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# INFLUENCE OF DRILL GEOMETRY AND CHIP SHAPE ON THE QUALITY OF DRILLED HOLE IN COMPOSITE MATERIAL

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**ABSTRACT**
*The drilling of composite materials is a very common and important process used in the process of assembling of composite structures. In the process of composite material drilling the following errors happen: delamination, fraying, edge chipping, spalling, surface roughness and dimensional errors.*
*The paper presents an experimental investigation of the drilling of carbon and aramide reinforced composite material. In this paper it is explained how hole errors depend on drill geometry and the shape of the removed material chips.*
**Keywords**: drilling, composite materials, hole quality

## 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 joining elements into complex construction sections and subsections. In this purpose, it is necessary to drill numerous holes with different dimensions. Having in mind the structure of composite materials that consist of fibres and a matrix that usually has low melting point (epoxy resins melt at about 160°C), the process can be considered complex. During the drilling process, created dust, beside the abrasive effect has a harmful influence on human health, so its expansion must be stopped, and it removed simultaneously with its' creation. Due to low melting point of the resin, melted resin sticks to the cutting tool together with dust particles, changing tool's cutting geometry, affecting its' life span and surface working quality. These features result in some specific problems which may lead to occurrence of characteristic material damage shapes[1,2,3]. Local dynamic load, especially bending load, may result in delamination of carbon and aramid fibres, due to different rigidity of fibres and the matrix. Delamination represents separation of surface layer during tool entrance in and exit from the material. Characteristic shapes of damage in composites with carbon and aramid fibres are fibre edge chipping and spalling. Aramid fibres are damaged during tensile stress dislocation under bending load. Characteristic fraying consists of fibre pulling and kneading. Despite fibre's high heat resistance, temperature limit is determined by matrix melting point. Overheating appears due to low thermal conductivity of fibres and matrix. In cutting process, overheating appears due to inadequately chosen process parameters. In order to describe the drilling results, it is necessary a qualitative and quantitative assessment of those features which basically define the machining quality with regard to geometrical errors and errors in the workpiece material properties. Some characteristic errors occurring in drilling fibre reinforced composites are illustrated in figure 1.

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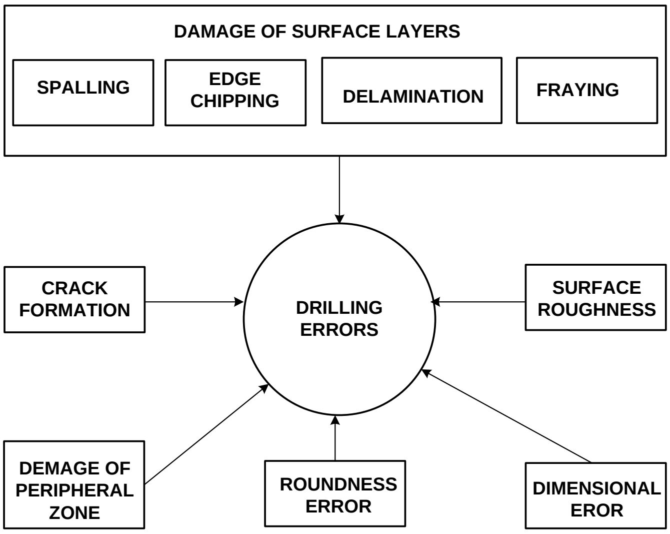



*Figure 1. Characteristic errors and quality criteria for drilling fibre reinforced composite materials*

## 2. EXPERIMENTAL WORK AND RESULTS OF THE INVESTIGATION

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

Drill "A" Drill "B"

