THE FILLING PROCESS OF A FLEXIBLE POUCH: TWO-WAY COUPLING OF PARTICLE-BASED CFD AND MULTI-FLEXIBLE-BODY DYNAMICS SIMULATION

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IN BRIEF

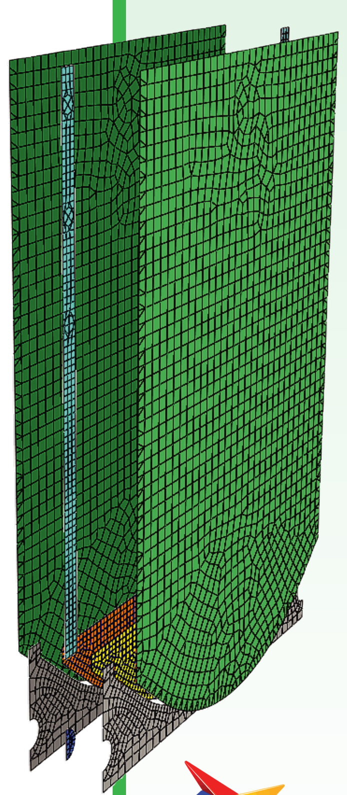
Packaging companies are always striving to stay one step ahead of their competitors in providing the best solutions for production capacity and quality, preserving the versatility of their machines. A large number of variables affects the dynamic behavior of the components and of the products when accelerations are considerable. Just a limited set of output data can be extracted from experimental tests to calibrate the processes. Coesia partnered with the University of Trento's Department of Industrial Engineering and EnginSoft to **simulate a stand-up pouch packaging machine** (Doypack®). The ambitious goal of deeply understanding the process in each stage and selecting the best set of parameters, even after changing the setup, is addressed in this work by performing a co-simulation study.

The focus of the project is devoted to the following stations of the machine:

