Can we control the microstructure of injection moulded parts?

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introduction

The macroscopic properties of injection-moulded products are defined by the molecular structure of the polymer, the processing conditions and the part geometry. The microstructure of the material develops accordingly to the local thermal-mechanical deformation at each material-fluid point. In order to relate flow histories with resulting microstructures, the use of experimental setups in which flow conditions can be manipulated is envisaged.

objectives

- Design a new experimental setup to generate different flow histories.
- Develop a numerical tool to model the experiments.
- Relate kinematics with microstructure.

methods

An innovative moulding tool, RCEM (Rotation, Compression and Expansion Mould) [1] is used to control the microstructure development of injection-moulded materials (see fig.1). One wall can rotate or translate during the filling stage, e.g. combine pressure driven, drag and squeezing flow. A finite-element model, VIP3D, is adapted to compute different flow kinematics as generated by the RCEM mould.

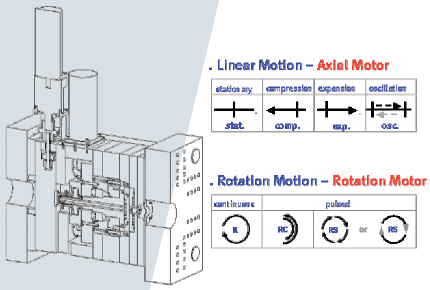

figure 1. *RCEM mould and the possible operating conditions.*

experimental results

Samples were injected under different conditions. The microstructure was analyzed by optical light microscopy.

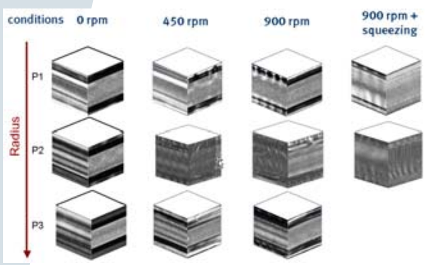

figure 2. *Polarized optical light microscopy results for two flow directions along the radius.*

modelling

Centre gated disk geometry modelled with brick elements.

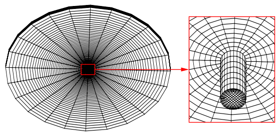

figure 3. *FE mesh. Number of nodes = 105221.*

Filling results for a gate velocity of 10 ms^{-1}:

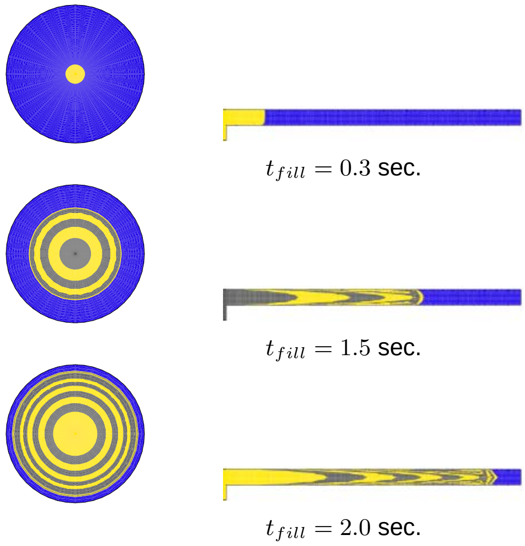

figure 4. *Material-time labels for different filling times. Cross sections are taken in the midplane (left) and in the radial direction.*

Effect of wall rotation on the shear field for different rotation speeds:

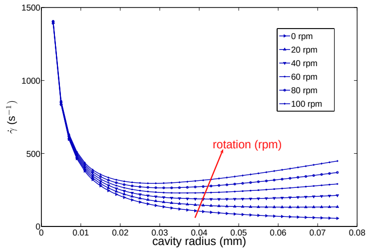

figure 5. *Shear rate along the radius as a function of rot. speed.*

conclusions / future work

The developed finite element model captures the different flow kinematics induced by the RCEM mould. Computations with non-Newtonian fluids and filling analysis under non-isothermal conditions are to be done.

References:

[1] Silva, C., et al.: *International Polymer Processing, Vol. XX, n.1, p.27-34.* (2005)

[2] Haagh, G.: *Ph.D. thesis, Eindhoven University of Technology* (1998)

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