Potential of friction to damp vibrations in the use case of a car tailgate

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Abstract

In modern cars, background noise is a common issue, and it is expected to become more pronounced as vehicles, particularly those with electric powertrains, become quieter, making it easier for passengers to detect disturbing sounds. This phenomenon, known as NVH (noise, vibration, and harshness), is often addressed by introducing additional mass into the structure, which reduces vibrations or shifts them to other frequencies. However, this method may not be sustainable in the long term.

In this study, we explore the possibility of damping vibrations through energy dissipation based on friction. We test the concept of damping through friction in the tailgate of a commercially available car, where a mass-based vibration damper is currently installed. We aim to replace the mass damper with small friction elements that can be distributed throughout the structure of the tailgate. This study investigates whether damping can be achieved through dissipated energy based on friction, which could provide a more sustainable solution to the NVH problem in cars.

However, the ideal contact conditions of the friction elements must be found for the application. For example, little energy is dissipated at low relative displacements or high contact pressures. The contact is in the so-called stick. However, if it is possible to adjust the contact so that a certain threshold value for the relative displacement is exceeded or a certain contact pressure is undershot, the contact can start to slide. In sliding the dissipated energy due to friction is significantly higher.

A design with screws was developed as friction elements. With the screws, a contact pressure can be specifically set by means of different tightening torques. As the relative displacement cannot be actively influenced, the contact pressure, i.e. the tightening torque, must be used to ensure that the contact can start to slide and thus dissipate energy. In order to test the concept, experiments were carried out on a geometrically simplified model of the tailgate.

For this purpose, a friction element in the form of a plate with screws was inserted into

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the model of the tailgate. The screws were mounted with four different tightening torques and the entire tailgate model was excited on a shaker. Acceleration sensors were used to measure the reaction of the tailgate model to this excitation of the shaker. Under a certain tightening torque, there is a reduction in the acceleration amplitude at the frequency relevant for the interference noise. It was also assessed whether an increase in the number of friction elements leads to a further reduction in the acceleration amplitude. For this purpose, three friction elements were used instead of just one.

In order to be able to better estimate the damping potential, tests were also carried out with similar materials on a Fretting tester. Here, the frequency responsible for the interference noise can be specifically stimulated. In addition, measuring the relative displacement in the contact and the frictional force in the experiment allows the energy dissipated by friction to be calculated. An energetic comparison between a contact in sticking and sliding is possible.