I PACKAGE OPENING PROCESS → II PACKAGE FILLING (DETERGENT) → III PACKAGE CLOSING PROCESS

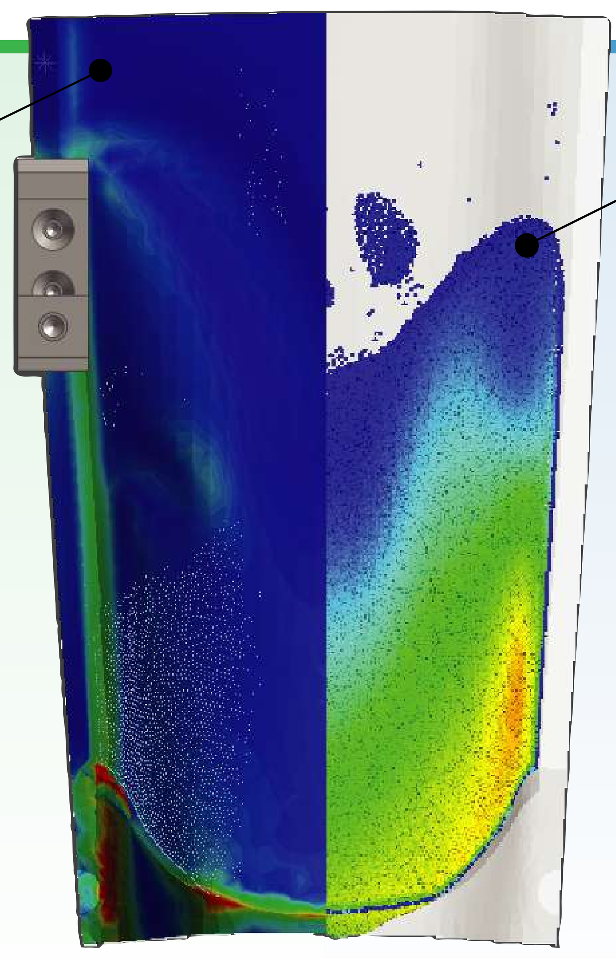
ANIMATION OF THE RESULTS

METHODS



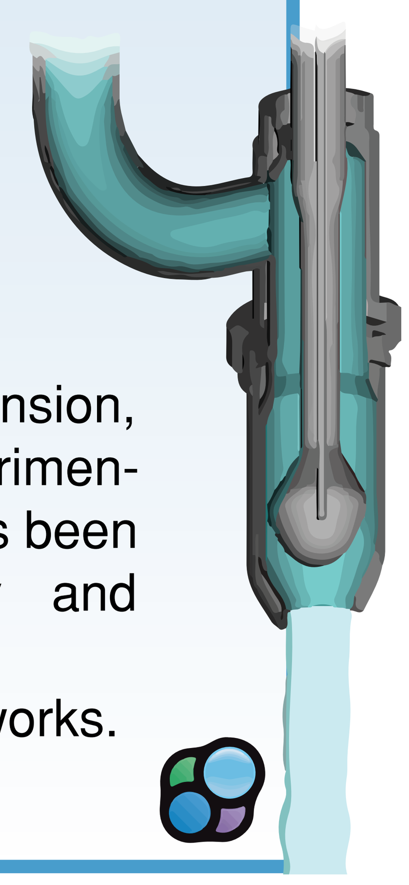
MULTIBODY AND FE STRUCTURE

While the clamps and the auxiliary components are regarded as rigid, the thin film of the pouch has been modeled such that the **large nonlinear deformations** are correctly represented. The structure of the package is realized by means of 4-node 6-DOFs shell elements, properly connected. The internal (Rayleigh) damping of the material, the contacts between the pouch and the clamps and the motion laws have been set up and assigned where needed.
This model part was created using RecurDyn.



PARTICLE-BASED MPS CFD

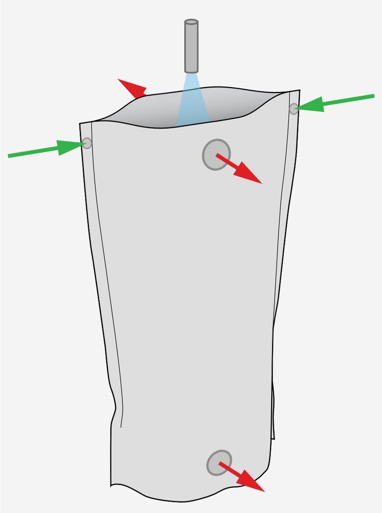
The modeling of the fluid has been addressed by choosing the **Moving-Particle Semi-implicit (MPS)** approach, which is a very effective method when FSI and free-surface fluid are present.
The fluid property (i.e. density, surface tension, **non-Newtonian viscosity** law) were experimentally tested and set up. The particle size has been selected taking into account accuracy and computational time.
This model part was created using Particleworks.



