



STUDY OF CHANGES OF PROPERTIES OF RECYCLED POLYMER FOR ITS REUSE IN PRACTICE

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Abstract:

The influence of recycle on mechanical properties of composite - thermoplastic PBT filled by GF was studied to examine the possibility of its reuse in practice. Samples from PBT contained 20%, 40%, 70% and 100% of recycled material were prepared by injection molding and their mechanical properties were tested by tensile test, bending test and impact test. The material made from 100% recycled material compared to the baseline had a decrease in tensile strength and yield strength of about 8%, elongation value hasn't changed. Influence of recycled material was mostly pronounced at Charpy impact test, where was decrease by 48%. Failure of the samples was also observed by scanning electron microscopy. By using recycled material in the production of plastic parts, it is possible to save material and thus protect the environment.

Keywords:

composite, recycle, mechanical properties, environment

INTRODUCTION

It is possible to say that we live in time of plastic. Nowadays, the plastics usually replace the traditionally used materials as wood, metal, glass, leather, textiles, stone, paper and natural rubber. Modern plastics (or polymers) possess a number of extremely desirable characteristics; high strength to weight ratio, excellent thermal properties, electrical insulation, resistance to acids, alkalis and solvents, to name but a few. These properties are the main reason of their extended using. Plastics are also economically advantageous in comparing to classical materials. The necessity of plastic recycling as new material is constantly increasing. [1,2] Plastics processing is nowadays the most important segment of production and consumption by volume among the all technical materials. Due to growing application of plastics in every industry, this material have unique place on the world market of used materials. The fact remains that the consumption of plastics is still rising up. [2,3]

Involvement in the production of these materials also have negative aspects. In environmental terms, plastics are too burdensome for the ecosystem. Their decomposition takes a long time and in their burning creates very large number of harmful emissions. Therefore it places a high priority on the ecological and especially effective recycling of used waste from these materials. Great development of plastic products also brought with it the problem of waste management. In practice, therefore there is a need to recycle more plastics and to use them again in the production of new products. [4]

Recycling also reusing is generally defined as the procedure which is the most effective exploitation of energy and material essence of products after end of its life and returning the material to life cycle of products. Quantity of utilized waste depends on quality of recycled material which is influenced by purity of the primary material. Production process with entrance of pure plastic waste

(inlet system after injection, remains of belts after punching) have great advantage in possibility of recycling the primary material, due to fact that this material is not contained by external factors. By subsequent processing of this material pure recyclate can be produced in required forms. This high quality recycled material reduces the input costs for raw materials . [1,2,5-7]

Characteristic sign of recycling is the aspect of double alleviate burden of environment, by:

- the inputs to the production system (by waste using there are saved the row materials),
- the outputs from production system (there is decreasing the quantity of emissions).

These aspects act either alone or together by waste using in one or two production processes. It is often the whole network of processes with changing of waste into secondary products. [7]

Mixing the pure primary material with recycled material often arises the material although with an identical baseline composition as the primary material, but the values of some of its properties may be altered. [1]

The benefits of plastic recycling:

- important saving of primary materials,
- usage of recycled product for new applications,
- new possibilities for products made from recycled materials,
- minimization, mainly of communal waste,
- creation of new job openings,
- conservation of matter (as opposed to energy assessment). [1,2]

Restrictions of plastic recycling:

- not all waste can be reused for the original use of products - e.g. packages,
- recycled product often has new properties, and the product recycled once becomes the waste later,
- recycling of recycled product may no longer be effective and justified,
- plastic parts and products of foreign production are also on the market, where identification of material and its postprocessing may not be effective and realizable. [1,2]

Nowadays, there is effort of producers to share the technological waste in production of new products as far as possible. The effort of plastics processor is in this time:

- to use the waste in production of new products with preserving or with making better their properties as far as possible,
- to find out the quantity of technological waste that can be processed in to basic material for specified production conditions for concrete molding of plastic. [2,7]

EXPERIMENTAL MATERIAL AND METHODS OF TESTING

The aim of the experiment was to investigate the effect of added recyclate into the basic material on the change of selected mechanical properties. Tests were done to determine the properties of polymer specifically by tensile test, Charpy impact test and bending test. Tests were conducted on the test specimens with a 0%, 20%, 40%, 70% and 100% recyclate in the basic material - Crastin® LW9330 PBT (Polybutylentereftalat), produced by company DuPont.

