PREPARATION OF SELF-REINFORCED COMPOSITES BY INJECTION MOLDING. INSERT OVERMOLDING

Jacek Andrzejewski[1], Marek Szostak[1]

[1] Institute of Materials Technology, Faculty of Mechanical Engineering and Management, Poznan University of Technology, Piotrowo 3 Street, 61-138 Poznan, Poland
Email: jacek.andrzejewski@put.poznan.pl, Web Page: http://www.plastics.put.poznan.pl

Keywords: injection molding, self-reinforced composite, poly(ethylene therepthalate)

Abstract

Presented studies discuss the concept of obtaining reinforced polymer composites by overmoulding a prepreg/insert made of srPET composite. Due to the use of poly(ethylene terephthalate) based matrix, the obtained samples meet the requirements of the single polymer composites, which was the main goal of the conducted research. For comparative purposes, two variants of polyester resin types was used, the PET homopolymer and low melting copolymer G-PET. In the case of both varieties, it was possible to obtain samples characterized by increased mechanical parameters, compared to the samples obtained by the classical injection technique, the increase in impact strength was particularly significant. The obtained materials were subjected to a detailed analysis of thermomechanical properties, which confirmed some significant differences resulting from the level of crystallinity of the applied matrix polymers, however, they did not reduce the positive character of the injection overmoulding process.

1. Introduction

The traditional concept of obtaining single-polymer composites mainly includes hot compaction methods. The technology of production of this type of material has not changed since the 1970s [1-3]. This also applies to composites based on thermoplastic polyesters, which in addition to polyolefin-based composites are nowadays increasingly practical applications [4]. Intensive development of modern methods of processing, especially injection molding technology, is the reason for significant changes in the approach to shaping composite materials. The main pressure associated with obtaining the best mechanical properties is currently only one of the factors determining the use of a given type of composites, while additional factors such as speed, efficiency and flexibility, determine its use. Attempts to adapt single-polymer composites to the requirements of injection molding technology have been made many times, both by preparing the composite granulate by co-extrusion method and by grinding composite panels [5, 6]. The results of most studies confirm the occurrence of a two-phase composite structure, however, the properties of the obtained materials are far from the standards obtained for materials obtained by classical methods. Currently conducted research is mainly focused on developing technology for obtaining a two-phase composite structure directly in the injection mold cavity, by overmolding the reinforcing fibers or fabrics [7, 8]. The presented concept uses the advantages of modern methods of obtaining hybrid composites [9], in which the composite reinforcement is in a form of insert, previously prepared using hot compaction technique. The schematic description of the method is presented in the Fig. 1.

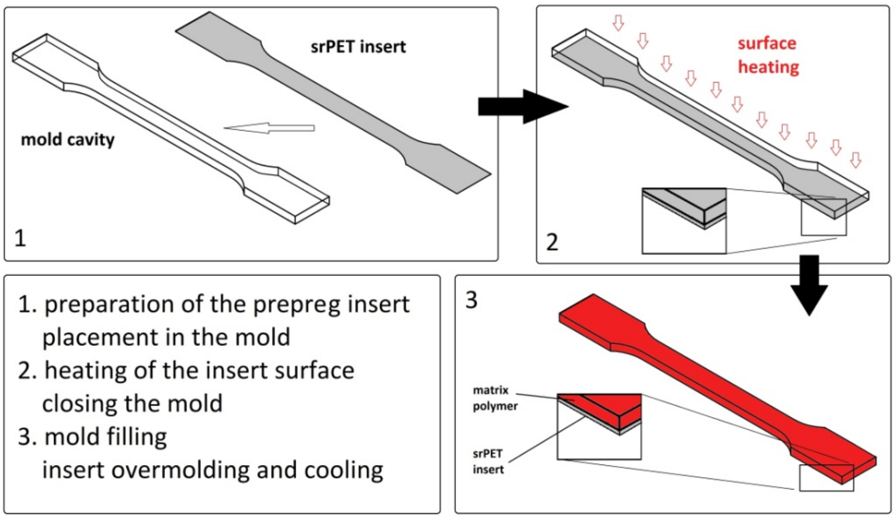

Figure 1. Tensile strenght and modulus pure matrix materials and insert overmolded samples.

