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INFLUENCE OF ENVIRONMENT ON BENDING STRESS OF COMPOSITE WITH REGRANULATE

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ABSTRACT: *The paper deals with the influence of added regranulate into basic material on changes of selected mechanical properties of polymeric material. Material Crastin® PBT (with 30 % of glass fibre) was used at testing. The mechanical properties were obtained during the bending tests in standard condition and after exposure of materials to fluorescent UV lamps.*
KEYWORDS: *Plastics, Mechanical Properties, Bending Test, fluorescent UV Lamps*

INTRODUCTION

Advances in technology, new construction and the manufacturing of machinery are closely associated with the development and application of new materials. Among the construction materials which recently experienced the fastest development include structural ceramics and plastics. Performances of advanced engineering plastics are not currently objectively appreciated. In the construction of machines and equipment is still preferred metal, although the percentage of plastics and composites is one of the important criteria of progressiveness of the product.

Plastics and their rapid development as well as continuous production brought with them the problem of waste management. In recent recycling of plastics years received the most frequent words in print and electronic media. Recycling is generally classified as a procedure which leads to the use of energy and material from product after ending its life cycle. It is actually a return of material into the production cycle to produce a new product. The basic objective is the saving of primary raw materials and environmental protection.

The use of regrind in the production of new products is important to reducing the amount of plastic waste and subsequent the reduction of environmental pollution. In recent years, the automotive industry promotes ecological considerations in the application of plastics, i.e. the possibility of easy recycling materials from discarded cars.

When testing the properties of plastics, particularly granulate is very important to study the degradation i.e. aging, particularly when it comes to so-called engineering plastic. At degradation plastic loses its specific properties.

The aging of plastics is divided into natural and artificial. The term natural aging means the slowly change of properties of plastics by interaction with light, air, carbon dioxide and water. These changes initially quite limit, and ultimately prevent further use of the product. At most a plastic is aging expressed by yellowing and embrittlement. The cause of degradation of plastics properties and shortening their life cycle are physical, chemical and physic-chemical effects of the environment and biological degradation of polymers.

Comparable alternative to natural aging is artificial aging, in artificial conditions and just the impact of UV radiation in the chamber on selected properties of the plastic with added of regranulate is the aim of this contribution.

EXPERIMENTAL VERIFICATION OF PLASTIC PROPERTIES

The aim of the experiment was investigate the influence of added regranulate into clean granulate on changes of selected mechanical properties. For experimental verification of impact of added regranulate bending test was chosen as the method for testing. The test was done on test specimens in a standard environment and exposed to fluorescent UV lamps in laboratory conditions.

The material used in experiments was PBT (polybutylene terephthalate) concrete Crastin ® LW9330 PBT, provided by DuPont.

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The material Crastin ® LW9330 PBT is mineral composite reinforced material with 30% glass filler. This material is characterized by excellent dimensional stability and low deformation characteristics. Crastin ® LW9330 PBT is a thermoplastic material which can be re-moulded as it is safe in terms of degradation during the moulding process. Both materials - pure plastic and regranulate must be dried before injection moulding. According to the manufacturer's recommendations, it can be up to 25% regrind may be used without significant loss of strength and toughness.

Processing of PBT material is simple, with good flow properties. This material belongs to the engineering plastics and is also used to produce of mouldings parts for car. For example moulded parts for the car company Renault is made from this material - Fig.1.

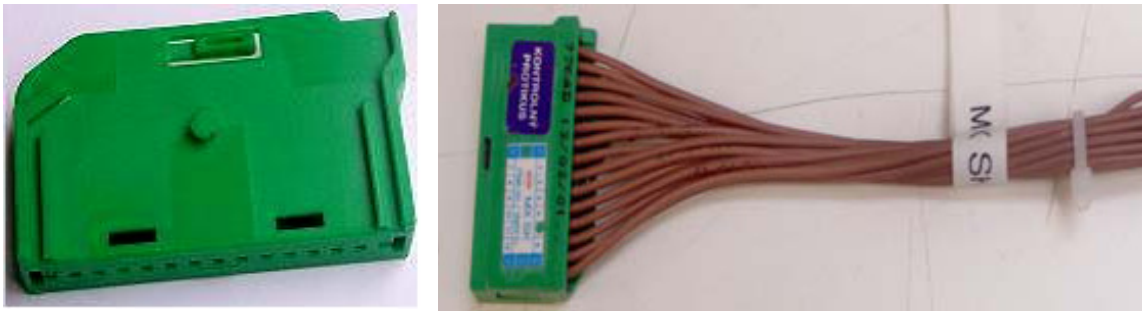

Figure 1. The molded part from experimental material and its utilization in praxis

Mixing of material with different % of regranulate was performed on the gravimetric mixing machine type WSB – 4. The experimental material was dried before processing in an oven at 120 ° C for 3.5 hours according to the material sheet.

