Analysis of Timoshenko smart beams with piezoelectric materials using a mesh free multiquadric radial basis function method

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ABSTRACT

Piezoelectric structural systems have been widely analyzed with finite element approaches and are receiving growing attention from the scientific community for their diverse applications, from composite smart materials to nano-electro-mechanical sensors and actuators. In the present work, a global interpolation scheme is proposed to describe the electro-mechanical static responses of piezoelectric smart beams operating as sensors and actuators. The deflection of a cantilever bimorph beam and a three-layered smart beam was investigated considering applied electric potential on the surfaces in the actuator configuration. For the sensor configuration, the distribution of developed electric potential was studied for the aforementioned beams under mechanical loads. The governing equations were derived by the application of Hamilton's principle and were subsequently solved using a grid free method based on Hardy's multiquadric radial basis functions [1]. The method relies on the Euclidean distance between nodes and on a shape parameter which must be warily selected to avoid matrix ill-conditioning. Unlike the traditional finite element or finite difference methods typically employed to solve partial differential equations, this global interpolation scheme is simpler to implement for its insensitivity to spatial dimension while presenting very accurate results [2]. The free undamped flexural vibration problem was later addressed using a radial basis function finite difference local interpolation (RBF-FD). Natural frequencies and mode shapes were studied considering closed and open-circuit boundary conditions and the time domain and frequency domain responses were then investigated considering a constant gain velocity feedback control system.

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