Measurement 47 (2014) 100–109

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Textile injection process characterisation by means of a spiral mould

Carlos Javierre, Ángel Fernández, Isabel Clavería *, Daniel Elduque

Department of Mechanical Engineering, University of Zaragoza, Maria de Luna 3, 50018 Zaragoza, Spain

ARTICLE INFO

Article history:
Received 27 June 2013
Received in revised form 18 July 2013
Accepted 19 August 2013
Available online 30 August 2013

Keywords:
Overmoulding
Textile injection
Spiral mould
Process characterisation
Viscosity
Injection pressure

ABSTRACT

New developments are being carried out within the injection moulding field, such as gas injection, bi-injection, co-injection, sequential injection, compression injection or textile injection processes. These techniques require new developments as they highly modify design and process conditions. In this work, the influence over the plastic material flow of the introduction of different film textiles into the mould is measured. A specific measurement system consisting of a monitorised spiral mould with pressure sensors has been used to measure the influence of different tissues over the mould pressures. As an application of this measurement system, a viscous model is generated to characterise the rheological behaviour of the thermoplastic and textile joint. The viscous model obtained is applied on a conventional CAE tool for the simulation of textile injection pressure results for the different film textiles analysed.

1. Introduction

Plastic injection parts obtained by a conventional injection process can achieve smooth or textured surface finishes, but in many cases, these types of surface finishes are not enough. Strong competition and new requirements of the market demand plastic injection parts with different surface finishes. Previously, superficial finish was given to the parts by subsequent injection processes. Nowadays, many non-conventional surface finishes can be obtained during the injection process by means of over injection processes. Within the over injection processes, different techniques can be differentiated depending on the required finish [1]. The injection process is common to all these techniques, but they differ in the superficial finish which is given to the injected part and the characteristics of the film on which the over injection is performed. Fig. 1 shows different parts made by over injection with different materials.

One of the sectors where this transformation process is widely used is the automotive industry, where many interior parts of medium and high range cars are made by over textile injection [2,3].

The introduction of textile during the injection has an important influence over the process which produces significant differences from the conventional injection process. These differences entail appreciable changes in the mould design, in the injection parameters and in the defects and problems which may appear on these parts.

Simulation CAE tools like Moldflow® or Cadmold® are used for the design of plastic injection parts [4–6]. However, there are not any specific modules for the over injection process simulation in those CAE software. It is impossible to directly simulate the over injection as it is a very complex process due to the film or sheet introduced into the mould, which modifies all the variables of the injection of the plastic part. The introduction of a film or sheet affects the main parameters needed to carry out a simulation [7]. The most important of these parameters are:

Thermal conductivity. Simulation programs are designed to simulate heat transfer processes, shown in Fig. 2 between the metallic material of the mould and the injected

* Corresponding author. Tel.: +34 649116405; fax: +34 976761861.
E-mail addresses: carlos.javierre@unizar.es (C. Javierre), angel.fernandez@unizar.es (Á. Fernández), isabel.claveria@unizar.es (I. Clavería), danielduque88@gmail.com (D. Elduque).

0263-2241/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.measurement.2013.08.034

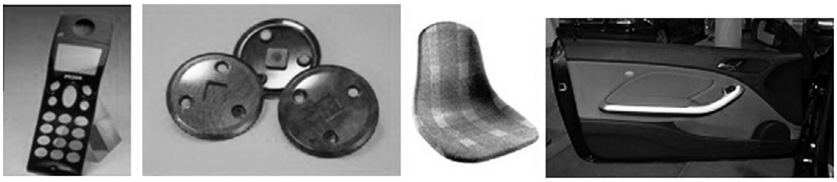

Fig. 1. Items made by over injection process.

