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The effect of processing parameter on mechanical properties of short glass fiber reinforced polyoxymethylene composite by direct fiber feeding injection molding process

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Abstract

This research describes the effect of processing parameters as matrix feeding speed, screw rotational speed and cylinder temperature of direct fiber feeding injection-molded process on properties of short glass fiber reinforced polyoxymethylene composite. The increasing of matrix feeding speed at screw rotational speed of 172 rpm led to the reduction of fiber loading content and increasing of fiber length. Whereas the higher screw rotational speed impacted on the increasing of fiber loading content and fiber length. However, its tensile properties were lower than the molded at screw rotational speed 172 rpm. When fiber loading content over 20 wt.%, tensile strength of both conditions reached the same values because the poor fiber distribution especially at screw rotational speed of 258 rpm. Then Kelly – Tyson's equation was used to predict their tensile strength. It was found that tensile strength at maximum fiber loading content at screw rotational speed of 172 rpm and 258 rpm are lower than the calculated strength values around 28.9 % and 31.8 %, respectively. The effect of cylinder temperature was also elucidated.

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Keywords: Polyoxymethylene; Short glass fiber; Direct fiber feeding; Injection molding; Kelly-Tyson

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1. Introduction

Polyoxymethylene (POM) is an engineering thermoplastic, which exhibits good-balance mechanical properties, good creep resistance, excellent thermal stability during molding, low friction coefficient and excellent anti-wear properties [1]-[3]. However, the incorporation of glass fiber into POM can improve its mechanical properties. Nowadays POM and POM composite are used to replace zinc and other metals, which is a part of automobile and machinery. The short glass fiber has been used to reinforce thermoplastic composites. By using this kind of fiber, there are many factors that impact on the mechanical properties of the final products such as interfacial adhesion, fiber length, orientation and distribution, which are determined by the bonding of materials and processing conditions [4]-[8].

In order to reduce fiber breakage problem that has a direct affected on mechanical properties of composite during the molded process. The reduction of fiber length decreases the reinfircing efficiency of fiber [9]-[11]. The original manufacturing was modified to a convenient technique, which has been called a direct fiber feeding (DFF) injection molded process. The short fiber reinforced composite material can be fabricated without the compounded process. The fiber can be guided into the vented area of injection barrel and directly fed into the polymer melt by the shearing motion of injection screw during plasticization process.

The processing parameters of direct fiber feeding injection molding precess as matrix feeding speed (MFS), screw rotational process and cylinder temperature were studied on their effects of fiber length, fiber oreintation, fiber distribution and mechanical properties. The modified Kelly – Tyson's equation was used to calculate fiber critical length and predict tensile strength of GF/POM composite.

2. Experimental

2.1. Materials

The main polymer matrix is POM co-polymer, which was obtained from Mitsubishi Engineering Plastic Co, Ltd., Japan under the trade name of Lupital F40-02. Density of POM co-polymer is 1.41g/cm^3 and melt flow index is 52 g/10 min. Glass fiber grade EX-1658 with 2400 tex, 0.40 wt.% sizing agent for polycarbonate was manufactured by Nippon electric glass Co., Ltd., Japan was selected as reinforcing fiber. The strength of glass fiber is 1,500 MPa.

2.2. Specimen preparation

The dumbbell specimens were carried out through the direct fiber feeding (DFF) technique by 18-tons injection molding machine (Sumitomo: model iM18) with vented barrel. The schematic drawing of DFF injection molding process are shown in Fig.1. Glass fiber roving strand was guided into the vent of devolatilizing unit of the barrel and fed into the melt by the shearing action of the injection screw during plasticization process. Furthermore, the normal feeding hopper of injection molding machine was replaced with the controllable feeding hopper in order to control the fed amount of matrix. The processing conditions as matrix feeding speed, screw rotational speed and cylinder temperature were varied to study their effect on properties of composite materials as shown in Table 1.

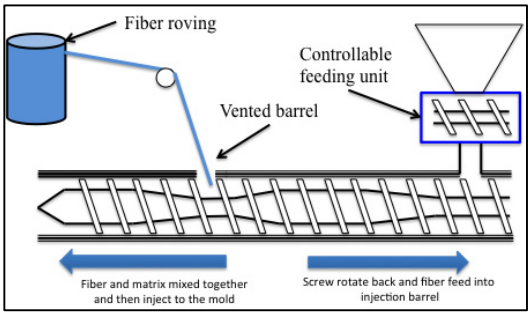

Fig. 1. The schematic drawing of DFF injection molding process.