Efficient 3D virtual elements for finite strain thermo-plasticity

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ABSTRACT

This work outlines an efficient low-order virtual element scheme for the coupled thermo-mechanical response undergoing large deformations. The virtual element method (VEM) has been developed over the last decade and applied to problems in elasticity for small strains and other areas in the linear range. Enlargements of VEM to problems of compressible and incompressible nonlinear elasticity and finite plasticity have been reported in the last years[2,3,4,5]. This work is further extending VEM to problems of finite strain thermo-plasticity [1] and considers details of its numerical implementation using the software tool AceGen [6]. The various formulations presented are based on minimization of energy, with a novel construction of the stabilization energy for the coupled problem. The formulation performance is underlined by means of representative examples. For comparison purposes, results of different finite element discretization schemes (FEM) are also demonstrated.

In this work we present an efficient 3D virtual element scheme for coupled thermo-mechanical plasticity under large deformations. To this end, we introduce a micromorphic approach to gradient thermo-plasticity model at finite strains. The key point is the introduction of dual local-global field variables via a penalty method, where only the global fields are restricted by boundary conditions. Hence, the problem of restricting the gradient variable to the plastic domain is relaxed, which makes the formulation very attractive for implementation, see [1,2]. In the presented contribution, the recently developed virtual element method (VEM) will be used, because of the flexible choice of nodes number in an element which can be changed easily during the simulation process, as addressed in [3,4]. Thus, the potential energy is formulated in terms of suitable polynomial functions, instead of computing the unknown shape functions for complicated element geometries, e.g. arbitrary convex or concave polygonal elements. The modeling capabilities and algorithmic performance of the proposed formulation is demonstrated by a number of numerical examples.

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