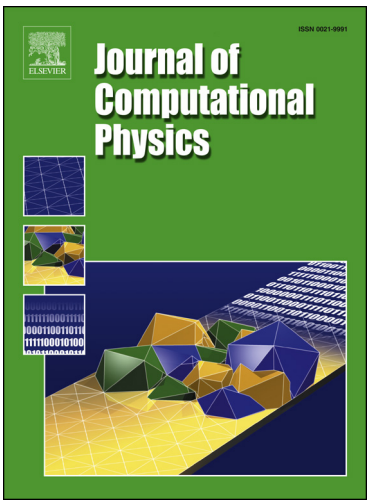
Accepted Manuscript



A non-intrusive reduced-order model for compressible fluid and fractured solid coupling and its application to blasting

D. Xiao, P. Yang, F. Fang, J. Xiang, C.C. Pain et al.

PII: S0021-9991(16)30576-9
DOI: http://dx.doi.org/10.1016/j.jcp.2016.10.068
Reference: YJCPH 6946

To appear in: *Journal of Computational Physics*

Received date: 20 January 2016
Revised date: 17 October 2016
Accepted date: 30 October 2016

Please cite this article in press as: D. Xiao et al., A non-intrusive reduced-order model for compressible fluid and fractured solid coupling and its application to blasting, *J. Comput. Phys.* (2016), http://dx.doi.org/10.1016/j.jcp.2016.10.068

A non-intrusive reduced-order model for compressible fluid and fractured solid coupling and its application to blasting

D. Xiao[a], P. Yang[a], F. Fang[a,c,*], J. Xiang[a,c], C.C. Pain[a], I.M. Navon[b], M. Chen[c]

[a]*Applied Modelling and Computation Group, Department of Earth Science and Engineering,Imperial College London, Prince Consort Road, London, SW7 2BP, UK.URL:* `http://amcg.ese.imperial.ac.uk`
[b]*Department of Scientific Computing, Florida State University,Tallahassee, FL, 32306-4120, USA*
[c]*Wuhan University, Wuhan, 430072, China*

Abstract

This work presents the first application of a non-intrusive reduced order method to model solid interacting with compressible fluid flows to simulate crack initiation and propagation. In the high fidelity model, the coupling process is achieved by introducing a source term into the momentum equation, which represents the effects of forces of the solid on the fluid. A combined single and smeared crack model with the Mohr-Coulomb failure criterion is used to simulate crack initiation and propagation. The non-intrusive reduced order method is then applied to compressible fluid and fractured solid coupled modelling where the computational cost involved in the full high fidelity simulation is high. The non-intrusive reduced order model (NIROM) developed here is constructed through proper orthogonal decomposition (POD) and a radial basis function (RBF) multi-dimensional interpolation method.

The performance of the NIROM for solid interacting with compressible fluid flows, in the presence of fracture models, is illustrated by two complex test cases: an immersed wall in a fluid and a blasting test case. The numerical simulation results show that the NIROM is capable of capturing the details of compressible fluids and fractured solids while the CPU time is reduced by several orders of magnitude. In addition, the issue of whether or not to subtract the mean from the snapshots before applying POD is discussed in this paper. It is shown that solutions of the NIROM, without mean subtracted before constructing the POD basis, captured more details than the NIROM with mean subtracted from snapshots.

Keywords: non-intrusive, ROM, compressible fluid-solid coupling, fracturing, blasting

*Corresponding author
Email address: `f.fang@imperial.ac.uk` (F. Fang)