Nonconventional Technologies Review
Romania, December, 2013

COMPARATIVE STUDY ON DETERMINING THE DRILLING TORQUE REGRESSION AT DRILLING COMPOSITES MATERIALS

Ocnărescu Constantin [1], Vulturescu Viorel [1], Ocnărescu Maria [2]
[1] Universitatea POLITEHNICA Bucureşti
[2] Colegiul Tehnic ”CAROL I”

Abstract: Composites material with polymeric matrix and fiberglass, because of their physical and mechanical properties, bring up special problems at the remaking by splinting. In this current article is present a comparative study of results obtained in determining the drilling torque regression at drilling. Determinations were done on three types of composites polymeric matrix with different concentrations of fiber glass.

Key words: composite materials, polymeric matrix and fiberglass, drilling torque.

1 INTRODUCTION

Composite materials are being used more and more in production, replacing traditional materials like glass, wood and even metals,

The concept of composite refers to a complex system, which is made up of many materials, of different nature. This class of materials is made up of a vast array of products. This is because the possibilities of modifying the basic components, the “assembly” and fabrication techniques, the level of quality and cost, are practically infinite.[1]

Fiberglass reinforced polymeric composite materials are made up of a polymeric matrix mixed up with filling materials (solvents, stabilizers), reinforced with glass fiber.

Polymeric composite materials have began to be used in various technical domains. Today, a lot of reinforcing materials and types of polymeric matrix are known, and by combining them, even the highest standards can be met.

Because of this, polymeric composite materials have become essential for the development of certain top fields like: microelectronics, medical technique, space and naval constructions.

Machining of composite materials differs significantly from the machining of conventional materials and their alloys. When machining reinforced composite materials, their behavior is not homogenous and also depends on the various properties of the reinforcing elements and of the matrix, the orientation of the fibers and the matrix volume to reinforcing element ratio. [2,3]

2 METHOD, MEANS AND DRILLING CONDITIONS USED WHEN DETERMINING THE TORQUE

For this, the fallowing experimental stand has been chosen: (figure 1, 2)

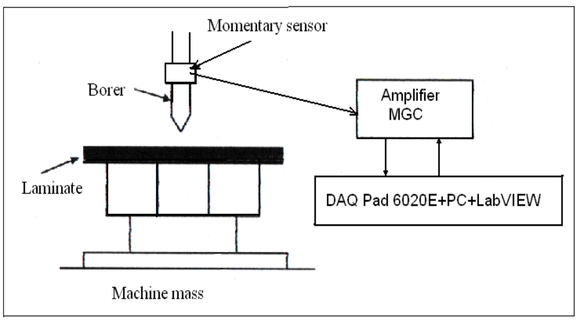

Figure 1. The image of the stand of determinations with the force moment pickup and the registration system

Figure 2. Experimental stand

Drilling machine used:

- drilling machine GU 25
  - power of work: 2,3 KW;
  - gamma of rotations: 28…2240 rot/min;
  - gamma of advances: 0,08….0,25 mm/rot.

Specifications drilling tools:

- helical drills: Φ6, Φ8, Φ10, Φ12, with 2κ= 130^0, made by DORMER

Material properties are the fallowing:

- probe structure:
  - 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
- Resistance to traction: 3450 N/mm^2
- Terminal expansion coefficient: 5 10^{-6} $^0C^{-1}$
- Heat conductivity: 1,3 W/(m ^{0}C)
- Specific heat: 840 J/(kg K)

In order to record the values of the torque variations at different splintering parameters (tool diameter, feed rate, r.p.m) we have used a computer system consisting of the following:

A transducer for measuring torque type T4A HBM

MGC amplifier, prodused by Hottinger Baldwin Messtechnic;

Data acquisition board type DAQ Pad 6020E;

PC;

LabVIEW software

A dynamometric key was used to calibrate the torque reader; the key was designed and produced by members of the TCM Desk; it was also calibrated;

The values for the torque achieved with the dynamometric key and read by the torque transducer type T4A HBM were recorded using the MGC amplifier, produced by Hottinger Baldwin Messtechnic.

The calibration constant for the Hottinger torque reader is:

$K_M = 21$Nm/V.

