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DEVELOPMENT OF MODIFIED CARBON FIBER-REINFORCED PLASTICS BASED ON POLYAMIDE 6

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Modern mechanical engineering is impossible to imagine without the use of structural plastics. One of the most effective polymer composites used in the construction of agricultural machinery is carbon fiber-reinforced plastic (CFRP) based on polyamide 6. The impact of operating conditions on polymer composites particularly in agricultural machinery structures has been studied in detail [1-3], and leading equipment manufactures devote considerable attention to the development of the polymer composites with predefined (programmed) properties. Until recently, there was no CFRP production in Ukraine. The production technology was complicated by the need to introduce chopped carbon fibers (CF) into the molten polymer matrix in a metered and uniform manner. As is well known, the properties of CF differ significantly from those of the polymer matrix, requiring the use of a dedicated feeder with special design solution. At the laboratory of polymer composites of DSAEU, CF feeder (Fig. 1) was developed and implemented into the processing line of the serial single-screw extruder ECG-45 (Fig. 2).

Thus, using the modernized extruder and a specialized processing technology, carbon fiber-reinforced plastics based on polyamide 6 were produced with varying carbon fiber contents (Table 1). Additionally, to reduce the number of stress concentrations within the material structure, a small amount of silicone lubricant was introduced in certain cases.

Fig. 1. Feeder system: 1 – hopper; 2 – vibration motor; 3 – tray

The resulting CFRPs were labeled as follows:" VPA-6" stands for carbon fiber-reinforced plastics based on polyamide 6; the second number ("16", "20", etc.) indicates the mass fraction of carbon fibers, %; the third number (if present), such as "0,5", "1,0", or "2,0", denotes the mass fraction of silicone lubricant.

Table 1. Impact strength *a* and standard deviation of value σ

№	Grade	*a*, kJ/m^2	σ, %
1	VPA6-16	42,15	5,64
2	VPA-6-20	41,67	3,92
3	VPA6-30	47,3	3,53
4	VPA6-20-0,5	43,14	3,76
5	VPA6-20-1,0	46,54	5,29
6	VPA6-20-2,0	50,55	12,49

The impact strength is one of the important characteristics of carbon fiber-reinforced plastics. It was determined according to **ISO 179-1:2010** – Plastics – Determination of Charpy impact properties. This characteristic is very sensitive to the presence of internal defects, for example, to the non-uniform distribution of CF in the polymer matrix, the presence of internal stresses, etc. It is important that CF are evenly distributed in the matrix and ensure the isotropy of the material. As seen from Table 1, the highest impact strength is shown by the CFRP of grade VPA6-30. And,

as we can see from the table, this material has the lowest value of σ – 3,53. This indicates a high uniformity of CF distribution in the polymer matrix and, as a result, high stability of parameter *a*. It is considered that if the value of σ does not exceed 10%, it satisfies the quality of the material. As we can see, the CFRP VPA6-20-2,0 has the highest *a* (50,55 kJ/m^2), but σ exceeds 10%. Analysis of the result of each experiment for determining *a* of this composite shows that there are values that significantly deviate from the statistics (Table 2). This means that the technology of introducing CF and silicone lubricant into the polymer matrix does not ensure parameter stability and must be changed.

Table 2. Impact strength of each experiment for the VPA6-20-2,0 composite

1	2	3	4	5	6	7	8	9	10
41,7	83,3	50	41,7	47,9	54,2	38,8	52,1	47,9	47,9

Thus, it was established that with the help of a modernized extruder and improved technology, it is possible to obtain carbon fiber-reinforced plastics based on polyamide 6 with a carbon fiber content of on 30% and silicone lubricant content of up to 1,5%.

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