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The Dynamics of a 3D Vibrating and Rotating Disc Gyroscope

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Abstract : Conventional configuration of the vibratory disc gyroscope is based on in-plane non-axisymmetric vibrations of the disc with a prescribed circumferential wave number. Due to the Bryan's effect, the vibrating pattern of the disc becomes sensitive to the axial component of inertial rotation of the disc. Rotation of the vibrating pattern relative to the disc is proportional to the inertial angular rate and is measured by sensors. In the present paper, the authors investigate a possibility of making a 3D sensor on the basis of both in-plane and bending vibrations of the disc resonator. We derive equations of motion for the disc vibratory gyroscope, where both in-plane and bending vibrations are considered. Hamiltonian variational principle is used in setting up equations of motion and the corresponding boundary conditions. The theory of thin shells with the linear elasticity principles is used in formulating the problem and also the disc is assumed to be isotropic and obeys Hooke's Law. The governing equation for a specific mode is converted to an ODE to determine the eigenfunction. The resulting ODE has exact solution as a linear combination of Bessel and Neumann functions. We demonstrate how to obtain an explicit solution and hence the eigenvalues and corresponding eigenfunctions for annular disc with fixed inner boundary and free outer boundary. Finally, the characteristics equations are obtained and the corresponding eigenvalues are calculated. The eigenvalues are used for the calculation of tuning conditions of the 3D disc vibratory gyroscope.

Keywords : Bryan’s effect, bending vibrations, disc gyroscope, eigenfunctions, eigenvalues, tuning conditions
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