Hybrid Thermo-Mechanical Contact Algorithm for 3D SPH-FEM Multi-Physics Simulations

Kirk Fraser[†]*, Lyne St-Georges[†], Laszlo I. Kiss[†] and Yves Chiricota[†]

[†] Université du Québec à Chicoutimi (UQAC)

555, boulevard de l'Université
Saguenay (Québec) G7H 2B1
e-mail: kirk.fraser1@uqac.ca

ABSTRACT

Numerical simulation of complex industrial processes has become increasingly common in recent years. Depending on the nature of the industrial application, multiple types of physical phenomena may need to be considered as well as the interaction of multiple disjoint bodies. This paper is focused on industrial applications with large plastic deformation, such processes are typically not well treated by finite element methods. For this reason, the smoothed particle hydrodynamics method (SPH) is used. In this work, we introduce a robust and straight forward thermo-mechanical contact algorithm for multi-physics SPH simulations in 3D.

Often, the transfer of thermal energy at a contact interface is simply neglected (such as in high speed cutting, Limido et al. [1] and friction stir welding, Pan et al. [2]). However, in many situations, neglecting the thermal contact aspect of the problem results in a significant source of error. Some authors have worked on SPH-SPH contact algorithms, but have noted that the approach is not well suited for all contact situations (see Vignjevic and Campbell [3]). In our approach, the contactor (master) and contacted (slave) are meshed with SPH elements. The free surface of the master part is meshed with zero thickness plate elements. Mechanical contact is then between the SPH elements of the slave and the plate elements of the master while thermal contact is between the SPH elements in the master and slave.

The SPH code is developed on the graphics processing unit (GPU) using CUDA Fortran. In the paper, we explain the implementation of the contact detection algorithm, the mechanical and thermal (following Jubelgas [4]) solvers, the detection of free surface particles (used in the contact algorithm and for adaptive thermal boundary conditions) as well as the thermo-mechanical contact. The XSPH method [5] is used to update the position of the particles and a novel adaptive neighbour search [6] approach is also used. Both thermo-fluid and thermo-solid test cases are provided to show the validity of the contact scheme.

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