Polymeric composite materials (PCM) are used in the building industry as construction, finishing, and heat-insulating materials and for sealing and protecting buildings and equipment from corrosion [1] due to their advantages over traditional materials: elevated performance properties, lightness, and technological effectiveness.

At the same time, in most cases the cost of the polymers comprising the composites is high. One way of reducing the cost of PCM is to use industrial wastes as fillers. This would solve not only the problem of the shortage of raw materials and the cost of the finished product, but would also decrease the ecological load in the region, of primary importance in modern conditions.

In the chemical fibre industry, a significant amount of wastes is either dumped or burned, polluting the air. In production of acetate fibres, spent filter materials (SFM), a mixture of hydrated cellulose fibres, cotton cloth, paper, cardboard, and cellulose acetate gel particles are burned. We developed different PCM using these wastes.

Composites based on phosphogypsum and carbamide—formaldehyde binders are currently used for manufacturing extrusion distillate articles for the construction industry [2]. However, these composites have insufficient strength and water resistance, and they thus cannot be used for fabrication of construction articles used in atmospheric conditions and in places with high humidity. In addition, polymer—phosphogypsum composites (PPGC) contain a significant (up to 20 parts by weight) amount of asbestos, a carcinogen.

We modified PPGC to increase the water resistance and strength and to decrease the asbestos content.

The starting composite had the following composition (in pts. by wt.):

- KFZh resin (GOST 14231—88) 35
- Asbestos fibre (GOST 12871—83) 15
- Phosphogypsum (USSR State Technical Specification TU 6-08-418-78) 50

Modification was conducted by varying the ratio of SFM and phosphogypsum and decreasing the asbestos content by increasing the proportion of binder.

It is known [3] that the curing rate of carbamide resins, a function of the pH of the system, can be altered by phosphogypsum. In studying the effect of different types of fillers on the kinetics of curing of PPGC, it was found in [4] that composites with a pH within the limits of 4.8-5.1 have a sufficient working life to make extrusion processing possible.

The results of the experiments showed that SFM do not significantly affect the pH equal to 2.9-3.4 for the system studied. To optimize the conditions of curing of the binder and processing of the composite into articles, slaked lime was added to the system in the amount of 2 pts. by wt., increasing the pH to 5.4.

To determine the possibility of processing PPGC based on SFM by extrusion, it was necessary to investigate the rheological characteristics of the composite as a function of the shear rate and concentration of filler. The rheological properties were determined on a Polimer-1 “cylinder—cylinder” rotary viscometer in conditions of continuous deformation of the sample at a shear rate of 0.015-15 sec⁻¹ according to GOST 15882—84.

SFM previously dried and ground to a particle size no greater than 2.5 mm were added to PPGC in the amount of 10-25 pts. by wt.; the asbestos content was decreased to 8 pts by wt., and the components were mixed in a laboratory mixer.

As the data in Fig. 1 show, SFM on the whole decrease the viscosity and shear stress of PPGC. Addition of 10 pts. by wt. of SFM decreased the viscosity by 1.2 times, and the shear stress by 3 times (curves 2 and 2′) in comparison to the unfilled composite (curves 1 and 1′). The effect of decreasing the characteristics studied by increasing the concentration of SFM in the composite to 20 pts. by wt. decreased slightly (curves 3 and 3′). The change in the viscosity properties of these composites was...
TABLE 1. Strength* of Extruded PCM as a Function of SFM Content

<table>
<thead>
<tr>
<th>SFM content, pts. by wt.</th>
<th>Breaking stress, MPa</th>
<th>Impact strength, kJ/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bending</td>
<td>compressive</td>
</tr>
<tr>
<td>0</td>
<td>25/8.0</td>
<td>52.5/15.6</td>
</tr>
<tr>
<td>10</td>
<td>26/13.5</td>
<td>42/25</td>
</tr>
<tr>
<td>15</td>
<td>30/21.0</td>
<td>64/54.4</td>
</tr>
<tr>
<td>25</td>
<td>22/7.7</td>
<td>55/31</td>
</tr>
</tbody>
</table>

* The data for dry samples are reported in the numerator and the data obtained after holding the samples in water for seven days are given in the denominator.

Fig. 1. Viscosity (1-3) and shear stress (1'-3') vs. shear rate for PCM with no SFM (1, 1'), PCM with 10 (2, 2') and 20 pts. by wt. of SFM (3, 3').

due to the physicochemical properties of the SFM: the activity of the cellulose acetate contained in the filler [5], the higher mobility of the particles in comparison to phosphogypsum decreased the friction and consequently the viscosity.

Experimental samples were prepared by extrusion on a pilot-industrial installation through molding heads 10 × 15 and 10 × 20 mm in section to study the physico-mechanical properties of the PCM. The tests were conducted by standard methods.

As the data in Table 1 and Figs. 2 and 3 show, the partial replacement of phosphogypsum by SFM and PPGC not only improved the technological properties of the PCM but also decreased the water absorption and increased the strength in the dry and wet state.

The water absorption of composites filled with 10-15 pts. by wt. of SFM (Fig. 3, curves 3 and 4) decreased in comparison to the starting value (curve 1) by more than 3 times, the strength of dry samples increased on average by 1.2-1.3 times and the strength of water-saturated samples decreased by 1.5-1.9 times (Table 1). The higher impact strength of the water-saturated samples in comparison to the dry samples was due to the plasticizing effect of the water, and the decrease in the strength characteristics and increase in the water absorption of PCM containing more than 20 pts. by wt. of SFM was due to the inhomogeneity of the composite.

The use of SFM as filler is thus promising since it increases the strength and water resistance of manufactured articles.