Modelling and simulations of the thermoforming of borosilicate glass vials for pharmaceutical applications

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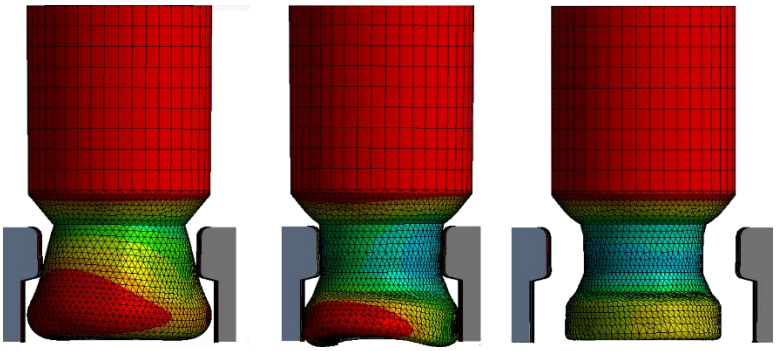
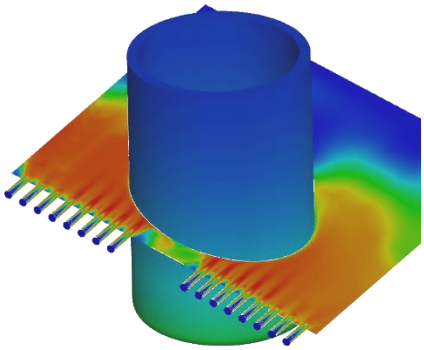
Many pharmaceutical products are stored in glass containers, in particular borosilicate glass vials are widely used to store vaccines and other kinds of drugs. Such vials are produced through a thermoforming process that starts from glass tubes and proceeds through several production steps. The correct design of the thermoforming process is of crucial importance to guarantee high reproducibility of the vials, long-term stability and adequate shelf-life of the stored medicines, while reducing the operational costs.

The aim of this research is to model and numerically simulate all the steps of the thermoforming process of glass vials to achieve an optimal design of the entire production line. The modelling addresses flow, mass, and heat transport as well as the mechanical deformation of the vials. The rheological properties of the glasses are of great relevance since glass is a strongly temperature-dependent material. At room temperature, glass is a highly hard and brittle material, whereas at high temperatures it becomes a viscoelastic body or a viscous liquid.

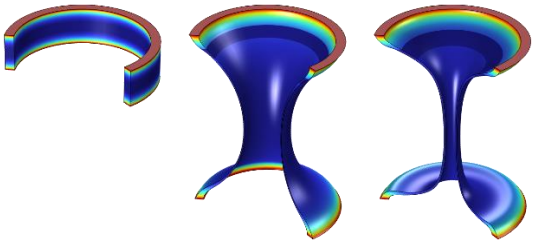


Structural mechanics simulation

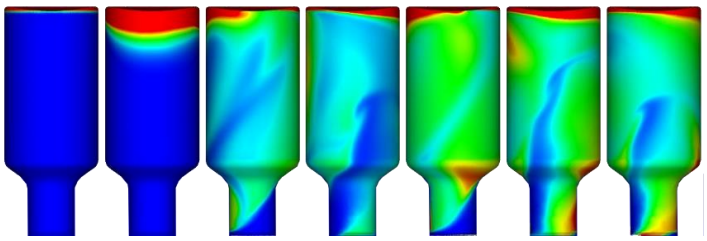


Glass heating simulation

The simulations also include the modelling of turbulent flows and chemical reactions to describe the combustion flames in the thermoforming stages. Furthermore, particular attention is addressed to the evaporation and adsorption of volatile species from the glass surface and to the subsequent fumes removal process to reduce the delamination propensity of the glass vials.



Cutting simulation



Fumes removal simulation

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