Simulation of gas-assisted injection moulding

Simulation of Gas-Assisted Injection Moulding

G.A.A.V. Haagh, H. Zuidema, F.N. van de Vosse, G.W.M. Peters, and H.E.H. Meijer

Eindhoven University of Technology,
Faculty of Mechanical Engineering,
Section Materials Technology,
P.O. Box 513, NL 5600 MB Eindhoven

Introduction

In *Gas-Assisted Injection Moulding* (GAIM), gas is injected into a mould that is partially filled with polymer. The gas drives the molten polymer core further into the mould until it is filled completely (Fig. 1).
The main process characteristic is that the pressure gradient in the gas is negligibly small compared to that in the polymer. As a results, the pressure can be significantly reduced (Fig. 2).

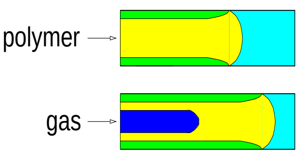

Fig. 1 *GAIM process.*

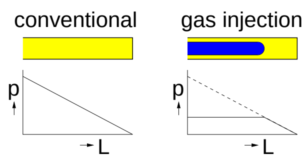

Fig. 2 *Pressure build-up.*

Objective:

To develop a computational model in order to predict the gas distribution inside GAIM products.

Modelling

- ☐ The model is based on a standard Galerkin finite element method to solve the Stokes equations on a *fixed* mesh (*i.e.* no remeshing!).
- ☐ Polymer and gas/air are marked with a material label c (polymer: $c = 1$; gas/air: $c = 0$). Interfaces are determined by $c = 0.5$.
- ☐ Gas and air are represented by a 'numerical gas', such that the viscosity ratio $\frac{\eta_{\text{polymer}}}{\eta_{\text{numerical gas}}} = O(10^3)$.
- ☐ Depending on the material label at the mould wall, either a no-slip (polymer) or a free-slip (air) boundary condition is imposed.
- ☐ For every time step, the Stokes equation is solved, and the material labels are convected through the mesh according to the computed velocities.

Results

Results are shown for isothermal flow of incompressible media exhibiting Newtonian viscosity behaviour with a constant flow rate at the entrance (Figs. 3, 4, and 5). The alternating black and yellow colours for the polymer visualise the fountain flow effect.

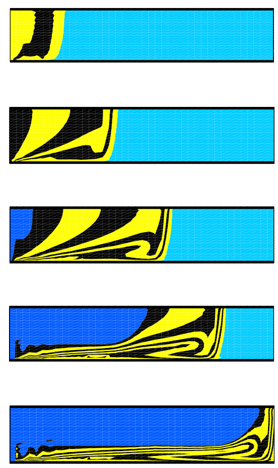

Fig. 3 *GAIM simulation for an axisymmetric tube.*

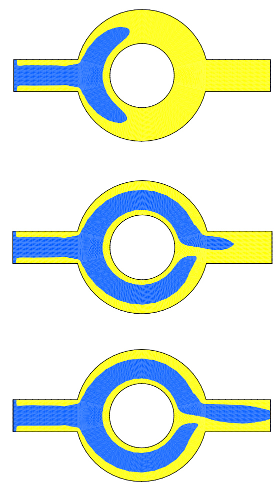

Fig. 4 *Simulation of gas flow in a bifurcation.*

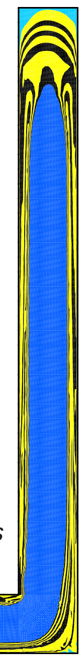

Fig. 5 *Simulation of gas flow around a sharp corner.*

Conclusions

- ☐ A computational model has been developed and tested for 2D simulations. It is able to predict the gas distribution without *a priori* assumptions about the residual polymer skin thickness, and covers the important aspects of the GAIM process.
- ☐ The model can easily be extended to 3D geometries, non-isothermal conditions and generalised Newtonian viscosity behaviour.

References:

[1] FINDEISEN, H., LANVERS, A., MICHAELI, W., BENDER, K., KIRBERG, K. (1991): 'Gasinjektionstechnik transparent gemacht', *videotape IKV Aachen*

[2] HAAGH, G., ZUIDEMA, H., VAN DE VOSSE, F., PETERS, G., MEIJER, H. (1996): 'Towards a 3-D finite element model for the gas-assisted injection moulding process', to appear in *Intern. Polym. Process.*