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REASEARCH CONCERNING THE MACHINABILITY OF A FIBER GLASS COMPOSITE MATERIAL

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Abstract: *In this paper is presented some aspects concerning the milling process for orientated fiber glass material.The objectivs is to develop a method for etablis the optimal cutting parameters function of cutting effors and tool direction. Some initial experiments were made using 6 components dynamometer mounted on a milling center.*
Key words: *Glass fiber reinforced, Delamination, Trajectory, Anisotropy*

1. INTRODUCTION

In terms of current technological development, raw materials and energy crisis worldwide, and increasing human aggression for the environment have led to new materials and unconventional technologies.

Aviation, and aerospace industry in general, like most vehicles exert a negative impact on the environment in terms of noise and emissions, impacts that must be drastically reduced.
Top field of applications (nuclear, military, aerospace and others) have spurred the activity of research, design and production, imposing special performances, which is justified by stiff competition in these areas. Composite materials have important qualities compared to traditional materials like: low weight, mechanical and chemical resistance, low maintenance cost, dynamic design.

The composite materials are the first with internal structure made by human from molecular point of view and preferential direction of distribution. These features make the composite superior to the characteristics of their components.

The composite materials with fibers are structured in 3 categories:

-*Polymer matrix composite* (PMC) - These materials are composed from a polymer resin like matrix and reinforcing fiber made of glass, carbon or aramid.

-*Metal Matrix Composites* (MMC's) - used increasingly more often in the automotive industry. These materials are composed by a metal (eg aluminum) as matrix and fiber reinforcement (eg SiC).

-*Ceramic matrix composites* (CMC's) - used in environments with very high temperatures. They use a ceramic matrix and very short fibers, such as those made of silicon carbide and boron nitrides.

2. MACHINABILITY ANALYSIS OF COMPOSITE MATERIALS WITH POLYMERS MATRIX

Metal cutting process is one of the most important stages in the quality of the finished product.

The main characteristics of composites with fibers that influence cutting process are:

Heterogeneity: is characterized by simultaneous processing of two different materials. Chips results are in the form of dust that may have a negative role on the tool (eg. dust glass is very abrasive) or electrical conductors (carbon dust may cause short circuits).

Anisotropy: in the case of fibers composite material the behavior is different depending on the direction of fibers. In this case, stiffness, for example, will be much larger than the longitudinal direction of fibers in the transverse direction, which can cause unwanted deformations.

The study of cutting process is very important because it provides information on chip formation and is also associated with cutting forces and other characteristics of the machining processing. Literature contains studies on machining of metallic materials and formation mechanism of the chip. This information is restricted to fiber materials because these materials have not a homogeneous composition and have anisotropic properties.

Recent studies have shown that the formation of chips depends on the angle between fiber orientation and direction of cutting speed. When the machining direction is perpendicular to fibers the cutting tool presses on the material. The chip is made by fracture in the front of the tool and in the same time some crack of 0.1-0.3 mm occurs in the material under the tool. For fiber parallel machining the crack occurs in the front of the tool cutting edge and has depth about one or two fiber diameter. The analysis results show that the chip formation has not a plastic deformation and cutting process consists of a series of breaks.

Some tests were made on the unidirectional laminates materials in order to investigate the effects of fiber direction over the chip.

Fundamental characteristics were studied in parallel processing and the perpendicular to the fibers. It was shown that the cutting process is controlled by the behavior of the material (fragmented), the arrangement of fibers and cutting tool geometry. Because these materials have anisotropic properties parallel and perpendicular to the direction of fibers, may not apply cutting isotropic models used in metalworking. The parallel processing can occur delamination and fiber buckling, while the processing is perpendicular dominant bending phenomenon.

Delamination: exfoliation occurs when the cutting process is parallel fiber having positive clearance angles. Compression and shear are developed along the fiber. Laminated surface is then pulled thereby forming a break in the material.

