The 40th International Conference on
Mechanics of Solids, Acoustics and Vibrations &
The 6th International Conference on
"Advanced Composite Materials Engineering"
COMAT2016 & ICMSAV2016
Brasov, ROMANIA, 24-25 November 2016

RESEARCH REGARDING THE MOMENTS REGRESSION REALTIONS AT DRILLING MINERAL COMPOSITE MATERIALS WITH 3% CONCENTRATION OF GLASS FIBER

Constantin Gheorghe Opran[1], Alexandru Patrascu[2], Florin Teodorescu-Draghicescu[3]
[1]University POLITEHNICA of Bucharest, Splaiul Independentei nr. 313, Bucharest, Romania,
constantin.opran@ltpc.pub.ro
[2] University POLITEHNICA of Bucharest, Splaiul Independentei nr. 313, Bucharest, Romania,
constantin.opran@ltpc.pub.ro
[3] University POLITEHNICA of Bucharest, Splaiul Independentei nr. 313, Bucharest, Romania,
florin.teodorescu@ltpc.pub.ro

Abstract: *The paper presents theoretical and experimental researches on cutting through drilling composite minerals products having concentration of 3% fiberglass resulting mathematical relations regression forces and moments depending on the parameters of the drilling process. The purpose of the research is to prevent delamination of the composite mineral fiber, highlight contraction phenomena that occur as a result of increased temperature in the process of drilling and also to determining the processing errors. The objective of the research is that during drilling operation to obtain a balance that does not affect material properties of composite mineral and lead to composite minerals for civil and industrial structures adapted to the conditions of use with high levels of reliability with high resistance of the spatial stress demands like earthquakes.*
Keywords: drilling, mineral composite materials, moments, regression relation

1. INTRODUCTION

Mineral fiber reinforced composite materials are used especially in the construction of bridges in the form of prefabricated elements, but also has widespread in other sectors such as industrial architecture, defense industry, machine tool industry, transport industry, wind industry. The main advantages of using composite materials minerals are: lower weight (less cost, low load on big structure, smaller equipment, the cost low potential of the structure and corrosion resistance (longer life, low maintenance and low cost of replacement) [1], [2].. The elements of the reinforcing products made of composite materials of mineral, depending on their nature, can improve tensile strength, rigidity, toughness and dimensional stability thereof. for the connection elements of the reinforcement are used assemblies of screws involving the development of multiple holes in reinforcing elements. By the drilling operation appears the necessity to optimize the manufacturing process and the determinate the mathematical and experimental influencing of the occurring factors. The criteria for assessing the workability by drilling products from composite materials minerals were: the cutting force. the cutting moment an the errors arising from processing of the product composite mineral (damage to the upper area, plucking elements of reinforcement of the matrix of the composite material of mineral and damage the lower zone) [3], [4].

2. EXECUTION OF EXPERIMENTS SAMPLES AND RESULTS

Mineral characterization of composite materials to be used to obtain regression relations of forces and moments is extremely important to have a clear picture of the problems that can occur during the processing of these materials. To execute the samples was carried out a scheme in Fig.1 can be seen that the amount of fiberglass composition of samples and was positioned where fiberglass fabric. Scheme execution mineral composite samples was performed according to Michael Rodgers Patent "Composite concrete" [5].

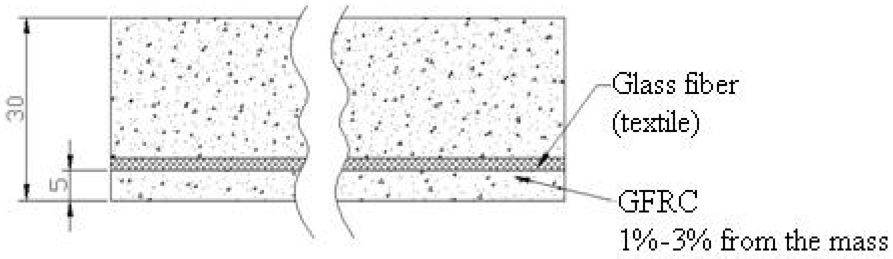

Figure 1: Scheme embodiment of samples

Experimental determinations were performed on three types of mineral fiber-reinforced composite materials of glass random in different percentages, using the experimental stand, cutting tools and measurement computer system and recording the results presented. (Fig. 2)

Determination of the regression relations will be based on experimental results recorded on cutting axial forces and moments, when drilling composites mineral products. (Fig. 3)

All three types of composite minerals were processed using the same cutting parameters and after the acquisition and processing of experimental data was performed a comparative analysis between the materials studied.

