ISSN 1995-4212, Polymer Science, Series D, 2026, Vol. 19, No. 2, pp. 533–535. © Pleiades Publishing, Ltd., 2026.
Russian Text © The Author(s), 2026, published in Vse Materialy, 2026, No. 4, pp. 44–47.

Specific Features in the Machining of Polymer Composite Materials

V. A. Skryabin[a], * and N. V. Sorokina[a]

[a] *Penza State University, Penza, 440026 Russia*

**e-mail: vs_51@list.ru*

Received March 5, 2025; revised August 20, 2025; accepted December 10, 2025

Abstract—In this paper, the specific features in the machining (cutting) of parts from polymer composite materials were considered. The materials for the cutting part of tools and their geometric parameters were selected, and technological regimes were recommended, considering the properties of polymer composite materials that characterize their machinability. The differences between the machining of polymer composite parts and the processing of metal products were revealed.

Keywords: machining, cutting, polymer composite parts, geometric parameters, cutting regimes

DOI: 10.1134/S1995421226700991

Polymer composite materials (PCM, composites) are a compound of two or several materials based on various types of plastics that serve as a matrix in such materials. Other elements of composites (PCM) are different reinforcing or decorative components that impart them with certain properties and serve as a mechanical barrier on the way of crack propagation under deformation.

The machining of composite materials significantly differs from metal machining due to their specific features. The machining of parts from composites often requires the complete revision of machining methods, used cutting tools, workpiece clamping techniques and, in some cases, even the use of specialized equipment and tool accessories. Fiberglass-reinforced plastic (fiberglass laminate) is one of the most highly demanded composite materials for parts processes by cutting tools [1–5].

Fiberglass-reinforced plastics (FRPs) are polymer materials reinforced with glass fibers. Their binding element (matrix) consists generally of thermosetting synthetic (phenol, epoxy, polyester, polyamide, furan, etc.) resins and thermoplastics (polyamides, polycarbonates, polypropylene, etc.).

There exist several grades of fiberglass laminate. They differ from each other only in a few parameters. At the same time, their common characteristics include high strength, enhanced moisture resistance, good thermal conductivity, ana nontoxicity. Here, it is also worth highlighting their fireproofness, biological stability, and insusceptibility to other negative environmental impacts. Workpieces from glass-fiber-reinforced plastics are used for the production of gears, bearings, washers, gaskets, metal cutting machine components, printed circuit boards (PCBs) and other parts.

Fiberglass laminate is produced in the form of sheets. The thickness of a finished sheet may be ranged within 0.5–100 mm. In addition, the material is manufactured in the form of various bushings, gears, or rods of different diameters and lengths. Fiberglass laminate consists of a nonwoven cloth impregnated with a special resin and pressed under high pressure. Various polyester or epoxy resins can be used for impregnation. For the machining of fiberglass plastics by turning, tungsten carbide hard alloys of VK, TK, and TTK group and tools with polycrystalline diamond (PCD) inserts are predominantly used as cutting tools. Synthetic diamond has the highest hardness and thermal conductivity at a low friction coefficient, enabling the sharpening of cutting edges with a minimum rounding radius. However, diamonds have a low resistance to bending, so the application of diamond inserts for interrupted cutting under shock loads is unreasonable. In the studies [4, 6–8], it was established that the instantaneous tool life of cutters with cutting inserts from hard alloys of VK group is 5–6 longer that for the cutter with cutting inserts from hard alloys of TK group, as the heat conductivity of the former is 1.6–2.6 times higher (Table 1).

As a rule, the rake surface of cutters should be polished and have no chamfers and grooves contribution to chip curling. The value of the rake angle γ is selected within 10°–20° and 0°–5° when turning laminated plastics along filler layers and perpendicularly to them (Fig. 1) [8].

Based on the performed experiments, it was established that the use of cutting tools with rake angles $\gamma < 20°$ and $\gamma < -5°$ is not recommended, as the operation of tools with such rake angles results in the formation of discontinuous chips and a sharp increase in machined surface roughness.

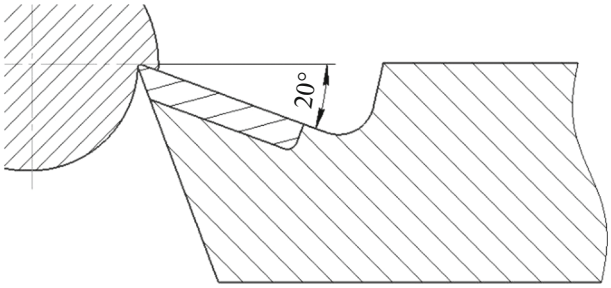

Fig. 1. Scheme for the turning of fiberglass-reinforced plastics.

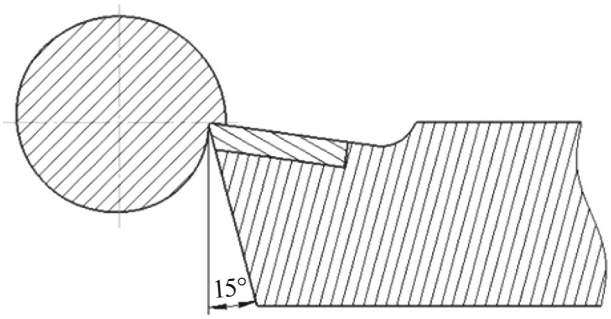

Fig. 2. Relief angle in turning.

