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# EXPERIMENTAL STUDY OF DRILLING CARBON AND ARAMIDE FIBRE REINFORCED COMPOSITE MATERIAL

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**ABSTRACT**
*Parts made out of composite materials are joined and connected by elements for joining into complex construction sections and subsections. For this purpose, it is necessary to fabricated numerous holes with different dimensions. Drilling is one of the most important cutting operations which are currently carried out on fiber reinforced composite materials. The following errors are present during the drilling of composite materials: delamination, fuzzing, edge chipping, spalling, surface roughness, roundness and dimensional errors. With correct choice of cutting regimes and cutting tool geometry it is possible to ensure required quality of the drilled holes. This paper gives research results of drilling carbon and aramide fibre reinforced composite materials.*
**Keywords**: composite materials, drill geometry, quality of drilling

## 1. INTRODUCTION

Composite materials are more and more used in demanding constructions, due to their hardness to weight and stiffness to weight ratios. Parts made out of composite materials are joined and connected by elements for joining into complex construction sections and subsections. For this purpose, it is necessary to fabricated numerous holes with different dimensions. In composite material drilling the following occurs: increased tool wear, machined hole surface damage, hole dimension deviation, cracking, peripheral hole zone damage and dust generation. These occurrences are undesirable so they must be removed or minimized. These problems were investigated by several authors [1, 2, 3], that devised methods and means for fabricating hole of increased quality. With correct selection of cutting regimes and cutting tool geometry it is possible to ensure required quality of the drilled holes. Sharpening angle of the drill and geometry of cutting edge has significant influence on all parameters defining functional quality of the tool.

## 2. EXPERIMENTAL WORK AND RESULTS OF INVESTIGATION

In experimental study, HSS drills 3,12; 5 and 8 mm in diameter were used to generate holes. Different drill bits geometry shown in Fig. 1. Apart from standard drill, drill modified geometry were used in this experimental work. Drilling processes were conducted on unidirectional carbon fibre reinforced composite, thickness 5 mm. Experimental work also were done on aramid fibre reinforced composite material, KEVLAR®, thickness 5 mm, [4].