Figure 2: Stand for measuring forces and moments when drilling composites mineral products [6]

Figure 3: Kistler torque measurement construction [6]

They conducted research based on statistical methods applied to take account of the programming experiments and computational methods of regression functions. In the determination of appropriate regression function is used in most cases, specific statistical methods and programming procedures regression analysis.

Research has final objective optimize mineral processing composite materials, namely, the setting inputs so as to obtain the best output (performance) of the studied process.

Table 1: Samples execution and their items ranging

Test Set	Concrete	Mass B250 [kg]	Weight glass fiber amount%		Nr. of tests
Set I	B 250	19	1%	190 g	10
Set II		17.1	2%	342 g	10
Set III		15	3%	450 g	10

The percentage of glass fiber in the composite material was chosen according to documentation in this field, the recommended proportion of up to 3% by weight of the matrix. The drills used are in accordance with DIN 8039 ISO 5468 with tungsten carbide type YG8 (density 14.7 g/cm^3, equivalent to ISO K20). The machine tool to carry out machining on the chosen mineral composite material is numerically controlled machining center 300. FIRST MCV measurement of forces and moments in drilling mineral composite products was carried out using a Kistler torque of the Faculty structure I.M.S.T. [6]. In this work was used software REGES to determine regression models: REGES (measurement program functions multivariate regression exponential, the regression coefficients, ratios, regression analysis, statistical errors and confidence intervals related). For each type of composite material and soft mineral used was made an experimental program structure, as follows: - In Table 2 shows the structures of the divided programs for different levels of experimental variation for the software variables which REGES.

Table 2: Structures of experimental programs – REGES

Mineral random composite program reinforced with 3% fiberglass	Structure			
	Test no. \ X_i	X_1	X_2	X_3
P1.3.	1	1	-1	-1
	2	-1	1	-1
	3	-1	-1	1
	4	1	1	1
	5	0	0	0
	6	0	0	0

The input parameters used in experimental programs are:
X1 - the diameter D in [mm];
X2 - advance (f) in [mm/rev];
X3 - cutting speed (v_c in [m/min].
Mineral composite material used for experimental tests was:
- Matrix material: cement - B250;
- Nature of the constituents: reinforcing element
- Glass fiber type E - classification code of the product reinforcement OCVTM - P207;
- Volume percentages of reinforcing elements: 1 ÷ 3% glass fiber by weight;
- Shape and dimensions of the reinforcement: short staple fibers and fabric;
- The arrangement of reinforcing elements in the matrix: random fiber orientation;

They were chosen to be studied, geometries of five different cutting tools, all having the same diameter φ8 mm, Fig. 3.

Figure 3: Cutting tools used in the study [6]

Following the analysis carried out on mineral composite materials and cutting tools used in the study were extracted and highlighted in Fig. 4, the main errors generated after processing.

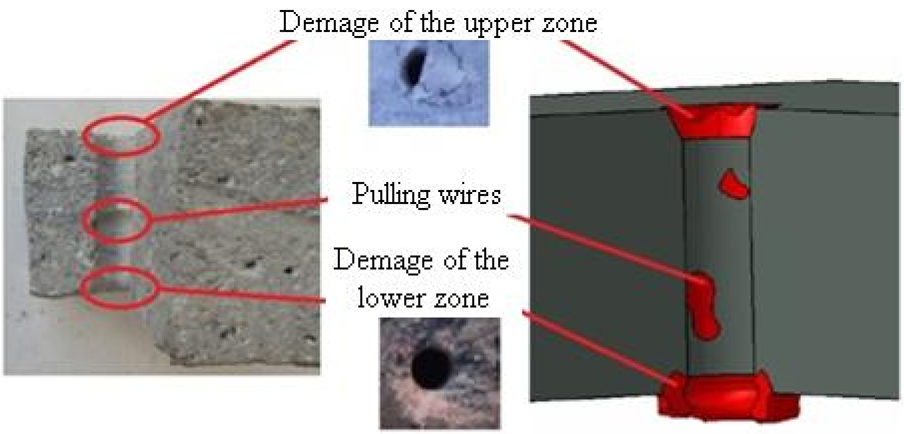

Figure 4: Errors resulting from the processing of composite materials [6]