As shown by studies, the relief angle α has the strongest effect on the tool life of cutters. It should be maximized, because increasing α reduces the effect of workpiece elastic recovery on the tool after the cutting edge passes. However, an excessive increase in α is unacceptable due to a decrease in the heat dissipation capacity of the cutting tool wedge (or tooth); therefore, when machining plastics, the optimal relief angle is α = 15°–20° (Fig. 2).

Table 1. Instantaneous tool life

Material of cutters	Fiberglass laminate ST	Phenolic plastic K-18-2
VK2	18	–
VKZM	13	20
VK6M	12.5	10.5
VK4	11.8	14
VK6	11	11
VK8	4	5
T30K4	4.3	1
T15K6	3.8	5.5
T5K12V	2	–
T5K10	1.9	2
TT10K8A	1.7	–
TT7K12	1.6	–
T14K8	1.5	6

The principal cutting edge angle φ changes within 30°–60°, ensuring low surface roughness. The auxiliary cutting edge angle φ_1 is usually selected within 12°–15°, because increasing φ leads to a 1.2–1.7-fold increase in the surface roughness height.

The cutting speed V exerts the primary influence on tool wear and life, followed by the longitudinal tool feed rate S and the depth of cut t. For this reason, when adjusting the machining parameters, the depth of cut must be selected first, followed by the feed rate and cutting speed, using the metal turning parameters as a baseline. When adjusting the depth of cut, it is necessary to take into account the allowance thickness, part rigidity, turning type, etc. When selecting the feed rate for finish turning, the possibility of achieving the specified surface roughness parameters is primarily taken into account, whereas maximum feed rates can be applied in rough machining.

For the rough turning of fiberglass-reinforced plastics, the experimentally established parameters are t = 3.0–5.0 mm, S = 0.1–0.5 mm/rev, and V = 80–160 m/min (Ra = 6.3–12.5 μm). For finish turning, t = 0.5–1.0 mm, S = 0.05–0.2 mm/rev, and V = 170–300 m/min (Ra = 1.6–3.2 μm).

It is important to note that, during the turning of fiberglass-reinforced plastics, cutting regimes and tool geometry influence not only the roughness of the machined surface, but also on its integrity. A certain challenge is also to achieve the dimensional accuracy of parts from fiberglass-reinforced plastics [9, 10]. The dimensional accuracy of parts is influenced by errors resulting from machining, internal residual stresses, thermal errors of measurements, and errors caused by environmental impacts. The errors of machining by turning appear due to tool wear, elastic deformations in the machine–tool–fixture–workpiece (MTFW) system, and equipment inaccuracies.

Based on the results of experimental studies and the earlier papers [4, 8], it was established that, compared to metals, polymer composite materials have lower mechanical properties, the cutting force components during their machining are much lower. As a result, the ratio between the cutting force components P_z, P_x, and P_y will be different. The cutting forces grow with an increase in the depth of cut and the feed rate, especially when tool wear progresses. For instance, during the turning of fiberglass laminate ST on a CNC lathe with a cutter equipped with an insert from hard alloy VK2 with V = 300 m/min, S = 0.21 mm/rev, and t = 3 mm, the forces P_z, P_y, and P_x grow with increasing cutter wear h_3 from 0.1 to 0.85 mm by 200% (P_z) and 105% (P_y and P_x). The empiric dependences of P_z, P_y, and P_x on the tool wear are $P_z = 110h_3^{0.62}$ N, $P_y = 440h_3^{1.05}$ N, and $P_x = 2.53h_3^{1.05}$ N, being close to the empirical formulas [4, 8].

FUNDING

This study was supported by ongoing institutional funding. No additional grants were received to conduct or direct this research.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflict of interests.

REFERENCES

1. A. N. Muranov, G. V. Malysheva, V. A. Nelyub, et al., "Investigation of properties of polymeric composition materials around a heterogeneous matrix," Polym. Sci., Ser. D **6**, 256–259 (2013).
2. V. A. Nelyub, "Application of polymer composite materials in shipbuilding for the repair of ship superstructures," Remont. Vosstanov. Moderniz., No. 5, 21–24 (2013).
3. G. V. Malysheva and N. V. Bodrykh, "Hot-melt adhesives," Polym. Sci., Ser. D **4**, 301–303 (2011).
4. V. A. Skryabin and A. G. Skhirtladze, "Features of milling and broaching processes in machining polymer materials," Tekhnol. Met., No. 4, 28–35 (2022).
5. N. I. Baurova, V. A. Zorin, and V. M. Prikhodko, "Manifestation of a synergistic effect in technological heredity," Polym. Sci., Ser. D **9**, 209–211 (2016).
6. P. L. B. Oxley and R. N. Roth, "Slip-line field analysis for orthogonal machining based upon experimental flow fields," J. Mech. Eng. Sci. **14**, 85–97 (1972).
7. A. G. Skhirtladze, V. A. Skryabin, V. Boriskin, et al., *Technology of Structural Materials* (Tonkie Naukoemkie Tekhnologii, Stary Oskol, 2006) [in Russian].
8. S. N. Grigoriev, A. G. Skhirtladze, V. A. Skryabin, et al., *Cutting of Materials* (Privolzhsky Dom Znaniy, Penza, 2012) [in Russian].
9. B. P. Shtuchny, *Machining of Plastics: Handbook* (Mashinostroenie, Moscow, 1987) [in Russian].
10. *Machining of Carbon Fiber-Based Materials: Technical Guide* (Sandvik Coromant, 2016) [in Russian].

Translated by E. Glushachenkova

Publisher's Note. Pleiades Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
AI tools may have been used in the translation or editing of this article.