

# Evaluation of the influence of storage conditions of dispersed fillers on the properties of composites based on them

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**Abstract.** The results of a study of the effect of storage conditions of dispersed fillers widely used in the repair of machines (mica, boron nitride, aluminum powder, carbon-containing powder) on the properties of composites based on them are presented. The results of the microstructure of the samples after exposure of the fillers under standard storage conditions, as well as high air humidity and a temperature drop, are presented. **Key words:** dispersed fillers, polymer composite materials, high air humidity, temperature difference.

## 1 Introduction

At present, in the manufacture of various machine elements, polymer composite materials (PCM) based on fibrous and dispersed fillers are widely used, which make it possible to impart desired properties to materials [1–3]. Among fibrous fillers, glass, carbon, and basalt fabrics, ribbons, and continuous and discrete fibers are most widely used [4–6].

The most diverse substances of organic and inorganic nature, consisting of particles of various sizes, from 2–10  $\mu\text{m}$  to 250–300  $\mu\text{m}$ , can act as dispersed fillers [7, 8]. Dispersed fillers are widely used in the composition of polymer composite materials during all types of repair work [9, 10]. The quality and complex operational properties of products made from PCM based on dispersed fillers, in addition to the correct choice of PCM components and strict adherence to production technology, are largely determined by the storage conditions of raw materials (dispersed fillers). The stability of the properties of dispersed fillers largely depends on the conditions of their storage, as well as on the intensity of the impact of various factors during storage [11, 12].

The use of powder formed bio-fillers during the manufacture of organic material-based polymer composite is one such route. In the process of adding bio-fillers, polymeric composites now have ability to substitute the conventional substances. Bio-fillers have the added benefit of lowering the total cost of composite material creation by reducing the amount of epoxy required. The wear, tensile and hardness qualities can also be improved. It is possible to improve overall qualities of a polymer composite by using the bio-fillers in the form of powder with the matrix material. The mechanical characteristics of polymeric composites are improved by adding reinforcing materials, while the element shape also has

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an impact. The seed of the tamarind is a significant seed-based sustainable natural material. In Asia, the tamarind tree is a very valuable as well as versatile tree that is growing in abundance. Tamarind growth has been predicted to be 25,000 metric tons per month. There is a 33 percent outer layer and a 67 percent inner kernel can be seen in tamarind seeds. Zyloglucan gum is found in tamarind seed in its powder form, making it an excellent resource for the gum. The stoichiometric ratio of fructose, galactose, and lactose in tamarind seed zyloglucan was 3.5:2.5:1. The zyloglucan can be utilized in the food product sector as a thickener, stabilizer, and emulsifying ingredient. The tamarind seed's characteristics have been the subject of just a few research publications still a big room for the potential research. Being a proven binding substance, though, it isn't utilized to its maximum potential. [20]

Epoxy-based polymer is a kind of polymer with multiple epoxy links that can have the excellent physical qualities with a limited shrinking capacity and stressless structure. It has a strong alkali resistance, as well as superior acid resistance. In a several usages, however, standard resin systems are unable to provide good mechanical stability. Most fungi are resistant to the cured epoxy systems, which have high dimensional and mechanical durability. They are good moisture barriers, with little moisture absorption and transfer. Epoxy resin have become more helpful as structural adhesives and matrix resins for advanced composites as the need for high-performance materials has grown. Epoxy resins are having strong strength, modulus, and adhesion properties for these applications. [20]

Violation of storage conditions can lead to irreversible changes in the quality of dispersed fillers, which will subsequently affect the quality of products manufactured or restored using them. But the influence of storage conditions of fillers on the change in their technological and operational properties cannot be predicted by calculation [13, 14] and can only be determined experimentally [15–19].

## 2 Main part

The purpose of this work is to determine the effect of storage conditions of dispersed fillers on the properties and structure of composite materials based on them.

