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STUDY ON DETERMINING THE DRILLING FORCE REGRESSION AT DRILLING COMPOSITES MATERIALS WITH POLYMERIC MATRIX AND FIBER GLASS

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Abstract: *Composite materials are harder to machine than metals, because they are anisotropic, they are not homogenous and their reinforcing fibers are very abrasive. Significant damage to the work piece may be introduced and high wear rates of the tools are experienced while machining. A presentation of the data obtained through experiments and an analysis of the drilling force when machining composites will be made in this article.*

Key words: *composites, cutting, drilling.*

1. INTRODUCTION

Today's advanced technology society continues to push the limits of conventional materials. Extreme and sometimes conflicting requirements force us to discover materials that can not be combined through known methods. Composites are such a category of materials, designed especially to face this challenge. From their discovery, the use of composite materials has grown very rapid in certain industrial areas, such as space industry, aircraft industry, car industry etc.[1] .

Composite materials which contain glass fiber, because of their physical and mechanical properties, raise special problems when it comes to drilling. From another point of view, because of the high cost of these materials, the study on machining must be done using fast methods of drilling which will lead to a minimum consumption of materials. [2, 3]. In the current paper, a series of results obtained in determining the forces that appear when drilling into STRATIMAT type composite materials, with polymeric matrix and glass fibers.

2. METHOD, MEANS AND DRILLING CONDITIONS USED WHEN DETERMINING THE FORCES

For this, the fallowing experimental stand has been chosen (Fig. 1).

Drilling conditions used during the experiments:

Drilling machine used:

- drilling machine GU 25;
  – power of work: 2.3 KW;
  – gamma of rotations: 28…2 240 rot/min;
  – gamma of advances: 0.08…0.25 mm/rot.

Specifications drilling tools:

- helical drills: Φ7, Φ8, Φ10, Φ12, Φ14 with $2\kappa = 130°$ of Rp5 cu HRC 62.

Material properties are the following:

- probe structure:
  – polyester resin HELIOPOL 4231 ATX;
  – glass fiber.

Fig. 1. The image of the stand of determinations with the force moment pickup and the registration system.

- Polyester resin HELIOPOL 4231 ATX:
  – viscosity (23ºC) DIN 53211 (65–80) s;
  – gel Time HELIOS KM 3205 (5–11) min;
  – acid Number DIN EN ISO 3682 30 mg KOH/g;
  – styrene Content DIN EN ISO 3251 (40–45)%;
  – density ISO 2811 (1100–1150) kg/m^3;
  – flash Point ISO 367 34°C.
- Glass fiber CSM-450-1900 (STRATIMAT)
  – is made out of E type glass fiber
  – time to dissolve the binder in styrene, max.60 s;
  –specific weight ISO 4605 450 g/m^{2}m;
  – width ISO 5026 100 cm;
  – humidity ISO 3344 0.2%.

In order to measure the axial forces of splintering one used a pickup for measuring the processing forces, made in The T.C.M. Department, I.M.S.T. Faculty [4].

For the display of the registration made by the pickup of forces and the pickup of moments, a N2300 electric dynamic tensometer is used.

The gauging of the pickup of forces was made with a lab dynamometer which bears a maximum loading of

10 kN compression read on a comparator with dial with the division value of 0.01 mm and an average constant value of gauging for the forces was obtained:

$$K_F = 6.9 \text{ N/div.}$$

3. EXPERIMENTAL RESULTS AND DATA PROCESSING

Technical literature [4, 5] provided equation (1), which has been the starting point in the analysis of cutting forces:

$$F = C_F \times D^{x_F} \times s^{y_F} \text{ [N].} \quad (1)$$

This equation has proved to be inappropriate since after the practical estimation of the polytrophic exponents and constants, several tests determinations has been performed and have showed a wide result scattering under the same cutting conditions.

