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APPLICATION OF GAUSS-KRONROD QUADRATURE INTEGRATION SCHEME WITH ENRICHEMENT IN SIMULATIONS OF HISTORY-DEPENDENT MATERIALS

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ABSTRACT

In finite element modeling of problems involving history-dependent materials, storing of the computational history of strains and stresses at the integration points is essential for accurate results. After each converged load-step, plastic strains are stored and accumulated at the integration points. This process is usually accomplished by employing Gauss quadrature integration scheme throughout the elements. However, a problem arises when the element is enriched with a new node which is common in contact problems. Enrichment of an element introduces a higher order term in the element shape functions associated with the nodes located on the interface. Thus, the order of interpolation has to be increased in the direction where the node is inserted. In hyper-elasticity, this process is usually accomplished by increasing the order of the Gauss integration scheme, thus introducing new integration points. However, this is not the case in simulating a history-dependent material, where the accumulated plastic strains data at the integration points must be preserved before enrichment.

In this paper, Gauss-Kronrod quadrature rule is applied to extend the applicability of the Enriched Discontinuous Galerkin Approach (EDGA) for plasticity. Gauss-Kronrod quadrature inherits Gauss points locations and provides an additional set of integration points that lays between the original Gaussian quadrature. When the enrichment is introduced and Gauss-Kronrod integration points are inserted, the values of the plastic variables at the new integration points can be computed by interpolation/extrapolation from the existing values using the element shape functions. To verify the implantation of the Gauss-Kronrod Integration Scheme, the patch test is used for a single Q4 element under uniaxial tension. The results showed that the Q4 element with Gauss-Kronrod quadrature integration points passes the patch test and reflects a constant stress distribution exactly, and also a consistent deformed shape with exact solution.

Keywords: Gauss-Kronrod Quadrature; History-dependent materials; Enrichment, Contact.

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