APCOM & ISCM
11-14th December, 2013, Singapore

Topology and Shape Optimization Considering Stresses and Applications to a High-speed Gear Shape

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Considering stress concentration is a challenging problem in the framework of the current normal topology optimization problem that minimizes usually a structural volume with the ill-posed problem formulation. A novel topology and shape optimization method has been developed on the basis of a level set approach in order to mitigate some problems encountered in the stress-based topology optimization based on SIMP (Solid Isotropic material with penalization) method. As a numerical example, the method was applied to the high-speed gears that rotate in 40,000-200,000 rpm and the optimum gear curves and undercuts were obtained under the loadings of various transmitting torques and contacting forces. This kind of high speed gears are recently applied for newly developed dental and surgical hand-pieces and there are urgent needs to improve their life cycles by redesigning the shape of a gear tooth. As results of numerical examples, the level set approach is very effective for stress-based optimization problems.

Keywords: Stress-based topology optimization, Level set, High-speed gear shape, Hand-piece