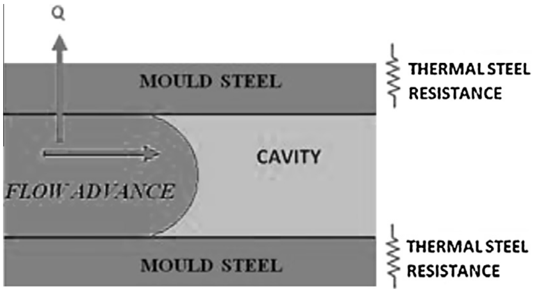

Fig. 2. Heat transfer diagram of a plastic injection process.

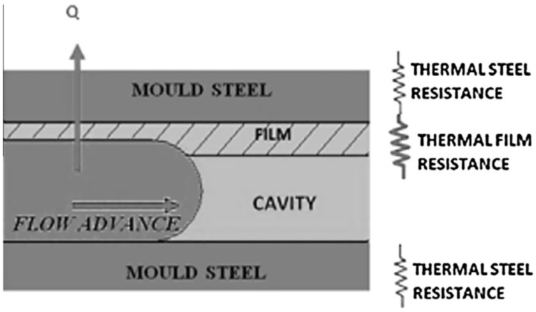

Fig. 3. Heat transfer diagram of a plastic injection process with a film.

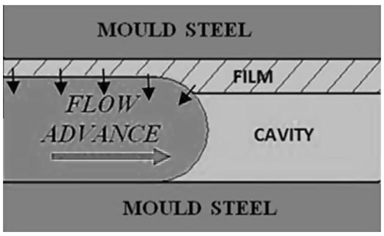

Fig. 4. Flow area in plastic injection process with a film.

plastic [8,9]. In order to calculate this heat transfer with Eq. (1), the program has thermal conductivity values of mould materials and different plastics in a database.

$$\lambda = t/R_{thermal} \quad (1)$$

where λ is the thermal conductivity, t is the thickness and $R_{thermal}$ is thermal resistance.

The film or sheets act as insulators during the injection process [10] as shown in Fig. 3, and simulation programs

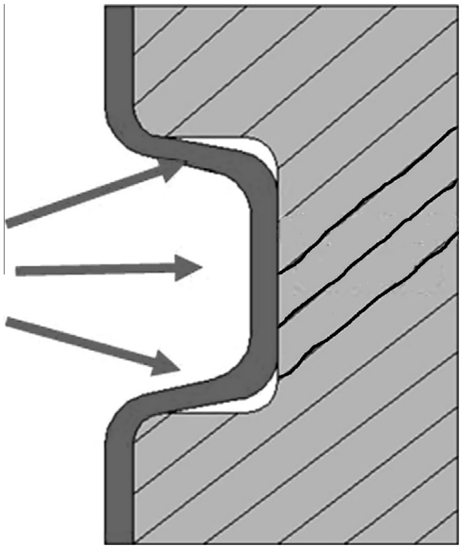

Fig. 5. Stressed film during the injection process.

are not prepared to evaluate how thermal conductivity is affected with the introduction of these sheets between the mould cavity and the injected plastic.

Compression. Unlike steel, sheets and films are not rigid materials [11], and they are compressed while plastic flows inside the mould, so the flow area varies during the injection cycle depending on process conditions as shown in Fig. 4.

Roughness. Texture and superficial finish of the film or sheet which contacts the plastic affects the flow advance during the injection [12], because the flow does not behave in the same way as over a polished surface like the steel of a mould. In over injection processes, only one side of the plastic part is contacting the film or sheet. The roughness difference between the mould steel and the film makes the flow asymmetric.

Films stress. During the injection of polymer material, the film is stressed due to the cavity geometry as described [13,14], see Fig. 5. Authors like Wong et al. have studied the influence of process temperature on film stretching [15].

All these factors seriously influence an over injection process, so they cannot be undervalued when performing a simulation of a process like that [16,17]. For example the effect on final part warpage is show in [18,19]. Regarding to rheological behaviour, Javierre et al. [20,21] have already developed a methodology to analyse rheological