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SELECTION OF TOOLS FOR MACHINING PARTS MADE OF POLYMER COMPOSITE MATERIALS

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ABSTRACT

The article presents the features of the choice of cutting tools in the processing of polymer composite materials. As a result of the analysis, the authors formulated their own recommendations. The solution of these problems is possible with highly qualified training (according to the requirements of the time) of specialists in materials science and technology, programmers, designers, calculators, operation and repair engineers. The choice of tools should not be limited only to carbide drills, which does not allow us to give an objective assessment of the optimization of the choice of the brand and material of the drill.

KEYWORDS: *Polymer Composite Materials, Similar Parts, Tolerance, Carbon, Cutting Fluid, Quality*

INTRODUCTION

Currently, a whole series of new-generation binders and carbon fiber plastics has been developed, which have begun to be introduced into the design of promising aircraft. The use of composite materials in aircraft structures for various design and technological solutions has been significantly expanding in recent years.

The variety of polymer composite materials (PCM) – carbon fiber plastics, fiberglass, organoplastics, etc., used in the designed structures, requires a special approach when choosing processing technologies, tools, tooling structures and methods for quality control of finished products. The solution of these problems is possible with highly qualified training (according to the requirements of the time) of specialists in materials science and technology, programmers, designers, calculators, operation and repair engineers. When designing parts and components made of PCM, it is necessary to take into account both the possibilities of existing production and the creation of new specialized production sites for specific technological requirements for the development and implementation of new developments – perhaps with a small reserve for the prospects for the development and implementation of PCM structures.

Main part

One of the priority tasks in expanding the use of PCM should be the task of creating "artificial intelligence", which will ensure the development of processes in the creation of materials, technologies and new promising structures almost without human participation – only according to the task developed by him and under his control.

For the design of structures from composite materials it is necessary to consider (to ensure the manufacturability) volumes, methods and types of machining – milling, drilling, laser cutting and hydraulic etc.

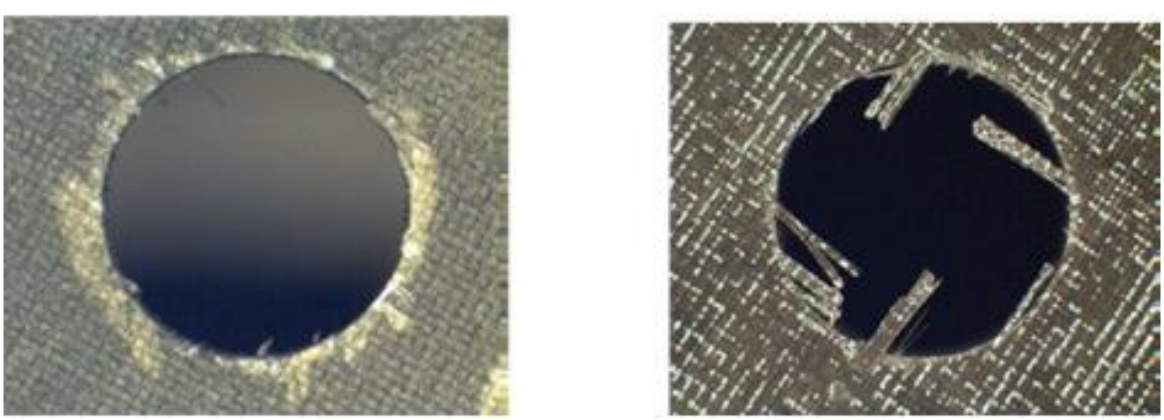
Difficulties in machining PCM are determined by their physical-mechanical characteristics: tendency to phase separation during processing due to their webbing, structural heterogeneity, the high hardness of the filler material and the low ductility of the binder, etc.

Currently, the most widely used tool for mechanical processing of PCM is a diamond-coated tool or a tool made of a hard-alloy material. Examples of such a tool are shown in Fig. 1. The greater the grain size of the diamond-coated tool, the greater the amount of material removed in one pass, but at the same time the cleanliness of the treated surface decreases. To obtain a high-quality cut, it is necessary to choose the tool that provides the required quality and cutting speed with optimal performance.

