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MOTION OF A FRICTION BELT DRIVE WITH TRANSVERSE DEFLECTIONS AND EVOLUTION OF CONTACT ZONES AT MIXED EULERIAN-LAGRANGIAN KINEMATIC DESCRIPTION

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Mechanical response of axially moving structures has been a subject of research since decades. The modern computational methods and advances in the theories of structural mechanics gave rise to the new modelling approaches, which allow solving challenging problems and considering effects, which were not accessible previously.

The established theories of such thin mechanical structures as strings, rods, plates and shells feature the conventional Lagrangian (material) kinematic description. The latter is inefficient for axially moving deformable bodies, when the material particles travel between qualitatively different domains of the system [1,2]. Problem specific non-material kinematic descriptions simplify the analysis. The reformulation of a specific structural mechanics theory is particularly non-trivial in problems with large deformations and switching contact conditions.

In the present contribution, we focus on the finite element model for the motion of a flexible belt in a two-pulley belt drive. At weak pre-tension, the gravity force largely deforms the free spans and essentially affects the domains of contact with pulleys. Consistent numerical treatment of the dry friction law with switching between slip and stick is challenging at mixed kinematic description, which features a problem-specific coordinate system. With the material coordinate and transverse deflections as functions of the circumferential coordinate along the undeformed contour of the belt, we uniquely define its configuration at any instant of time. In the quasistatic analysis, we sequentially seek equilibria by minimizing the total energy of the system for each time step. The kinematic conditions in the zones of sticking contact with the rotating pulleys bring the belt into motion, and the evolution of the zones of slip is treated in the course of the time integration. Beginning with the academic two-dimensional example of the belt as a beam [3], we proceed to the challenging and practically relevant three-dimensional simulation of its lateral runout using a nonlinear shell model with time-varying domains of stick and slip contact on the surfaces of the rotating drums and geometrical imperfections.

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