Processing Composites Materials with Polymeric Matrix

AURELIAN VLASE[1], CONSTANTIN OCNĂRESCU[1], MARIA OCNĂRESCU[2]
[1] University "Politehnica" of Bucharest, 313 Splaiul Independenþei, Bucharest , România
[2] Doamna Stanca" High School, 52 Porumbacu Str., Bucharest,Romania

Due to of their physical and mechanical properties composite materials, raise many problems regarding the drilling. This article contains, a series of experimental results and an analysis of the force when drilling into composite materials with polymeric matrix and glass fiber is made.

Keywords: composite material, drilling, machining

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 behaviour 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 [2-4].

Method, means and Drilling Conditions used to determine the Cutting Forces

For this study a stand of experimentations was used (fig. 1, 2).

The machine tools used;

- boring machine GU25;
- power of work: 2.3 kW;
- range of rotations: 28…2 240 rot/min;
- range of advances: 0.08…0.25 mm/rot.

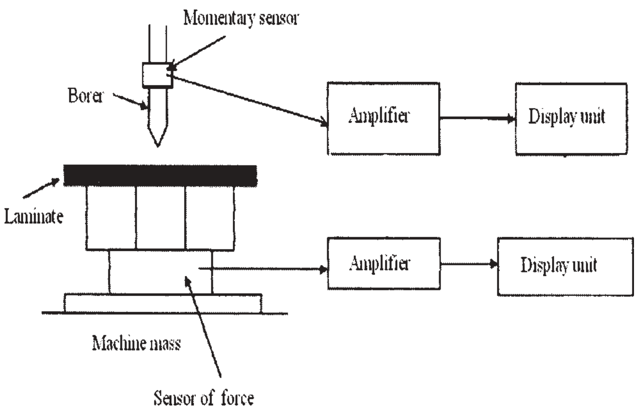

Fig. 1. The schematic representation the experimental stand

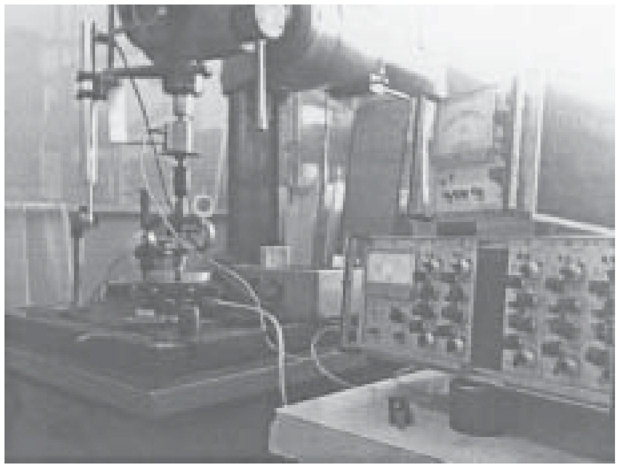

Fig. 2. The image of the stand of determinations with the force moment pickup and the registration system

The characteristics of the splintering tools:

- helical drills: Φ7, Φ8, Φ10, Φ12, Φ14 with $2\kappa = 130^0$ of Rp5 cu HRC 62

The characteristics of the studied polymeric composite material:

- probe structure:
  - polyester resin HELIOPOL 4231 ATX
  - glass fiber

- polyester resin HELIOPOL 4231 ATX:

- viscosity (23°C)	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	(1 100-1 150) 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	4500 daN/m^3
- width	ISO 5026	(100; 125)±2 cm
- humidity	ISO 3344	0.2%

In order to measure the axial forces of splintering, it has been used a pickup for measuring the processing forces. The pickup was made in the T.C.M. Department, I.M.S.T. Faculty [5].

* email: constantinocnarescu@yahoo.com

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

The gauging of the pickup of forces was made with a lab dynamometer which bears a maximum loading of 10kN compression. The readings were made on a comparator with dial with the division value of 0.01 mm. The average constant value of gauging for the forces was obtained:

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

Experimental part

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

$$F = C_F \times D^{x_F} \times s^{y_F} \quad [daN] \qquad (1)$$

This equation has proved to be inappropriate since after the practical estimation of the polytrophic exponents and constants, several tests determinations have 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 were kept constant. It was introduced a speed factor:

$$F = C_F \times D^{x_F} \times s^{y_F} \times v^{z_F} \; [daN] \qquad (2)$$

The C_F constant and the x_F, y_F, z_F, polytrophic exponents were estimated. The equation (2) has been linearized using the logarithm:

$$lgF = lgC_F + x_F lgD + y_F lgs + z_F lgv \qquad (3)$$

Table 1shows a selection of the most conclusive machinings.

