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Water-assisted Injection Molding: Validation of 3D Simulations by Experimental Data

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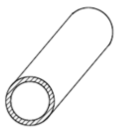
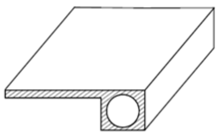
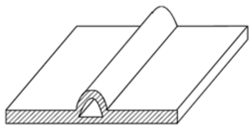
INTRODUCTION AND PROBLEM STATEMENT

Water-assisted injection molding (WAIM):

> recent technique (1998) to produce hollow or partly hollow parts





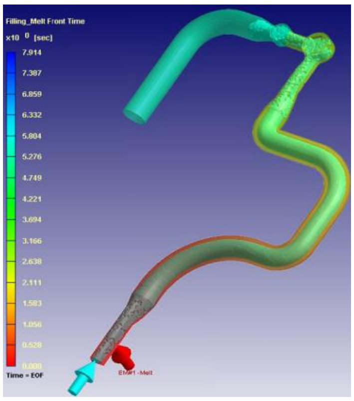


> 3D simulations can be used to

- design the process
  - process parameters
  - material
  - geometry
  - …
- predict product quality
  - residual wall thickness (RWT)
  - penetration length
  - …

RELEVANCE? ➡ **VALIDATION**= comparison of simulation results with experimental data for:

- different material parameters [1], [2]
- different melt temperatures [3]

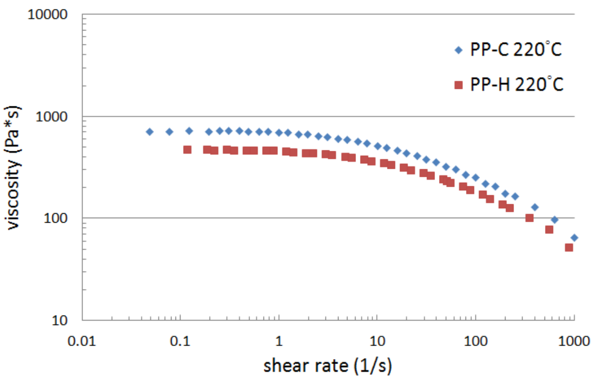


Moldex3D simulation result

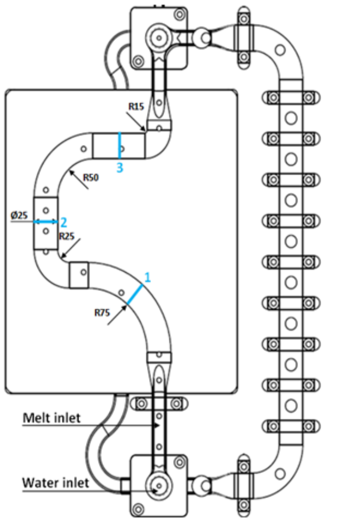
EXPERIMENTS AND SIMULATIONS

Process parameters

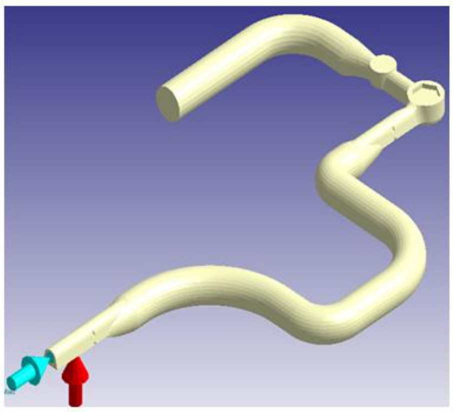
Property	Value
Filling time (s)	3.81
Prefill (%)	71.5
Melt temperature (°C)	200/220
Mold temperature (°C)	20
Water injection delay time (s)	2.5
Water hold time (s)	3
Water pressure (MPa)	20
Water temperature (°C)	20



Shear viscosity of PP-C and PP-H at 220℃



Mold cavity with dimensions (in mm) and indication of the measuring points



Model used in simulation software (Moldex3D) with indication of water (blue) and melt inlet (red)

ABSTRACT

Water-assisted injection molding (WAIM) is a recent and promising technique to produce hollow or partly hollow parts. A shorter cycle time in combination with a lower material and process cost are the main advantages. The combination of extra water-related process parameters with both material and hardware requires however extra lead-time and/or experience with the process. Simulation tools offer the possibility to design the process in order to deduce a suitable process and material combination and are consequently able to predict product quality. This study validates simulation results with the aid of experimental data for different material parameters and melt temperatures. It was found that simulation results show the same influence of the material parameters and melt temperatures on the residual wall thickness (RWT) as the experimental data and this within a reasonable deviation. Therefore, this comparison indicates a good agreement between the simulations and experimental data.

