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OPTIMAL DESIGN WITH RESPECT TO MIXED CREEP RUPTURE TIME OF BARS UNDER NONUNIFORM TENSION

Aneta Ustrzycka, Krzysztof Szuwalski

Cracow University of Technology, Kraków, Poland, anetaustrzycka@wp.pl

Abstract
Among many new possibilities of optimization criteria, which offers optimization of structures in creep conditions, the most important seems to be time to rupture. Until now, most frequently the brittle creep rupture theory, allowing application of the rigidification theorem was used. Papers making advantage of the ductile rupture theory, requiring finite strain analysis, are rather scarce. In present paper, for the first time, as the optimization criterion serves the mixed rupture theory. Within this theory two effects are simultaneously taken into account: diminishing of cross – sectional area due to large strains (as in ductile rupture) and growth of microcracks (as in brittle rupture), as well. Difficulty of the problem results from two types of nonlinearities: geometrical (finite strain theory), and physical – the Norton's creep law, here generalized for true stresses and logarithmic strains. Moreover, additional factor of time causes, that problem may be described only by set of partial differential equations.
As an example of structure under optimization serves a bar with a mass at the end, rotating in horizontal plane with constant angular velocity. The own mass of the bar is taken into account, what results in nonhomogeneous stress state – body forces depend on the spatial coordinate. The initial distribution of cross – sectional area along the axis of the bar, leading to maximal time of the mixed creep rupture is being sought. The system of five partial differential equations, in dimensionless form, describing the problem was derived. The system must be integrated with respect to material coordinate (Runge – Kutta fourth order method) and to time with variable step (Euler's method). The parametric optimization with one, or two free parameters describing the initial shape of the bar is applied. The obtained results are compared with the bars of uniform initial strength, which usually are optimal with respect to brittle creep rupture time.