The data which are included in table 1 are introduced in equation (3). A linear inhomogeneous system of 4 equations with 4 variables (x_F, y_F, z_F, lg C_F) was obtained:

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

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 introducing this solution in the equation (2)

$$F = \mathbf{126.9} \cdot D^{0.61} \cdot s^{0.485} \cdot v^{-0.163} \; [N]. \qquad (5)$$

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 figures 3 to 8. These only apply to composite materials with a polymeric matrix and glass fiber STRATIMAT glass fiber

Results and discussions

Figure 3 displays the variation of the of the axial force against feed rate s, where v = 13.38 m / min, for different drill diameters, *D*.

The increment of the forces is exponential with the increment r of the drill diameter and of feed rate, s.

Figure 4 shows the variation of the axial force against feed rate *s*, where D = 12 mm for different drilling speeds of the tool.

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

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	7.8	19	151.8
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

Table 1
EXPERIMENTAL RESULTS

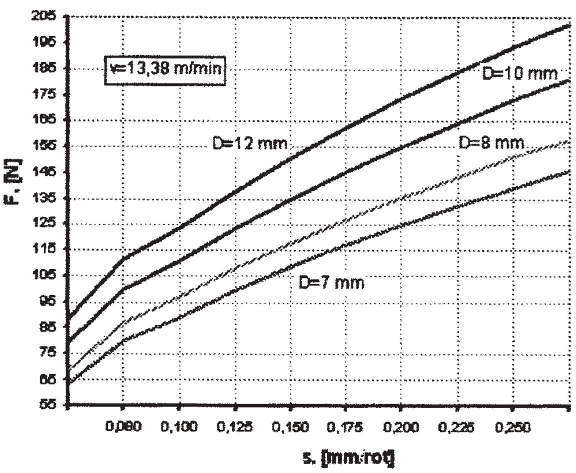

Fig. 3. Diagram of axial force variation against feed rate, considering different drill diameters

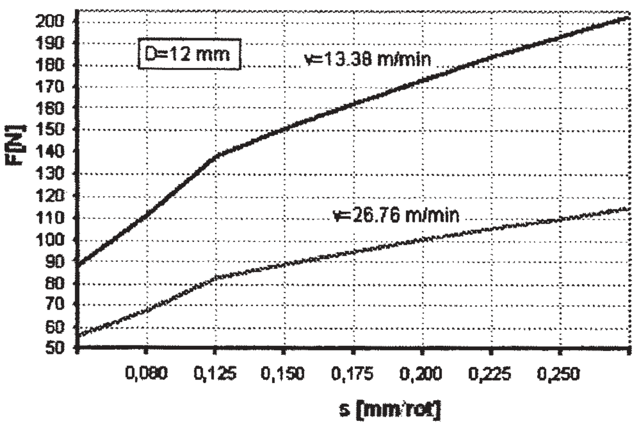

Fig. 4. Diagram of axial force variation against feed rate, considering different drilling speeds of the tool

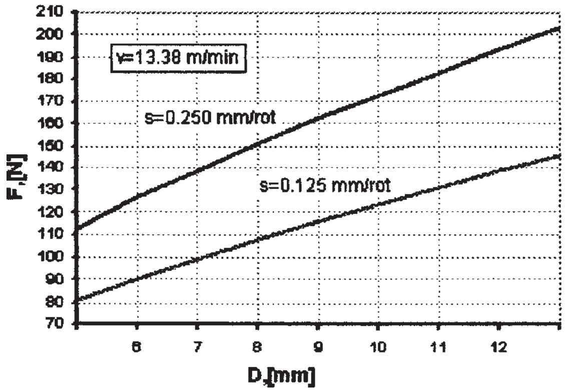

Fig. 5. Diagram of variation of axial force against drill diameter considering different feed rates

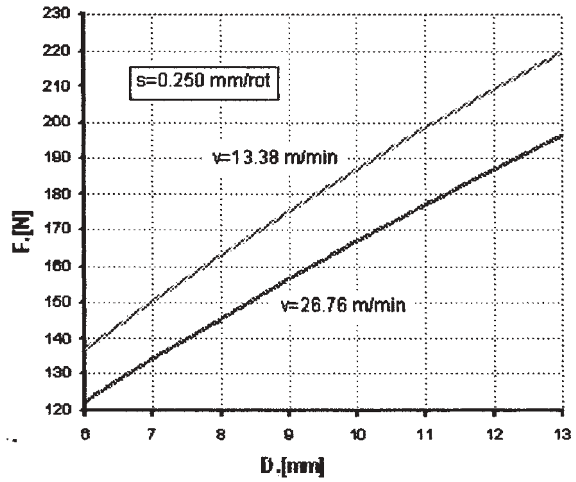

Fig. 6. Diagram of variation of axial force against drill diameter, for different drilling feed rates

Figure 5 indicates the variation of the axial force against drill diameter, *D*, where *v*=13.38m/min, for different feed rates, *s*.