During the machining at various speeds, different parameter values were recorded even if all the other machining conditions are kept constant. It was introduced a speed factor:

$$F = C_F \times D^{x_F} \times s^{y_F} \times v^{z_F} \text{ [N].} \quad (2)$$

In order to the C_F constant and the x_F, y_F, z_F, polytrophic exponents were estimated, the equation (2) has been linear zed by using the logarithm:

$$\lg F = \lg C_F + x_F \lg D + y_F \lg s + z_F \lg v. \quad (3)$$

Table 1 shows a selection of the most conclusive machined:

In the data included in Table 1 are substituted in the equation (3), a linear inhomogeneous system of 4 equations with 4 unknowns (x_F, y_F, z_F, $\lg C_F$) is obtained:

$$\begin{cases} \lg C_F + x_F \cdot \lg 12 + y_F \cdot \lg 0.25 + z_F \cdot \lg 13.38 = \lg 193.2 \\ \lg C_F + x_F \cdot \lg 7 + y_F \cdot \lg 0.25 + z_F \cdot \lg 7.8 = \lg 151.8 \\ \lg C_F + x_F \cdot \lg 12 + y_F \cdot \lg 0.125 + z_F \cdot \lg 13.38 = \lg 138 \\ \lg C_F + x_F \cdot \lg 12 + y_F \cdot \lg 0.25 + z_F \cdot \lg 26.76 = \lg 172.5. \end{cases} \quad (4)$$

The system has the following solution:

$$C_F = 126.9; x_F = 0.61; y_F = 0.485; z_F = -0.163.$$

The axial cutting force formula for the drilling is obtained by inserting this solution in the equation (2):

$$F = 126.9 D^{0.61} s^{0.485} v^{-0.163} \text{ [N].} \quad (5)$$

Experiments 5 and 6 were conducted to test the relation of regression (5). Calculation errors were lower than 2%.

Diagrams of the variation of forces are shown in Figs. 1 to 6. These only apply to composite materials with a polymeric matrix and glass fiber STRATIMAT.

4. ANALYSIS OF THE RESULTS

Fig. 2 shows the variation of the axial force as a function of feed rate *s*, where *v* = 13.38 m/min for different drill diameters, *D*.

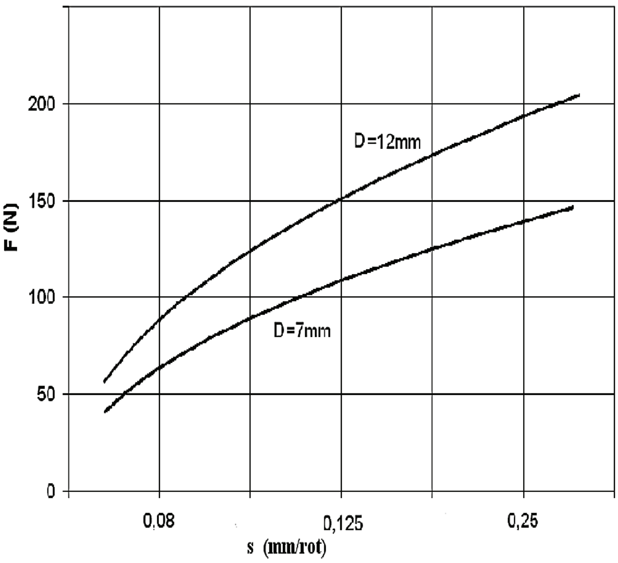

Fig. 2. The variation of the axial force of feed rate, for different drill diameters.

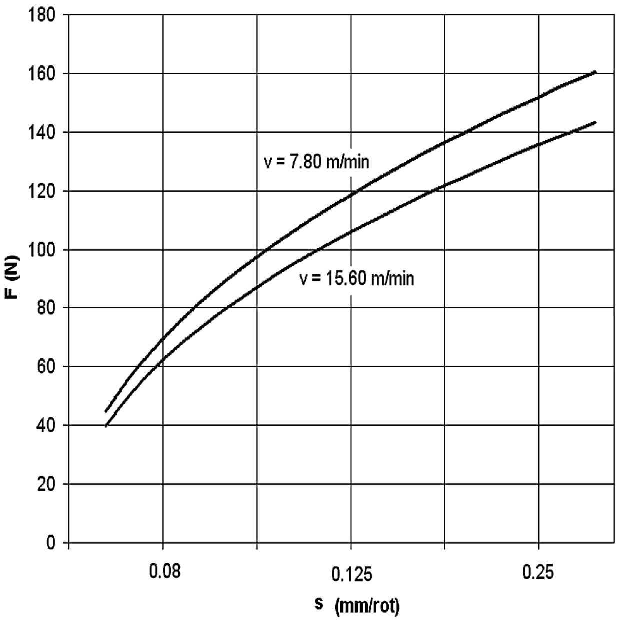

Fig. 3. The variation of the axial force as a function of feed rate, for different drilling speeds of the tool.

