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DETERMINING THE DRILLING TORQUES REGRESSION AT DRILLING IN COMPOSITE MATERIALS WITH POLYMERIC MATRIX AND 20% GLASS FIBRES

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Abstract: *Composite materials because of their physical and mechanical properties raise many problems when it comes to drilling. This article will present the experimental results and the analysis of the torque when drilling into composite materials with polymeric matrix and 20% glass fiber, using a special drill for these materials, made by HUFSCHMIED.The article contains an analysis of the variation of the drill torques as a function of drill parametric (feed rate, drill diameters and drilling speeds of the tool..*

Key words: *composite material, drilling, machining, torques regression, glass fiber.*

1. INTRODUCTION

Composite materials are used extensively because of their higher strength to weight ratios and, when compared to metals, offer new opportunities for design. However, being non-homogenous, anisotropic and reinforced with very abrasive fibers, these materials are difficult to machine. Significant damage to the work piece may be introduced and high wear rates of the tools are experienced.

Traditional machining methods such as drilling, turning, sawing, routing and grinding can be applied to composite materials using appropriate tool design and operating conditions [1].

Drilling is the most common composite machining operation, since many holes must be drilled in order to install mechanical fasteners.

Machining of the composite materials differs significantly from the machining of conventional materials and their alloys. When machining reinforced composite materials, their behavior is not only inhomogeneous, but also depends on the properties of the reinforcing elements and those of the matrix, on the fiber orientation and the matrix – reinforcing element ratio [2, 3].

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

For this, the fallowing experimental stand has been chosen: (Figure1)

Drilling machine used:

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

Specifications drilling tools:

- drills with special shape: Φ6, Φ8, Φ10, Φ12, made by HUFSCHMIED (Figure 2)

Material properties are the fallowing:

- probe structure:

Fig. 1. The registration system.

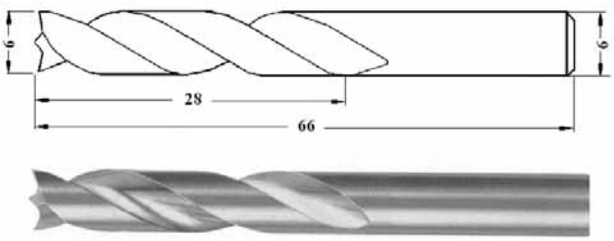

Fig. 2. Drills made by HUFSCHMIED.

- polyester resin AROPOL S 599
- glass fiber EC12-2400-P1800(65), produced by SC.FIROS SA;

The product code of EC12-2400-P1800 (65), according with ISO 2078, is the following:

- E = glass type;
- C = continual process;
- 12 = diameter of the monofilament (/);
- 2400 = length density - finesse;
- P1800 = FIROS cod;
- (65) = length density - finesse;

The main properties of the EC12-2400-P1800 (65), are:

- density: 2.54 g/cm^3;
- longitudinal elasticity constant: 72400 N/mm^2;
- terminal expansion coefficient: 5 10^{-6} $^0C^{-1}$;
- heat conductivity: 1.3 W/(m $^\circ$C);
- specific heat: 840 J/(kg K).

The computer system consisted of the following (Fig. 2):

- A transducer type T4A HBM for measuring torque was used;
- A transducer for measuring forces, made by the T.C.M. Desk, of the I.M.S.T Faculty. Bucharest;
- MGC amplifier, produced by Hottinger Baldwin Messtechnic;
- Data acquisition board type DAQ Pad 6020E;
- PC;
- Lab VIEW software.

3. EXPERIMENTAL RESULTS AND DATA PROCESSING

Technical literature [5, 6, 7] provided equation (1), which has been the starting point in the analysis of cutting moments:

$$M = C_M \cdot D^{x_M} \cdot s^{y_M} \cdot v^{z_M} \text{ [Nm].} \quad (1)$$

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:

$$M = C_M \cdot t^{x_M} \cdot s^{y_M} \cdot D^{z_M} \cdot v^{w_M} \text{ [Nm].} \quad (2)$$

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:

$$\lg C_M + x_M \cdot \lg t + y_M \cdot \lg s + z_M \cdot \lg D + w_M \cdot \lg v = \lg M \quad (3)$$

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_M, y_M, z_M, C_M) is obtained:

$$\begin{cases} \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0.25 + z_M \cdot \lg 11.15 = \lg 1.029 \\ \lg C_M + x_M \cdot \lg 6 + y_M \cdot \lg 0.25 + z_M \cdot \lg 6.69 = \lg 0.392 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0.125 + z_M \cdot \lg 11.15 = \lg 0.617 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0.25 + z_M \cdot \lg 22.30 = \lg 0.819 \end{cases} \quad (4)$$

The system has the following solution:

$y_M = 0.738$, $z_M = - 0.329$, $x_M = 2.219$, $C_M = 0.038$.

