11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

A MASSIVELY PARALLEL PROGRAM TO MODEL BRITTLE CRACK PROPAGATION WITH THE PHASE FIELD FORMULATION

Vahid Ziaei-Rad[1], **Yongxing Shen**[2,3*]

[1]Laboratori de Càlcul Numèric, Universitat Politècnica de Catalunya (UPC BarcelonaTech), 08034 Barcelona, Spain, vahid.ziaei@upc.edu

[2]Laboratori de Càlcul Numèric, Universitat Politècnica de Catalunya (UPC BarcelonaTech), 08034 Barcelona, Spain

[3]University of Michigan-Shanghai Jiao Tong University Joint Institute, Shanghai Jiao Tong University, Shanghai, 200240, China, yongxing.shen@sjtu.edu.cn

Key words: *Phase field, GPU implementation.*

Recently the phase field method has been developed for the numerical simulation of brittle fracture [1]. Phase field models for fracture employ a continuous field variable to represent cracks. The width of the transition zone between cracked and un-cracked areas is controlled by a regularization parameter which smoothens the boundary of the crack over a small region.

The major advantage of using a phase field is that the evolution of fracture surfaces follows from the solution of a coupled system of partial differential equations. In contrast to discrete descriptions of fracture, phase-field description does not require numerical tracking of discontinuities in the displacement field. This greatly reduces implementation complexity, and is anticipated to be particularly advantageous when multiple branching and merging cracks are considered in three dimensions.

The numerical implementation of such models is sensitive to the choice of the regularization parameter (for smoothing the cracked zone) in conjunction with the mesh size, as the mesh has to be fine enough to resolve high gradients of the crack field appearing in the transition zones. This is one of the main computational challenges of the implementation.

Recently, graphics processing units (GPUs) have had great success in accelerating many numerical computations [2]. Therefore, massively parallel programming with GPU can be considered as a candidate solution for the problem of high computational costs in the phase field method. We will present our approach to develop a massively parallel program to explicitly solve the brittle crack evolution problem with the phase-field formulation on a single graphical processing unit (GPU), using a standard finite element method (FEM) on unstructured meshes. We will also discuss implementation issues such as the ever-decreasing critical time step.

REFERENCES

[1] C. Miehe, F. Welschinger, and M. Hofacker. Thermodynamically consistent phase-field models of fracture: Variational principles and multi-field FE implementations. *Int. J. Numer. Meth. Engng*, Vol. **83**, 1273–1311, 2010.

[2] C. Cecka, A. Lew, and E. Darve. Assembly of finite element methods on graphics processors. *Int. J. Numer. Meth. Engng*, Vol. **85**, 640–669, 2011.