For experimental studies, the most common dispersed fillers in the repair of machines were chosen as objects of study: mica, boron nitride, aluminum powder, and carbon-containing powder. These fillers are widely used in the repair of machines and make it possible to provide several operational properties of PCM [12, 13]. The fillers were divided into 3 groups and kept in a standard polyethylene package for 6 months under various conditions. Samples of the 1st group were references and were stored under standard conditions in a heated warehouse at a temperature of +22°C (series 1/E). Samples of the second group were stored in a heated warehouse at a temperature of +22°C but under conditions of high air humidity >98% (series 2/B). The samples of the third group were stored in an unheated open warehouse under conditions of natural differences in air humidity and temperatures from +30°C to -30°C (series 3/T). Data on the types of fillers used and storage conditions for each series of samples are presented in Table 1.

**Table 1.** Sample data.

Series No samples	Binder	Filler	Conditions storage
1/E	EDP + PEPA	Mica	Standard conditions
1/E		Boron nitride	
1/E		Aluminum powder	
1/E		Carbon powder	
2/B	EDP + PEPA	Mica	High air humidity > 98%
2/B		Boron nitride	
2/B		Aluminum powder	
2/B		Carbon powder	

3/T		Mica	Temperature difference from +30°C to -30°C
3/T		Boron nitride	
3/T		Aluminum powder	
3/T		Carbon powder	

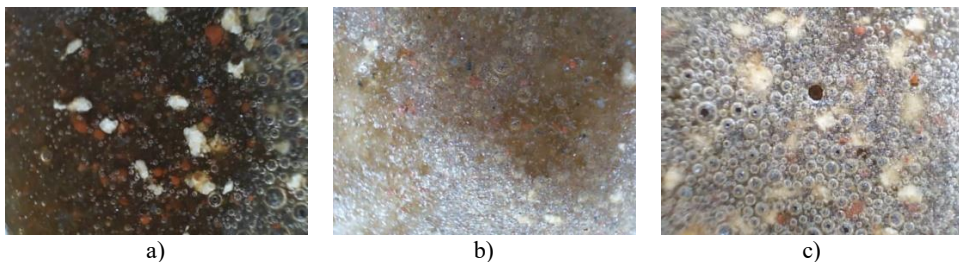
At the end of storage under specific conditions, a visual inspection of the fillers was carried out, similarly to how the input control of raw materials is carried out at the repair site (Table 2). After storage in conditions of high air humidity, a strong dampening of the filler was recorded, which was noticeable to the naked eye (the greatest dampening was recorded for mica and boron nitride). The filler batch, which was stored under conditions of temperature difference, did not show any visual changes.

**Table 2.** Assessment of changes in the properties of fillers after storage in various conditions.

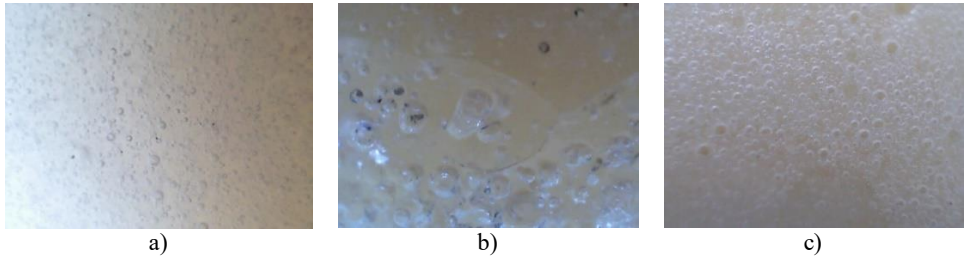
Filler	Terms storage	Change properties after 6 months storage
Mica	Standard conditions	Without changes
Boron nitride		
Aluminum powder		
Carbon powder		
Mica	High air humidity > 98%	Severe dampness
Boron nitride		Severe dampness and increased clumping
Aluminum powder		Strong clumping, difficulty mixing filler and binder
Carbon powder		Without changes
Mica	Temperature difference from +30°C to -30°C	Without changes
Boron nitride		
Aluminum powder		
Carbon powder		

In the second stage, composite material samples were made from these fillers and an epoxy binder (EDP with PEPA hardener). The obtained samples were examined under a microscope. The results of the observation are presented in fig. 1-4.

PCM samples filled with mica (Fig. 1, b, c), which were stored under improper conditions, had an inhomogeneous texture (color change), a large number of pores, and air inclusions. The largest number of defects was recorded in samples that were stored under conditions of temperature differences. At the same time, during the visual control of mica, which was stored under conditions of high air humidity, strong dampening was recorded, and in mica, which was stored under conditions of temperature difference, no visual changes were detected.