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

$$M = 0.038 \cdot D^{2.219} \cdot s^{0.738} \cdot v^{-0.329} \text{ [Nm].} \quad (5)$$

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

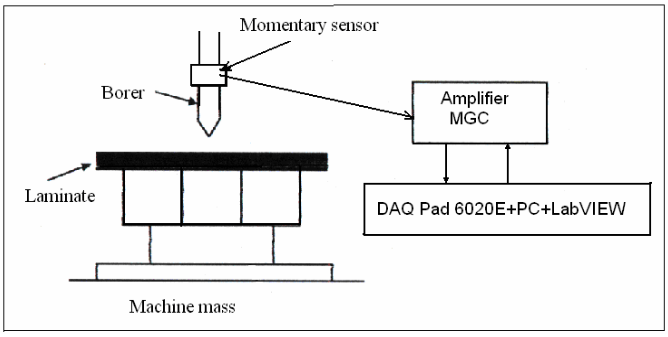

Fig. 3. The schematic representation of the stand of determination.

Table 1

Experimental results

Nr. Crt.	Diameters d, mm	Feed rate s, mm/rot	Rotation n, rot/min	Drilling speeds v, m/min	Torque	
					V	Nm
1	10	0.25	355	11.15	0.049	1.029
2	6	0.25	355	6.69	0.0187	0.392
3	10	0.125	355	11.15	0.0294	0.617
4	10	0.25	710	22.30	0.039	0.819
5	12	0.125	710	26.76	0.033	0.693
6	8	0.25	355	8.92	0.032	0.680

4. ANALYSIS OF THE RESULTS

Diagrams of the variation of torque are shown in Figs. 4 to 9.

Figure 4 shows the variation of torque as a function of feed rate *s*, where *v* = 11.15 m/min, for different drill diameters, *d*.

Figure 5 shows the variation of torque as a function of feed rate s, where *d* = 10 mm, for different drilling speeds of the tool, *v*.

Figure 6 shows the variation of torque as a function of drill diameter, *d*, where *v* = 11.15 m/min, for different feed rates, *s*.

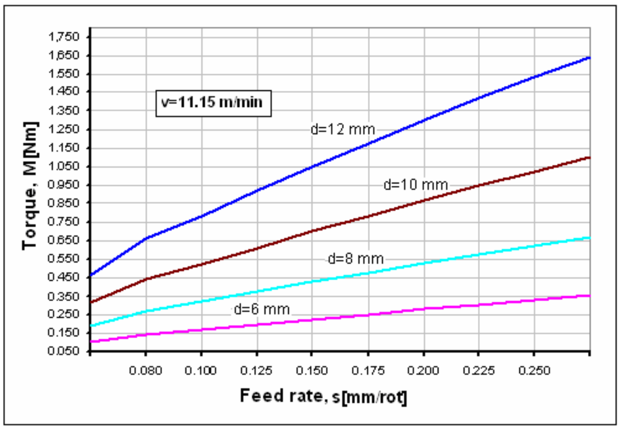

Fig. 4. Shows the variation of torque as a function of feed rate, for different hole diameters (*v* = constant).

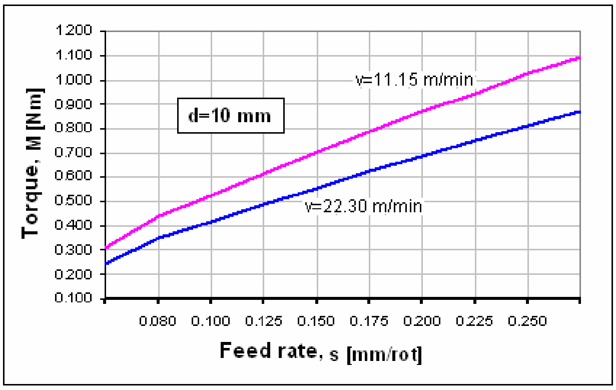

Fig. 5. Shows the variation of torque as a function of feed rate, for different drilling speeds of the tool (*d* = constant).

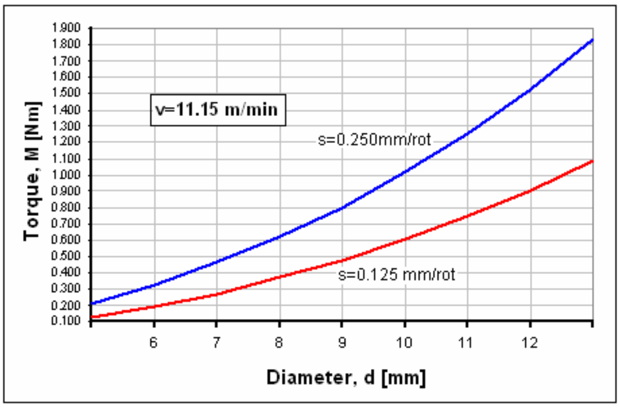

Fig. 6. Shows the variation of torque as a function of hole diameter, for different feed rates (*v* = constant).