TWO-WAY FLUID-SOLID INTERACTION

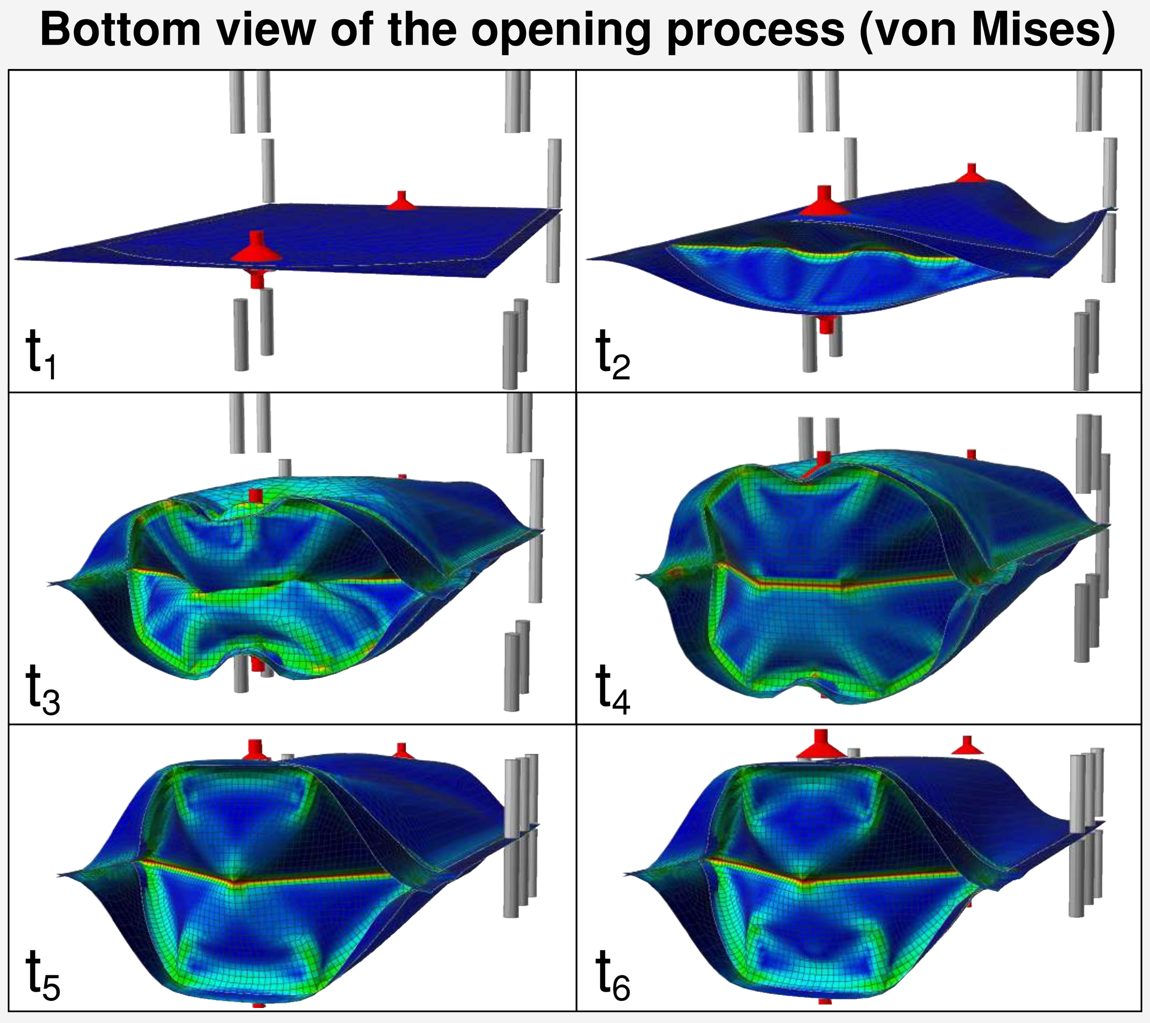
RESULTS

I PACKAGE OPENING PROCESS

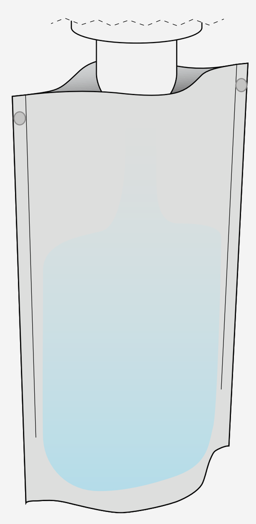


Two pairs of suction cups (red) and the pressurized air help the proper fulfillment of the opening process. The adhesion of the suction cups was modeled by constraining the nodes of the pouch structure. The pressure was assigned through an equivalent orthogonal force at each involved node. Stability issues of the bottom gusset could be faced in this station. Variational analyses to investigate the effects of the physical properties of the film were carried out.

Bottom view of the opening process (von Mises)