Using experimental programs have been conducted experiments on cutting forces and moments when drilling composites mineral products. For all three programs have been considered three independent variables (cutting tool diameter D [mm], the advance f [mm/rev] and cutting speed v_c [m/min]), and these three (-1, 0 + 1) and two levels of variation (-1, +1). Table 3 indicates the values established for mineral drilling composite products where each of the three independent variables shows three levels of variation (-1, 0, +1). In Table 4 are shown the values set for drilling of composite materials of mineral products, wherein each of the three independent variables of variation has two levels (-1, +1).
Minimum and maximum speed values used in this study ranges between 250 and 1920 rev/min depending on the diameter of the cutting tool used (D having values of 5.8 to 12mm) in order to obtain the desired minimum and maximum values [7], [8], [9], [10].

Table 3: Independent variables with three levels of variation

Natural variables	Code	level coded		
		-1	**0**	**1**
Diameter [mm]	X_1	5	8	12
The advance f [mm / rev]	X_2	0,08	0,12	0,16
Cutting speed: v_c [m / min]	X_3	9,42	16,86	30,159

Table 4: Independent variables with two levels of variation

Natural variables	Code	level coded	
		-1	**1**
Diameter [mm]	X_1	5	12
The advance f [mm / rev]	X_2	0,08	0,16
Cutting speed: v_c [m / min]	X_3	9,42	30,16

Multivariable regression functions can be defined as the relationship linking cutting forces or cutting times as dependent variables and determinants, as independent variables. The shape of the regression function that were used for creating the program [12], [13] is:

$$F_z = f(D, f, v_c), \text{ in N} \quad (1)$$

$$F_z = C_F \cdot D^{x_F} \cdot f^{y_F} \cdot v_c^{z_F}, \text{ in N} \quad (2)$$

$$M_z = f(D, f, v_c), \text{ in Nm} \quad (3)$$

$$M_z = C_M \cdot D^{x_M} \cdot f^{y_M} \cdot v_c^{z_M}, \text{ in Nm} \quad (4)$$

Where: F_z - the axial component of the cutting force in N; M_z - the moment axially Nm; f - shaped relationship of dependency; D - the diameter of the cutting tool, in mm; f - advance in mm / rev; v_c - cutting speed in m / min; C_F and C_M - constant; x_F, y_F, z_F - polytropic exponents parameters considered appropriate; x_M, y_M, z_M - polytropic exponents parameters considered appropriate. The experimental results obtained when drilling mineral-reinforced composite material with a random 3% of glass fiber for the axial component of the cutting force when cutting F_z and M_z are shown in Table 5 [6].

Table 5: Experimental results to determine F_z and M_z product's material mineral reinforced composite material with a 3% glass fiber [6]

Cutting Force F_z [N] Utting Moment M_z [Nm]									
The processed material: composite mineral randomly reinforced with a 3% fiberglass									
P 2.3.			Diameter: D, [mm]	Advance: f, [mm/rot]	Revolution: n, [rot/min]	Cutting speed: v_c, [m/min]	F_z [N]	M_z [Nm]
D	f	v_c						
-1	-1	-1	5	0.08	600	9.42	163.45	0.30
-1	-1	1	5	0.08	1920	30.16	137.39	0.26
-1	1	-1	5	0.16	600	9.42	182.80	0.34
-1	1	1	5	0.16	1920	30.16	153.65	0.29
1	-1	-1	12	0.08	250	9.42	228.46	1.02
1	-1	1	12	0.08	800	30.16	192.02	0.86
1	1	-1	12	0.16	250	9.42	255.51	1.14
1	1	1	12	0.16	800	30.16	214.76	0.96
$F_z = f(D,f,v_c)$, $F_z = a_0 + a_1 D + a_2 f + a_3 v_c + a_{12} Df + a_{13} Dv_c + a_{23} fv_c + a_{123} Dfv_c$, in N $M_z = f(D,f,v_c)$, $M_z = a_0 + a_1 D + a_2 f + a_3 v_c + a_{12} Df + a_{13} Dv_c + a_{23} fv_c + a_{123} Dfv_c$, in Nm									

After regression analysis, performed using DOE PRO XL software were obtained following multivariable regression functions:

- In drilling mineral reinforced composite material with a random 3% fiberglass:

F_z = 110.625 + 8.781D + 185.720f-0.792v_c + 14.739Df-0.063Dv_c-1.337fv_c-- 0.105Dfv_c in N

