SFB 1120

Annual report 2018

Subproject B3

Title

Self-optimizing process control strategies for highly segmented mold temperature control for
Injection moulding

Project management/-processing

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Task definition

The overall objective of the project is to be able to actively control the temperature control in the injection mould during the cooling phase in the injection moulding process in order to be able to influence the specific volume of the moulded parts. This requires high-speed control processes that are able to record the recorded data from the process on the one hand, and on the other hand to output these directly as manipulated variables in a suitable control approach. In the previous project years, a suitable tooling and measuring technology was developed. The aim at the end of the first and the beginning of the second funding period was to be able to carry out first practical validations and to implement the theory in a real model-predictive control system. This required calibrations of the sensor technology to ensure correct data acquisition. In order to establish a correct control of the target variable specific volume, a model had to be developed that could correctly predict the complex material behaviour of the plastic and the propagating heat flows.

Procedure

In a first step, the infrared sensors close to the cavity were calibrated. For this purpose, the voltage signal of the sensors was correlated with a temperature value of the melt. As the emission and absorption behaviour of infrared radiation is

material-dependent, it is not possible to refer to literature values.
In parallel, model predictive control was initially implemented for one side of the injection mold. Based on the Tait approach, the specific volume for a semi-crystalline polypropylene can be determined with the measured values of temperature and pressure. Based on reference curves recorded for the undisturbed process, it is now possible for the algorithm to control the specific volume and compensate for possible induced disturbances. For this purpose, different scenarios are predictively calculated and the scenario that comes closest to the reference curve is selected for the next time step. This procedure is very computationally intensive and therefore the complexity of the model must be well estimated so that the computing time of the prediction does not exceed 100 ms. The time of 100 ms was selected because this is the relevant switching time of the CO_2 valves. A faster control of the valves is not target-oriented, because below this controlled variable the valves for cooling cannot react.

Results

In the last year of the project, the theoretical concepts of the control system could be transferred to a practical test phase. First comparative tests between the model-predictive control and a conventional PID controller were carried out. It was shown that the model-predictive control is superior to the PID approach, because the PID controller is not able to take the dead time of the system into account. The model predictive approach, on the other hand, can make a good prediction within the prediction horizon. The current control of the ejector side results in computing times of approx. 50 ms. Thus the goal of calculating the prediction for both sides in 100 ms is theoretically achievable.

Summary and Conclusion

In the fourth year of the project, model predictive control was implemented for one side of the injection mould. First test series show that a reproducible control is possible.

In the next test series, a precise comparison of the PID controller with the model-predictive control will be carried out. Furthermore, the model-predictive control for the second half of the mould is to be set up. Here, in particular the computational effort of the model is to be minimized. In cooperation with other subprojects of the SFB, more complex material models will be developed to improve the prediction.

Publication

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