*Figure 1. Different drill bits geometry*

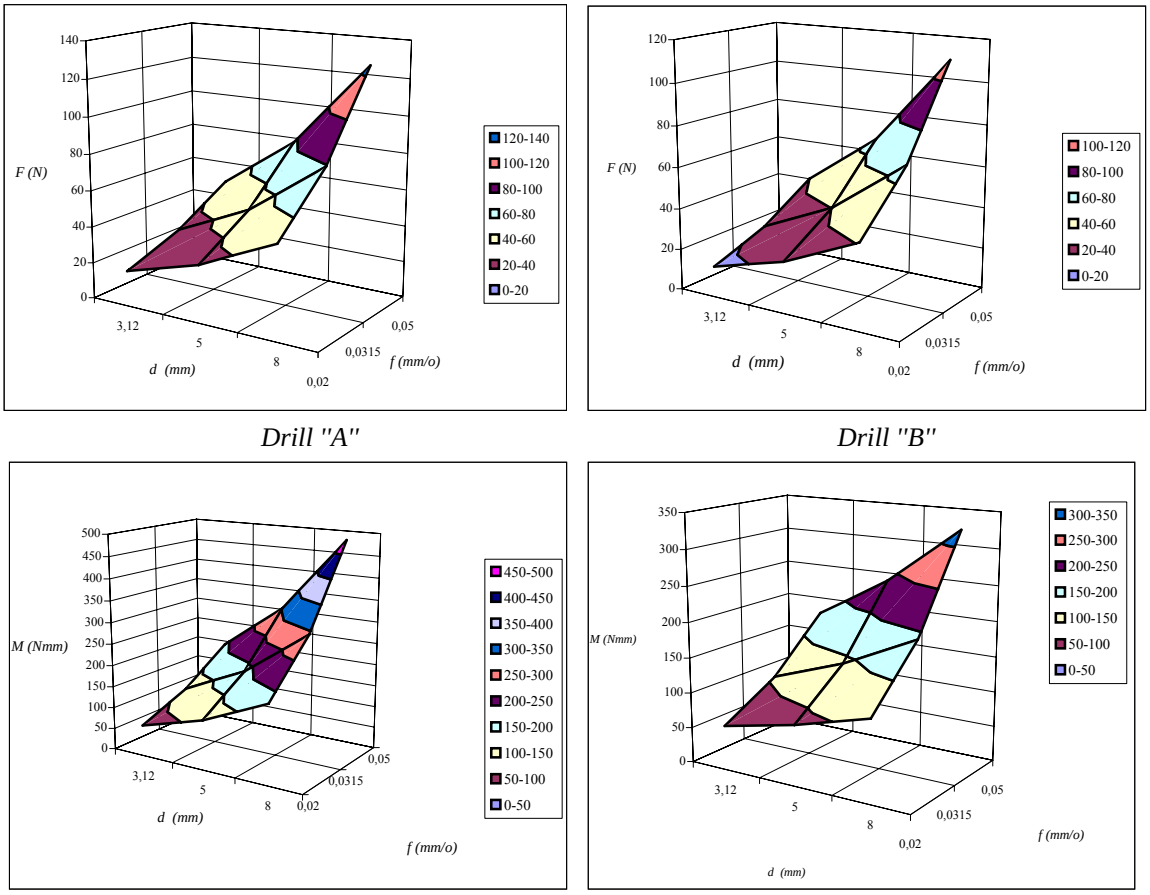



*Figure 2. Thrust force and torque during drilling carbon fibre reinforced composite*

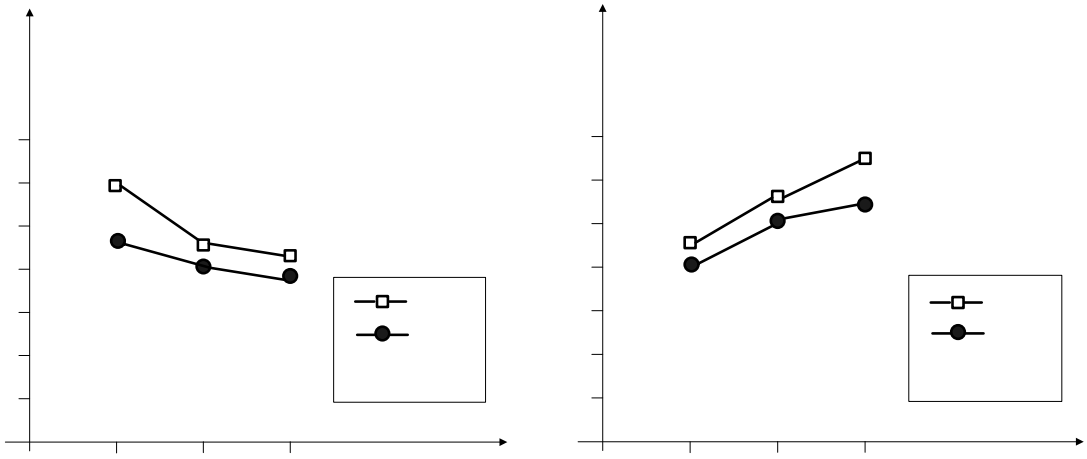
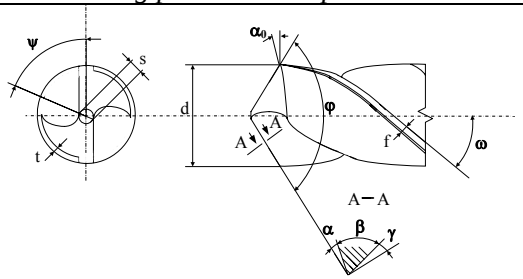
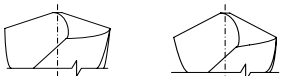
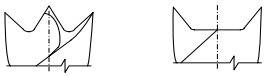


*Figure 3. $R_a$ in correlation to feed and cutting speed*

*Table 1. Elements for optimization drilling proces in composite materials and holes overview*

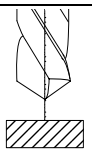
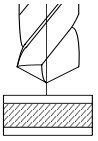


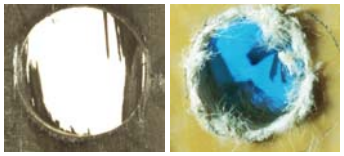
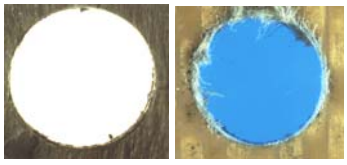
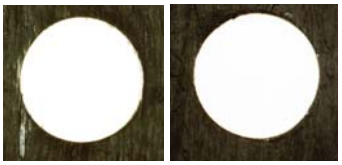

| **Tool material** | | |
|---|---|---|
| High speed steel | Carbide | Polycrystalline diamond (PCD) |