Crastin ® LW9330 PBT is mineral glassy composite reinforced with 30% glass fiber. The material is characterized by excellent dimensional stability and a low deformation characteristics. According to the producer's recommendations, it can be up to 25% recyclate used without significant loss of strength and toughness [3]. The material belongs to the engineering plastics and possibilities of the material utilization to produce components are shown in Figure 1.

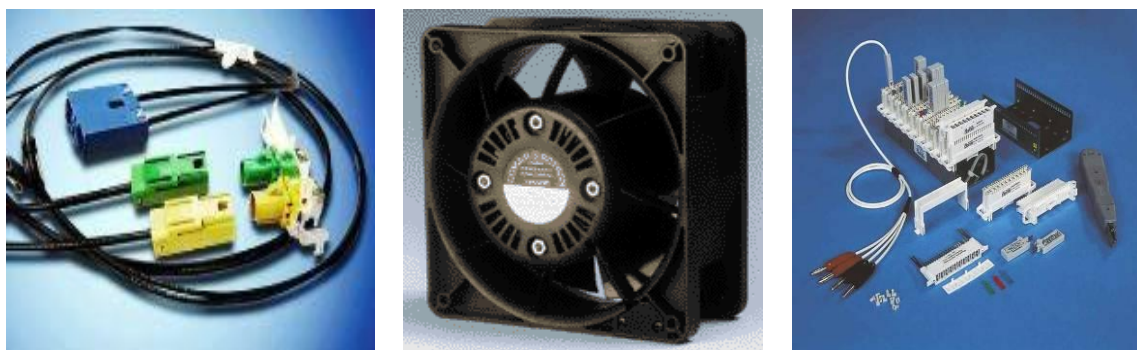


Fig. 1 The using of the test material in practice

Mixing of material for the experiments with different % recyclate was performed on the gravimetric mixing machine type WSB - 4. The experimental material was after processing dried at 120 °C for 3.5 hours according to material letter.

The samples were made by injection moulding, with using of the injection press type Battenfeld, type HM 1000/350 according to STN EN ISO 294-1. The tested samples were made in multiple ISO injection mould. The tested samples for tests after moulding are shown in Figure 2.



Fig. 2 Tested samples after processing for tests

The experimental verification of the influence of recyclate on mechanical properties by tensile test was performed according to STN EN ISO 527 and samples type 1A was used for testing. The test samples were controlled scilicet after injection moulding and after the conditioning time. The tensile machine TIRA- test 2300 was used for the test. Five samples of each of materials were tested.

The evaluation of impact resistance of plastics was made according to STN EN ISO 179 – 1. It was tested for 10 samples of each type of materials. The test samples were subjected to the tests with notch. Impact strength test was carried out on Charpy hammer type PSW 60/500.

Bending test was performed according to EN ISO 178 (STN 64 0607) on the machine TIRA- test 2300. Five test samples were tested for each type of material with recyclate.

Break surfaces of testing samples were observed on scanning electron microscope JEOL JSM – 7000F, Japan.

EXPERIMENTAL RESULTS

Figure 3 presents yield strength (σ_Y) of samples with various % of recyclate in tested materials. Graphic dependence of measured values of tensile strength (σ_M) is shown in Figure 4 and relative elongation values are shown in Figure 5.

