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Thin-walled tubes under torsion: multi-objective optimal design. (English) Zbl 1433.74089

Optim. Eng. 21, No. 1, 1-24 (2020).

Summary: The lightweight design of a thin-walled tube under torsion is addressed in the paper. A multi-objective optimization approach is adopted to minimize the mass while maximizing the structural stiffness of the thin walled tube. Constraints on available room (maximum diameter), safety (admissible stress), elastic stability (buckling), minimum thickness (forced by manufacturing technologies) are included in the problem. The analytical solution of the multi-objective optimization problem is obtained by applying a relaxed formulation of the Fritz John conditions for Pareto-optimality. Relatively simple analytical expressions of the Pareto-optimal set are derived both in the design variables (tube diameter and wall thickness) and objective functions (mass and compliance) domain. Simple practical formulae are provided to the designer for the preliminary design of thin-walled tubes under torsion. Finally, the comparative lightweight design of tubes made from different materials is presented and an application of the derived formulae to a simple engineering problem is discussed.

MSC:

74P10 Optimization of other properties in solid mechanics
90C90 Applications of mathematical programming
90C29 Multi-objective and goal programming

Keywords:

multi-objective optimization; analytical solution; thin-walled tube; twisted shaft

Full Text: DOI

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