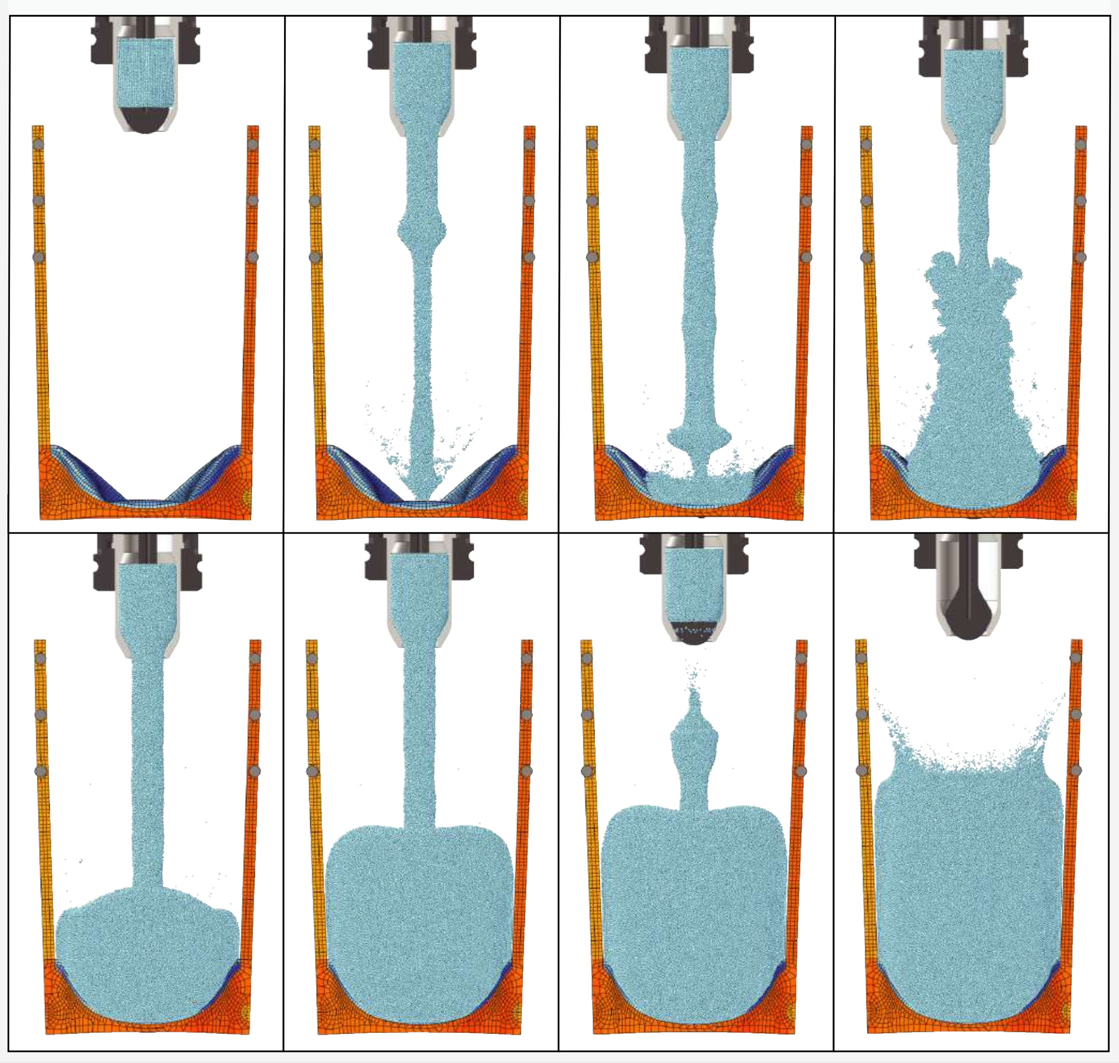


II PACKAGE FILLING (DETERGENT)

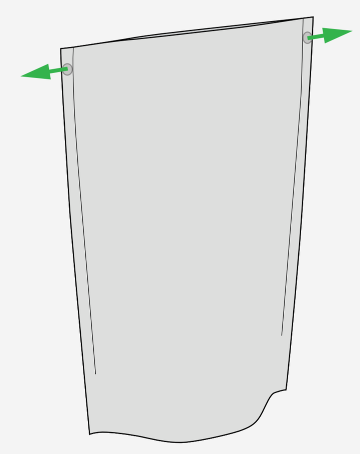


The package is filled up with a liquid detergent, with the aid of a nozzle. The shutter controls the flow of the fluid that comes from a pressurized vessel. Then, the detergent moves inside the pouch while approaching the closing station.
The **sloshing phenomena** were studied considering two opening configurations (A1 and A2). In addition, two different materials (M1 and M2) were assigned to evaluate their effect in terms of **package deformation**.

