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RECENT DEVELOPMENTS ON MPM AND ITS APPLICATION IN IMPACT AND EXPLOSION SIMULATION

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ABSTRACT

In this talk, the basic formulation of MPM and our recent developments on MPM for impact and explosion problems are briefly reviewed, including an efficient implementation of MPM, improved contact method, adaptive material point method, parallelization based on OpenMP and MPI scheme, material point finite element method, hybrid FE-MP method and adaptive FE-MP method, coupled finite element material point method, adaptive finite element material point method. A 3D explicit parallel MPM code, MPM3D, has been developed for the numerical simulation of impact and explosive problems. Several numerical examples such as explosively driven flyer, shaped charge, debris cloud, projectile penetration of steel plate and reinforced concrete, slope slide and metal cutting are presented to demonstrate the application of MPM3D, which shows that MPM3D is a powerful tool for impact and explosion simulation.

Keywords: meshfree/meshless method, material point method, impact, explosion.

INTRODUCTION

Dynamic response of material and structure under impact and blast loading involves extremely large deformation, multi-physics coupling and nonlinearities. Material Point Method (MPM) (Sulsky, 1994), which makes use of both Lagrangian and Eulerian description of material, is suitable for modelling problems with extreme large deformation. In explosion problems simulation, material usually undergoes extreme large ductile deformation without fracture, where numerical fracture was observed in the MPM. Therefore an adaptive particle splitting scheme in the direction with the largest deformation is proposed (Ma, 2009). To better simulate the problems involving impact and penetration, an improved contact algorithm with contact/sliding/separation description is proposed (Huang, 2011), which has been successful applied to solve penetration problem. In order to take advantages both of MPM and Finite Element Method (FEM), a series of work on coupling FEM with MPM has been conducted (Zhang, 2006; Lian, 2011; Lian, 2012), which has been successfully applied to solve hyper-velocity impact problem and penetration problem. As MPM makes use of both mesh and particle data, it is more expensive in terms of storage than other methods. Therefore, several schemes are developed to reduce the memory requirement and computational cost, including the local multi-mesh contact algorithm, dynamic internal state variables for materials, dynamic grid and moving grid technique (Ma, 2010). All of the above are implemented in our 3D explicit parallel MPM code, MPM3D, which is developed using objective-oriented design by C++ program language with Qt, VTK and CMake, and can be run on different platforms including Windows, Linux and Mac OS. Several constitutive models, equations of state (EOS) and failure models have been implemented in our MPM3D code.

RESULTS AND CONCLUSIONS

The results of several numerical examples such as explosively driven flyer, shaped charge, debris cloud, slope slide, projectile penetration of steel plate and reinforced concrete are presented.

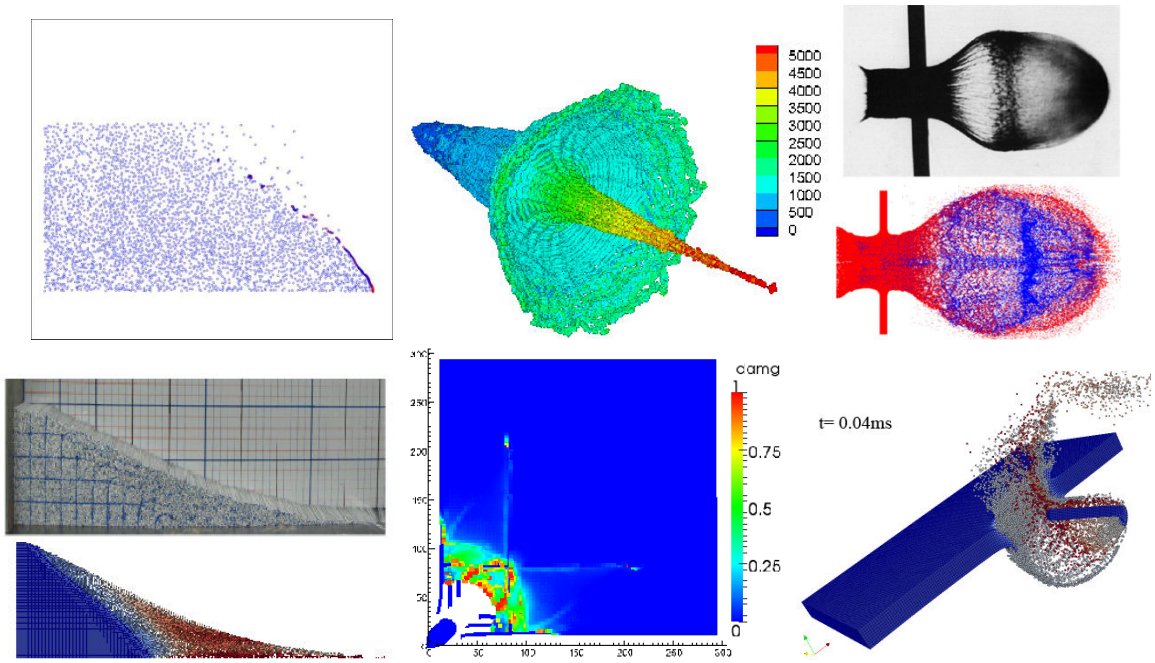

Fig. 1 - Numerical results by MPM3D

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