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A Finite Element Formulation of Minimization Problem for Stable Plastic Cycling

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Direct approach was extended to stable elasto-plastic cycle determination and verified by Bree problem of pressurized thin-walled tube under repeated thermal loading. The structure was discretized using rectangular quadratic finite elements. The object function of the optimization problem equals to the work of fictitious elastic stresses on the plastic strain subtracted from the energy dissipation, with both being integrated over the cycle time and spatially over the body. The plastic strains and initial residual stresses are subject to the inequality conditions of admissibility of the total stress at any time moment. The conditions of plastic strain incompressibility, cycle closure and initial residual stress self-balance are enforced by means of quadratic penalties. After first phase optimization undertaken to satisfy the inequality conditions and the following object function reduction by means of a simple primal-dual algorithm, the plastic strains for every half-cycle obtained in plastic ratchetting agree well with the analytical solution to the problem, even though the former was obtained only for two time points over a cycle.

Keywords: Direct computation, Finite elements, Stable cycle, Plastic ratchetting, Inelastic shakedown