Figure 7 shows the variation of torque as a function of drill diameter, d, where *s* = 0.250 mm/rot and for different drilling feed speed, *v*.

Figure 8 show dependence on the torque as a function of drilling speed *v*, where *s* = 0.250 mm/rot, for different drill diameters, *d*.

Figure 9 show dependence on the torque as a function of drilling speed *v*, where *d* = 10 mm, for different feed rates, *s*.

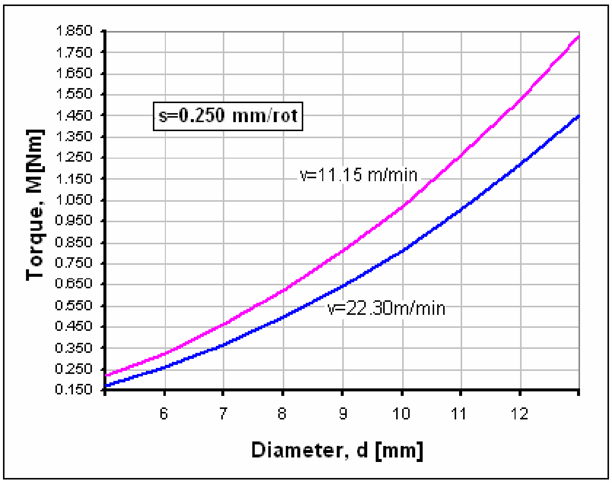

Fig. 7. Shows the variation of torque as a function of hole diameter, for different drilling feed rates (*d* = constant).

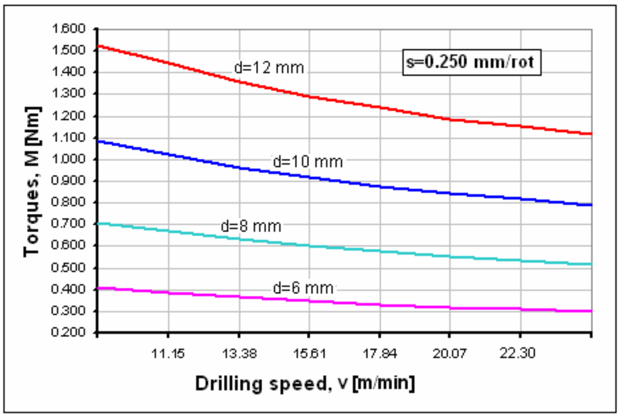

Fig. 8. Shows the variation of torque as a function of drilling speed, for different hole diameters (*s* = constant).

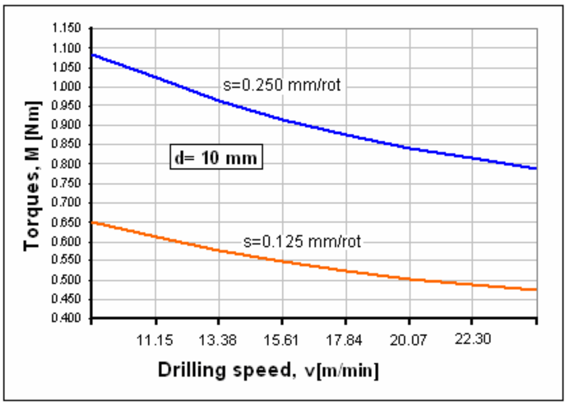

Fig. 9. Shows the variation of torque as a function of drilling speeds, for different feed rates (*d* = constant).

5. CONCLUSIONS

From the analysis the results of torque at drilling in composite materials with polymeric matrix and 20% glass fibers, the following important conclusions can be drawn:

- from the diagrams, one can notice that the cutting torques using the special drill grow at an exponential rate if the diameter of the drill or the feed is increased;
- keeping the diameter of the tool constant, the rise of the torques is exponential with the rise of the feed rate;
- it can be noticed that the torque rise exponential with the rise of the drill diameter and the feed rate, for constant cutting speed;
- it can be noticed that the torques when drilling with special drills rise exponential with the rise of the drill diameter and have higher values if the cutting speed decreases, if the feed rate is constant;
- if we keep the feed rate constant, the torques subtract exponential with the rise of the drill speed, the values of the torque being higher if the diameter of the drill is increased;
- the result of drilling using this type of drill is satisfactory from the point of view of the quality of finished surfaces, especially at the exit point of the tool, although the high values of cutting forces must be considered, when comparing to classic drills;
- the variation of the diagrams shows that the cutting torques for the curved drill decrease at an exponential rate if the working speed and the feed rate increase, if the diameter is kept constant.

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