Modeling of PET preform cooling in Injection Molding Process

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Introduction

The first step to produce beverage bottles is consisting in injecting a PET preform. This market evolution speed is constantly increasing, leading to the need to predict production cycle time. This prediction has to be as accurate as possible with the most versatility to embrace easily new injection molding technologies released to the market.

How is it possible to give an estimation of a preform injection cycle time? The best way is to analyze what are the phenomena that limit our injection cycle time. A good parameter to study is the preform temperature over its production process. As we inject high temperature resin, we have to wait until it cools down to release part from the mold at fastest possible speed, still guaranteeing the utmost quality level. Analyzing the preform thermal evolution all along the process is essential to understand limits of cycle time.

As we cannot use analytical solutions to predict this kind of thermal evolution due to its complexity, we have no choice but to use numerical simulation. A significant number of commercial software provides developed and powerful tools to simulate different kinds of physical phenomena. They suffer significant disadvantages such as the need of very specific user skills, as well as excessive modeling and computation time. In our context of estimating a significant number of cycle times per day, we are targeting exact opposite, meaning a simple user interface and a fast simulation time.

Content

In order to model the heat transfers that occur inside of the mold during the injection process, we are solving the heat equation with Thermal Contact Resistance model over the mold domain using FreeFEM++. Melt flow is not modeled inside of FreeFEM++ because we consider injection as instantaneous [1]. Different simulations with different geometrical domains are used in order to reproduce with accuracy the real process steps.
Figure 1 to 4 show the different boundary conditions inside of the heat transfer simulation with the different geometrical domains where the preform evolves during its complete injection molding process.