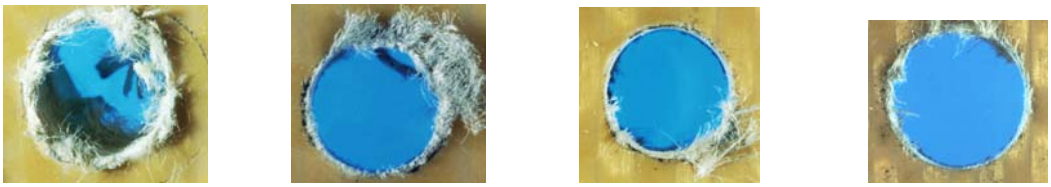
| **Drill point geometry** | | |
|---|---|---|
|  Cutting edges formed by conical sharpening (CS) |  Cutting edges formed by CS and remodeled main edges |  Modified cutting edges - improved cutting geometry |

| **Tool material** | **Fabrication regimes for drilling** | |
|---|---|---|
| | Cutting speed (m/min) | Feed rate (mm/rev) |
| High speed steel | 12 - 18 | 0,02 -0,05 |
| Carbide | 40 - 120 | 0,03 - 0,1 |
| Polycrystalline diamond (PCD) | 30 - 150 | 0,02 - 0,25 |

| **Cutting tool geometry** | | | | |
|---|---|---|---|---|
| φ | ψ | $\alpha_0$ | ω | s/d |
| 90° - 95°<br>116° - 118°<br>140° - 142° | 50° - 55° | 10° - 12° | 20°, 30°, 45° | 0,14 – 0,16 |

| **Drilling method** | |
|---|---|
|  Drilling without buckplate |  Drilling with buckplate |

| **Holes overview** | | |
|---|---|---|
|  Low quality drilled holes |  Average quality drilled holes |  High quality drilled holes |



v = 11,3 m/min f = 0,05 mm/rev Drill "A" | v = 11,3 m/min f = 0,02 mm/rev Drill "A" | v = 14,13 m/min f = 0,05 mm/rev Drill "B" | v = 17,6 m/min f = 0,02 mm/o Drill "B"

*Figure 4. Drilled holes in aramid fibre reinforced composite materials (KEVLAR®)*

## 3. CONCLUSION

Based on above stated, following conclusions are made:

- Thrust force and torque depend on cutting speed, feed rate, tool geometry and tool wear.
- Chisel edge has significant impact on increase thrust force. Reducing chisel edge length, thrust force may be considerably reduced.
- Feed rate significantly contribute to drilled hole quality.
- Drilling aramid fibre composite material with standard drill geometry has as its consequence errors development, like fuzzing, and therefore composite material reinforced with aramide fibre, is requiring special (optimal) tool geometry.
- Errors that occur during drilling of fibre reinforced composites are in functional dependence with cutting tool and conditions of machining, cutting tool geometry and cutting tool wear.
- Increased implementation of composite material parts is limited due to impossibility of machining parts with certain quality, by using existing technological means and technology.
- For efficient manufacture of composite material parts, it is essential to continue research of machining process and optimise it by choosing means and machining regimes. Special consideration must be taken in choosing material and tool geometry.

## 4. REFERENCES


[1] Konig, W., Wulf, C., Grass, P., Willerscheid H.: Machining of fibre reinforced plastics, Manuf. Technol., Annals of CIRP, 34 (2), 536–548, 1985

[2] Ho-Cheng, H., Dharan, C. K. H.: Delamination during drilling in composite laminates, Journal of Engineering Industry, Vol. 112, pp. 236–239, 1990

[3] Bhattacharya, D., Horrigan, D., P., W.: A study o hole drilling in Kevlar composites, Composites Science and Technology 58, pp. 267–283, 1998

[4] Koboević, N.: Metode i načini osiguranja kvalitete pri izradi otvora bušenjem u kompozitnim materijalima, (magistarski rad), Sveučilište u Mostaru, Fakultet strojarstva i računarstva, Mostar, 2003

[5] Koboević, N., Mišković, A.: Ensuring hole fabrication quality in composite material as prerequisite for implementation in industry, Proceedings of the 3rd International Conference on Revitalization and Modernization of Production, RIM 2001, pp. 277–284, Bihać, Bosnia and Herzegovina, 2001

[6] Koboević, N., Mišković, A.: Parameters for defining machining quality of composite materials components, Proceedings of the 6th International Scientific Conference on Production Engineering CIM 2000, pp. I-119–I-126, Lumbarda, Croatia, 2000