TECHNOLOGY OF MANUFACTURING HOLLOW GLASS-FIBER-REINFORCED BLADES FOR AXIAL FANS

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At present, steel or aluminum is used to manufacture blades of axial fans with rotor diameters of from 2.5 to 7 m intended for cooling towers and air-cooled units. During operation in corrosive media (H₂O, HNO₃, HCl, SO₃, H₂S, etc. vapors and sprays), metal blades corrode and fail. Moreover, the noise and vibration which accompany the operation of fans with metal blades create unfavorable working conditions.

We have developed technology for manufacturing blades from glass-fiber-reinforced plastic (Fig. 1). In comparison with a metal blade, the glass-fiber-reinforced plastic blade has a perfect aerodynamic shape, its weight is a third to a seventh that of the metal blade, it does not corrode, does not vibrate, is noiseless during operation, and is simple to install and remove.

The blades are made by vacuum-compression molding from glass-fiber-reinforced plastic with an epoxy-resin binder and a filler of glass fabrics T-11 (state standard GOST 19170-73) and TR-0.7 (branch standard CСТ 6-11-209-74). A pouch of 1847 rubber with a thickness of 0.6-1.0 mm is used for molding the inner cavity of the blade.

A basic engineering diagram of the manufacture of hollow glass-fiber-reinforced plastic blades is shown in Fig. 2. A bundle 2 assembled in a specific sequence from precut glass-fabric blanks is placed in a horizontally positioned half of the metal mold 1 with a nonsticking coating. Then the bundle is covered with the rubber pouch 3 with a special umbrella-type* supporting device intended for molding sharp blade edges and rigidly fixing the pouch width equal to the chord of the inner blade cavity.


Fig. 1. Hollow glass-fiber-reinforced plastic blade for an AVO fan with a rotor diameter of 2.8 m.
To vacuum pump

Fig. 2. Basic engineering diagram of the manufacture of hollow blades.

Fig. 3. Relation of the viscosity, $\eta$, of a binder consisting of 100 parts by weight of epoxy resin $\overline{E}D-20$ and 49 parts by weight of maleic anhydride at 60°C to the holding time $t$, for various contents $c$ of accelerator UP 606/2: 1-6) for $c$, values of 0.1, 0.2, 0.4, 0.6, 0.8, and 1.0 parts by weight, respectively.

The bundle is turned layerwise to the upper side of the pouch, the mold is covered with the other half of the mold, and it is mounted vertically with the throat downward. The cavity, filled with the glass filler, is vacuum-treated through an upper sleeve for 5-10 min, and then compressed air with a pressure of 1.4-1.5 kgf/cm$^2$ is fed into the rubber pouch.

Simultaneously, the metal mold is heated with hot water to 60°C. The binder, an epoxy resin at a temperature of 60°C and a pressure of 0.5 kgf/cm$^2$, prepared in a reactor 7 is fed into the mold through an automatic valve 8 and impregnates the glass-fabric bundle. The average upward velocity of the binder in the mold is 200 mm/min. The completion of impregnation is assessed according to the transparency of the binder in a viewing connecting piece 5 located on the vacuum line. The excess binder is collected in a trap 6. The automatic valve, combined with a photoresistor and mounted on the pressure line, precludes accidental air feed to the impregnated glass filler.

After completion of impregnation, the feed of the binder is terminated, and the air pressure in the pouch is gradually increased to 2.5 kgf/cm$^2$ to ensure more complete impregnation of the glass fabric and the required glass-to-resin ratio of 30:70. The blade is cured at a mold temperature of 120°C for 1.5 h.

To increase the strength of the blade and remove internal stresses in the glass-fiber-reinforced plastic after removal from the mold, the blade is heat-treated at 140°C for 2 h.

It is known that it is necessary to use a low-viscosity binder for impregnation under vacuum. We determined that when a rubber pouch is used for molding the inner cavity of a blade with a complex spatial configuration, rapid and high-quality impregnation of glass fabric is ensured with a binder viscosity of not more than 350-400 cP. This makes it necessary to thin highly viscous epoxy resins. Investigations showed that the most acceptable thinner in this case is maleic anhydride, which simultaneously serves as a curing agent. Figure 3 shows the relation of the viscosity of a binder at 60°C with various contents of accelerator UP 606/2 to the holding time, by using which we can select the binder composition on the basis of the durability required for carrying out all the preparation and impregnation process operations.

Since the blades operate in corrosive media, we investigated the corrosion resistance of some coatings applied to the blades with a spray gun after heat treatment. The best results were obtained with the use of yellow enamel $\overline{E}P-140$ (technical specification MRTU 6-10-599-66). Because of the scarcity of enamel $\overline{E}P-140$, we developed an epoxy-polyamide enamel similar in properties with the following composition: 100 parts by weight of epoxy resin $\overline{E}-40$, 50 parts by weight of polyamide resin L-19, 70 parts by weight of yellow lightfast pigment, and 250 parts by weight of solvent R-4.

The basic parameters and characteristics of the developed glass-fiber-reinforced plastic blades manufactured by the described technology are given below:

| Diameter of the working fan rotor, m | 2.8 | 5 | 2.5 |
| Length, mm | 1200 | 2210 | 955 |