The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Efficient Assessment of Noise Transmission Through Highly Flexible Slender Structures

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Keywords: *Cosserat rod, Linearization, Mechanical impedance*

The development of battery-electric vehicles is accompanied by new cooling concepts. As a consequence, existing hose assemblies are modified or additional hoses must be introduced. Finding a conflict-free hose routing in nowadays very narrow design space is already a non-trivial task. Additionally, one aims to produce the hose with certain pre-curvatures, such that the transmission of noise into the vehicle cabin is reduced.
To efficiently support this routing in early, purely virtual stages of the product development, we suggest the computation of mechanical impedance [1], starting from a geometrically non-linear Cosserat rod model with a staggered grid discretization [2]. Typically, we use this Cosserat rod model for transient simulation with large deformation at moderate frequencies, where the geometric non-linearity is essential. Now, we linearize the equations of motion at a static equilibrium state by applying algorithmic differentiation [3] and use the resulting system matrices to compute the mechanical impedance $\mathbf{Z}(\omega)$ in the frequency domain. However, it is benefitial to start from a geometrically non-linear model, since this allows to consider large deformations in the equilibrium state and still is correct.
Depending on the application case, one may directly study entries of the impedance matrix $\mathbf{Z}(\omega)$ to understand the transmission of uniaxial excitations. Alternatively, if the excitation vector $\hat{\mathbf{u}}(\omega)$ is known, one can compute $\hat{\mathbf{f}}(\omega) = \mathbf{Z}(\omega)\hat{\mathbf{u}}(\omega)$ and consider the force and moment response at hose connectors of interest. First numerical experiments are promising and reflect well-known effects of certain pre-curved hoses. Current work focusses on sensitivity studies to deduce most relevant model parameters, which is particularly important for industrial applications.

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