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Characterization method for blisters created in film insert injection moulding

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Abstract

During film insert injection moulding (FIM) of Polypropylene (PP) with a dual layer membrane made of a Polyethylene Terephtalate (PET) membrane layer and a non-woven PP support, blisters creation in the PET-layer was observed. To investigate the influence of the process parameters on the blisters behaviour, a reliable characterization method is necessary. This paper suggests the combination of an optical measurement system, which is based on focus variation, and of image processing software to obtain the bearing area curve, which can be used to compare the surfaces of parts moulded with different sets of process parameters. This method can be used to determine a set of parameters that minimizes the blister creation in the film insert moulding process. The effects of mould temperature and injection speed were investigated.

Key Words: Film Insert injection Moulding, blister creation

1. Introduction

FIM is a special technique of injection moulding. In this process a polymer film, which is inserted in the open mould is overmoulded with a thermoplastic material. This technique is widely used in the packaging industry as well as in the automotive industry for decoration purposes but can also be used to realise a permanent joint between the film insert and the bulk material [1].

Due to the integration of the film insert, the injection moulding process becomes more challenging, since the film insert influences polymer flow, cooling and shrinkage. This can lead to higher warpage of the part due to higher internal stresses because of non-uniform cooling behaviour [2]. Good adhesion between film insert and overmoulded part has to be guaranteed. It is necessary to choose a compatible combination of film and overmoulding material. The adhesion between insert and overmoulding material is influenced by processing parameters (melt and mould temperatures, injection speed and pressures) [1].

Warpage in FIM and adhesion between thermoplastic polymers have been investigated in several research works [1-6].

For a following project, FIM using a membrane as film insert to create plastic parts with implemented oleophobic areas is wanted. During the tests for the compatibility of the two materials for FIM, blisters creation in the membrane was observed at certain combinations of the process parameters. This behaviour has, to the author's knowledge, previously not been reported in literature. The process parameters investigated in this work were: mould temperature, melt temperature, injection speed and packing pressure.

2. Film Insert Injection Moulding

For the moulding Experiments a Ferromatik Milacron K60 injection moulding machine was used. PP-homopolymer (SABIC PP 579S) was used in combination with a PET membrane (SABEU TRAKETCH® PET 23 B K320 D0,22 hl PP50). This membrane consists of a PET membrane layer with a nominal value of 23 µm and a non-woven PP support layer. The total thickness of this two layer film is indicated as 200 µm ± 20 µm in the datasheet. Membrane strips of 10 mm width and 140 mm length were inserted in the mould prior to moulding.

The mould consists of two cavities, which are milled into the moving half of the mould. Both cavities are forming rectangular plates of 78 mm×28 mm ×3mm and are filled through a fan gate. One of the cavities has a structured surface. The unstructured cavity was used for the FIM-experiments. At the top end of this cavity a 10 mm×10 mm×200 µm groove was milled. This groove was used to position the membrane strips in the mould. The membrane strips were fixed to the open mould using adhesive tape (see Figure 1). When the mould was closed, the membrane was additionally clamped between the two mould halves.

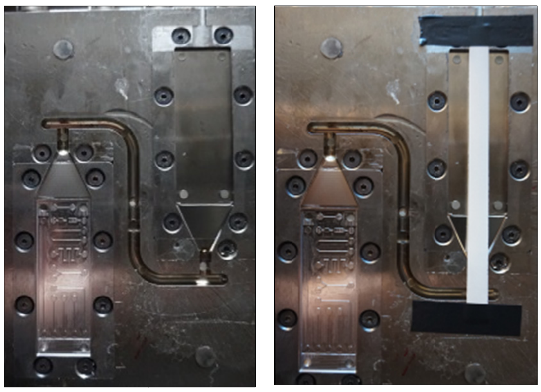

Figure 1: Mould cavities without (left hand side) and with (right hand side) inserted membrane

To investigate the influence of the moulding parameters injection speed and mould temperature in terms of adhesion and blister creation, different sets of moulding parameters where used. This was done by varying one parameter at a time while the other parameters were kept constant. After the parameters where changed, 5 parts were moulded without adding a membrane stripe, to achieve stable moulding conditions and then one part with membrane was produced.

3. Metrology

Because it was found, that it was not possible to separate the membrane from the injection moulded part by hand, adhesion was not investigated further. These manual peel tests showed that the membrane broke before it started to delaminate from the injection moulded substrate.

To evaluate the blister behaviour, the parts had to be prepared by spray coating them with a thin layer of "HELLING 3-D Laserscanning Anti-Glare-Spray" to reduce reflectivity and transparency of the PET layer.