RESULTS AND DISCUSSION

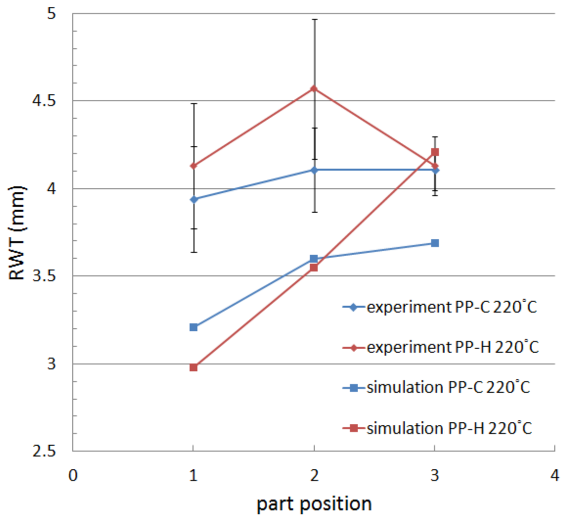
Influence of the material parameters

- an increasing molecular weight gives rise to a decreasing RWT [1] [2], which is both seen in experimental data and simulation results

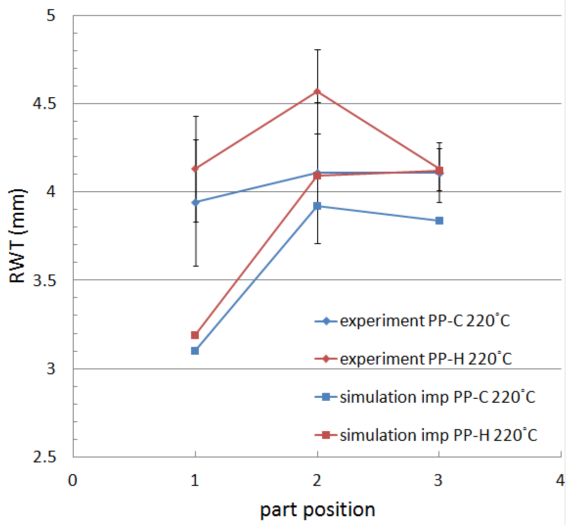
Remark: taking into account pump losses (± 27,5%) of the experiments by decreasing the water pressure in the simulations, improves the correlation between both results

RWT (in mm) for experiments and simulations for PP-C and PP-H at 220°C

Position	Experiment		Simulation 1		% difference		Simulation 2		% difference	
	PP-C	PP-H	PP-C	PP-H	PP-C	PP-H	PP-C	PP-H	PP-C	PP-H
1	3.94	4.13	3.21	2.98	18.53	27.85	3.10	3.19	21.32	22.76
2	4.11	4.57	3.60	3.55	12.41	22.32	3.92	4.09	4.62	10.50
3	4.11	4.13	3.69	4.21	10.22	-1.94	3.84	4.12	6.57	0.24



Influence of material parameters on the RWT for experiments and simulations



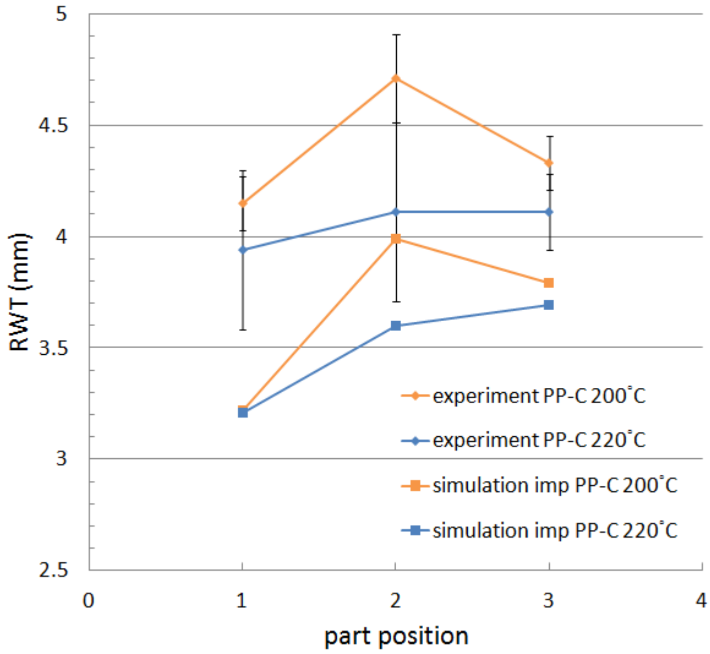
Influence of material parameters on RWT for experiments and adapted simulations

<u>Influence of the melt temperature</u>

- an increasing melt temperature gives rise to a decreasing RWT [3], which is seen in experimental data and simulation results

RWT (in mm) for experiments and simulations for PP-C at 200 and 220°C

Position	Experiment		Simulation 2		% difference	
	PP-C 200°C	PP-C 220°C	PP-C 200°C	PP-C 220°C	PP-C 200°C	PP-C 220°C
1	4.15	3,94	3.35	3.10	19.28	21.32
2	4.71	4.11	4.34	3.92	7.86	4.62
3	4.33	4.11	4.09	3.84	5.54	6.57



Influence of melt temperature on RWT for experiments and adapted simulations

CONCLUSION

This study validates simulation results for water-assisted injection molding by comparing simulation results with experimental data for different material parameters and melt temperatures. The experimental data indicate that an increasing molecular weight as well as an increasing melt temperature give rise to a decreasing residual wall thickness (RWT). This influence of both parameters on the RWT was also seen in the simulation results and this within a reasonable deviation. This way, it can be concluded that the simulation results are in good agreement with the experimental data.

FURTHER INVESTIGATION

Further investigation will examine the influence of other material parameters on the residual wall thickness. This way, a qualitative as well as a quantitative relation between the material properties and the residual wall thickness can be deduced, since this influence as well as their principle mechanism is not (fully) understood.