*Figure 2. Different drill bits geometry*

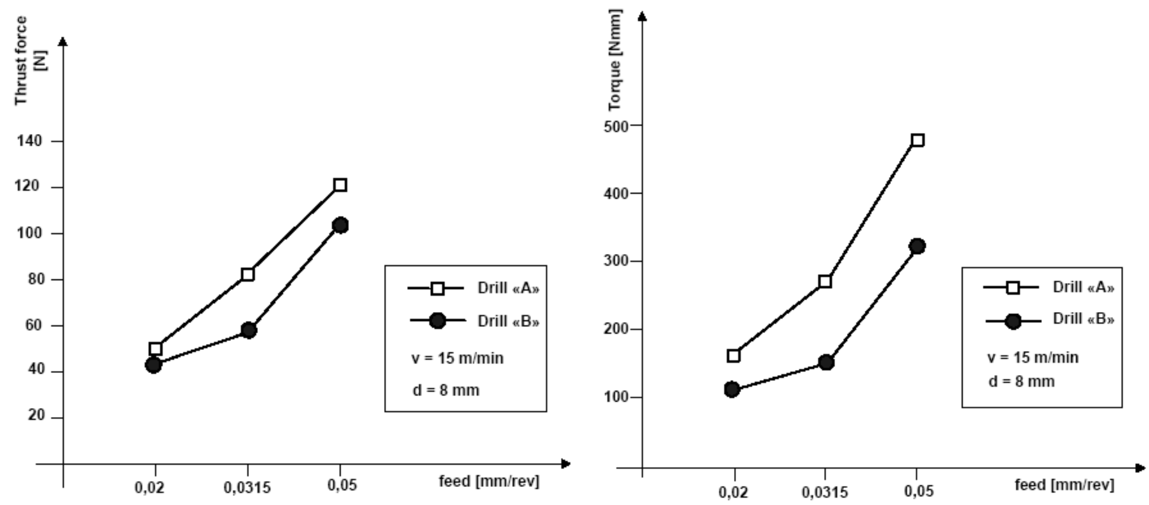



*Figure 3. Thrust force and torque during drilling carbon fibre reinforced composite*

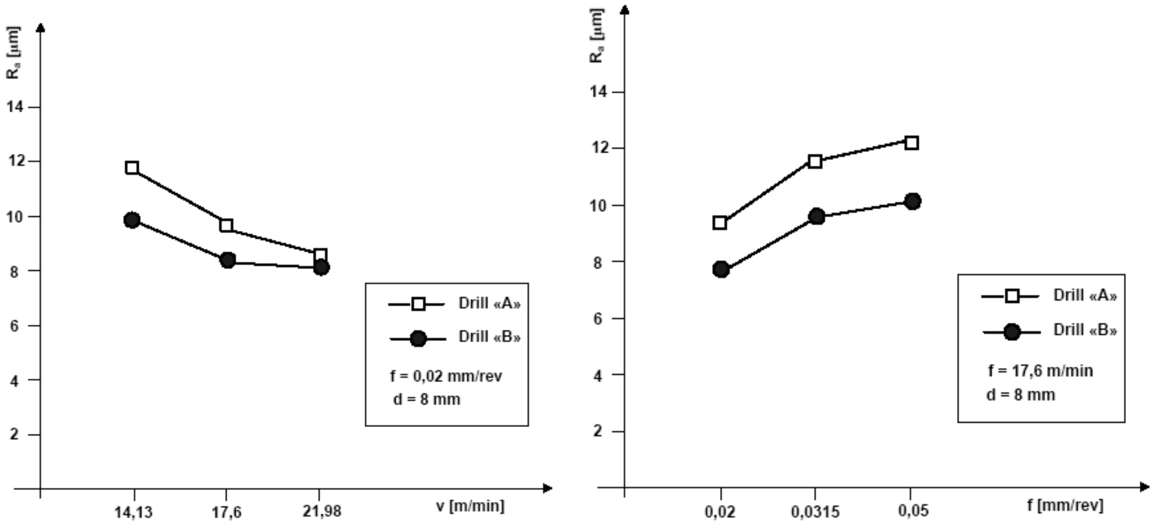
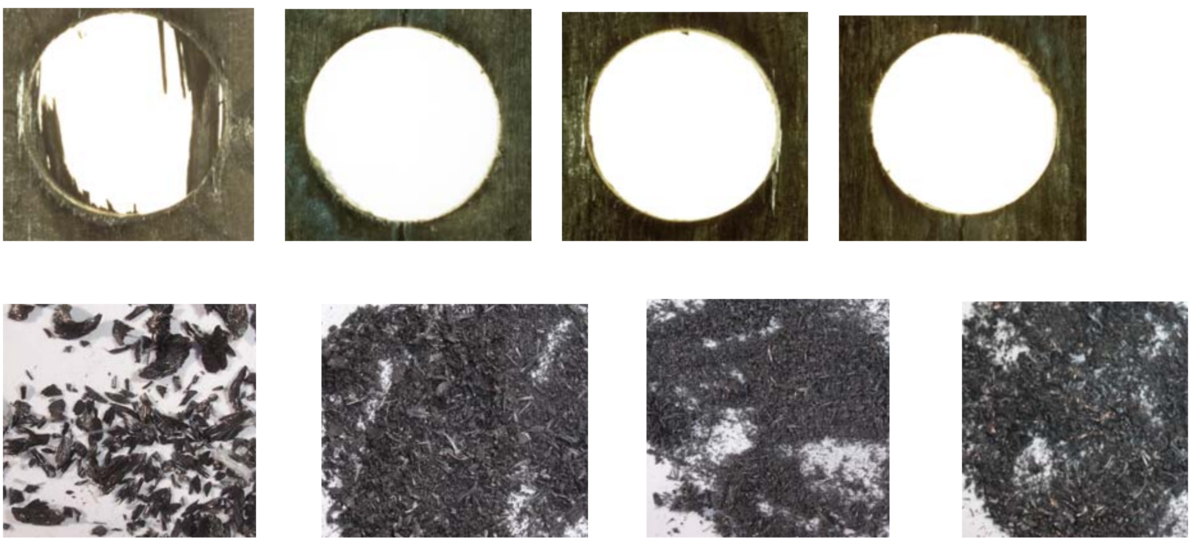


