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INFUENCE OF PROCESSING CONDITIONS OF POLYMETHYL METHACRYLATE ON THE OPTICAL AND MECHANICAL PROPETIES OF PRODUCTS

Study of the mechanical and optical properties of PMMA, including the addition of recycled materials, have been conducted. the possibility of using recycled materials in the manufacture of products made of PMMA was shown. Found that the optical properties deteriorate with the introduction of secondary PMMA over 10%.

Introduction. Polymethylmethacrylate (PMMA), the so called Plexiglas, obtained by polymerization or copolymerization of methyl methacrylate with other monomers, acrylic series, characterized by an extremely high transparency, high softening temperature (90–140°C), good mechanical properties, which can significantly increase upon drawing. Plexiglas usually has good resistance to aging, i.e. mechanical properties and light transmission Plexiglas virtually unchanged over time when exposed to ultraviolet rays and inclement weather, so Plexiglas not require additional protection from UV radiation. The light transmittance of plexiglass to 92% of visible light, which is greater than any other polymeric material [1]. For colored plexiglass during prolonged outdoor use may change color to varying degrees depending upon the particular manufacturer of the material and color. The main operational drawback polymethylmethacrylate - surface cracking under mechanical stress in the presence of oxygen. In the initial stages of this process it manifests as clouding ("blue") material, then crack growth occurs until the destruction of the product. The main ways to combat microcracking ("silvering") are plasticized poly hood and orientation. This improves the strength characteristics and the complex.

Main part. The most common method of processing PMMA – injection molding. On the physic-mechanical and optical properties of the product affect the process parameters, such as melt temperature, melt duration of injection, duration recharge mold (holding pressure), mold temperature and cooling time [2–3].

Effect of temperature on the value of the melt molding shrinkage appears very ambiguous. With a certain degree of approximation we can say that in amorphous polymers (this relates to PMMA) shrinkage decreases slightly with increasing temperature. It is possible that the observed effect – a consequence of structural changes in the polymer occurring when the duration of his stay in the melt.

Mold temperature – is the most important parameter that determines not only the quality and durability of the product, but also the duration of the cycle.

Thermoplastic PMMA has a low thermal stability and is very sensitive to overheating and temperature changes of the mold.

Depending on the method and parameters of the process in a wide range of processing may vary the characteristics of the light scattering of the same polymer. Comparison block PMMA polymerized in form, with the same configuration block, diecast, showed that in the latter, along with a high birefringence, a sharp decrease optical homogeneity, and he has a high light scattering.

Table 1

Basic material properties

Propeties	Method of testing	Acryrex CM-205	Plexiglax 8N
MFR, 230°C, 3.8 g, g/10 min	ASTM D1238	1.8	–
Density, 23/23°C, g/см^3	ASTM D792	1.19	1.19
Water absorption, 24 h at 23°C, %	ASTM D570	0.3	0.3
Flexing strength, MPa	ASTM D790	110	115
Optical transmission, size 3 mm, %	ASTM D1003	92	92
Shrinkage by casting, %	ASTM D955	0.2–0.6	–
Coefficient of elongation at the limit fluctuation, 23°C, %	ASTM D638	5	5.5

The amount of light scattering in casting of PMMA decreases with increasing casting temperature and increases with increasing temperature of the mold. The light transmittance of the samples obtained by the polymerization in the form 1.5–2.0 times higher than the die casting.

The optical properties of the product during processing of PMMA following factors:

– Injection of the melt into the cold mold: mold temperature should be stable and keep the temperature at about 60°C;

– Undry material: drying temperature used in the production of PMMA 70–80°C for 2–3 h;

– Ingress of impurities, recycled material PMMA polymer dust. Physical-mechanical properties and extrusion molded plexiglass differ little from each other – both species are sufficiently high tensile strength, crashworthiness, heat resistance and moisture resistance.

However, cast acrylic has a high surface quality and optical clarity, it is a high impact and heat resistance, has a better chemical resistance, better polish.