Each part was measured at three positions: (1) close to the fan-gate, (2) in the middle of the part, and (3) at the front end (see Figure 2). Each measurement was repeated five times.

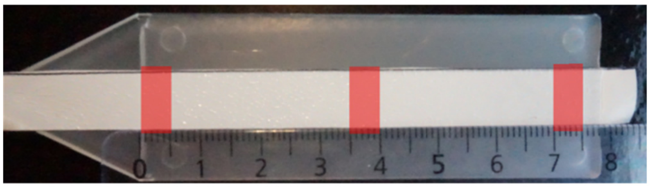

Figure 2: FIM-Part with areas for measurement (red). Scale: minor tick equals 1 mm

Measurements were taken, using an ALICONA InfiniteFocus system for optical 3D form and roughness measurement, which is based on focus variation. For all measurements the objective with 10x magnification was used.

For each measurement an area of 11 mm × 1.45 mm within the 5 mm wide areas in Figure 2 was scanned. The scans started 0.5 mm above the upper edge of the membrane and ended 0.5 mm under the lower edge.

The obtained surface data was evaluated using SPIP™ Image Metrology software.

To compensate for effects, which are originating in measuring a tilted part or in warpage of the moulded part different steps for plane correction were conducted. At first the image was levelled by adjusting the areas above and below the membrane to each other. Afterwards the minimum height value was set to zero to remove the offset. Finally the image was cropped to the width of the membrane and the "Global Bow Removal" option was used to compensate for waviness due to warpage in the part. From the resulting image the bearing area curve was calculated. These curves can be used to compare the roughness in terms of the maximum height of the blisters, and the portion of the area covered by blisters of a specific height. The effect of this levelling procedure on the measured profile can be seen in Figure 3.

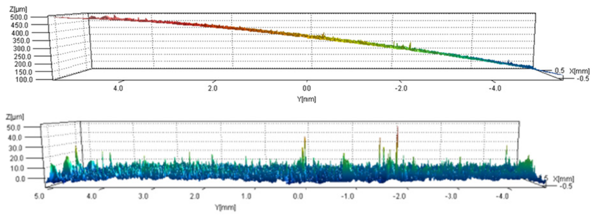

Figure 3: Profile before (top) and after (bottom) levelling of the data

4. Results

Figure 4 shows the dependency of the blister creation on the mould temperature for one measurement at the front end of each part. From these curves the tendency that an increase in mould temperature reduces the generation of blisters can be expected.

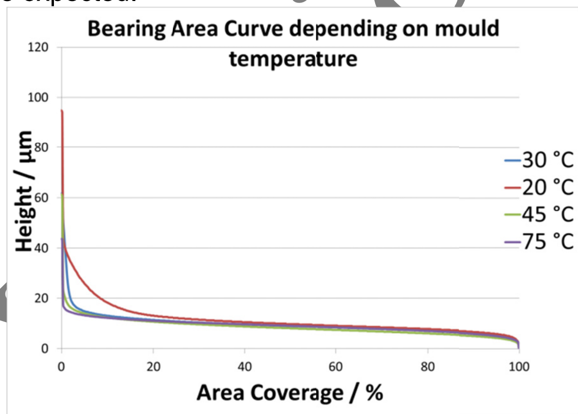

Figure 4: Blister height and area coverage depending on mould temperature

In Figure 5 blister height depending on injection speed, for one measurement in the middle of the part, is shown. Contrary to the dependency on mould temperature no clear tendency can be found for injection speed in this case.

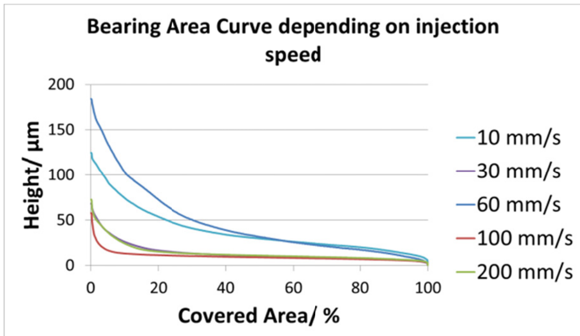

Figure 5: Blister height and area coverage depending on injection speed

5. Conclusion

To verify the trends described before, further measurements will be evaluated. This will include the evaluation of the repetition of the measurements to verify the repeatability of the measurements and the evaluation of the measurements on the different positions of the part shown in Figure 2 to see if the blister creation depends on the position. Furthermore several parts moulded with the same set of process parameters will have to be measured to investigate the process dependency of the blister creation.

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