An adaptive remeshing with cohesive zone approach to ductile failure: application to the Second Sandia Fracture Challenge

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ABSTRACT

A wide range of numerical methods have been developed, in the last decades, to efficiently simulate 3D crack propagation: X-FEM, GFEM, BEM or FEM with adaptive remeshing. These approaches have been successful in many situations, yet many issues are still encountered when dealing with complex aspects such as crack lips contact in finite strain, highly non-linear elastic-plastic material behaviors, dealing with both crack initiation and propagation stages... Recent developments have been carried out in order to address some of these issues: variational formulation of fracture, phase-field, or thick level-set, are some promising strategies to deal with the complete damage to failure problem. However, mixing both complex non-linear material behavior in finite strain and non-trivial damage model, to simulate the complete ductile failure process remains a challenging problem.

In this context, the approach herein developed is focused on the capability to mix very complex highly non-linear elastic-plastic material models (for ductile or thermo-mechanical-fatigue failure) with a numerical strategy suitable to simulate a complete scenario from the finite strain plastic deformation of a structure through damage, crack initiation, propagation and up to complete failure. Concerning the material behavior part, a wide range of models can be used in the context of fatigue or critical failure. Sharing some aspects with a previously developed technique [1], we perform local remeshing in identified critical zones where the material dissipation is maximal, and a specific mesh transfer algorithm is applied to ensure further calculation. However, in order to deal with both damage and failure aspects, this new approach aims to insert, in the identified damage zones, a cohesive surface whose size and orientation will be dynamically controlled, in order to satisfy a maximal dissipation criterion during the failure process (using some algorithms previously presented in [2]). To highlight the performance and robustness of this method, various numerical assessments will be presented. In particular, the case of the Second Sandia Fracture Challenge [3] will be addressed, and these new results will be compared to the original blind predictions obtained during our participation to this round-robin.

REFERENCES

[1] S Feld-Payet, V Chiaruttini, J Besson, F Feyel, A new marching ridges algorithm for crack path tracking in regularized media, IJSS, 71, 2015, 57-69.

[2] V Chiaruttini, D Geoffroy, V Riolo, An adaptive algorithm for cohesive zone model and arbitrary crack propagation, V Chiaruttini, D Geoffroy, V Riolo, M Bonnet, EJCM/REMN, 21, 3-6, 2012, 208-218.

[3] B. L. Boyce, S. L. B. Kramer, et. al., The second Sandia Fracture Challenge: predictions of ductile failure under quasi-static and moderate-rate dynamic loading, International Journal of Fracture, Volume 198, 2016, 5-100.