Static and kinematic shakedown analyses involving temperature-dependent properties

†*S.Y. Leu[1], Y.Z. Wang[1] and J.S. Li[2]

[1]Department of Aviation Mechanical Engineering, China University of Science and Technology, Taiwan, R.O.C.
[2]Department of Bio-Industrial Mechatronics Engineering, National Taiwan University, Taiwan, R.O.C.

*Presenting author: syleu@cc.cust.edu.tw
†Corresponding author: syleu@cc.cust.edu.tw

Abstract

Engineering structures are usually subjected to combined thermo–mechanical cyclic loading. It is reasonable to apply classical shakedown theorems to deal with cyclic elastic-plastic analysis of structures exposed to thermal loading of low amplitude with temperature-independent properties (e.g. Oueslati and de Saxcé, 2009; Hasbroucq et al., 2010). However, it is shown (e.g. Hansen and Schreyer, 1994) that both yield stress and Young's modulus are monotonically decreasing functions of the temperature. Accordingly, the temperature dependence of material properties, e.g. yield stress and Young's modulus, cannot be neglected if cyclic thermal loading are high amplitude (e.g. Oueslati and de Saxcé, 2009; Hasbroucq et al., 2010).

As illustrated in literature (e.g. Vu and Staat, 2007; Chen et al., 2014), the shakedown limit is overestimated if temperature dependence of yield stress is neglected. It is also observed (Peigney, 2014) that temperature-dependent moduli change the mathematical nature of the evolution problem.

The paper is to contribute to analytical formulation and numerical implementation for static and kinematic shakedown analyses involving temperature-dependent properties. First, it is to establish static and kinematic formulations for shakedown analysis of structures with temperature-dependent elastic modulus and yield stress. Second, numerical effort will be made to develop algorithms based on the computing tool MATLAB for static and kinematic shakedown analyses involving temperature-dependent elastic modulus and yield stress. Finally, the step-by-step finite-element analysis by using ABAQUS is also performed to verify the analytical formulation and numerical implementation.

Keywords: **Shakedown analysis**, **Temperature-dependent properties**.

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