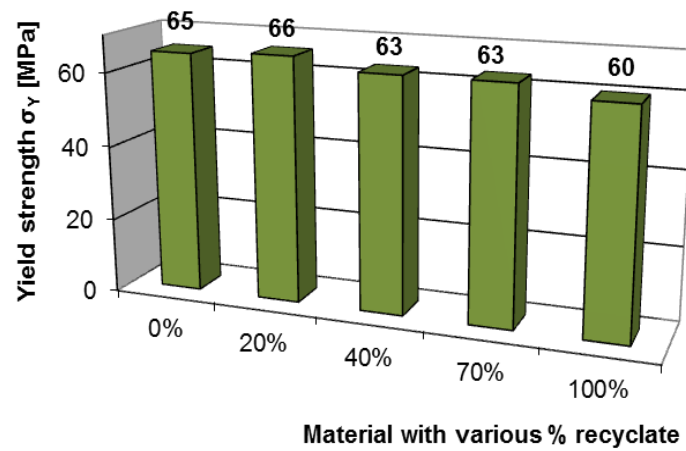


Fig. 3 Average values of yield strength of tested materials

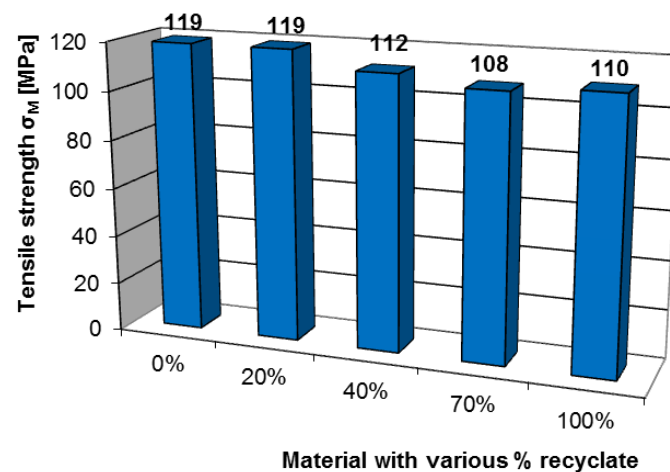


Fig. 4 Average values of tensile strength of tested materials

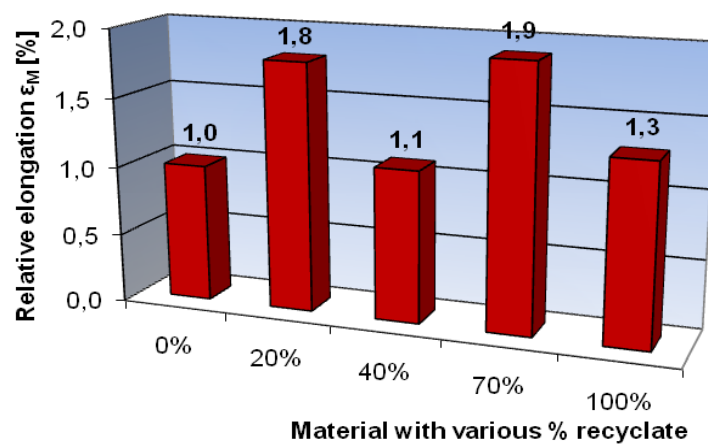
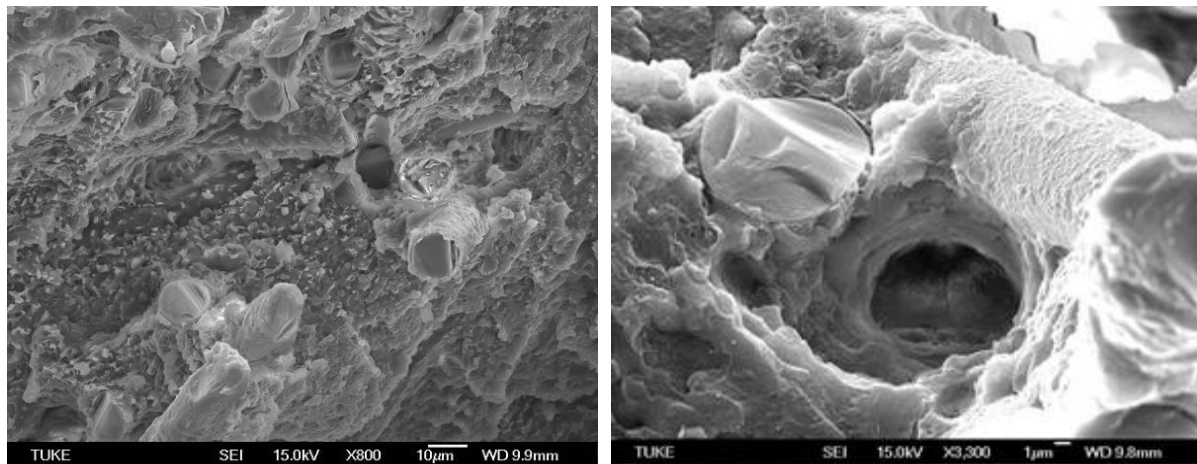


Fig. 5 Average values of relative elongation of tested material

Figure 6 shows the rupture of material after tensile test observed by scanning electron microscope. There are shown the torn glassy fibers as well as the matrix materials.



a) b)
 Fig. 6 Structure of tested material after tensile test
 a) 0% recyclate, b) 100% recyclate

The graphic processing of average values of impact strength by Charpy method of tested materials for each tested material with recyclate is shown in Figure 7. The break surfaces of tested samples after impact strength test are shown in Figure 8.