PRODUCTION AND TESTING OF SAMPLES

The samples were produced by injection moulding on press Battenfeld, type HM 1000/350. For the production of samples was used modular injection mould die, with universal frame and interchangeable plates shaped to produce of test specimens – Fig.2.

Figure 2. Injection mould die with testing samples

Before testing the samples were marked as follows:

- *A - the basic material Crastin ® LW9330 PBT, contents of 0% regranulate,*
- *B - 20% of the regranulate in the basic material,*
- *C - 40% content of the regranulate,*
- *D - 70% of the regranulate in the basic material,*
- *E- 100% of regranulate.*

The bending test was used to test the mechanical properties. Bending test was performed according to EN ISO 178, the tip radius of the ballast was R_1 = 5.0 mm, supports radius R_2 = 5.0 mm, the distance was 64 mm. The test was performed on samples in a standard ambient and other samples were exposed to artificial aging effects of UV fluorescent lamps according to EN ISO 4892-3.

Nature of the test consisted of UV lamps; samples are exposed to the effects of fluorescent UV lamps in the UV chamber and during the period of 28 days in 12 hour cycles – Fig. 3. Bending test was performed to detect changes in the properties of the materials after aging. For each test 5 samples were tested from each material and each environment.

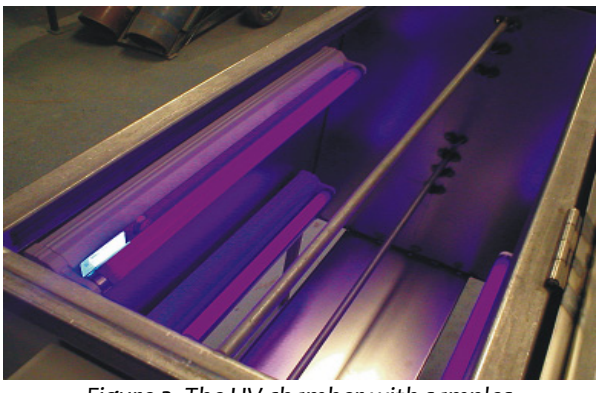

Figure 3. The UV chamber with samples

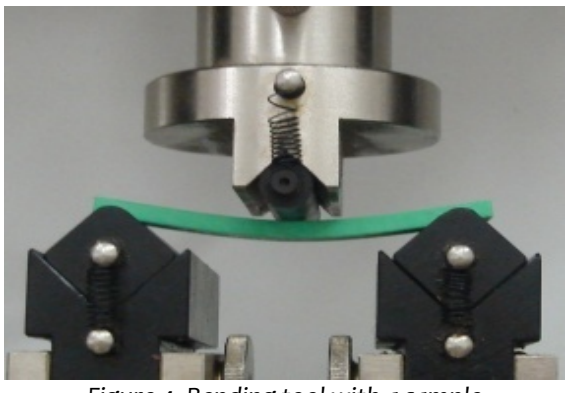

Figure 4. Bending tool with a sample

Bending test was performed on the verified tensile machine TIRA-test 2300, bending tool with a sample is shown in Fig. 4.

a)

b)

Figure 6. Failure of testing samples
a) testing samples with 0% regranulate;
b) testing samples with 100% regranulate

