Analysis of the thermal coupling of melt, microstructure and mould for precise prediction of shrinkage and warpage in the injection moulding process

IKV – INSTITUT FOR PLASTICS PROCESSING

Subproject B04

SUBPROJECT LEADER: PROF. DR.-ING. CH. HOPMANN

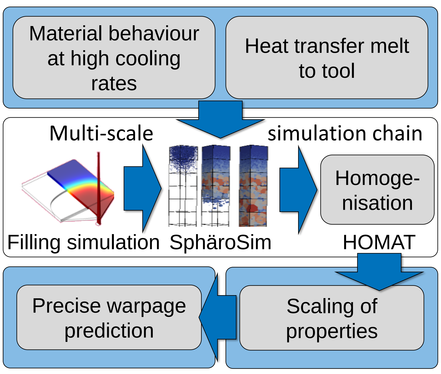
Executed and planned work

RESEARCH OBJECTIVE

- Measurement and prediction of heat transport under process conditions
- Extension of the microstructure simulation SphäroSim
- Warpage prediction based on simulated microstructure

Current challenges

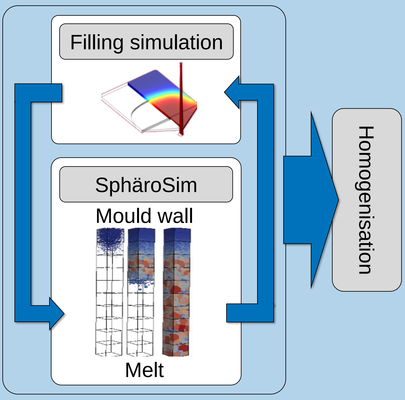
- Methodology of coupling filling and microstructure simulation
- Development of pvT models for high cooling rates
- Measurement of the heat transfer coefficient under process conditions

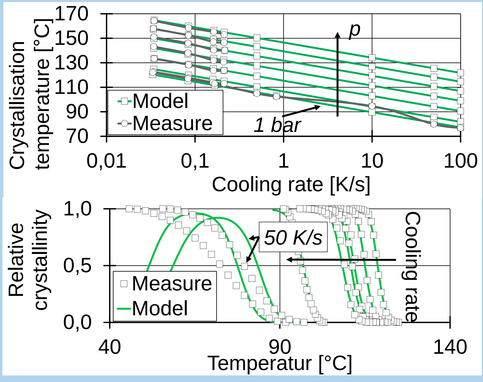


RESULTS

Methodology of the self-consistent multi-scale simulation

- Extension of SphäroSim by taking into account the heat of crystallisation via implemented thermal diffusion
- Coupling of the filling simulation with SphäroSim via comparison of the measured variables:
  - Local temporal solid fraction
  - Local degree of crystallisation
  - Local temperature distribution
- Iterative adjustment of the simulation parameters enables consistency in the measured variables in both simulations
- Consistency of the measured variables transfers the accuracy of SphäroSim to the filling simulation





Continuous Two-Domain pvT-Model

- Prediction of crystallisation temperature from pvT data and flash DSC data
- 99.5% coefficient of determination of the model
- pvT behaviour for simultaneously high pressures and high cooling rates possible

Solidification model in SphäroSim at high cooling rates

- Measurement of solidification enthalpy at cooling rates between 0.01 and 100 K/s
- Unphysical prediction of solidification at 50 and 100 K/s
- Adaptation of the solidification model by additional terms for high cooling rates

FURTHER PROCEDURE

Current work

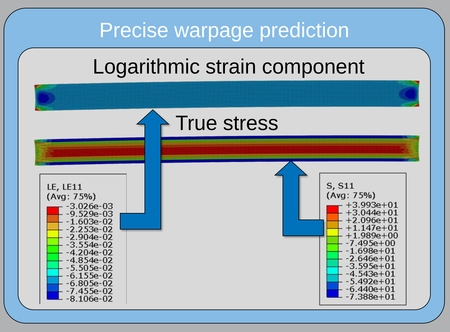
- Measurement of the heat transfer coefficient between tool and material under process conditions
- Finalisation of the multi-scale simulation chain with distortion simulation in ABAQUS
- Calculation of residual stresses from the microstructure
- Prediction of warpage from the simulated microstructure

Open research questions

- Is an empirical extension of the solidification model useful?
- Validation of the self-consistent iterative multi-scale simulation chain

Questions phase 3

- What influence does post-crystallisation have on the final degree of crystallisation and thus on warpage?
- How can the distortion prediction from the multi-scale simulation chain be used to compensate for distortion?



Präzision aus Schmelze

RWTH AACHEN UNIVERSITY