The graphical representation of bending stress value of tested materials for each type of mixture of base matrix and recyclate is shown in Figure 9. The break surfaces after bending test are shown in Figure 10.

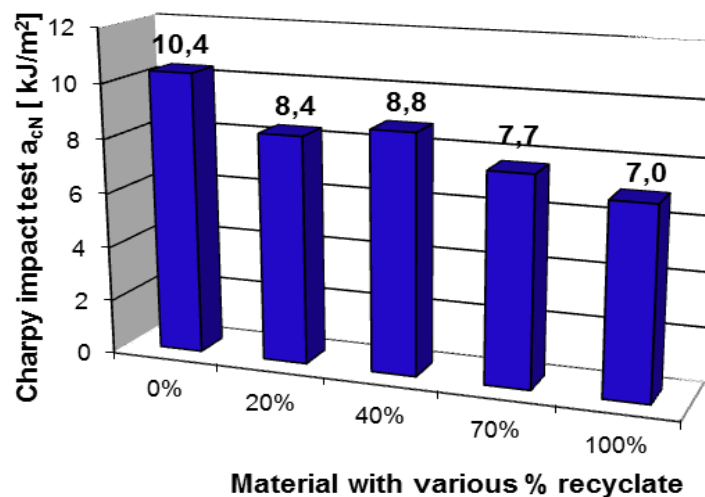
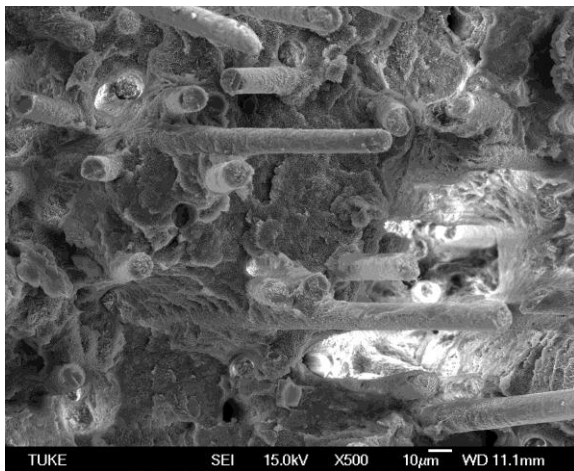
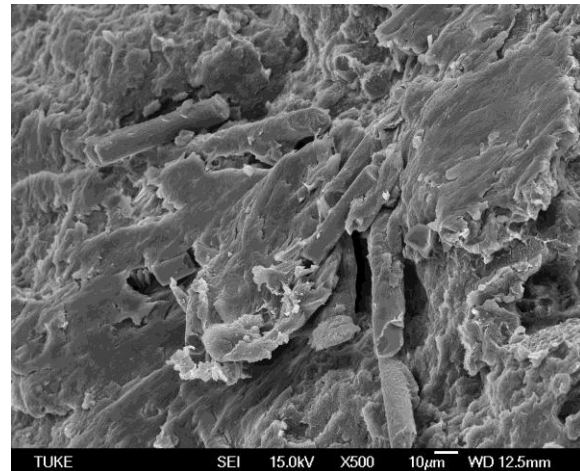


Fig. 7 Values of impact strength of tested materials



a)



b)

