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STUDIES ON THE SIMULATION FOR THE MILLING PROCESS OF PA 66 – GF 30

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ABSTRACT:
The finite element modeling (FEM) simulation permits the prediction of the cutting forces, stresses, and temperatures of the cutting process. This work follows to create a three-dimensionally model for the milling operation, considering the real geometry of the insert, for parts from polyamide PA 66 – GF 30. Polyamide PA 66 – GF 30 is a technical thermoplastic material which has excellent mechanical and physical properties and which is more and more often used in the automotive engineering industry.

KEYWORD:
Modeling, face milling, 3D FEM (Finite element method), polyamide.

INTRODUCTION

Polyamide processing through milling presents some particularities different from the metal milling, meaning the variation in value of the exit and enter parameters (Chavarria, 2004).
In the last year, the applications of the finite elements has strong developed because of the many advantages and of the development of the powerfully computers.
The finite element simulation permits the prediction of the cutting forces, stresses, and temperatures of the cutting process. These physical quantities are useful to design the cutting tool and determine the best cutting parameters (Pittalà & Monno**,** 2010).
Then an accurate mathematical model of the milling operations is necessary in order to properly design the geometry of the insert and the cutting process in terms of cutting parameters.

PRESENTATION OF STEPS FOR SIMULATION

The simulation PROCESS runs in three stages: preprocessing, processing (simulation) and postprocessing.
Preprocessing stage itself contains several phases, such as:
- Select system units;
- Setting process parameters: cutting speed, cutting depth and cutting feed;
- Introduction of process conditions: ambient temperature, the coefficient of friction and heat transfer between insert and workpiece ;
- Define tool, by creating a new insert and loading its in software;
- Define insert hoder by setting the necessary angles;
- Specify the total number of insert elements (between 5000 and 60,000);
- Specify the dimension of the part, which is subject to processing: part diameter and arc angle that defines the processing;
- Defining the workpiece material;
- Specify the number of elements for the workpiece, between 5000 and 80,000;

- Specification of simulation controls, data verification and database generation for the simulation model.

Further detail of these steps will be defined only stages in which tool and workpiece material, because the two are specific processing is studied.

The tool used is an end-milling cutter, the active part was represented by a square changeable cutting plate, presented in figure 1.

The material of the plate is H10 (HW) uncoated hard metal, containing mainly tungsten carbide (CW). The firm SANDVIK Coromant recommends this material to process non-ferrous materials, plastic materials and wood.

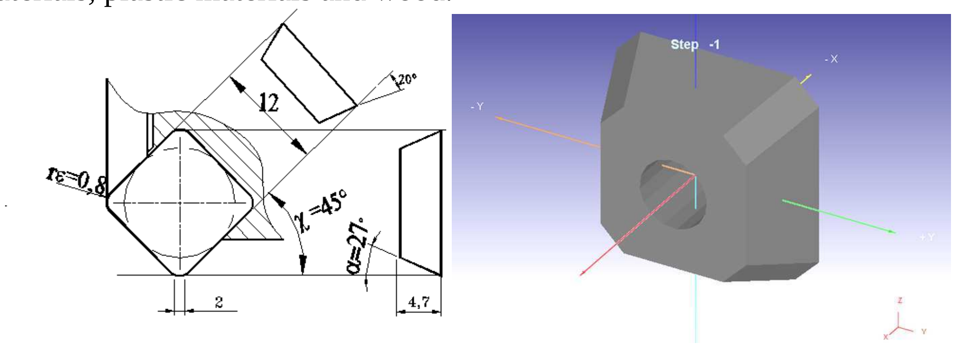

Fig. 1. The tool used: 1-the plate; 2- the plate in deform3D.

To represent this tool to deform 3D, first must create the model 3D using Catia software, to save the file with a .stl extension, and introduced in the program. Positioning the support plate was made in Deform3D, by adjusting the respective angles as shown in figure 1.

The PA 66 GF 30 polyamide is a thermoplastic material having excellent mechanic properties. The adding of fiber glass in the basis polyamide, PA 66, led to an important improvement of some mechanic properties.

This polyamide contains 30% fiber glass and being thermal stabilized it offers a high level of mechanic resistance, rigidity, creeping strength and dimensional stability, as well as excellent wearing resistance.

This fiber glass polyamide resists to high working temperatures (Sonbaty E. et al, 2004). Because of mechanical and physical properties this material is more and more often used in the automotive engineering industry.

In table 1 there are presented the mechanical characteristics of PA 66 – GF 30 polyamide (DSM, 2010).

For the simulation was adopted for processing scheme, face milling, the version that the tool axis is horizontal (fig. 2).

