EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1167

CRITICAL PLANE APPROACH FOR FATIGUE RESISTANCE USING STRESS-BASED TOPOLOGY OPTIMIZATION

Maxime Collet[1], Simon Bauduin[2], Eduardo Fernández Sánchez[2], Pablo Alarcón Soto[2], Pierre Duysinx[3]

[1]Univeristy of Liège, Belgium
maxime.collet@uliege.be

[2]University of Liège, Belgium
s.bauduin@uliege.be, efsanchez@uliege.be, palarcon@uliege.be

[3]University of Liege, Belgium
p.duysinx@uliege.be

Keywords: topology optimization,fatigue failure,stress constraints

Abstract: Fatigue is responsible for almost 80% of the overall breakages in mechanical components. Such a failure phenomenon must be prevented as soon as the early stage of design. Since the seminal works by Augut Wöhler, the literature counts various methods able to prevent fatigue failure. In the automotive industry, the components undergo a high number of cycles leading to consider the stresses as variables into the fatigue criteria. Topology optimization has become a valuable tool used to propose preliminary designs as attested by several commercial software on the market. Combining fatigue design with a stress-based topology optimization procedure is therefore natural. In this work, the coupling of the Dang Van criterion within a topology optimization code is investigated to provide fatigue resistant layouts. The choice of the Dang Van criterion is encouraged by its wide usage in the automotive industry . The former is based on the concept of critical plane in the vicinity of which plastic yielding occurs. With the hypothesis of reaching the elastic shakedown state, the criterion establishes that crack initiation is prevented if the microscopic stress state remains below a prescribed threshold. Following the framework proposed by Dang Van, the fatigue failure procedure is introduced into a density-based topology optimization code embedding stress constraints. The first step of the procedure is to construct the microscopic stress using a regular finite element analysis and evaluate a damage value in the sense of Dang Van. A sub-optimization routine is necessary to solve a min-max problem in order to find the residual stress tensor to construct the microscopic stresses. This sub-optimization might be time consuming and must be dealt with care. In a second step, this work shows how the fatigue resistance procedure is implemented into a density-based topology optimization using stress constraints and in particular how the sensitivity analysis is performed using the adjoint approach. The optimization process is carried out with the Method of Moving Assymptotes along the qp-relaxation to overcome the singularity phenomenon of the stress constraints. The proposed optimization framework is evaluated in terms of its numerical performances and is compared to classical results obtained by a regular stress-based topology optimization on several benchmarks.