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SHAKEDOWN ANALYSIS OF STRUCTURES UNDER THERMOMECHANICAL LOADING BASED ON THE RSDM

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Mechanical and civil engineering structures are generally subjected to high levels of loading. Typical examples of such structures are nuclear reactors and aircraft gas propulsion engines on the one hand and buildings, pavements and bridges under seismic loading on the other. Under all these kinds of loading, these structures are forced to develop plastic strains.

The complete response of a structure, which is subjected to a given thermomechanical loading and exhibits inelastic time independent plastic strains is quite complex. To accomplish this task, one has to know the exact time history. A better alternative, that requires less computing time, is offered by the direct methods that may predict whether, under the given loading, the structure will become unserviceable due to collapse or excessive inelastic deformations. Moreover, if the complete time history of loading in not known, but only variation intervals of the loading is known, direct methods is the only way to establish safety margins.

Most of the Direct Methods are based on the two theorems of plasticity and formulate the problem as a mathematical programming problem. In the present work a direct method is exposed which approaches the problem in a different way. The method makes use of a recently published Direct Method, called the Residual Stress Decomposition Method (RSDM) [1], which assumes the decomposition of the residual stresses, at the steady cycle, to Fourier series in time. The RSDM may predict any cyclic elastoplastic stress state for a given cyclic loading history. With the proposed approach thermomechanical loading of prescribed limits is converted to an equivalent loading which has a prescribed time history. The procedure approaches the shakedown loading from above with an iterative way by shrinking the load domain until only the constant term of the Fourier series remains. An implementation of the method for thermomechanical loads will be presented.

The method is formulated within the finite element method and an elastic-perfectly plastic material with a von Mises yield surface is assumed. The stiffness matrix needs to be decomposed only once. The whole approach is shown to be stable and computationally efficient, with uniform convergence.

Examples of application for various structures under thermomechanical loads will be presented during the workshop.

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