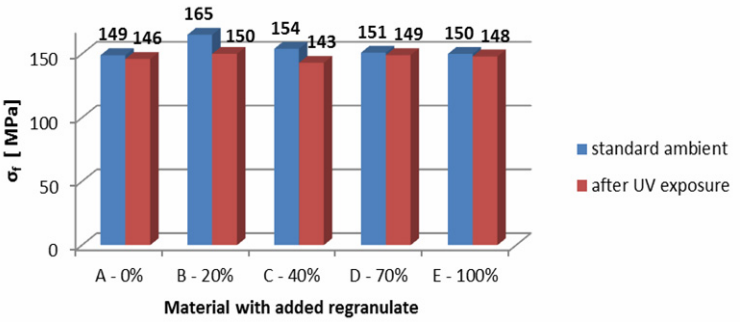

Figure 5. Bending stress of testing materials

ACHIEVED RESULTS OF THE EXPERIMENT

Comparison of average measured values of bending stress of testing materials in a standard environment and those found after aging by UV lamp is shown on Fig. 5.

Breach of samples is shown in Fig. 6. The all samples were broken completely with fragile fracture.

Fracture surfaces of test specimens were examined by scanning electron microscope JEOL JSM - 7000F, Japan. Fracture surface after bending test - the test sample of pure material, i.e. without the addition of granulate is shown on the following figures. On Fig. 7 is shown a matrix of material with glass fiber after bending tests. On Fig. 8 are visible holes from buckled or tore out glass fibers.

Fracture surface of test sample made from 100% regrind is shown in Fig. 9 and Fig.10. Detailed breach of glass fibres in the material of 100% regrind is shown on Fig. 11.

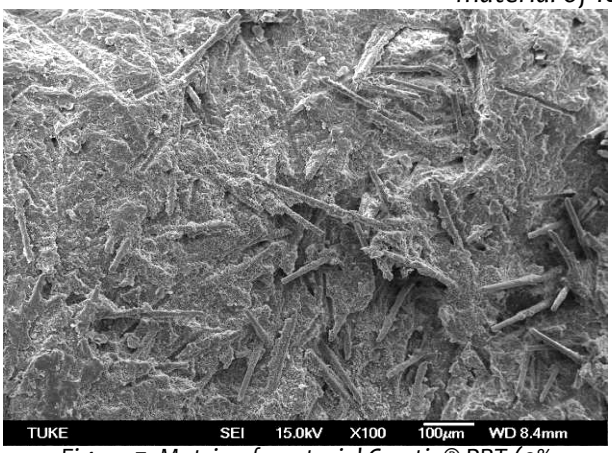

Figure 7. Matrix of material Crastin® PBT (0% regranulate)

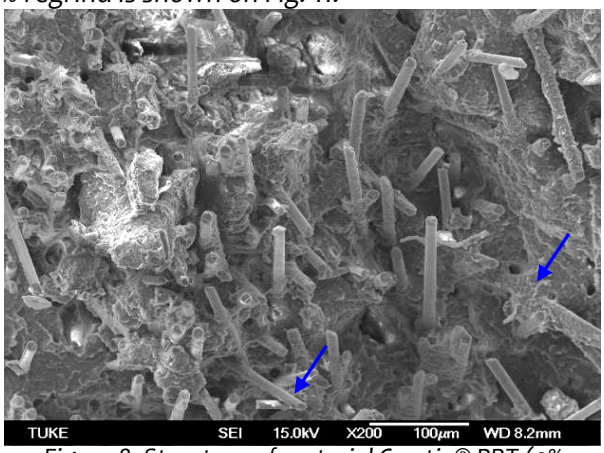

Figure 8. Structure of material Crastin® PBT (0% regranulate) – yank out glass fibre

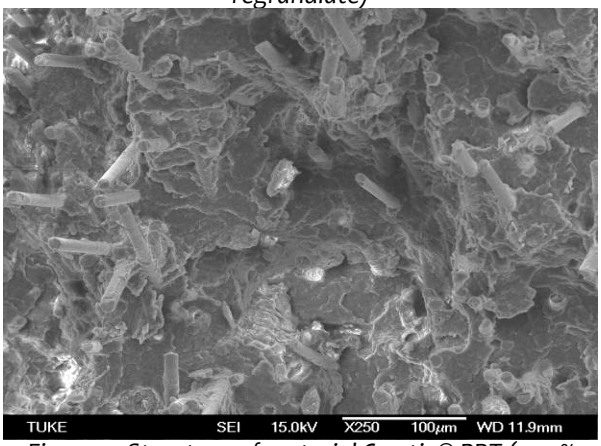

Figure 9. Structure of material Crastin® PBT (100 % regranulate)

