Review of processing techniques on material properties between compression and injection moulding of thermoplastic materials

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ABSTRACT –This paper reviews the processing techniques on material properties of thermoplastic materials in compression and injection moulding. Plastics materials can be divided into thermoplastics and thermoset materials. For thermoplastics, they have higher viscosity compared to thermoset materials. This could be a challenge in producing thermoplastic-based material via the compression moulding. In term of flowability, injection is suitable when compared to compression, especially for the thermoplastic materials. In addition, high mechanical properties can be obtained using injection because of the flow orientation that occurs during this process when compared limitation of flow orientation in compression moulding. However, compression moulding technique is more preferable to moulded of thermoplastic materials with fibre content due to better mouldability.

1. INTRODUCTION

Compression moulding is a method of plastic moulding process in which the moulding material (in the form of powders or pellets) is preheated, and then it is placed in an open, heated mould cavity that is suitable for moulding complex and high-strength objects [1]. In compression moulding, a major advantage of using compression moulding process is because of the low capital cost due to the simplicity of the process [2] and lower moulding equipment cost with a short cycle time [3]. The objective of this paper is to review the processing techniques on material properties of thermoplastic materials in compression moulding process compared to the injection moulding process.

2. VISCOSITY

In compression moulding, typically, a thermoset material can flow easily to fill cavity because it has low viscosity and resulting in a better even coverage. In addition, the thermoset material solidifies through cross-linking among the polymer chain and this process is a time-consuming process.On the other hand, thermoplastic is melted upon heating, and the melting thermoplastic is forced to flow and fill the mould or cavity before the material solidified when cooled. The cycle time can be shorter since thermoplastics do not require curing. But, thermoplastic has a higher viscosity. Because of that, it can be a challenge during the filling of the mould. Higher pressure forces the melting thermoplastics to fill the cavity in the mould. All of this requires a careful design of the mould cavity and compression moulding process parameters. So that, the material can flow smoothly and evenly [4].

This is also stated by Ning et al. [5] when melting thermoplastic polymers, it has a much higher viscosity than thermoset polymers. It seems that thermoplastic polymers are more suitable in injection moulding when compare to compression moulding technique. Meanwhile, thermoset polymers are commonly processed using compression moulding technique.

3. MECHANICAL PROPERTIES

Mechanical properties are largely associated with the distribution and density of intermolecular and intramolecular interactions in the network [6]. Various researches of the compression moulding process and its influence on the material structure and mechanical properties have been conducted. Picher-martel et al. [7] investigated the flow mechanisms of Randomly Oriented Strands (ROS) thermoplastic composites by compression moulding. Materials such as Carbon/PEEK (PolyEther-EtherKetone) composite samples were manufactured by hot press technique. In this process, strands of thermoplastic composite pre-impregnated tapes are distributed randomly in a mould cavity. They found that larger strands resulting in high yield stress and equivalent viscosity

Graupner et al. [8] studied the effect of fibre loading, fibre fineness, and two different processing technique such as injection and compression moulding on the impact and tensile strength of lyocell/PLA composites. They found that composites fabricated by compression moulding technique has higher tensile and impact strength compared to the injection moulding technique. Deep and Mishra [9] fabricated PMMA/MWCNT nanocomposites using a compression moulding process. They found that with incorporating carbon nanotube as the filler material into the PMMA, there is an increase in thermal conductivity.

Sodeifian et al. [10] investigated the mechanical, morphological, rheological, and crystallinity properties of pure polypropylene (PP)/glass fibre (GF) and PP/GF composites containing maleic anhydride polyolefin (POE-g-MA). Two different methods have been used to produce the composites such as 3D printing called Fused Deposition Modeling (FDM) and compression moulding. In their findings, the composites prepared using compression moulding method exhibited higher values of strength and modulus, as compared to composites that have been prepared using 3D printing.

From here, it can be seen that fibre content thermoplastic materials are preferable to be manufactured using compression moulding method.

4. FLOW BEHAVIOUR

Graupner et al. [8] reported that flow direction can affect the tensile strength of their composite material. During injection moulding process, the polymer chains are mainly oriented with the flow direction or shear flow. Meanwhile, there is limited flow direction during compression moulding process. It can lead to a lower orientation and resulting to a lower tensile strength in compression moulding part. They also stated that in compression moulding, too low pressure can lead to a poor compaction of the composite. In their study, they found the tensile properties of PLA matrix fabricated by injection moulding have higher tensile strength as compared to compression moulding samples. This is because, during injection moulding, the polymer chains are predominantly oriented with the flow direction (shear flow) while there is no preferred flow direction during compression moulding, leading to a lower orientation and resulting in lower tensile strength.

For PLA composites, Graupner and Müssig [11] studied the influence of fibre loading, fibre length, fibre orientation and voids on the material properties of cellulose fibre-reinforced polylactide (PLA) composites from two different methods such as compression moulding and injection moulding process. They found that apart from the melt front of the PLA matrix, limitation flow processes appear during compression moulding, while the fibres processed with the injection moulding technique are oriented due to various factors like flow processes, fibre/fibre interaction, fluid pressure, back pressure, design of the tool, mould temperature, melt viscosity, shear deformation and more.

Perez-Rocha et al. [12] conducted a comparative study of the mechanical performance of PP and PP/PP-g-MAH blends reinforced with carbon fibre (CF) obtained by two different moulding techniques such as injection moulding and compression moulding process. Higher elongation properties of the composites obtained through injection moulding process as compared to the compression moulding process. This is because the injection moulding process allows the polymer chains and CF to orientate parallel to the flow direction, which is not the case for the compression moulding process. In addition, to obtain better flow behaviour, injection moulding is better than compression moulding. Hence, the higher strength of material for the thermoplastic polymers can be obtained via injection moulding due to the flow orientation rather than a limitation of flow orientation in the compression moulding process.

5. CONCLUSION

This paper reviews about processing techniques on material properties of thermoplastic materials in compression moulding compared to the injection moulding process. As a conclusion, thermoplastic materials are more suitable to produce using injection moulding process because of the flow orientation occurs in injection moulding and it can lead to higher mechanical properties of material when compared to compression moulding technique. However, thermoplastic materials that contain a filler such as fibre, there are are more preferable to be produced using compression moulding technique.

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