VERIFICATION OF A TRANSMISSION SYNCHRONIZATION MODEL

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Motivation

A computational model of the gearshifting mechanism may speed up the development of a new gearboxes. However, such model should be verified against other models as well as validated against experiments to ensure reasonable accuracy. In this contribution, results from the developed mathematical model [1] of a generic synchronizer (gearshifting mechanism) against the model in [2] is presented. The mathematical model is based on constrained Lagrangian formulism (CLF) and the generic synchronizer is consist of engaging sleeve, synchronizer ring and the gearwheel with dimensions relevant to that of a heavy truck.

Gearshifting process

Presynchronization, main synchronization, blocker transition and engagement are mainly four phases of the gearshifting process and further divided into eleven sub-phases as shown in Figure 1. During phase 1 the fluid is squeezed out between the cones and the ring get axial indexing position. Speed difference reduces during phase 2 while the sleeve has no translational movement. During phase 3 the ring get angular indexing position and the engaging teeth get indexing position to initiate the engagement. The engagement teeth come in full contact during phase 4.

Verification

The shift force (F_s) is applied and the sleeve rotational speed (θ_s) as well as axial displacement (x_s) and the gear rotational speed (θ_g) are obtained from the CLF based model as shown in Figure 2. Fluid friction in phase 01 and coulomb friction in phase 02 is used in [1] but in [2] a model of dry friction is used which causes the difference between solid and dotted lines of θ_g as shown in Figure 2.

Equations

The CLF based model is given below

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\mathbf{q}}}\right) - \frac{\partial L}{\partial \mathbf{q}} + \left[\frac{\partial \boldsymbol{\Phi}}{\partial \mathbf{q}}\right]^T \boldsymbol{\lambda} = \boldsymbol{Q}^A \qquad (1)$$
$$\boldsymbol{\Phi}(\mathbf{q}, \mathbf{t}) = \mathbf{0}$$

where $\mathbf{q}$ is vector of generalized coordinates, $L\,(\mathbf{q}, \dot{\mathbf{q}})$ is Lagrangian, $\boldsymbol{Q}^A$ is a vector of generalized forces due to non-conservative applied loads, $\boldsymbol{\lambda}$ is Lagrange multiplier vector and $\boldsymbol{\Phi}$ is holonomic kinematic constraints.

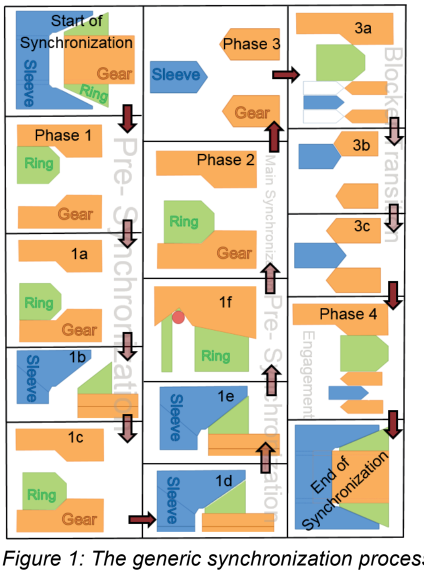

Figure 1: The generic synchronization process.

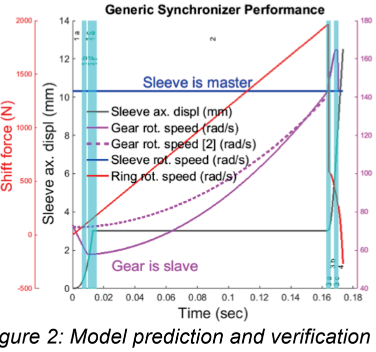

Figure 2: Model prediction and verification of gearshifting performance.

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References

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[2] D. Häggström, et al., Predicting friction in synchronizer systems, Tribology International, vol. 97, pp. 89-96, 2016.