Table 1

Experimental results

Nr. crt.	Hole diameters *d* [mm]	Feed rate *s* [mm/rot]	Rotation *n* [rot/min]	Drilling speeds *v* [m/min]	Forces div.	Forces [N]
1	12	0.25	355	13.38	28	193.2
2	7	0.25	355	17.8	19	132.78
3	12	0.125	355	13.38	20	138
4	12	0.25	710	26.76	25	172.5
5	10	0.125	710	22.29	16	113.69
6	8	0.25	355	8.92	23	161.23

The rise of the forces is exponential with the rise of the drill diameter and of the feed rate, *s*.

Fig. 3 shows the variation of the axial force as a function of feed rate *s*, where *D* = 7 mm for different drilling speeds of the tool.

The rise of the forces is exponential with the rise of the feed rate.

Fig. 4 shows the variation of the axial force as a function of drill diameter, *D*, where *v* = 13.38m/min, for different feed rates, *s*.

It can be noticed that the axial forces rise exponential with the rise of the drill diameter.

Fig. 5 shows the variation of the axial force as a function of drill diameter, *D*, where *s* = 0.25mm/rot for different drilling feed speed.

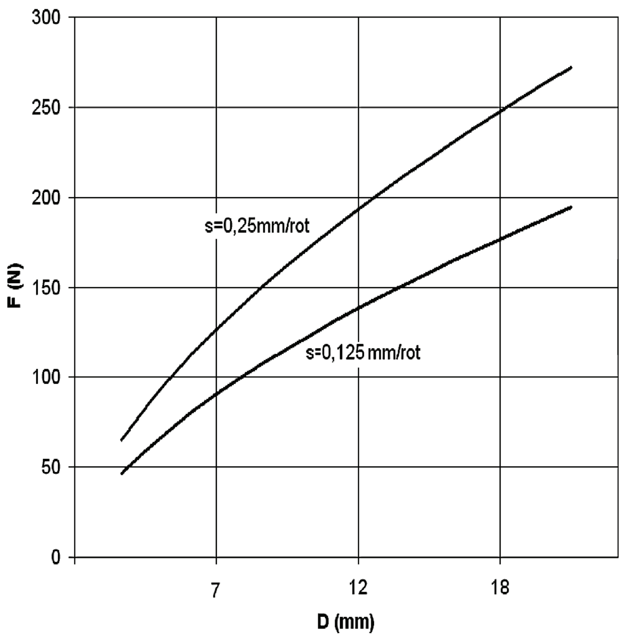

Fig. 4. The variation of axial force as a function of drill diameter, for different feed rates.

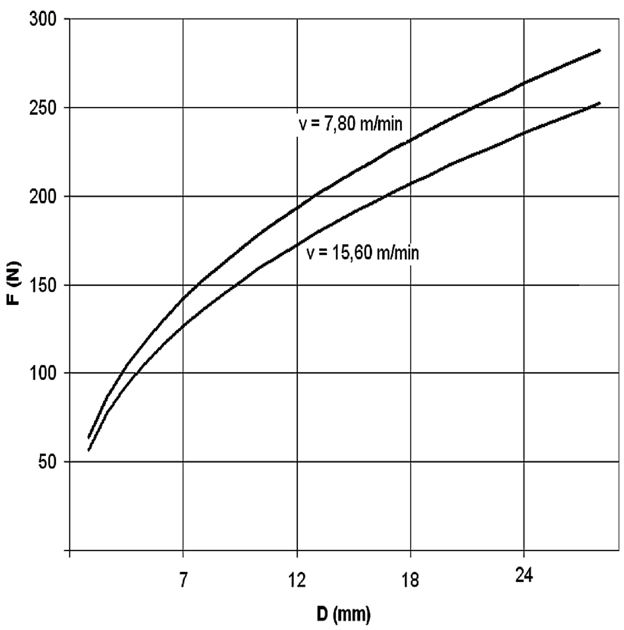

Fig. 5. The variation of axial force as a function of drill diameter, for different drilling feed rates.