Fig.1. Examples of machining tools

When choosing a tool, it is necessary to take into account the features of the PCM structure. The more viscous the matrix, the stronger the heat during cutting and the binder sticks to the cutting edge with intense heating of the tool and the part, which affects the quality of the surface of the cutting zone. The choice of tools should not be limited only to carbide drills, which does not allow us to give an objective assessment of the optimization of the choice of the brand and material of the drill. Taking into account the requirements for the quality of holes and drilling modes, when conducting an experiment with a drilling speed of 16,000 and 26,000 rpm (when feeding 0.01–0.15 mm per revolution), it was possible to obtain a satisfactory tool life (750 holes before replacing it).When using a manual electric drill mounted on a tripod, the process is inefficient with possibly unstable quality of the results in production. In the manufacture of parts of aircraft structures, one of the mass processes of mechanical processing of PCM is drilling. When making holes, it is necessary to take into account their functional purpose – holes for assembling power elements of structures, functional (for fuel overflow, in noise-absorbing panels, condensate drain, etc.) and technological. In each of these cases, the requirements for the quality of the holes are determined by the requirements of the design documentation. The quality of the resulting holes on the input and output edges, the accuracy and cleanliness of the surface of the cylindrical part of the hole are extremely important in terms of reliability, durability and operability of the structure. The maximum productivity and stable quality of the through holes in the PCM is ensured by properly selected tools and cutting modes during drilling, as well as the structural rigidity of the technological equipment. An important role in ensuring the quality of the hole surface is played by the durability and geometric shape of the cutting edges of the tool. The main defects that occur during mechanical processing are: cracking of the binder, delamination, pulling out of the fibers, non-cutting of the fibers, thermal destruction of the binder.

The cutting edge usually breaks the matrix (binder) brittle and cuts the reinforcing fibers. To eliminate these defects, special tool designs are used, their geometric shape is optimized, and technological drilling modes are used, using special devices. When drilling PCM, defects often occur at the inlet and outlet of the hole, due to the peculiarities of the drill's force action on the work piece (Fig. 2). At the inlet, there are delaminations and material rupture, and at the outlet – delamination and non-cutting of fibers. Since holes are stress concentrators, such defects contribute to reducing the fatigue and static strength of structures. Tominimized efects, tool companies offer special drill designs.



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a) b)

Fig. 2. Local delamination of the material layers in case of violations of the axial feed of the tool during drilling (a) and fiber fragments (chips) on the inner surface of the hole due to wear of the cutting edge and violations of the drilling modes (b)

Typical hole quality requirements:

– roughness Ra<4.8 microns;

- delamination

-no chips (torn fibers in the hole).

When processing PCM, a decrease in the quality of the resulting holes can occur long before the tool breaks.

Improving the productivity of the cutting process. Speeding up the tool feed and cutting speed increases the productivity of the process, but the more important factor is the quality of the hole. The poor quality of the hole leads to the need for two-stage processing with different tools. An example of obtaining a high-quality hole with two-stage drilling processing is shown in Fig. 3.

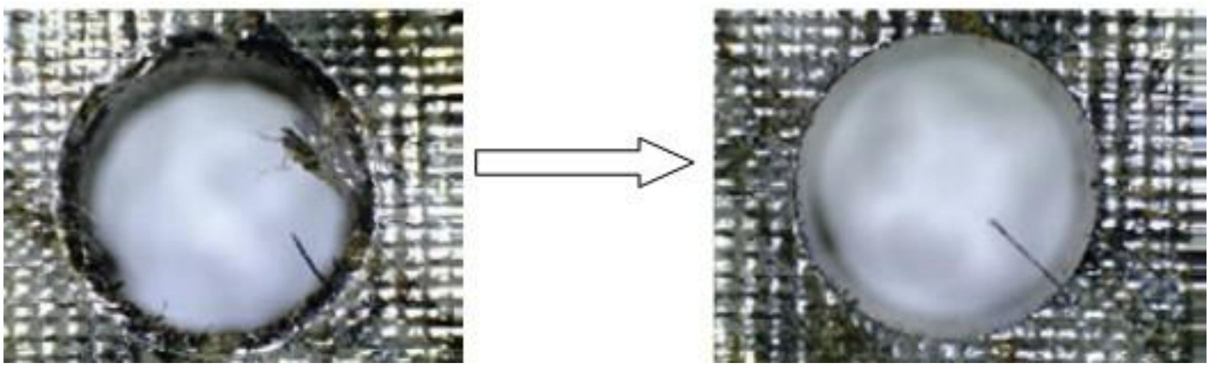


Fig. 3. Hole quality in two-stage machining with two tools

Unlike metals, PCM based on a polymer matrix has low thermal conductivity and heat resistance. At temperatures >(300-350)°C begins the thermal degradation of the binder. This leads to a sharp deterioration in the quality of the treated surface, the appearance of cauterization and reflow in the defective boundary layer (Fig. 4).

