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EMPLOYING HIGH SPEED MACHINING ON A COMPLEX PART

BY

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Abstract. This paper presents the influence of high speed milling process over the time savings. High-speed machining is used in all areas of business. It can be used for mass processing or for making moulds for various applications.

Keywords: High Speed Machining, the influence of feed on machining, part design, cutting speed, productivity and quality gained.

1. Introduction

High Speed Machining represents the removal of material at very high cutting speeds. HSM is often mistaken as a machining method that favours the removal of heat from the cutting zone of the chip, instead of a combined phenomenon that is taking place between the part, the tool and the chip that are different from those observed in conventional machining.

High-speed machining is used in all areas of business. It can be used for mass processing or for making moulds for various applications.

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The main feature of high-speed machining is the specific values of this speed.

In fact it is a combination of feed speed correlated with the speed of the main spindle of the machine tool.

The values of this speed vary depending on the material used, but this machining process is more efficient than conventional machining.

High-speed machining therefore saves time. Between 4 and 10 times shorter than traditional techniques, chipping is faster.

By using HSM, both productivity and quality are gained.

The most important difference between HSM and conventional machining centres during the process of machining is the difference between the appearances of the chips. At low cutting speeds the chip is formed continuously by a mechanical phenomenon of deformation and tearing. At HSM, are formed small and fine chips generated by a constant breaking of the material in the cutting zone and the results are a smother surface, with smaller energy consumption and a chipper tool cost.

The cut is mainly the result of three components: due to friction, due to the required force for plastic deformation of the material in the cutting zone and due to the required breaking force. The balance between these three components makes the difference between HSM and conventional machining.

In conventional machining process, the chip formation is based only on plastic deformation. This mechanism consumes lots of energy and tends to damage the material and the affect the wear of the tools. Other negative results on conventional machining are residual tension that are induced to the material, beginnings of breakings that appears in the material, marks on machined surfaces (Osan *et al.*, 2018).

Increasing the cutting speed, will increase the friction between the material and the tool, also material deformation and the heat generation. All those will affect the machining conditions.

2. HSM advantages for increasing the production

The mechanical engineering industry has developed in recent years in a special way due to the interdisciplinary approach to the different manufacturing technologies of the parts and components that make up mechanical assemblies and sub-assemblies.

However, the classical material removal manufacturing technology involves machining by cutting, but is not able to meet the mechanical requirements for certain parts and components.

Among the main manufacturing operations is machining by stamping, which has contributed to the machining and finishing of precision parts.

Even if the plastic deformation force increase at the beginning of the machining process, during this process, it will decrease if the temperature in the cutting zone start to increase to a certain level (Khani *et al.*, 2012).

Not only the plastic deformation force will decrease during the early phases of HSM process, but also the friction between the material and the tool and the shear forces that are involved in this process.

The result of all those transformations is that in the HSM zone, the thermal phenomenon is close to the fusion process.

But while the force required for plastic deformation initially increases with speed, it decreases with increasing temperature.

As the cutting speed increases further, the temperature takes over, until an instantaneous shift in equilibrium occurs. Friction, deformation and shear forces suddenly drop and the HSM zone is entered, governed mainly by thermal phenomena (impact phenomenon close to fusion).

The power consumed for deformation becomes negligible: the angle of friction decreases, the cutting forces decrease as well as the vibrations, the chip slides better on the cutting face of the tool and becomes less thick (Zhang *et al.*, 2009).

And although greater thermal energies are involved, the exchanges between tools, chips and work piece no longer have time to take place. The cutting energy is mainly dissipated with the chips and lubricants: the machined material does not heat up or heats up very little.

The material being machined is therefore subject to less mechanical stress, less vibration and less heating, and will be machined at a significantly lower energy cost.

3. Study case

Considering the HSM of the part taken into account just from using the same machining parameters.

We would like to mention here the cut deeps of 0.5 mm, the overlap ratio of 20%, the offset on part of 0.3 mm, the climb in cutting mode, the tool path style is helical, the helical movement is made in both directions, the feed rate/turn is 0.15 mm and the mode of engaging the material is in ramping mode (Fig. 1), (Seguy, 2008).

If we will modify only the numbers of tooth from 2 in the first configuration and 4 in the second, we will find that for the same others parameters, the machining time will change dramatically from 195 minutes of machining to 132 minutes (Fig. 2), (Keyal, 2007).

The dynamics of machining requires knowledge of the forces involved in the material removal process, as well as knowledge of specific material properties and dimensional metrology and inspection.

In short, machining of materials by cutting is a process that requires extensive experience in various fields of activity, which is now manifested by the presence of computers in everyday life occupying a special place in mechanical engineering.

A country's machining potential is an indicator of its development in this direction.

