STUDY OF SELECTED PROPERTIES OF THERMOPLASTICS AFTER AGEING

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Abstract
Changes in selected mechanical properties of thermoplastic composites – ABS, POM, PC and PBT during and after exposure materials to ultraviolet radiation, freeze and heat were investigated. The samples of composites were produced by injection molding. The samples were exposed for one month to UV, -20°C and +50°C temperatures. To determine the changes of mechanical properties after ageing of polymeric materials, tensile test and bending test. Tensile strength, relative elongation and bending strength were performed to identify the impact of ageing.

Key words: injection molding, thermoplastic composites, ageing

INTRODUCTION
Very few types of plastics exist in nature. They are mostly synthetic products, made by combining small molecules into large ones, known as polymers (from the Greek 'many parts'). Continued exposure to many of the common environments of our planet-sunlight, air, oxygen, water, cold, heat, and micro-organisms-can cause polymers to decompose into small molecules similar to those from which they were made. This process is called ageing, and it leads to brittleness and eventual failure.

One of the most important aspects in the product development, which must be taken into consideration, is the prediction of the product lifetime. Fiber-reinforced polymer composites are widely used in aerospace and automotive applications where changes in physical and mechanical properties of composite components can influence their functionality. The absorbed water, above a threshold defined for a given temperature and a given ageing time, results in more undesirable effects on the mechanical properties of these materials since the not only interacts with polymer matrices, physically, i.e. plasticization, and/or chemically, i.e. hydrolysis of the ester groups, as in the unfilled systems but also attacks the fiber-matrix interface, which results in embrittlement of the fiber-reinforced composite. Such factors may cause material degradation, which in turns means that the material will lose its load carrying capacity. Based on the completed tests, it is possible to conclude that the largest decrease in material properties is caused by cooperation between high moisture and temperature exceeding glass transition temperature for the examined plastic material. Under such unfavorable conditions, attenuation decreases which can be observed in the form of decrease in hysteresis size and decrease in the magnitude of force necessary to destroy the examined sample. At the same time, material fracture mechanism changes from ductile to brittle.

TESTED MATERIALS
In the studies for experiments were used four types of polymer composites: ABS, POM, PC, and PBT.

- **Material Acrylonitrile butadiene styrene LG ABS XR 401 White (ABS)** – is rigid opaque plastic. The most important mechanical properties of ABS are impact resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. Impact resistance does not fall off rapidly at lower temperatures. Stability under load is excellent with limited loads. Thus, changing the proportions of its components ABS can be prepared in different grades. Two major categories could be ABS for extrusion and ABS for injection moulding, then high and medium impact resistance. Generally ABS would have useful characteristics within a temperature range from –20 to 80 °C.

- **Material Polyoxymethylene (POM), Orbiform M 130 NA** also known as acetal, polyacetal and polyformaldehyde, is an engineering thermoplastic used in precision parts requiring high stiffness, low friction and excellent dimensional stability. POM is intrinsically opaque white, due to its high crystalline composition, but it is available in all colours. Material marked Orbiform M 130 NA was used on tests.

- **Polycarbonate DCK (PC)** is a particular group of thermoplastic polymer. They are easily
worked, molded, and thermoformed and polycarbonates find many applications. Polycarbonate is a durable material. Although it has high impact-resistance, it has low scratch-resistance and so a hard coating is applied to polycarbonate eyewear lenses and polycarbonate exterior automotive components.

- **Polybutylene terephthalate Crasit (PBT)** is a thermoplastic engineering polymer that is used as an insulator in the electrical and electronics industries. PBT is closely related to other thermoplastic polyesters. It has somewhat lower strength and stiffness than polyethylene terephthalate, PET, is a little softer but has higher impact strength and very similar chemical resistance.

**EXPERIMENTAL METHODS**

Tensile test was performed to determine the mechanical properties of selected materials after ageing. The samples for experiments were produced by injection molding on machine type ARBURG Allrounder 370S Golden.

Tensile test was performed under STN EN ISO 527-1 at TIRAtest 2300 and A-type of samples was used. Bending test was performed according to STN EN ISO 178 at machine TIRAtest 2300. Five samples from each material and degradation environment were tested. Material ABS after tests is shown on Figure 1.

After the injection molding process, the samples were exposed to different climatic conditions; they are having an impact on ageing of testing materials. For a period one month the samples were exposed to the effects of ultraviolet radiation into chamber UV. The samples were irradiated continuously for 12 hours, followed by a 12 hour idle interval (360 hours of exposure). The others part of the samples was placed in a freezer at BEKO CSA22020 on temperature -20°C ± 3°C for a period one month. Heat aging was carried out in a laboratory dryer ECOCELL 55. The samples were exposed to a temperature of + 50 °C for 12 hour cycle for all tested materials for a period of one month.

**EXPERIMENTAL RESULTS**

Graphic dependence of measured values of tensile strength ($\sigma_M$) is shown on Figure 2, relative elongation ($\varepsilon_M$) values are shown on Figure 3 and values bending strength ($\sigma_f$) of tested materials are shown on Figure 4.
Breach of the PBT samples after tensile test material is documented on Figure 5.

Fig. 5 PBT samples after ageing and tensile test

CONCLUSION

This paper deals with the impact of aging on the mechanical properties of polymers in different environments. Based on performed tests to determine the mechanical properties of tested material were given next conclusions:

- Values of $\sigma_M$, $\varepsilon_M$ and $\sigma_f$ at tested materials changed minimally compared to samples from the standard environment.

- The greatest difference of $\varepsilon_M$ was observed at ABS material in low-temperature environments – an increase of 30.38%. At the tensile test and bending test were created small cracks in different locations over the length of the samples.

- At POM occurred an overall breach without fracturing and cracking. At PC material were peeled small parts. In the tensile test of material PBT was an overall breach that was accompanied by the cleavage of small parts.

- At the sample of PBT material after UV degradation is clearly visible the colour change from white to yellow. It is necessary to consider the use of such material in this environment. In other investigated materials in various environments the color change didn’t occurred.

References


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