The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Level-set topology optimization of fracture-resistance of macro structure undergoing ductile failure

Nima Noii[1], **Hassan Ali Jahangiry** [2], **Fadi Aldakheel**[1,3], **Peter Wriggers**[1]

[1] Institute of Continuum Mechanics, Leibniz University of Hannover, An der Universität 1, 30823 Garbsen, Germany,
[2] Faculty of Civil Engineering, Semnan University, Semnan, Iran,
[3] Zienkiewicz Centre for Computational Engineering, Faculty of Science and Engineering, Swansea University, Bay Campus, SA1 8EN, UK.

Keywords: *Level set method , Topology optimization, Phase-field fracture, Graident plasticity, Reaction–diffusion equation.*

This work presents a mathematical formulation for *topology optimization of a macro structure* undergoing ductile failure. The prediction of ductile solid materials which exhibits dominant plastic deformation is an intriguingly challenging task and plays an extremely important role in various engineering applications. Here, we rely on the phase-field approach to fracture which is a widely adopted framework for modeling and computing the fracture failure phenomena in solids [2]. An incremental minimization principles for a class of gradient-type dissipative materials are used to derive the governing equations.

First objective here, is to optimize the topology of a structure thus having a predefined structural weight while it can be sustained for a material damage, with an specific threshold for the fracture area [1]. Another novel objective of this research is formulating an alternative objective function for fracture resistance of *composites structure*, whereas an optimum shape of the spatial distribution of inclusion phase will be determined. To obtain optimal topology to enhance the structural resistance due to fracture, the Level-Set-based is formulated. The Level-Set-based topology optimization is employed to seek an optimal layout with smooth and clear boundaries. Sensitivities are derived using the analytical gradient-based adjoint method to update the level set surface. The level set surface evolves using the reaction-diffusion equation in finite element discretization to maximize the strain energy of structure while a certain volume of design domain is prescribed. Several numerical examples are presented to demonstrate the ability and efficiency of the proposed method.

REFERENCES

[1] N. Noii, H. A. Jahangiry, F. Aldakheel, P. Wriggers. Level-set topology optimization of failure initiated from finite deformation of macro structure with experimental verification . submitted to *Int. J. Plast*, 2022.

[2] N. Noii, A. Khodadadian, J. Ulloa, F. Aldakheel, T. Wick, S. Francois, P. Wriggers. Bayesian inversion for unified ductile phase-field fracture. *Comput Mech* Vol. **68**, pp. 943–980, 2021.