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EFFECTIVE VS. DESIGNED SHAPE ACCURACY AT HIGH SPEED CUTTING

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***Abstract**: The shape of a part manufactured by cutting is designed in a constructive axis system. The part shape rises in effective working plan which is rotated against the machine and constructive axis systems. For this reason, especially in high speed machining, when the deviation angle between the coordinate systems are greater than in classical cases of cutting. It follows there from that the values of cutting angles are different from designed and that is why, the accuracy of dimensional and surface parameters of the part manufactured are expected to diminishing. The paper prepares the theoretical aspect for a precise answer of this question on the near future.*
***Key words:** machining, cutting angels, high speed, accuracy, working parameters.*

1. INTRODUCTION

The machining of metals plays a crucial role in a range of manufacturing activities, while metal cutting is commonly associated with big industries, including the high speed cutting and ultra precision machining of delicate components.

Machine tool manufacturers have created machines capable of maximizing the utility of each generation of cutting tool materials. Designers and machinists have optimized the shapes of tools to lengthen tool life at high cutting speeds, while lubricant manufacturers have developed new coolants and lubricants to improve surface finish and permit increased rates of metal removal. Automatic machines, computer numerically controlled (CNC) machines and transfer machines produce better tool efficiency. Machining today requires a wider range of skills as: computer programming and physical realities of the tool-work interface is as important as ever. (Schey, 1999).

Many new alloys have been developed to meet the increasingly severe conditions of stress, temperature and corrosion imposed by the needs of our industrial civilization. Some of these materials are easy to machine, but others, such as high-alloy steels, become more difficult to cut as their useful properties improve. (Huston & Knobeloch, 1998).

"Machinability" is not a unique property of a material! It is a mode of behavior of the material during cutting. Tool material and cutting speed are perhaps the two most important parameters to include. (Yang & Liu, 1999)

2. WHY THE KNOWLEDGE IN CUTTING PROCESS IS SO IMPORTANT

To better understand and control the cutting process, a lot of cutting models was imagine. Modeling methods are now discussed in five generic categories:

• Empirical modeling typified by Taylor's equation^

• Closed-form analytical modeling typified by Merchant's shear plane solution;

• Mechanistic modeling typified by DeVor *et al,'s* analysis of forces *vs.* chip thickness;

• FEA modeling typified by Sandstorm's high speed machining study;

• Artificial intelligence and other modeling methods that combine many of the above;

The goals of any kind of model are to predict physical behavior or known *a priori* conditions. Essentially, {known inputs + an accurate model = desired outputs}.

The metal cutting practitioner would like to know the tool life tomorrow, starting from today's input of the work material being purchased; the cutting inserts available; the features that have to be machined in the new "part-drawings" that have just arrived from the CAD/CAM sub-contractor; and how quickly the original client needs the part.

The metal cutting theorist would like to help with this question but, along the way, might also like to predict shear plane angle, cutting forces, and temperatures, as well as estimating the likely tool life at any given speed**.** (Jawahir, Dillon, Balaji, Redetzky & Fang, 1998).

A lot of scientifically papers, all over the world, provide experimental data on why" machining forecasting" is about as reliable as "weather forecasting. (Komanduri & Raff, 2000).

The key parameters that the day-to-day practitioner finds valuable are: (Trent & Wright, 2000)

1. Prediction of tool life
2. Prediction of the accuracy of component being machined
3. Prediction of surface finish on the part being machined
4. Prediction of chip control
5. Prediction of the loads on the tool, and/or workpiece,

From the authors' experiences in industry, the five parameters above are more-or-less arranged in their order of importance. In high precision machining, the accuracy is so critical that "#1 and #2" above will be reversed: the tool will be changed as often as desired accuracy dictates. In another circumstance, the machining of pure copper is "easy" from a tool-life point of view but "hard" from a surface finish viewpoint - here, "#1 and #3" might switch places.

3. EFFECTIVE VS CONSTRUCTIVE CUTTING ANGLES

Generally, to define the relative position between tool and work piece, in a case of cutting process is the same like the defining the relative position between two different coordinate systems. In fig. 1 is shown the case of orthogonal touring when the machine axis can be considered supposed against with the constructive system of cutting tool and the effective system O_{fe} X_{fe} Y_{fe} Z_{fe} is rotated because of kinematic angle deviation ή.

In this theoretical case is well known that six parameters are needed: three of them which describe the coordinate of the origin O_f against O – these are linear travel parameters (1_X, 1_Y, 1_Z for example), and the other are three angular parameters which characterize the spatial rotation of the axis of $O_f X_f Y_f Z_f$ system against with the axis of $OX_mY_mZ_m$ system. (Pop, 1989).

The theoretical parameters will be considered the factors or the elements which determine the axes position of the coordinate system of the tool X_f, Y_f, Z_f, as against with the axes position of the coordinate system attached on piece XYZ.