M_z = -0.219 + 0.098D-0.198f + 0.0023v_c + 0.150Df-0.0007Dv_c-0.0017fv_c-- 0.0008Dfv_c in Nm

3. INTERPRETATION OF THE RESULTS

As a result of experimental researches on cutting through drilling composite mineral products reinforced with different percentages of fiberglass, using software REGES caused to the cutting force F_z [N] as follows: the regression models are appropriate; interactions between input variables significantly influence the values of the output quantity; greatest influence, where F_z is given by the diameter of the cutting tool, followed by the cutting speed and cutting feed; greatest influence, where M_z is given by the diameter of the cutting tool, followed by cutting feed and cutting speed [11], [12], [13].

4. CONCLUSION

Analyzing the results obtained, the following issues related to the force F_z [N] and the moment M_z [Nm] cutting in drilling mineral reinforced composite products with a percentage between 1% and 3% of glass are:

- Recorded values of cutting force are much higher than those reported for other types of composite materials (bio composites, polymer matrix, etc.);
- Cutting the recorded values of the moment are similar to those reported for other types of composite materials (bio composites, polymer matrix, etc.);

Processing of the experimental results was performed using the program REGES and DOE PRO XL. From the study data obtained through these programs, it notes that:

- The parameters of the cutting regime that presents the greatest influence on the size of the cutting force F_z [N] are diameter of the cutting tool and cutting speed;
- The parameters of the cutting regime that presents the greatest influence for cutting the size of the moment M_z [Nm] are diameter of the cutting tool and cutting feed;

Recorded the highest values of cutting force were obtained in drilling mineral products from composite materials reinforced with a 3% fiberglass. Thus comparative analysis of the three types of materials used in the study can say that with increasing percentage of composite reinforcing elements mineral cutting force values are higher. [6], [12], [13], [14].

REFERENCES

[1] Mark S, John H., *Development using fibre-reinforced polymers (FRP) in construction*, JEC Composites Magazine no. 85, pp. 30-32, 2013.

[2] Brahim A., *Eco-characterisation of composite materials*, JEC Composites Magazine no. 42, p. 58-60, 2008.

[3] Tsai S., *Strength & Life of Composites*, Composites Design Group, Stanford University, Stanford, USA; 2008

[4] Tsai S., Melo J. D., *Composite Materials Design and Testing: Unlocking mystery with invariants*, Composites Design Group, Stanford University, Stanford, USA; 2015.

[5] Jiping B., *Advanced fibre reinforced polymer (FRP) composites for structural applications*, Woodhead Publishing, 2013.

[6] . Pătrascu A. , Research concerning the drilling machinability of products made from mineral composite materials, PhD Thesis , university POLITEHNICA of Bucharest, Romania, 2012.

[7] Said M, Krimo A., *Delamination-crater interaction in demage of Glass/epoxy composite plates subjected to impact fatigue*, Key Engineering Materials, Vol 498, pp.139-150, Trans Tech Publication Schwizerland, 2012.

[8] Bouchra H-R, Laurence P, Valerie N., *Development of the adhesion test characterizing the interface fiber/polymer matrix*, Key Engineering Materials, Vol 498, pp. 210-218, Trans Tech Publication Schwizerland, 2012.

[9] Rao S-N, Schott N., *Understanding plastics engineering calculations*, Hanser Verlag, Munich, Germany, 2012.

[10] Dimitrios L., *A revolutionary range of polycristalline diamond [PCD] tooling blanks*, JEC Composites Magazine no. 95, pp. 68-69, 2015.

[11] Wouter W., *Predicting in-and aut-of-plane demage evolution in wowen fibre-reinforced composites*, JEC Composites Magazine no. 100, pp. 64-67, 2015.

[12] Pătrascu A, Vlase A, Gheorghe V, Balotă D., *Behaviour at impact of fiber reinforced elements in mineral composite products*, ModTech International Conference, Chisinau, Republic of Moldova, pp. 829-832, 2011.

[13] Pătrascu A, Opran C, Gheorghe V., *Research regarding the influence of reinforcement elements to the vibration characteristics of the mineral composite products*, 3rd International Conference „Advanced Composite Materials Engineering”, COMAT, Brasov, Romania, pp.181-186, .2010.

[14] Zhiyuan Z, Yukiu Y, Hiroyuki H., *Fracture behaviour of glass mat composite with open hole*, JEC Composites Magazine no. 81, pp. 46-48, 2013.