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

Figure 6 indicates the variation of the axial force against drill diameter, *D*, where *s*=0.25mm/rot for different drilling feed speed.

Figures 6 indicates that the axial forces rise exponential with the rise of the drill diameter.

Figure 7 displays the dependence of the axial force on the drilling speed *v*, where *s*=0.25 mm/rot, for different hole diameters.

The axial forces decrease exponential with the increment of the drill speed.

Figure 8 indicates the dependence of the axial force on drilling speed v, where D=12 mm, for different feed rates, s.

It can be noticed that the axial forces decrease exponential with the increment of the drill speed.

Conclusions

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

From both theoretical and experimental researches, the following facts can be deduced:

1. A pickup of forces was used to determine the axial force when drilling into composite materials with polymeric matrix and type STRATIMAT glass fiber;

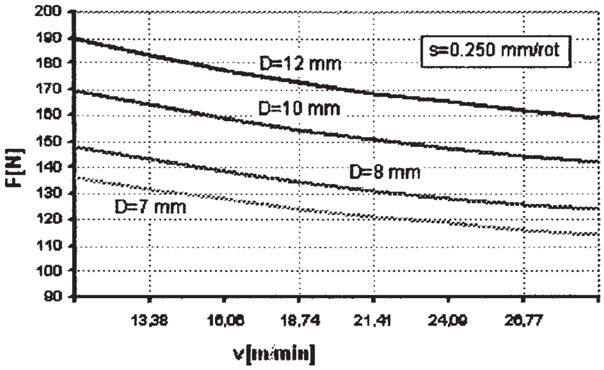

Fig. 7. Diagram of variation of axial force against drilling speed, for different hole diameters

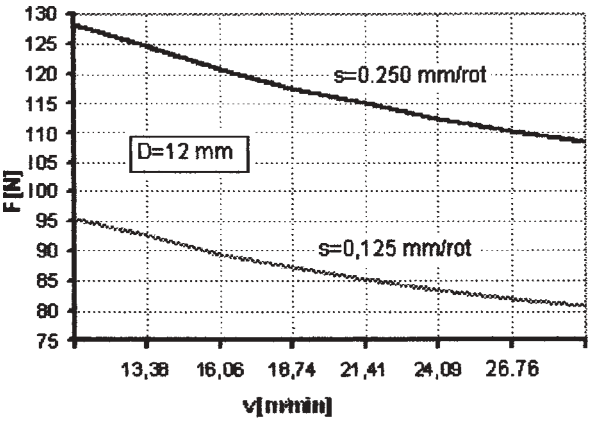

Fig. 8.Diagram of variation of axial force against drilling speed, for different feed rates

2. The range of the forces from 0 to 200 N allowed the use of drills with diameters in the range of 7 to 14 mm;

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

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

5. During the experiments, no cooling liquids were used because of their abrasive actions on cutting tool.

References

1. HUBCA, Ghe., IOVU, H., TOMESCU, M.,º.a.,(1999) -Materiale compozite", Edura Tehnicã

2. DUMITRAª, C., OPRAN, C., (1994), Prelucrabilitatea materialelor compozite, ceramice ºi minerale", Edura Tehnicã

3. VLASE, A., (1996), Tehnologia construcþiilor de maºini", Editura Tehnicã

4. GHEORGHIU, H., HADÃR, A., CONSTANTIN, N., (1998), Analiza structurilor din materiale izotrope ºi anizotrope", Editura Printech, Bucureºti, pag.159;

5. TURDEANU, E., ILIESCU, M., GÃVAN, M., (2005), Captor pentru mãsurarea forþelor de prelucrare, B.O.P.I. No. 4;

6. VLASE, A., (1993), Calculul analitic al regimurilor de aºchiere la gãurire, Îndrumar, I.P.B;

7. PREDINCEA, N., º.a. (2002), Procedee de prelucrare prin aºchiere", Editura BREN, Bucureºti.

Manuscript received: 5.04.2007