Fig. 8 Structure of material after impact test
a) 0% recycle, b) 100% recycle

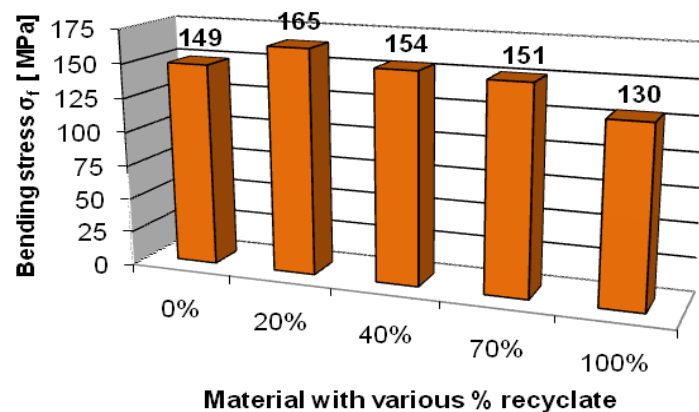
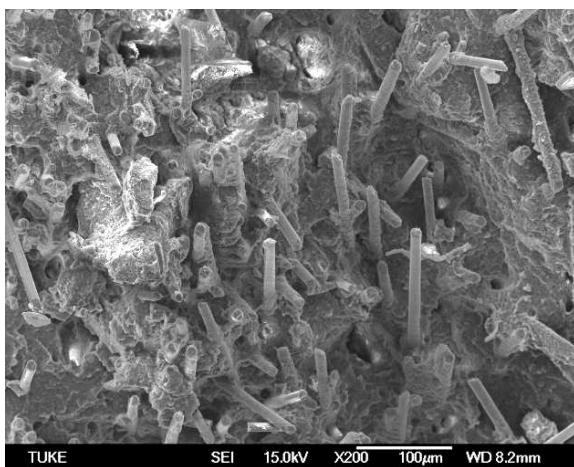
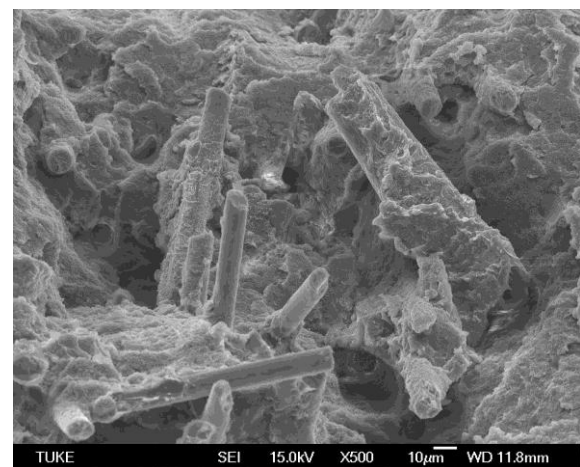


Fig. 9 Bending stress of tested materials



a)



b)

Fig. 10 The structure of material after bending test
a) 0% recycle, b) 100% recycle

Figure 11 shows the products used in automobiles which are made from tested PBT material with addition of recyclate.



Fig. 11 The molding made from PBT material and his using in automobile

Based on realized dimension control of moldings and effect of recyclate quantity in primary material to moldings quality it is concluded that in 20 % of recyclate the capability index is in border of system stability. Values of dimension stability had tight dispersion, and ranged in the borders given by tolerance band. Consideration of usage of recyclate to produce molded parts in automotive industry is appropriate step due to saving of primary material and resources. Based on this experiments and research, we can conclude, that usage of 20% of technological recyclate is highly recommended and will not decrease the quality of final molded part.

DISCUSSION

Based on tests performed to determine the mechanical properties of tested material with recyclate were given next conclusions (comparing the material with 0% and 100% recyclate):

- the value of yield strength of tested material has decreased, about 8%,
- evaluating of tensile strength allocated similar results, it means that the increasing percentage of recyclate added to material Crastin® LW9330 PBT leads to slight decrease of tensile strength value in about 7,6%,
- the measured value of relative elongation of tested materials was in range from 1% to 1,9%, so there were minimal changes of relative elongation values because of addition of recyclate,
- all samples tested by Charpy method showed the breach of type C – complete perforation; measured values impact strength of tested material with recyclate were lower than at primary material and they was decrease of impact strength in about 48%, material with addition of recyclate becomes more fragile and prone to cracking,
- the values of stress in bending of tested material were in range from 130 MPa up to 165 MPa; the highest value of stress in bending was measured at the material with 20% of recyclate (comparing to primary material measured bending stress value was 10,74% higher), what is consistent with producer recommendations about using material without significant change of material properties.

CONCLUSIONS

Rising application of plastic material for technically difficult parts places greater demands on the level of knowledge about the behavior of these materials, especially in conditions of mechanical

stress. General behavior of plastics under specific conditions of usage is also needed to verify in practice.

The aim of this contribution was to find out the effect of recycle added to PBT material filled with glassy fibers, by examining the mechanical properties. The effect of recycle was the most visible in impact strength test by Charpy method. As it is shown in SEM figures, the glassy fibers after tests were broken, what can affect the decreasing of measured values of mechanical properties.

We can state, that there is also need to verify the technological conditions of molding for selected technological tests before application of finished products with recycle.

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