3 EXPERIMENTAL RESULTS AND DATA PROCESSING

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

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

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:

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

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:

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

Table 1 shows a selection of the most conclusive machined.

Table 1. Experimental results

Nr. det.	Hole diameters D, mm	Feed rate s, mm/rot	Rev, n, rot/min	Drilling speeds v, m/min	Torque [Nm] Content fiber glass		
					20%	30%	40%
1	10	0,25	355	11,15	0,819	0,829	0,840
2	6	0,25	355	6,69	0,399	0,409	0,415
3	10	0,125	355	11,15	0,609	0,615	0,619
4	10	0,25	710	22,30	0,714	0,756	0,798

5	12	0,125	710	26,76	0,702	0,73	0,75
6	8	0,25	355	8,92	0,609	0,617	0,625

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:

- composites materials with polymeric matrix and 20% fiber glass

$$\begin{cases} \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 11{,}15 = \lg 0{,}819 \\ \lg C_M + x_M \cdot \lg 6 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 6{,}69 = \lg 0{,}399 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}125 + z_M \cdot \lg 11{,}15 = \lg 0{,}609 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 22{,}30 = \lg 0{,}714 \end{cases} \quad (4)$$

The system has the following solution:

$C_F = 0{,}059$; $x_F = 1{,}606$; $y_F = 0{,}427$; $z_F = -0{,}198$;

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

$$M = 0{,}059 \cdot D^{1{,}606} \cdot s^{0{,}427} \cdot v^{-0{,}198}\ [N] \quad (5)$$

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

- composites materials with polymeric matrix and 30% fiber glass

$$\begin{cases} \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 11{,}15 = \lg 0{,}829 \\ \lg C_M + x_M \cdot \lg 6 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 6{,}69 = \lg 0{,}409 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}125 + z_M \cdot \lg 11{,}15 = \lg 0{,}615 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 22{,}30 = \lg 0{,}756 \end{cases} \quad (6)$$

The system has the following solution:

$C_F = 0{,}063$; $x_F = 1{,}516$; $y_F = 0{,}431$; $z_F = -0{,}133$;

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

$$M = 0{,}063 \cdot D^{1{,}516} \cdot s^{0{,}431} \cdot v^{-0{,}133}\ [N] \quad (7)$$

Experiments 5 and 6 were conducted to test the relation of regression (7). Calculation errors were lower than 2%

- composites materials with polymeric matrix and 40% fiber glass

$$\begin{cases} \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 11{,}15 = \lg 0{,}840 \\ \lg C_M + x_M \cdot \lg 6 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 6{,}69 = \lg 0{,}415 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}125 + z_M \cdot \lg 11{,}15 = \lg 0{,}619 \\ \lg C_M + x_M \cdot \lg 10 + y_M \cdot \lg 0{,}25 + z_M \cdot \lg 22{,}30 = \lg 0{,}798 \end{cases} \quad (8)$$

The system has the following solution:

$C_F = 0{,}047$; $x_F = 1{,}454$; $y_F = 0{,}440$; $z_F = -0{,}073$;

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

$$\mathbf{M = 0{,}065 \cdot D^{1{,}454} \cdot s^{0{,}440} \cdot v^{-0{,}074}\ [N]} \quad (9)$$

Experiments 5 and 6 were conducted to test the relation of regression (9). Calculation errors were lower than 2%

4 ANALYSIS OF THE RESULTS

Diagrams of the variation of torque are shown in figures 3 to 8. These only apply to composite materials with a polymeric matrix and 20% glass fiber.