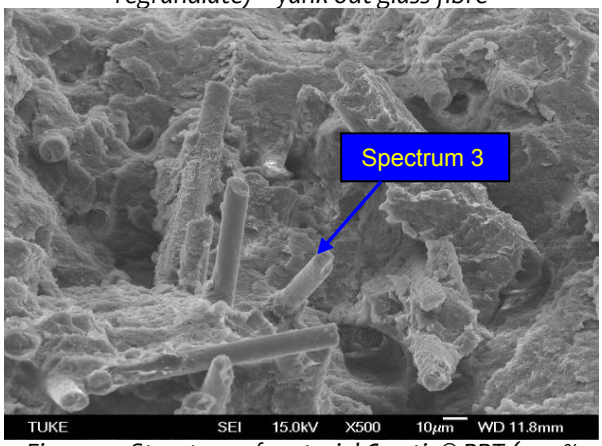

Figure10. Structure of material Crastin® PBT (100 % regranulate)

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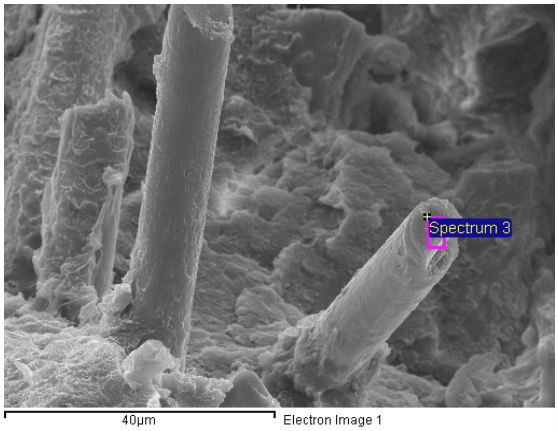
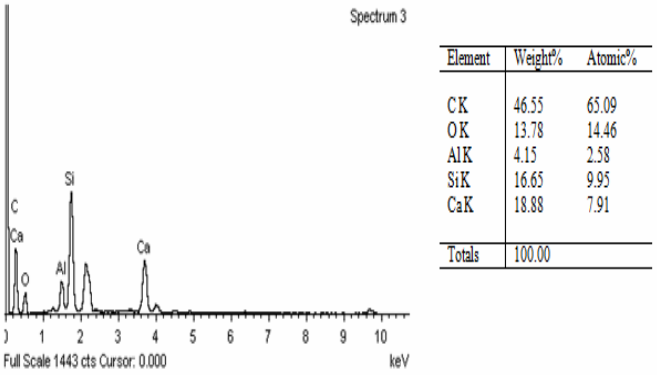


Figure 11. The failure of glass fibre – detail



Element	Weight%	Atomic%
CK	46.55	65.09
OK	13.78	14.46
AlK	4.15	2.58
SiK	16.65	9.95
CaK	18.88	7.91
Totals	100.00	

Figure 12. Chemical composition Spectrum 3 of failure glass fibre

Percentage values of individual elements (Spectrum 3) in a glass fibre are shown in the Fig.12.

Based on experimental tests, we have reached the following conclusions:

- *Bending stress σ_f in a standard environment ranged from 149 MPa to 165 MPa. Test samples exposed to artificial aging ranged from 143 MPa to 150 MPa. - Figure 5.*
- *Highest value of bending stress showed a material with the addition of 20% regrind, which would suit the manufacturer's recommendations of the use of material without substantially altering the material properties. Conversely, the lowest tension value in bending, 143 MPa was measured at the material from 70% regrind content. These σ_f values were measured at test samples in a standard environment.*
- *After carrying out tests on samples exposed to UV lamp (aging) compared to standard conditions value σ_f for each material was decreased. Degradation in the UV lamp had influence on bending stress of the test material.*

CONCLUSIONS

The increasing application of plastics for technically difficult parts place ever greater demands on the level of knowledge about the behavior of these materials, especially under conditions of mechanical stress. But this assumes to handle general principles of behavior of plastics under various conditions of use in practice.

Before applying the finished parts molded with regrind is necessary to verify the process conditions for the next injection molding with selected technological tests in terms of the finished molding applications in practice.

ACKNOWLEDGEMENT

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