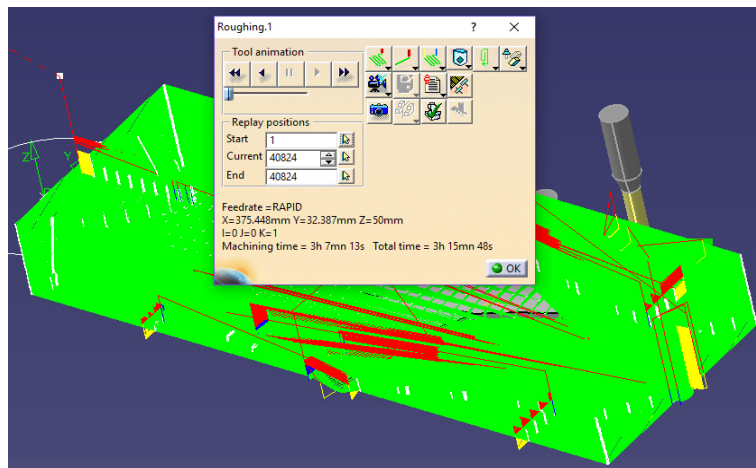


Fig. 1 – Two teeth milling.

The published information is fully in line with the technological revolution aimed at increasing the cutting speed, the changes that have resulted in the creation of machining possibilities that take into account the hardness of processed materials, but also the processing without lubricating fluid.

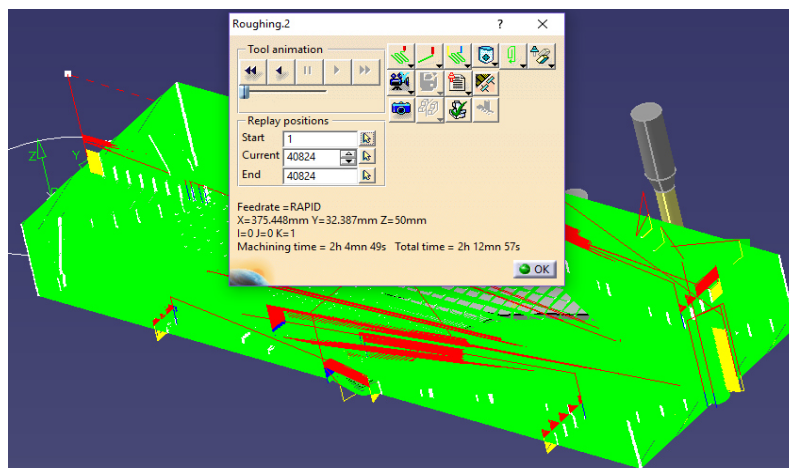


Fig. 2 – Four teeth milling.

One of the main elements of this complex equation is the chipping tool, which is the last link in the machining process, and especially the coating applied to it.

The purpose of coatings is to ensure even greater tool wear resistance and to further enhance machining performance by improving chipping conditions, increasing productivity and machining performance.

3. Conclusions

The chipping process attracted enormous interest long before chipping techniques evolved.

At that time, the cutting of materials was done with very simple hand tools, some of which have survived to the present day without significant modification.

Muscular effort and the "talent" specific to each guild was replaced by the use of special machines, known as machine tools (lathes, milling machines, drilling machines, grinding machines, mortising machines, planing machines, etc.).

Thus, the boring tool becomes a part of the machine tool system, the clamping device, the boring tool, which, during operation, acts directly on the blank by removing the material to produce a surface conforming to that specified in the drawing.

In addition to increasing productivity, developments in the performance of CNC machine tools should lead to an improvement in machining accuracy on the one hand, and reduce manufacturing time on the other. Very high speed machining techniques, which are increasingly used, fulfil this dual requirement.

The high feed rates that can be achieved on these CNC machine tools and the spindle speeds that allow conventional machining limits to be exceeded have resulted in increased productivity.

Research since the introduction of CNC machine tools has shown a significant reduction in cutting forces at very high speeds.

As a result, dimensional and geometric accuracy in terms of surface finish has been substantially improved, especially when machining alloys, but also unconventional materials.

REFERENCES

- Keyal P., *Optimal ball-end and fillet-end mills selection for 3-axis finish machining of point-based surface*, International Journal of CAD/CAM, vol. 7, 2007.
- Khani R.A., Fakhrabadi N., Mahdavinejad M.M.S.D., *Optimization of milling parameters using artificial neural network and artificial immune system*, Journal of Mechanical Science and Technology, vol. 26, pp. 4097-4104, 2012.

- Osan A., Cosma M., Nasui V., *Milling convex surfaces with toroidal cutting edge*, International Conference on Innovative Ideas in Science and Social and Technological Development, 2018.
- Seguy A., *From the spindle speed selection to the spindle speed variation for chatter control in thin wall milling: modelling and experiments* (in French), PhD University of Toulouse, France (2008).
- Zhang H., Jackson M.J., Ni J., *Stability analysis on spindle speed variation method formachining chatter suppression*, International Journal of Machining and Machinability of Materials 5, pp. 107-128 (2009).

UTILIZAREA PRELUCRĂRII DE MARE VITEZĂ PE O PIESĂ COMPLEXĂ

(Rezumat)

Această lucrare prezintă influența procesului de frezare cu viteză mare de prelucrare asupra timpului consumat pentru realizare. Prelucrarea cu viteză mare este utilizată în toate domeniile de activitate. Ea poate fi utilizată pentru prelucrarea pieselor în masă sau pentru realizarea de matrițe pentru diverse aplicații.