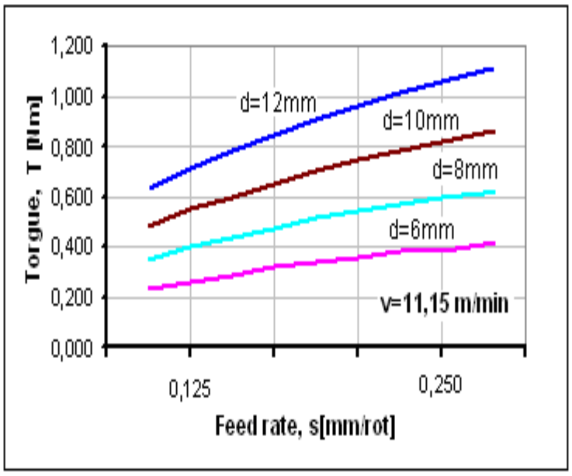

Figure 3. Shows the variation of torque as a function of feed rate, for different

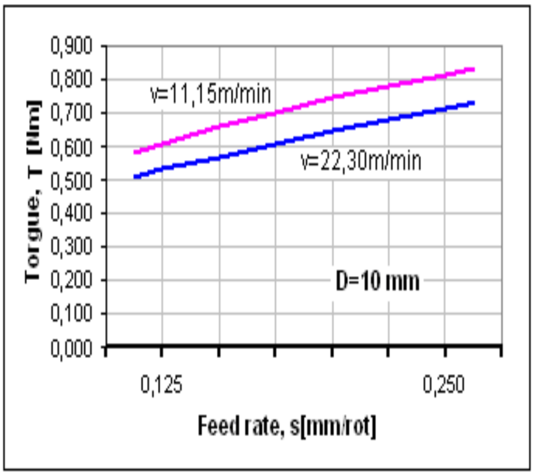

Figure 4. Shows the variation of torque as a function of feed rate, for different

hole diameters (v=ct) drilling speeds of the tool (s=ct)

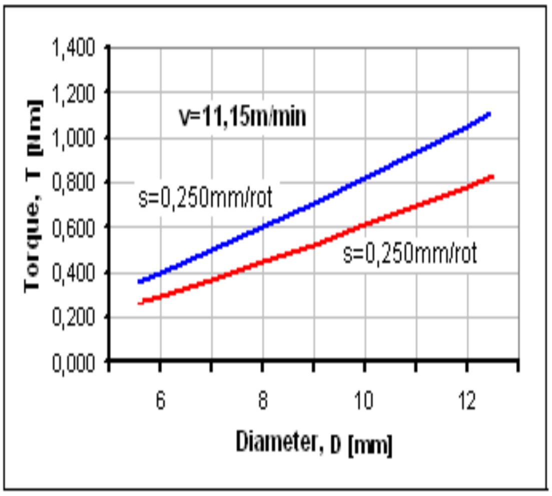

Figure 5. Shows the variation of torque as a function of hole diameter, for different feed rates (v=ct)

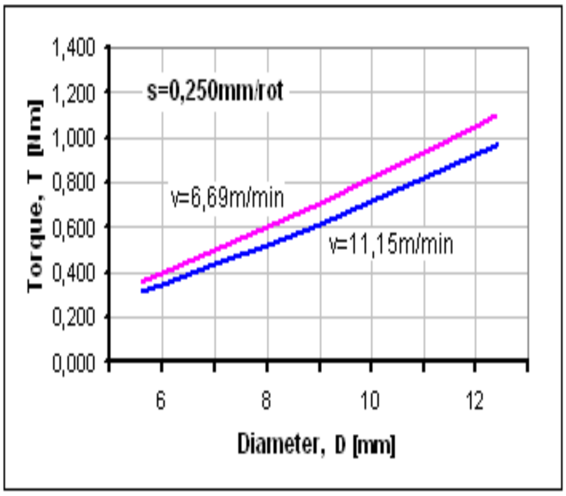

Figure 6. Shows the variation of torque as a function of hole diameter, for different drilling feed rates (D=ct)

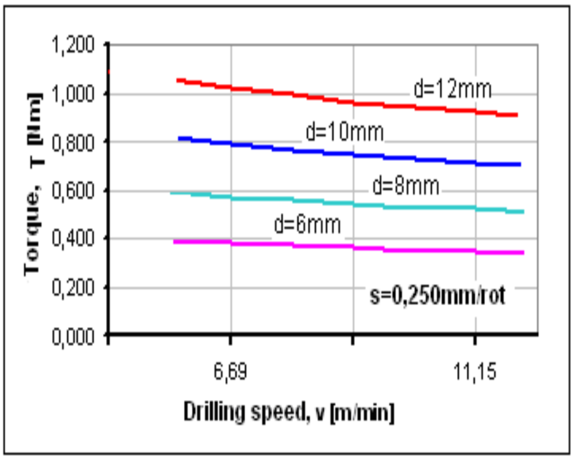

Figure 7. Shows the variation of torque as a function of drilling speed, for different hole diameters (s=ct)