The presented results are part of research conducted within the scope of mechanical and thermomechanical properties. Studies are also complemented by microscopic observations aimed at confirm the formation of a permanent connection between reinforcing prepreg and molded resin.

2. Results and discussion

2.1. Mechanical results

The results of mechanical tests confirmed significant changes in mechanical parameters after the overmolding process. Interestingly, in the case of G-PET based samples, the increase is observed both for the tensile modulus and strength, while for PET based materials some deterioration in strength indicates a less-favorable reinforcing effect (Fig. 2).

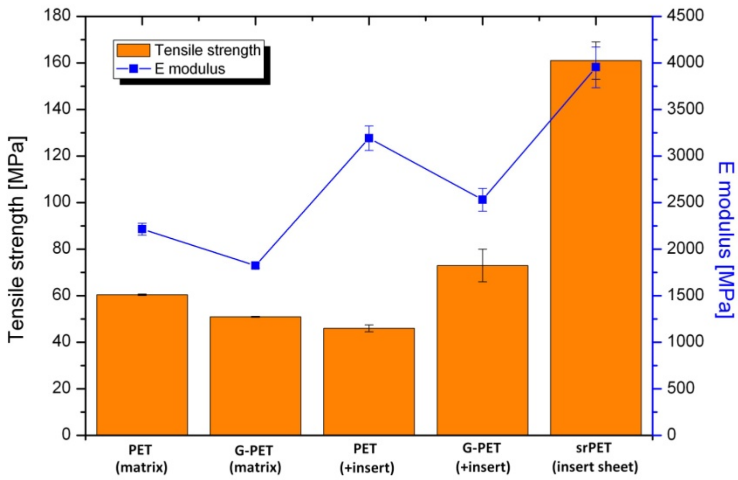

Figure 2. Tensile strenght and modulus pure matrix materials and insert overmolded samples.

The reason for this phenomenon is cracking of the PET matrix as a result of the formation of a significant amount of the crystalline phase, which causes a decrease in elongation at the yield point visible in Fig. 3. The analysis of the elongation value allows to observe a certain relation regarding the value of the maximum elongation, which for all reinforced samples is about 16%. It is also the average elongation at break of the composite prepreg, which allows to conclude that close to the terminal fracture, most of the stresses in the sample were transferred by the composite insert.

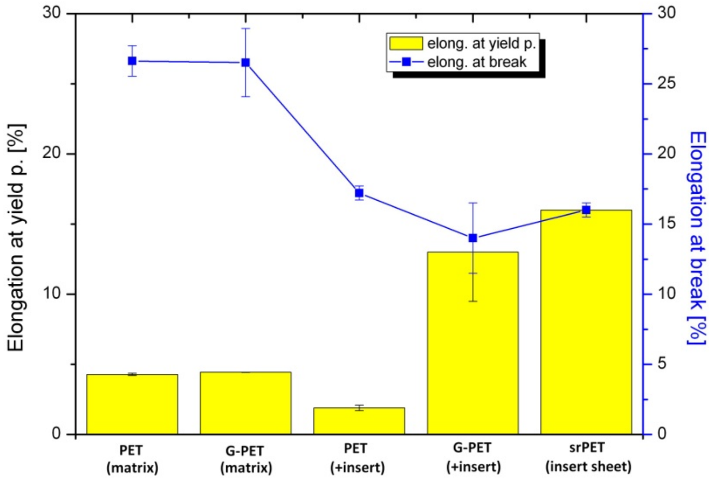

Figure 3. Elongation at yield point and at break for pure matrix materials and insert overmolded samples.

2.2. Structure evaluation

The appearance of composite samples visible in Fig. 4, confirms the majority of conclusions from the mechanical tests analysis.

