Manufacturing and evaluation of mechanical properties of PHBV biocomposities with cellulosic fibrous fillers

Abstract

The aim of the doctoral dissertation was to manufacture, evaluate mechanical and processing properties of polymer biocomposites in the poly (3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) with fibrous cellulose fillers and propose the methodology for predicting the properties of products manufactured from this biocomposite in injection molding technology.

The paper includes the analysis of the current state of the use of cellulose fillers in the PHBV matrix. The essence of the problem i.e. waste accumulation and utilization from non biodegradable petrochemical plastics was presented. The characteristics of poly (3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) - green polymer was presented. PHBV is rarely used as a material for the production of injection products because of the relatively high manufacturing costs. It was indicated that one of the methods of improving the properties and reduce cost of production of the above the biopolymer is use of cellulose fibers (flax, hemp and wood) as a filler in the PHBV matrix. This was the basis for formulating the goal of the doctoral dissertation.

The experimental part of the thesis concerns the biocomposites produced for various types, lengths and methods of surface fibers modification. Moreover, biocomposites were produced using a variety of methods and for a changing proportion of fibers in the polymer matrix. Structural analysis (optical microscopy, SEM), chemical (TGA) and thermal (DSC) analysis were performed. The possibilities of processing, mechanical properties and quality of obtained biocomposites and molded parts were evaluated.

The estimation of the problems of manufacturing products for the selected biocomposite was made. Optimization of molded detail was carried out using the Taguchi method. Microstructure of products was evaluated based on the injection speed using CT computer tomography. The influence of fiber orientation in the polymer matrix on the mechanical properties of biocomposites was evaluated. The impact of the forming cavity geometry and the injection speed on fiber orientation in the polymer matrix was analyzed using a developed program for digitizing the fiber image on the top layer of the molded detail.

Computer simulations were carried out for a selected biocomposite in order to assess the possibilities of manufacturing molded detail and mechanical properties prediction. In order to perform numerical analysis of injection molding proces, characteristics for the biocomposite: thermal, rheological and pVT were determined. The prediction possibilities of mechanical properties of biocomposites, including type of fiber geometry, homogenization method (Mori Tanaka, Double Inclusion, numerical homogenization) and fiber content were evaluated.

The paper also indicates the direction of application for the selected biocomposite and proposes a methodology for predicting the properties of the product produced from this material.

Keywords: biocomposites, PHBV, natural vegetable fibers, prediction of properties