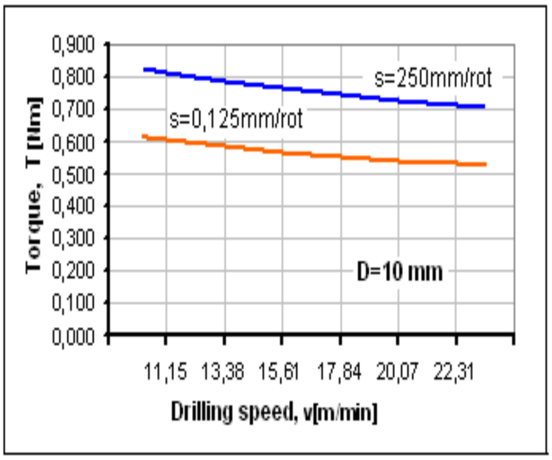

Figure 8. Shows the variation of torque as a function of drilling speeds, for different feed rates (D=ct)

5 CONCLUSIONS

From the analysis of the results obtained, the fallowing conclusions can be drawn:

- In order to determine the torque that appears when drilling into composite materials, a transducer for measuring torque was used, type T4A HBM;
- From analyzing the graphics, a growth of the torque could be notices, as the feed rate and drill diameter increased. However, an exponential decrease in torque can be seen, when the splintering speed increases.
- The machining of these types of material require higher splintering torque, the higher the concentration of glass fiber.
- After analyzing the graphics obtained during the experiments, it has been noticed that the density of maximum splintering torque is greater, the higher the concentration of glass fiber;
- The maximum and minimum values of the torque are exactly equal, as seen from the graphics; the maximum values represent the torque present when the drill cuts through the glass fiber; the minimum values for the torque are recorded when the drill cuts through the matrix.
- From the graphics, it can be seen that, as the drill approaches the exit-point of the material, there is an area of random recordings, that being the moment when the drill, aside of the cutting action, causes the tear of the glass fiber from the material.
- Although the result of the drilling with this type of drill does not meet high standards regarding the

exit-surface of the hole, it must be mentioned that the values for the recorded torque for this type of drill are much smaller than for other types.

6 REFERENCES

1. HUBCA, GHE., IOVU, H., TOMESCU, M.,ş.a., *Materiale compozite*, Ed. Tehnică, Bucureşti, 1999.
2. ŞTEFĂNESCU F., NEAGU G., MIHAI A., *Materiale compozite*, Editura Didactică şi Pedagogică, Bucureşti, 1996.
3. DUMITRAŞ C., OPRAN C., *Prelucrarea materialelor compozite ceramice şi minerale*, Editura Tehnică, Bucureşti, 1994.
4. VLASE A., - *Tehnologia construcţiilor de maşini*, Editura Tehnică, Bucureşti, 1996.
5. VLASE A., GHEORGHIU S., *Tehnologii de prelucrare pe maşini de găurit*, Editura BREN, Bucureşti, 2007.
6. Predincea, N., ş.a. *Procedee de prelucrare prin aşchiere*, Editura BREN, Bucureşti, 2002.

Correspondence to:

[1] Constantin OCNĂRESCU, Professor, PhD, University “Politehnica” of Bucharest, Romania, Street Splaiul Independenţei, Nr. 313, Bucharest, România, E-mail: constantinocnarescu@yahoo.com, 021.4029632.

[1] Viorel VULTURESCU, Professor, PhD, University “Politehnica” of Bucharest, Romania, Street Splaiul Independenţei, Nr. 313, Bucharest, România, E-mail: vvultur@yahoo.com, 021.4029632.

[2] Maria OCNĂRESCU, Drd. Eng., “Technical College Carol I” High school, Street Porumbacu, Nr. 52, Bucharest, Romania, E-mail: ocnarescu_maria@yahoo.com, 0722697695;