Buckling: It occurs when the fibers are subjected to axial compression beyond the critical value by cutting tools. Disposal between fiber and matrix in front of cutting edge will propagate in the material along the fiber. Elastic fibers will deform until it forms a discontinuous fragment through the fracture. Since the chip is formed along the fibers' parallel processing, surface obtained is smooth, without burrs.

Bending: When processing the perpendicular fiber orientation, material is removed by bending. Because the material is not bound to the surface of the piece, it tends to slip.

Until today studies have been conducted for developed drilling operations of pultrusion fiber composites. For Machining studies were performed only on the direction orthogonal directions of fibers.

3. STUDY OF MILLING A FIBERGLASS COMPOSITE

3.1 Methodology and experiments

The material values stated in this article are valid in temperature range of -20^{0}C to 60^{0}C. The values are based on test results for dry condition.

We made an experimental study in terms of variation of cutting forces and moments for different paths and cutting parameters of the process. Preliminary data acquisition and interpretation was made with a Kistler dynamometer and related software.

It will make an action plan that will establish a number of types of paths as follows: -linear paths along the fiber; -linear trajectory perpendicular to fibers; -linear paths that form angles with the fiber direction; -circular path; -trajectories on parametric curves (Fig. 1).

For each process will measure forces and moments in three directions and will check the types of defects occurring in the material. Each trajectory will be split depending of mesh defects and their level. These will be correlated with data acquired during measurements.

For this first phase the experiments was made for linear and perpendicular paths along the fiber for different cutting depth, feed rate and main spindle speed.

3.2 Results

In machining of pultrusion composite materials the values of forces and moments are lower than similar metal machining, but the study of their variation is very important and necessary.

In figure 2 is presented some data obtained from experimental measurements for a cutting direction along the material fibres for 1.5 mm depth, 2785 rot/min and 751 mm/min feed rate.

	[MPa]
Flexural Strength, 0^0	240
Flexural Strength, 90^0	100
Tensile Strength, 0^0	240
Tensile Strength,90^0	50
Compressive Strength, 0^0	240
Compressive Strength, 90^0	70
Shear Strength	25

Tab. 1. Typical Strength Values

	[MPa]	[…]
Modulus of elasticity, E_0	23000	
Modulus of elasticity, E_{90}	8500	
Modulus in shear	3000	
Poisson's Ratio $\gamma_{0,90}$	50	0.23
Poisson's Ratio $\gamma_{90,0}$	240	0.09

Tab. 2. Typical Stiffness Values

Fig.1. Fiber glass material machined –first test

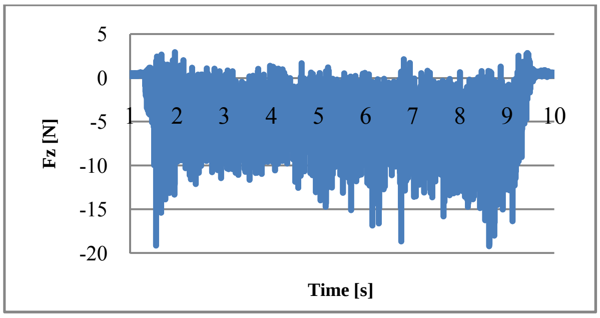

Fig. 2. Variation of force

The data signal was obtained by using a Kistler dynamometer mounted on a milling center. The results will be used in a machining parameter optimisation.

4. CONCLUSION

Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Although many factors affect the surface condition of a machined part, machining parameters such as cutting speed, feed rate and depth of cut have a significant influence on the surface roughness for a given machine tool and work piece set-up. It is known that the mechanism of cutting in GFRP composites is due to the combination of plastic deformation, shearing and bending rupture.

The increase in feed rate increased the heat generation and hence, tool wear.

The process parameters influencing on the machining of GFRP composites has been assessed.

1.This experiments shows that it is convenient to predict the main effects and interaction effects of different influential combinations of machining parameters.

2.Feed rate is the factor, which has greater influence on surface roughness, followed by cutting speed.

In our research the objective is to develop a method to correlate the milling cutting parameters with tool trajectory in order to obtaine complex surface machining based on forces variation analysis.

5. ACKNOWLEDGEMENTS

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