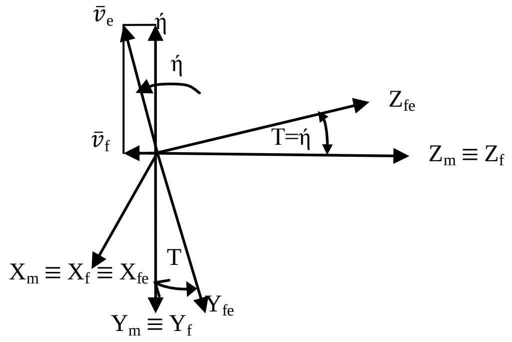

Fig. 1. Relative position of two coordinating systems

The technological parameters will be considered the factors which are necessary for the proper setting up the tool, as against with the working piece (constructive values of the tool, the geometry and dimensions of the working part, the smugness of the surface generation etc.). Between the theoretical and technological installation parameters of the tool there are the interdependence mathematical relations which allows the theoretical assembly values will be expressed depending on the certain values of the technological parameters and vice versa.

For example which are presented in figure 1, considering an M point of contact between cutting tool and the cylindrical surface of a workpiece with 60 mm in diameter, the effective coordinates, when the constructive coordinates M and the work parameters are known, are:

$$Me = M \times C = \begin{vmatrix} r \\ 0 \\ r \end{vmatrix} \begin{vmatrix} 1 & 0 & 0 \\ 0 & cos\,\eta & -\ sin\,\eta \\ 0 & sin\,\eta & cos\,\eta \end{vmatrix},$$

and thus:

x_{Me}=r ; y_{Me}= -r sin η; z_{Me}=r cos η

4. THE SPECIFIC OF HSC (HSM)

How do work materials behave when the cutting speed is raised as high as 3,500 m min^{-1} for aluminum alloy?

What are the forces on the tool?

What is the effect on tool life?

How good is the part accuracy?

These are some of the questions which must be answered to better control high speed cutting process. (Liu & Barash, 1984).

In this paper only some theoretically consideration about a possible answer at the last question is questioned.

To reach this goal, in figure 2 and 3 the scheme for determination of main effective cutting parameters of the tool is presented and then, using a manufacturing example, the difference between the values in the cases of classical turning vs. HSM is briefly presented.

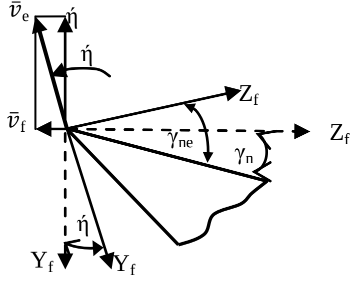

Fig. 2. Schema for effective normal rack angle determination, γne

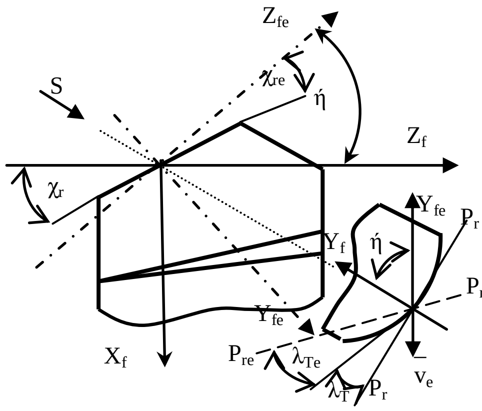

Fig. 3. Scheme for effective normal clearance angle α_{ne}, effective side rake angle λ_{Te} and effective setting angle χ_{re} determination

$$\alpha_{ne} = \arccos\,[\frac{1}{cos\lambda_{Te}}(\cos\alpha_n \cdot \cos\eta + \sin\alpha_n \cdot \sin\chi_r \cdot \sin\eta)];$$

$$\gamma_{ne} = \arcsin\,(\sin\gamma_n \cdot \cos\eta + \cos\gamma_n \cdot \sin\chi_r \cdot \cos\eta)$$

$$\lambda_{Te} = \arcsin\,(-\cos\chi_{nr} \cdot \sin\eta)$$

$$\chi_{re} = arctg\left(\frac{\tan\chi_r}{\cos\eta}\right)$$

Applying the above equation for: λ_T=0; χ_r=45°; α_n=5°; γ_n=6° at: - classical turning: Φ60mm, f=0,1 mm/rot; v=100 m/min

- high speed cutting: Φ60mm, f=0,2 mm/rot; v=475 m/min;

the result of dimensional accuracy and shape quality shows some meaningful differences.

5. CONCLUSION

If the geometrical parameters of the tool are well determined by calculus in advance, the tool setting on the CNC machine can be done in such a manner than the accuracy of the part can be obtained as it was designed. Thus, the number of tool adjustment and finishing passes can be diminishing and save supplementary costs.

The future research plans are dedicates to experimental attest of this theoretical calculus, first for longitudinal and face turning and then for form turning.

Improved appreciation of tool geometry also will lead to better understanding of cutting phenomenon.

6. REFERRING

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