Thesis title: Numerical modeling of thermoforming process of thermoplastics using shell based SPH method

Thermoplastics are 50% lighter than steel and 30% than aluminum, while exhibiting much higher strength and shock/impact resistance. They are generally made of two components: - a reinforcement armature made of glass/carbon fiber, and a matrix which is a resin that permeates the reinforcing fibers and solidifies. Due to the stringent environmental regulations and governmental recommendations for energy-saving, thermoplastic structures are driven the widespread adoption in many applications in the transport industry.

This thesis deals with the development and extension of an original method [1] called "Shell Smoothed Particle Hydrodynamics" (SSPH) for the numerical modeling of thermoforming process of thermoplastic structures [2]. Since its development by the research team in 2014, the SSPH method has been extended to the analysis of isotropic and composite structures undergoing large displacements and impact [3], to the optimization [4] and more recently to the thermomechanical behavior of functionally graded materials [5].

It is proposed here, to develop a numerical modeling based on the coupling of the SSPH method for the structural discretization with a thermo-viscoplastic material model for the simulation of thermoforming process of thermoplastic structures. In the framework of the PhD thesis, the developed Discrete Kirchhoff shell SPH model suitable for the forming of thin thermoplastic sheets, will be extended to large viscoplastic strains. The strong form of resulting shell equilibrium equations will be discretized directly by the improved shell based SPH method and solved by an explicit dynamic type scheme. Compared to FEM, the advantage of the shell SPH lies in the absence of elements, allowing to capture naturally all defects and shape distortions which often arise during thermoforming of thermoplastic structures. A second part of the thesis work will concern the optimization of process parameters such as temperature and pressure in order to design guidelines for thermoplastic structures forming which will help to prevent such defects and permits the formability of the final workpiece. To this purpose, the application of advanced optimization techniques will be used since it is effective in determining a set of solutions including a set of several design alternatives [6].

The numerical developments will be done with Python at first and then will be implemented in the open-source software OpenRadioss (www.openradioss.org). Indeed, this software offers numerous advantages such as contact algorithms and various time integration schemes. For the validation of the SSPH model, several benchmarks of thermoforming and thermo-impact of thermoplastic structures will be evaluated and the results will be compared to those obtained by experiments and the classical finite element method.

This research thesis is original and has never been addressed by the international scientific community of thermoplastic forming; hence the developments will allow the publication of several articles in peer-reviewed international journals.

Keywords: Numerical modeling; thermoforming; SPH; optimization; process parameters;

Skills of the applicant: Expected candidate should have basic knowledge of forming processes, finite element and basics of programming.

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