Large-DOF MBS with Contact and Friction: Pushbelt CVT

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Explanation, simulation and validation of a mathematical model for the spatial dynamics of pushbelt CVTs
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1 Pushbelt Variator

- The variator of the transmission system comprises two pulleys and the pushbelt with approximately 400 elements and two ring packages of nine to twelve steel rings.

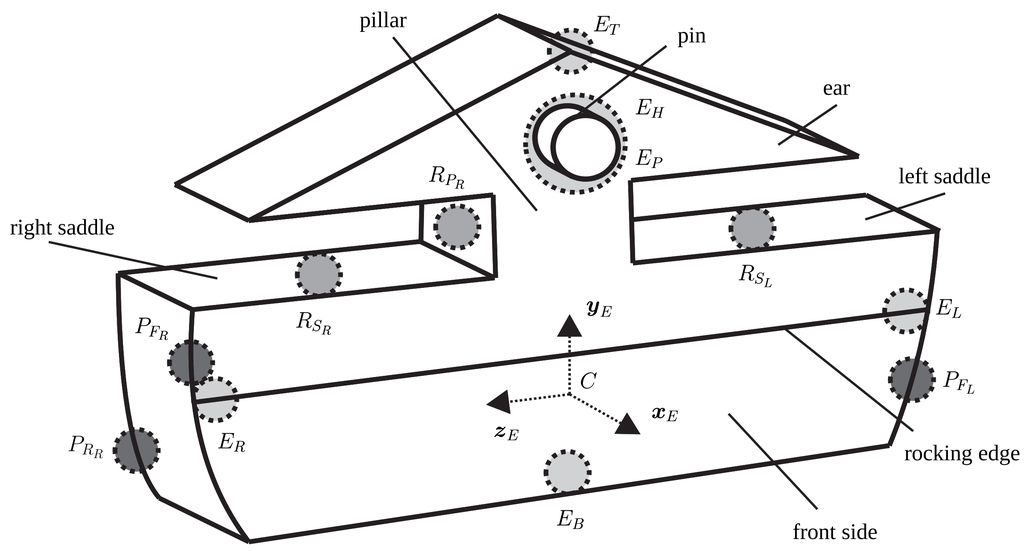
- The torque is transmitted from the input to the output pulley via friction forces between the pushbelt and the sheaves and further on via push and tension forces within the pushbelt.

2 Bodies

- The overall model of the variator is separated into the subsystems elements, ring packages and pulleys. A modular structure allows for substitutions of sub-models. The model of the pushbelt variator is characterised by a large degree of freedom (about 3500).
- The elements are modelled as rigid bodies with degree of freedom equal to six for translation and Cardan rotation.
- The two ring packages have to cope with free spatial motions including geometrically nonlinear large translations and deflections but linear material laws because of the representation of transient states. Spatial large deflection finite element beams based on co-rotational and inertial ideas are used for modelling.
- The pulleys allow for rigid tilting and axial translation of the loose sheaves as well as axial rotation in general.