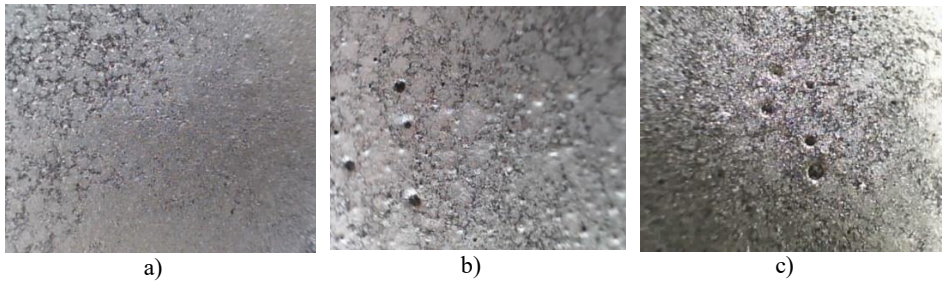
**Fig. 1.** Microstructure of samples filled with mica: a – when the filler is stored under standard conditions; b - when storing the filler in conditions of high humidity; c - when storing the filler under conditions of temperature difference.



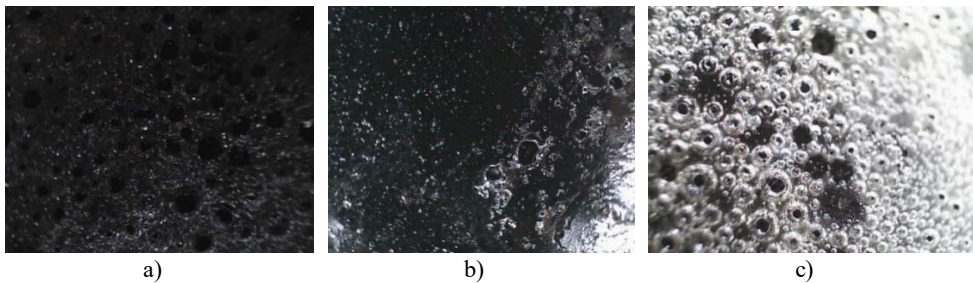
**Fig. 2.** Microstructure of samples filled with boron nitride: a – when the filler is stored under standard conditions; b - when storing the filler in conditions of high humidity; c - when storing the filler under conditions of temperature difference.

Visual inspection of PCM with boron nitride (Fig. 2) as a filler showed that the largest number of structural defects is observed in samples made using a filler stored in conditions of high humidity. At the same time, during the visual control of boron nitride, which was stored in conditions of high air humidity, strong clumping was also recorded.

The least influence of filler storage conditions on the PCM structure was recorded for samples filled with aluminum powder (Fig. 3). At the same time, during visual control of aluminum powder, which was stored in an unheated warehouse, strong clumping was recorded, and difficulties in mixing the filler and binder. It is assumed that when aluminum powder with disturbed storage conditions is used as a filler, technological defects have a delayed effect (the so-called technological heredity).



**Fig. 3.** Microstructure of samples filled with aluminum powder: a – when the filler is stored under standard conditions; b - when storing the filler in conditions of high humidity; c - when storing the filler under conditions of temperature difference.



**Fig. 4.** Microstructure of samples filled with carbon-containing powder: a – when the filler is stored under standard conditions; b - when storing the filler in conditions of high humidity; c - when storing the filler under conditions of temperature difference.

### 3 Conclusions

The largest number of structural defects was recorded in PCM samples filled with carbon-containing powder (Fig. 4, c), which were stored in an unheated warehouse under conditions of temperature difference. At the same time, during the visual control of the feedstock, it was not possible to fix the change in the quality of this filler.

Thus, for all samples of PCM with fillers, which were stored under improper conditions, structural defects were recorded in the form of clumping, pores, and foaming.

It has been established that for several fillers, during the input control of raw materials, it is impossible to visually detect a violation of storage conditions, which later, during the manufacture of PCM, hurt the properties of the material. Therefore, when conducting input control of dispersed fillers, it is necessary to make a test sample of PCM and control its structure.

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