It can be noticed that the axial forces rise exponential with the rise of the drill diameter.

Fig. 6 shows dependence on the axial force as a function of drilling speed *v*, where *s* = 0.25mm/rot, for different hole diameters.

The axial forces subtract exponential with the rise of the drill speed.

Fig. 7 shows dependence on the axial force as a function of drilling speed *v*, where *D* = 12 mm, for different feed rates, *s*.

It can be noticed that the axial forces subtract exponential with the rise of the drill speed.

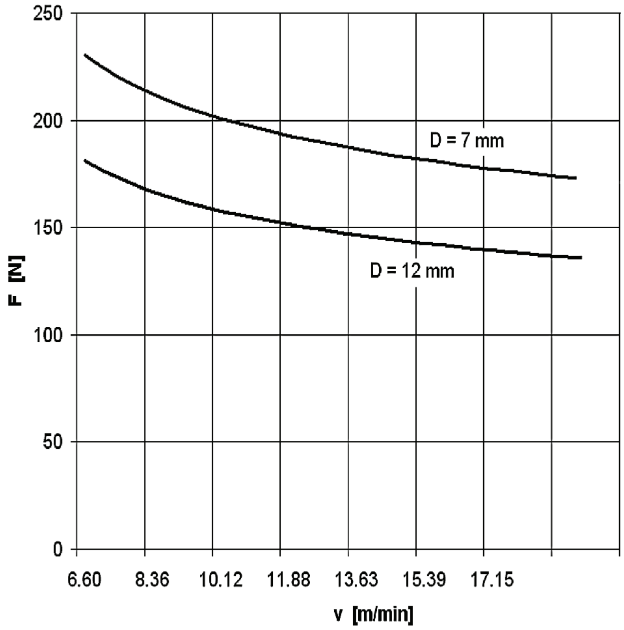

Fig. 6. The variation of axial force as a function of drilling speed, for different hole diameters.

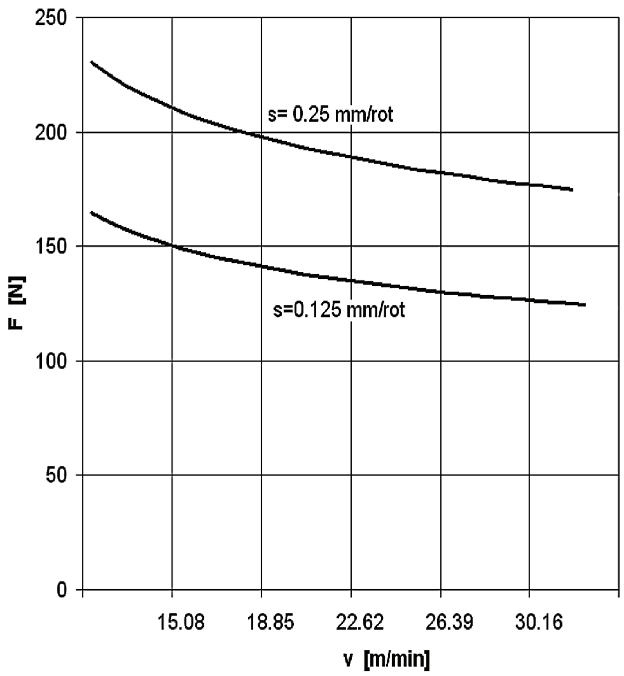

Fig. 7. The variation of axial force as a function of drilling speed, for different feed rates.

5. CONCLUSIONS

From both theoretical and experimental research, the fallowing facts can be deduced:

To determine the axial force when drilling into composite materials with polymeric matrix and type STRATIMAT glass fiber, a pickup of forces was used.

The range of the forces of 0 to 200N allowed for drills with diameters in the range of 7 to 14 mm to be used.

For the experiments done to determine the equation of the axial force, from the analysis of the charts there was deduced an exponential rise of the forces of splintering with the rise of the feed rate and the diameter of the drill, and a decrease of the force with the rise of the splintering speed.

Concerning the shape of the splinters removed from the material, these were fragmentation splinters.

During the experiments, no cooling liquids were used because of the abrasive actions which they would do on the cutting tool.

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