Extrusion plexiglass at elevated temperature has a higher ductility, resulting in a more accurate reproduction of complex molds at molding.The best method of obtaining optical products considered destination polymerization form optical surfaces [4]. This method produced spectacle and constroke lenses, mirrors, sheets, rods, etc. It is possible to achieve the minimum values of internal stress and optical inhomogeneity in detail, as well as the lack of staining, high quality surfaces of the parts, which is determined solely by the quality of the surfaces of the polymerization form. In the manufacture of plastic lenses for the control parameters take their focal length and resolution. However, polymerization in the form of different long duration, resulting mainly used for products is very critical applications.

Test materials PMMA two brands Plexiglax 8N and Acryrex CM-205 are similar in properties (see table) and the transition from one material to another in the production of a particular type of product technological parameters do not change. Note that Acryrex CM-205 is more flexible and less prone to cracking.

Optical defects in organic glasses may arise and intensify after heating the molding or orientation [1]. This phenomenon, called optical heat sensitive, due to heterogeneity of the polymerization process in the preparation of organic glass sheets. As a result of the differences in reaction rate for individual sections of the polymerizing mass and having internal stresses are frozen, that upon heating at temperatures above the softening temperature of the organic glass causes deformation, leading to the appearance of optical defects. Reducing the optical quality may occur during mechanical processing of organic glass such as heat generated by the implementation of polishing may lead to non-uniform expansion of the polymer.

With a cast PMMA molding process should be carried out in strictly defined circumstances, asking the melt temperature T_r material, mold temperature T_f and a flow rate of injection Q (or the filling). Suggested modes of injection molding: melt temperature 200–230°C, 40–80°C forms, specific injection pressure of 100-160 MPa and the temperature difference between adjacent areas of the cylinders 5–10°C. Temperature of the product at the time of removal from the mold should not be higher than the glass transition temperature ($T_I \leq T_S$), which is 90–110°C, depending on the brand, to ensure sufficient rigidity of the disclosure form products. Temperature of the mold in relation to the melt temperature (T_r-T_f) affects the rate of cooling of the melt flowing into the mold. It affects the orientation of the polymers in the surface layer during the application process and consequently on the strength characteristics of the product. By the relaxation of internal stress and to improve the optical uniformity of the heat treatment causes the polymer samples molten at a temperature below the polymer T_g. Voltage in the details of PMMA decrease with prolonged annealing (conditioning) at 50–80°C for several hours.

In examining the effect of parameters of the injection molding process on the optical properties of the produced parts found that variation of the refractive index of the arithmetic mean for the PMMA pellets and parts up to $5 \cdot 10^{-4}$. During the processing of optical homogeneity of PMMA is much worse, which is also attributed to the orientation of the macromolecules, the internal stresses generated during casting.

In the manufacture of parts from thermoplastic PMMA, a large amount of secondary material which is added to the virgin material even at 10%, since it leads to unacceptable defects – turbidity parts.

Researches properties PMMA addendum 7–9% recycled material, which was crushed in a grinder with low speed, after which it served in the machine hopper to the primary raw material. The items had turbidity within acceptable limits.

In trials with secondary products of PMMA was found that in some detail, there are black blotches, which is unacceptable in the manufacture of products with a light transmission ≈80–90%. This defect persists technologically by reducing temperature molding and injection speed, blowing crusher for the entry of foreign materials, etc. In our opinion, this is due to the structural heterogeneity of PMMA, in particular, the so-called “rash” This term denote small bumps and troughs appearing on the surface of organic glasses after heating

at a temperature which is 20–30°C above the T_g of the polymer. One of the reasons for the defect – dirt (inorganic impurities) which are contained in the starting monomer and the centers of formation of «rashes». They appear in the PMMA at the stage of synthesis and secretion.

Conclusion. During the study of the mechanical and optical properties of PMMA found that there is the possibility of using the technology in some secondary products PMMA and more research is needed.

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