Progressive filling of the package

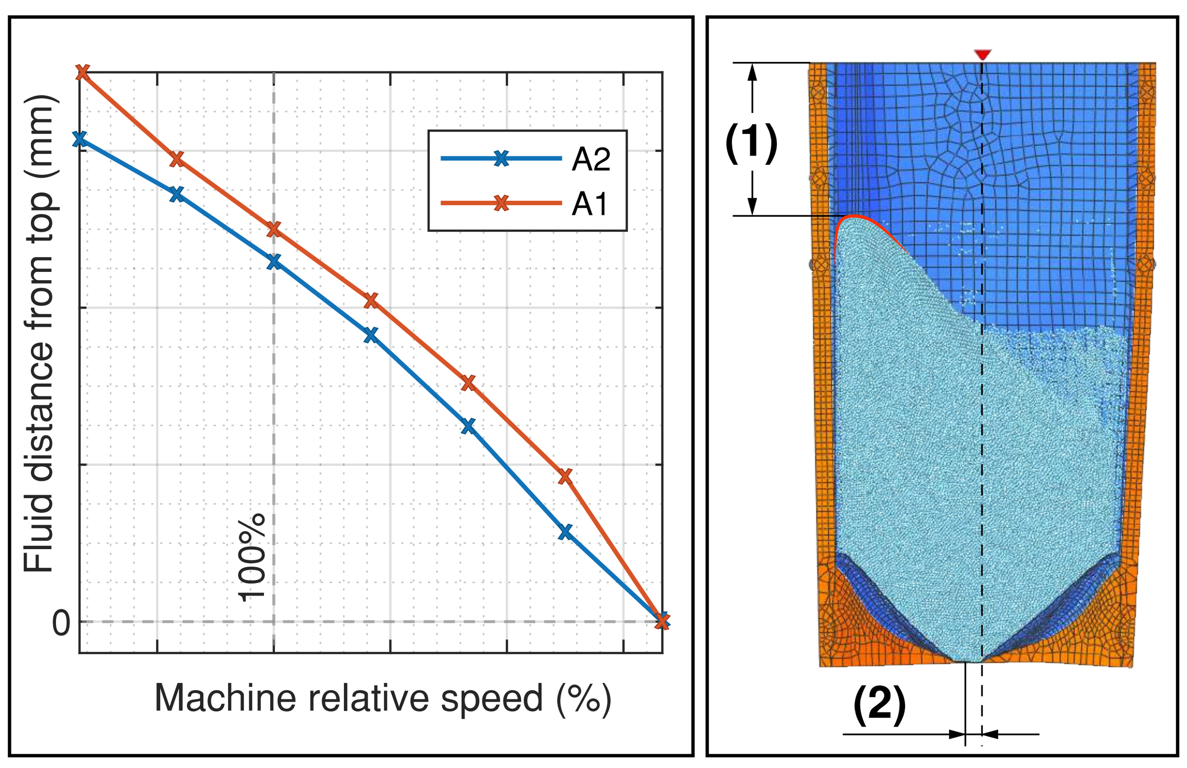


III PACKAGE CLOSING PROCESS

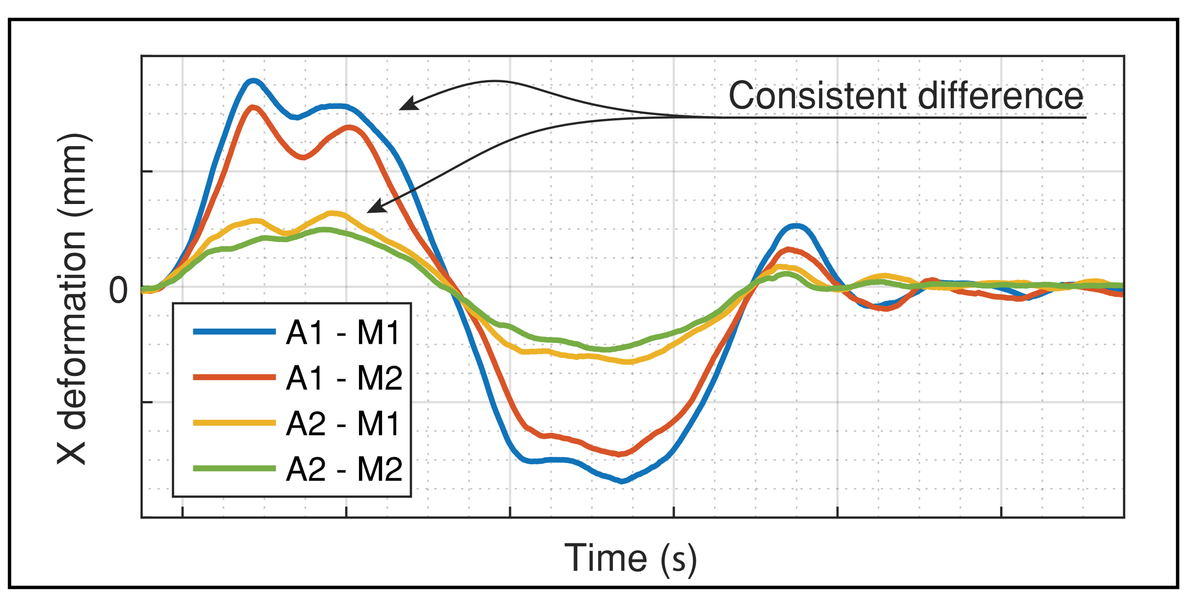


In the closing station, the clamps that support the filled pouch are moved apart to restore the flat configuration, before heat-sealing the top part of the package.

Sloshing analysis (1)



Deformation analysis (2)



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