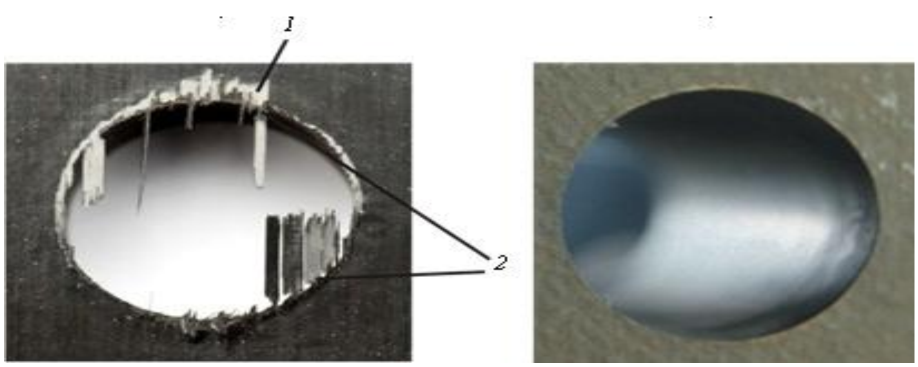
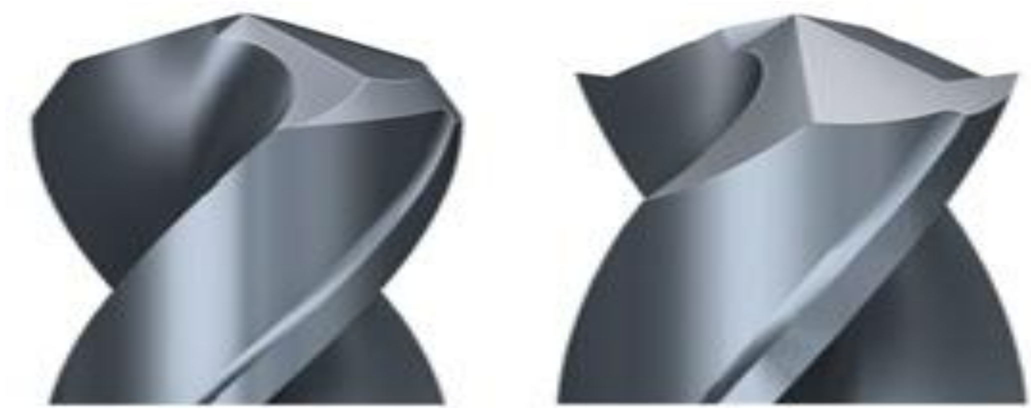


Fig. 4. Poor-quality (a) and high-quality (b) holes in carbon fiber:1 – delamination of the material; 2 – non-cutting of the fibers

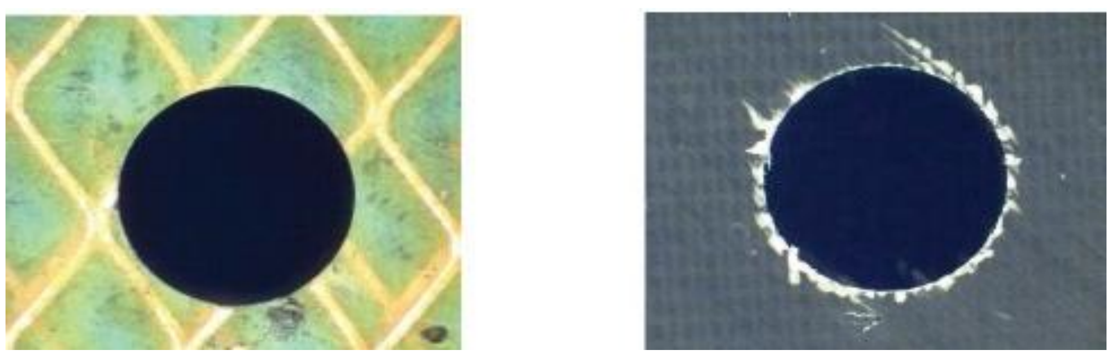
To reduce the delamination at the entrance of the hole, double-sharpened drills are used, and to eliminate the non – cutting of the fibers, drills with sharp edges on the periphery are used (Fig. 5). In order to avoid delamination, sometimes it is necessary to use conductors pressed against the surface with a force sufficient to prevent delamination. Drilling is usually carried out with cutting speeds of 100-200 m/min at low feed rates in the range of 0.02–0.1 mm/rev. At the entrance and exit of the drill to avoid delamination, reduce the force and the amount of feed per revolution.



a) b)

Fig. 5. Drills for PCM with double sharpening (a) and with undercut edges (b)

The choice of the process strategy for drilling PCM The upper and lower surfaces of the part differ significantly in the quality of the input and output edges of the holes during drilling. To improve the quality of holes, a number of technological techniques are used: drilling direction, surface protection with technological overlays, etc. Coatings or additional surface layers above the carbon fiber or fiberglass layer can significantly affect drilling performance and quality.Thus, a lightning-proof layer in the form of a fine or large copper mesh (Fig.6, a) allows you to drill carbon fiber with accelerated feed without losing the quality of the hole; fiberglass-increases the risk of delamination, worsening the quality (Fig. 6, b). Both materials can be easily processed with the right choice of tools and processing modes.



a) b)

Fig. 6. Lightning protection layer on carbon fiber (a) and carbon fiber with a layer of fiberglass (b)

CONCLUSION

When processing PCM, the cutting fluid is usually not used, so the cutting product is a fine fire-hazardous and harmful to human health dust, which must be removed from the cutting area by a special dust removal system. When processing PCM parts, the cutting volume is usually small: the parts are already molded and only requires, as in this case, drilling assembly holes or holes in the form of perforations – for example, in noise-absorbing panels.

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