FLUID DYNAMIC AND THERMAL MODELING OF THE INJECTION MOLDING PROCESS IN OPENFOAM®

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In the injection molding industry the reduction of the development time of tools and machines has been one of the most important issues in the last decades. A progressive trend has been emerging during the last years, where the computer-aided optimization has been proven as one of the key steps in achieving this goal. Commercial products offer 'click-along' solutions, however, the results of these black-box systems have been proven to be only correct in certain cases. For a serious and general optimization methodology of development the correctness of the results has to be guaranteed for all possible geometries, processing conditions as well as materials.
OpenFOAM® offers an excellent foundation for the development of a tool for the description of the injection molding process. First steps have been made to describe the filling phase of the process [1]. Recently, the code has been validated with experiments and proven to deliver results of the quality of commercial products or better. The code has been optimized in regards to runtime. Also the description of the subsequent packing and cooling phase has been implemented.
Due to the complexity and interdependency of quantities of fluid dynamic and thermal processes during the discontinuous process a wide variety of phenomena have to be modelled correctly. During the filling phase high local velocity values lead to high shear rates within the polymers reducing the local viscosity by magnitudes. This has a significant impact onto the pressure distribution and with that the processing conditions. In the subsequent packing phase the fluid dynamic phenomena become less dominant and thermal processes increase in importance, where during the last cooling phase of the production process these quantities play the dominant role for the process.
Thus it is of utmost importance for the solver and most importantly the boundary conditions to recognize these phases and to handle the change of the conditions during runtime. With this it is possible to focus on only dominant phenomena in each phase and other quantities are neglected in order to reduce calculation time for the industrial application.
Experimental validation has shown promising agreement in both pressure and temperature during the entire discontinuous process of injection molding. In figure 1 the pressure and temperature during the process is compared to the simulation results. The achieved good agreement promises the possibility to use OpenFOAM® as an intrinsic part of the development stage of injection molding tools and machines as well as of a certain machine simulation methodology of an intelligent, self-regulating injection molding machine

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References

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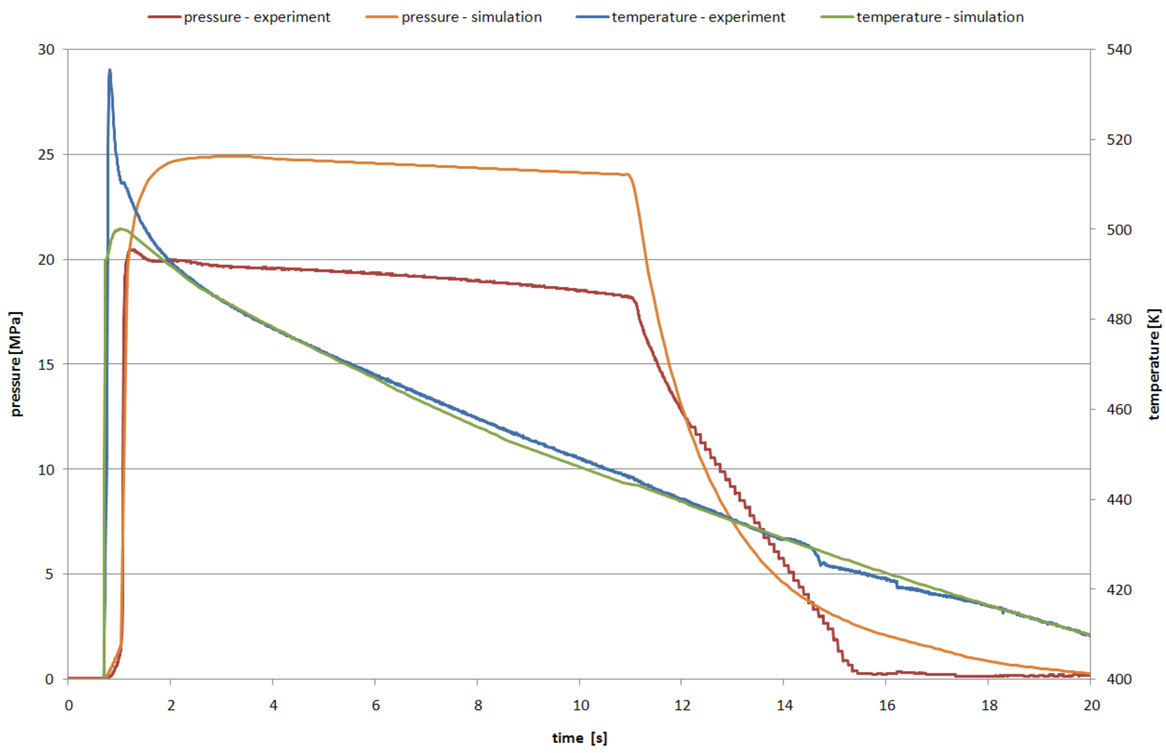

Figure 1: Time evolution of pressure and temperature during the injection molding process in experiment and simulation