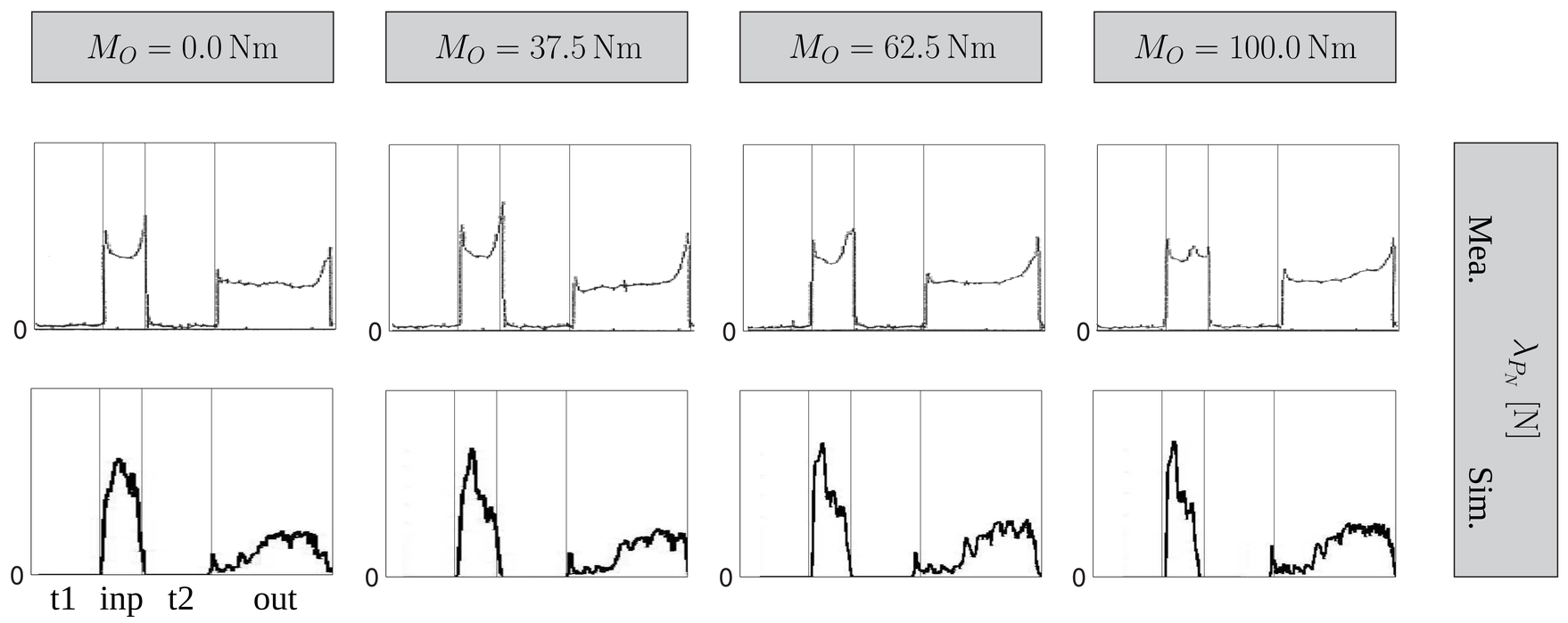
3 Contacts

- The model of the pushbelt variator is characterised by numerous contacts (about 5500).
- The shape of the left and right body side of the elements are represented by two circular arcs. The sheaves have frustum contour. For the element-pulley contact, the normal direction is unilateral and linearly flexible representing the axial stiffness of the elements. Friction is described by a three-dimensional Stribeck law.



- Neglecting the rotational influence between the elements and the ring packages, two contact points in the middle of the element saddles and at the element pillar define the contact behaviour of the elements. The respective counterpart is a flexible band parametrised according to the neutral fibre of the ring packages. The contact law is bilateral with planar Stribeck friction.
- Between two adjacent elements, contact points are defined at the top and the bottom, as well as a contact circle is given at the rocking edge. These contours interact with the planar rear side. The pin-hole contact is described with two circle-frustum configurations. A frictionless, flexible and unilateral contact law is chosen.

4 Validation: Pulley Normal Force



- Measured (top row) and simulated (bottom row) pulley normal forces as functions of the reference path are represented at increasing load torque levels up to 100 Nm for underdrive transmission ratio and primary angular velocity $100\pi\,{}^{1}/_{\mathrm{s}}$.
- Overall a good match between measurements and simulation has been achieved.

SCHINDLER, Thorsten: *Fortschritt-Berichte VDI : Reihe 12, Verkehrstechnik, Fahrzeugtechnik*. Vol. 730: *Spatial dynamics of pushbelt CVTs*. als Manuskript gedruckt. Düsseldorf : VDI Verlag, 2010. – `http://mediatum.ub.tum.de/node?id=981870`.

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