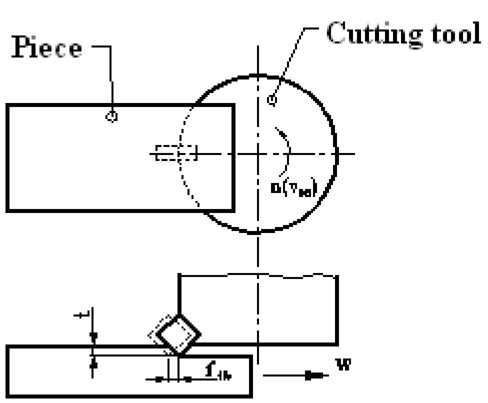

Fig. 2 The scheme of face milling

Cutting regime parameters are:

- cutting speed, $\mathbf{v_{aș}}$;
- cutting feed, $\mathbf{f_{th}}$,;
- cutting depth, **t**.

The experiments were performed by finite element simulation, using software Deform 3D. Cutting regime parameters are presented in the table 2:

Table 1. Mechanical characteristics of PA 66 – GF 30 polyamide (DSM, 2010)

Properties	Testing method ISO /(IEC)	Unit of measure	PA 66-GF30
Density	1183	[g/cm^3]	1,29
Mechanical characteristics to 23^{o}C			
Elasticity test: -tensile strength and break;	527	[MPa]	75
-elongation at break;	527	[%]	12
-modulus of elasticity.	527	[MPa]	3200
Compression test -flow limit for 1/2/5% nominal deformation.	604	[MPa]	28/55/90
Extention test in elasticity -load which generate 1% deformation in 1000h ($\sigma_{1/1000}$).	899	[MPa]	18
Impact bending resistance - Charpy	179/1eU	[KJ/m^2]	>50
Brinell hardness H358/30 or H961/30	2039-1	[N/mm^2]	165
Rockwell hardness	2039-2	-	M 76

For the simulation was adopted for processing scheme, face milling, the version that the tool axis is horizontal (fig. 2).

Table 2. Cutting regime parameters

Independent variables / The level	v [m/min]	f_{th} [mm/th]	t [mm]
Superior (+1)	294.37	0.08	1.56
Medium (0)	235.50	0.063	1.25
Inferior (-1)	186.43	0.05	1

THE RESULTS AND THE PROCESSING OF THE SIMULATION DATA

Cutting force, Fz, recording to the 12 experiments have the shape from the figure 3. Chart force will be presented for testing 8:

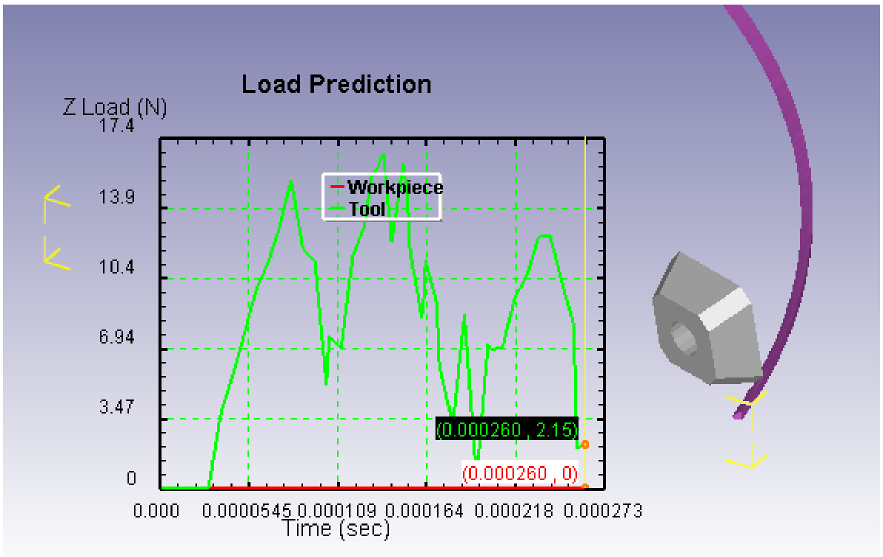

Fig. 3 Cutting force evolution

After running simulations to plan research result the average values of cutting force, Fz, tab. 3.

Table 3 Average values of simulated cutting force

	The values of the enter and exit parameters			
Exp	*v [m/min]*	*s [mm/d]*	*t[mm]*	***Fz [N]***
1	186.43	0.05	1.00	16.3
2	294.37	0.05	1.00	17.1
3	186.43	0.08	1.00	32.5
4	294.37	0.08	1.00	28.7
5	186.43	0.05	1.56	25.3
6	294.37	0.05	1.56	17.6
7	186.43	0.08	1.56	25.1
8	294.37	0.08	1.56	17.5
9	235.5	0.063	1.25	21.2
10	235.5	0.063	1.25	21.2
11	235.5	0.063	1.25	21.2
12	235.5	0.063	1.25	21.2

CONCLUSIONS

In this paper three-dimensional FEM simulations of face milling of PA 66 GF 30 have been performed in order to provide useful guidelines for the 3D FEM simulation of milling process.
The finite element simulation permits the prediction of the cutting forces, stresses, and temperatures of the cutting process.

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