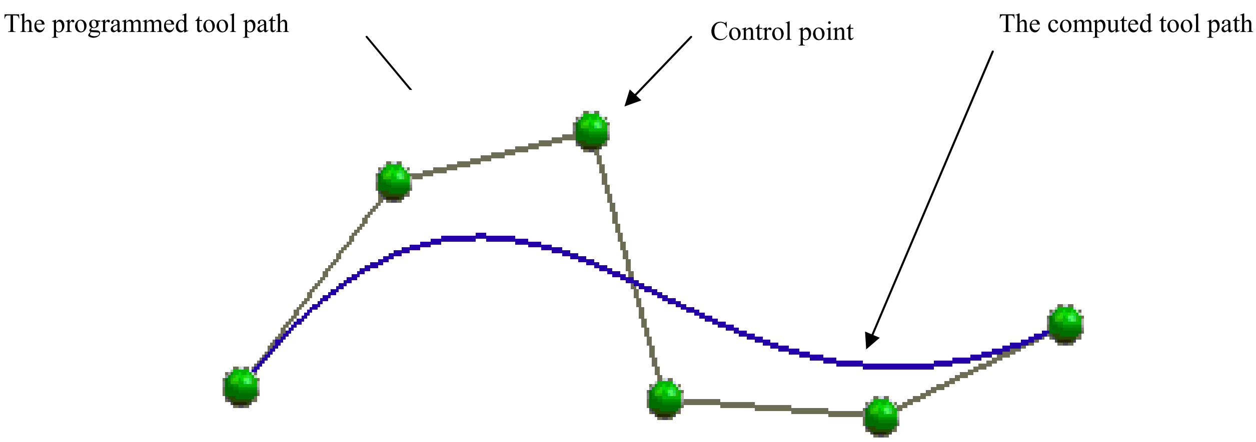

Fig. 1. *NURB function*

High productivity milling – HPM

This milling strategy obtains a high removal rate using a cutting depth and a radial engagement optimal for the tool, to achieve maximum feed rates.

Unlike high speed machining, which use high spindle speeds, high productivity machining uses the spindle speeds which generates the largest torque. A characteristic feature of this strategy is plunge milling. Plunge milling is used when milling large cavity, having a high removal rate, and being more stable than conventional milling.

The cutting tools used in high productivity milling are mostly made out of carbide, or insert cutting tools, with a special geometry designed to deal with the heat generated in the cutting process.

The machines must have sufficient installed power to deal with the forces involved in cutting metal, with a rigid structure and installation to eliminate the chips quickly from the cutting zone.

High feed milling - HFM

High feed milling obtains a high removal rates at a relatively low spindle speeds by engaging the tool on entire diameter combined with a low depths of cut. This strategy is mainly for insert cutting tools with angle of attack of 15 to 45 degrees. There are a few forms of inserts which are suitable for this type of application square or trigon shapes. Figure 2 shows that for keeping the same feed per tooth you have to increase the table feed.

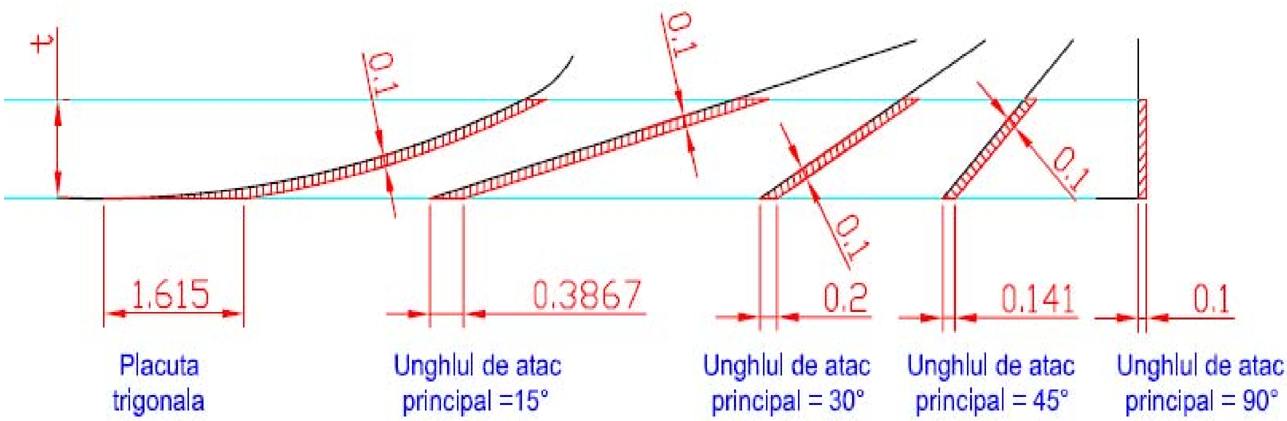

Fig. 2. *Table feed for different attack angles*

The advantage of this strategy is that it has a high productivity, no vibration; the forces are mainly axial – resulting a stable cutting process, suitable for old machines.

Micro milling

Micro milling is a strategy which uses tools with a diameter of 0.1 mm, but it can go down to 20 microns. For this strategy due to low cutting depths there is an increase in the specific energy required, the cutting forces cold exceed the tool bending limit even before the tool experiences any significant wear, and leads to the breakage of the tool bit. Built up edge, and also chip clogging during the micro milling process would cause the tool bit to break.

For the tools with a diameter of a few microns the geometry is not the same with their full-size counterparts, instead they have a simple geometric cross sections, as is shown in fig. 3.

These tools, due to small diameters have to be very precise machined with zero radial run out. Material used manufacture this tools are carbide, HSS or diamond.

The machines used for this strategy must be very precise, must have high spindle speeds (20,000÷150,000 rpm), thermal stability and high resolution of the translation mechanisms. Most micro milling machines are sold with sensors to measure the forces acting on the tool bit, and advanced CAM software to predict the chip load throughout the micro machining process.

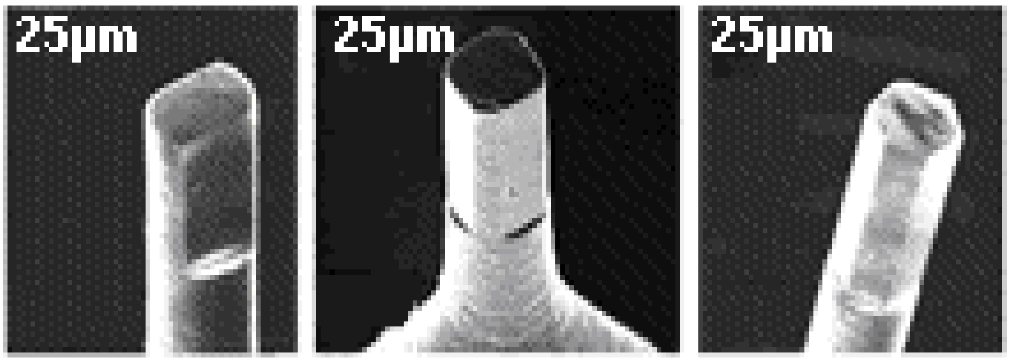

Fig. 3. *Micro mills geometry*

This strategy is mainly used for nuclear and medical industry and also for die and mold industry.

3. CONCLUSION

Understanding each milling strategy and understanding each one’s possibility will materialize in an optimization of the entire production system and in increasing productivity, using the technological base in a more optimum manner, resulting:

- lower the production times;
- low production costs;
- minimum amount of cutting tools.

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