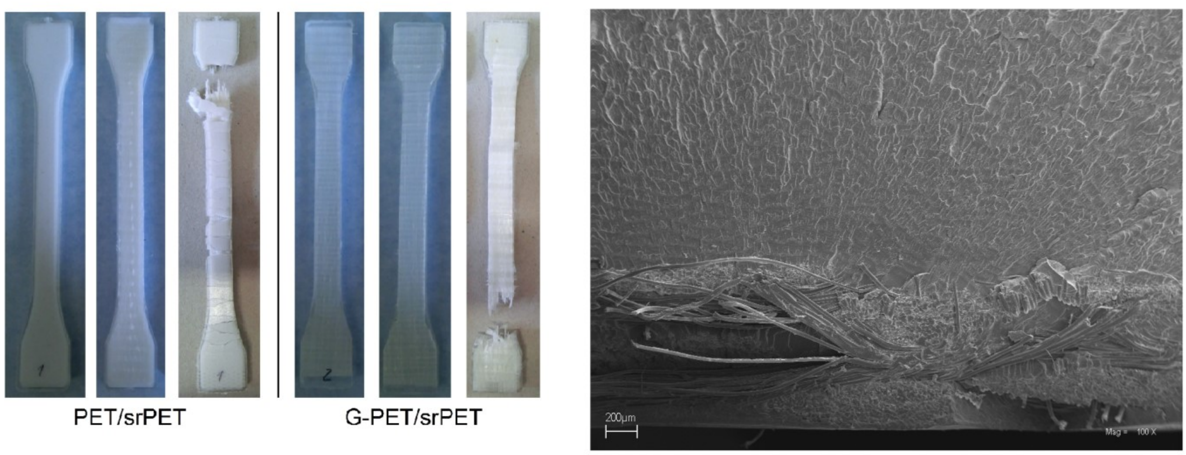

Figure 4. Samples before and after tensile test (left); enlargement of fractured sample (right).

Due to the increased crystallinity level of PET samples, a part of the sample shaped during the overmolding phase gradually breaks during the specimen elongation process. However, the element does not break completely due to the transfer of the main stresses on the composite insert. Sample prepared from the G-PET copolymer retains its continuity until the break of the whole specimen, which in this case would indicate a more favorable arrangement of the materials. In both cases, the applied procedure of preheating the surface of the prepreg allowed for a permanent connection of the reinforcing composite with injected resin.

3. Conclusions

The results of the conducted tests confirm the positive character of the changes in mechanical properties, resulting from the reinforcement of the samples using a composite insert. The greater efficiency of the reinforcement occurs for samples based on the G-PET copolymer, but in both cases the use of a polyester matrix is the cause of the very strong interface between the composite insert and the injected material. The reason for this phenomenon is the relatively low glass transition temperature and the low level of crystallinity of the used PET based materials, which in combination with the heating procedure, allows easier diffusion on the joining surface of both materials.

Acknowledgments

This work was supported by the Ministry of Science and Higher Education in Poland (grant number 02/25/DSMK/4340).

References

[1] N.J. Capiati, R.S. Porter. The concepr of one polymer composites modeled with high density polyethylene. *Journal of Material Science,* 10:1671–1677, 1975.

[2] I.M. Ward, P.J. Hine. The science and technology of hot compaction. *Polymer,* 45:1413–1427, 2004.

[3] M. Żenkiewicz, K. Moraczewski, P. Rytlewski, M. Stepczyńska. Characteristic and applications of single polimer composites. *Polimery,* 60:3–11, 2015.

[4] C. Schneider, S. Kazemahvazi, M. Akermo, D. Zenkert. Compression and tensile properties of self-reinforced poly(ethylene terephthalate) composites. *Polymer Testing,* 32:221–230, 2013

[5] A. Kmetty, T. Barany, J. Karger-Kocsis. Self-reinforced polymeric materials: A review. *Progress in Polymer Science,* 35:1288–1310, 2010.

[6] A. Kmetty, T. Tabi, J.G. Kovacs, T. Barany. Development and characterization of injection molded, all-polypropylene composites. *Express Polymer Letters,* 7:134–145, 2013.

[7] J. Wang, Q. Mao, J. Chen. Preparation of polypropylene single-polymer composites by injection molding. *Journal of Applied Polymer Science,* 130:2176–2183, 2013.

[8] J. Wang, S. Wang, D. Chen. Development and characterization of insert injection moulded polypropylene single-polymer composites with sandwiched woven fabric. *Composites Science and Technology,* 117:18–25, 2015

[9] L. Sherman. The new lightweights, injection molded hybrid composites spur automotive innovation. *Plastics Technology* 58:27–31, 2012.