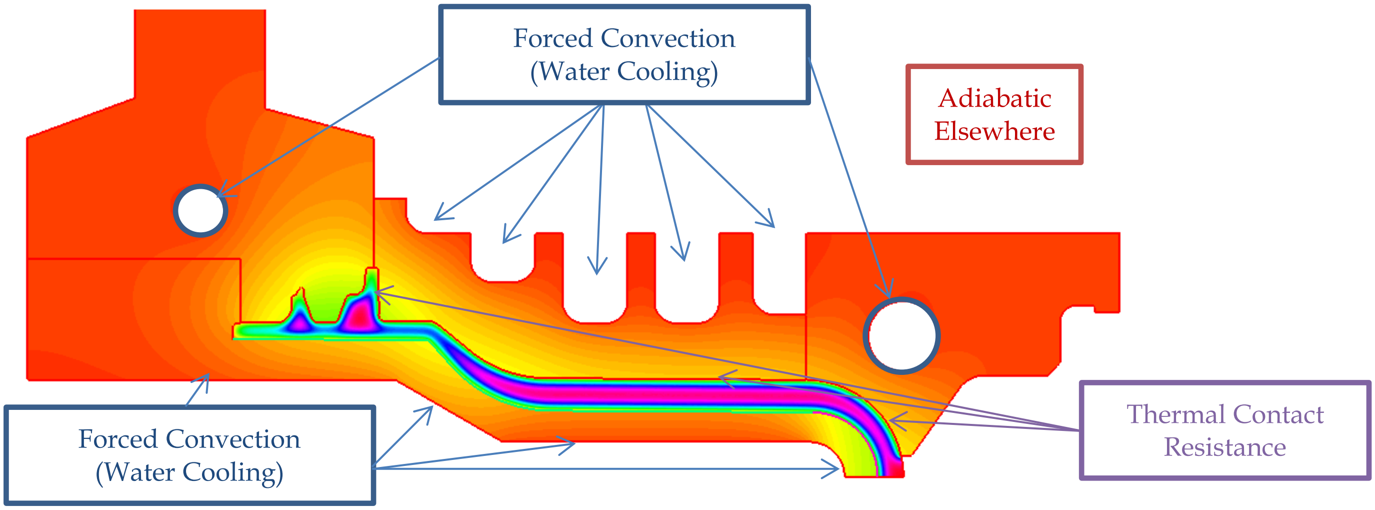

Figure **1**. Preform Injected and cooling inside of the mold

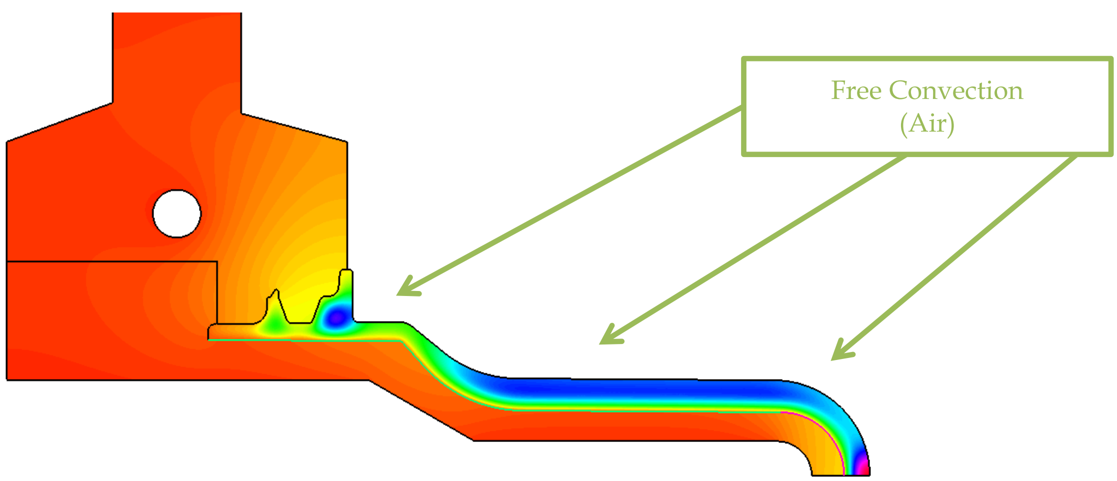

Figure **2**. Preform cooling during the mold opening

Figure **3**. Preform during the transfer to the cooling tubes

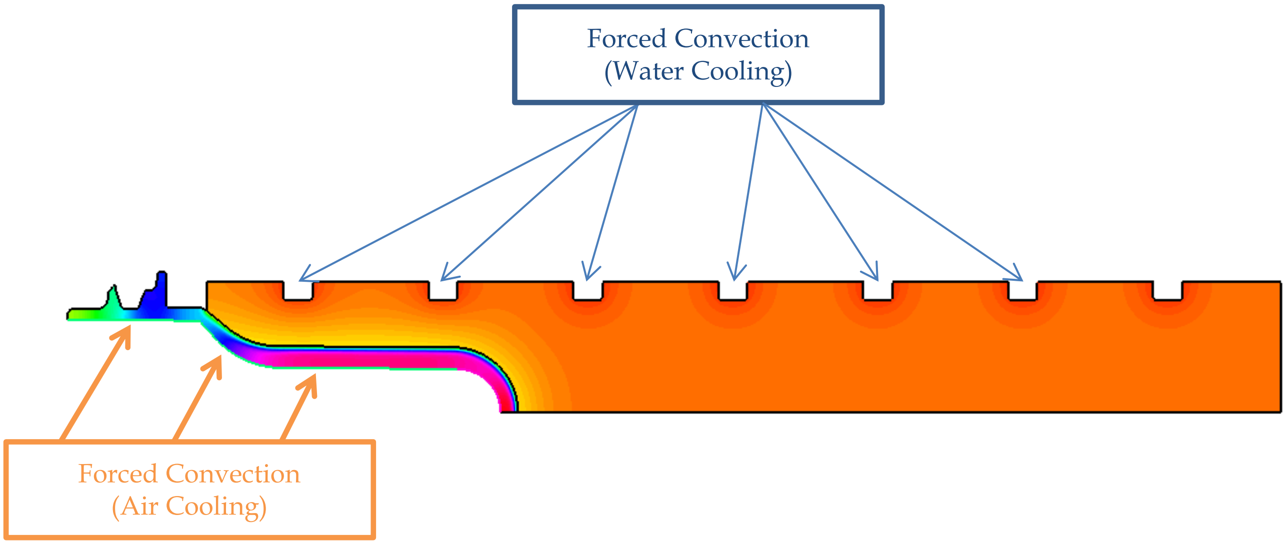

Figure **4**. Preform continuing its cooling inside of external cooling tubes

A stiffness model is used in order to calculate the right cooling time before being able to transfer the preform to the tube (Figure 3.) [2]. This model ensures that the preform is stiff enough to resist to the ejection forces applied to it.

Reference

[1] E. Boillat, R. Glardon, and D. Paraschivescu. Optimisation thermique de moules d'injection construits par des processus génératifs. Journal de Physique IV, 102 :27–38, 2002.
[2] Haoyu Xu and al., Productivity evaluation with a new stiffness-based ejection criterion of injection molding, 1999.

Keywords

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Numerical Simulation
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