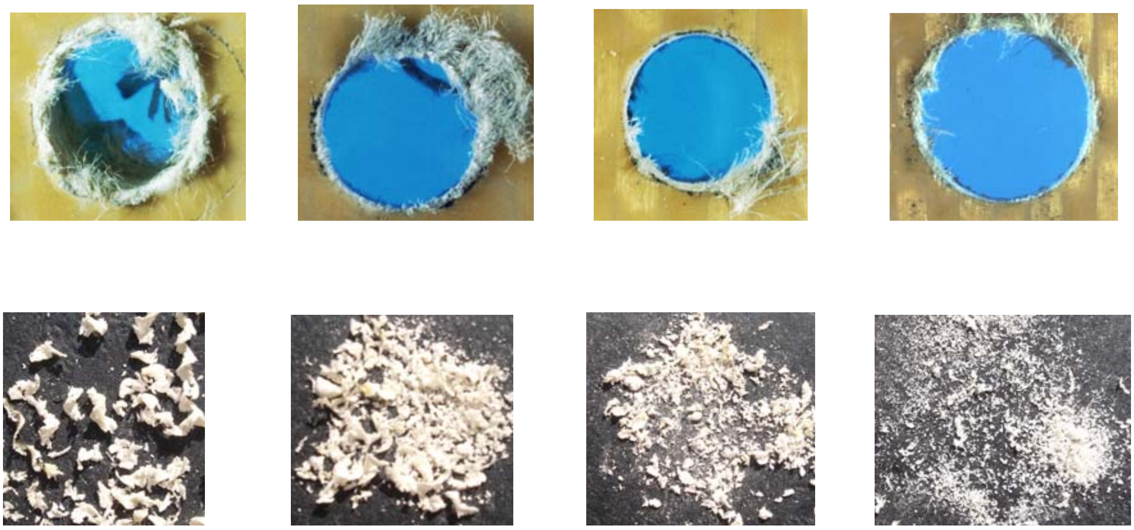

*Figure 4. $R_a$ in correlation to feed and cutting speed during drilling carbon fibre reinforced composite*



| | | | |
|---|---|---|---|
| v = 17,60 m/min | v = 14,13 m/min | v = 17,60 m/min | v = 21,98 m/min |
| f =0,05 mm/rev | f = 0,02 mm/rev | f = 0,05 mm/rev | f = 0,02 mm/rev |
| Drill “A” | Drill “A” | Drill “B” | Drill “B” |

*Figure 5. Drilled holes in carbon fibre reinforced composite materials*

Experimental results show that drilling force is proportional to material removal rate. Large thrust force will destroy the interlaminar integrity of the lamine before they are completely cut. Drill with modified geometry (drill “B”) reduce thrust force andobtain lower surface roughness. Large feed rate produces large chips while higher cutting speed causes early material fracture. High cutting speed with low feed rate provokes plastic deformation in composite chips and, chips are smaller and surface roughness is lower.



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

*Figure 6. Drilled holes in aramid fibre reinforced composite materials*

## 3. CONCLUSION

Based on above stated, following conclusions are made:

- Thrust force and torque depend on the cutting speed, feed rate, tool geometry and tool wear.
- Chisel edge has a significant impact on the 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 for the consequence errors development, like fraying, and therefore composite material reinforced with aramide fibre, is requiring special tool geometry.
- Errors that occur during drilling of fibre reinforced composites are in functional dependence of the cutting tool geometry, wear, machining regimes and tool material.
- Aiming to obtain efficient manufacture of composite material parts, it is essential to continue research of machining process and optimise it choosing means and machining regimes. Special consideration must be taken in choosing material and tool geometry.

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