As part of the model-based research approach selected by the world-leading steering systems supplier, JTEKT Co., the current project aims to fulfill the need for understanding turning dynamics as well as to provide fast and reliable models in the perspective of future mixed mechanical and control optimization approaches.

To achieve these goals, it focuses on three different axis: the kingpin model, the compliant elements modeling and the McPherson suspension model.

**Kingpin Model**

The kingpin model focuses on the lower part of the steering system, from the rack bar to the kingpin axis. Illustrated in the nearby figure, it was simplified to a rigid approach and compared both to a simulation program and actual test bench measurement. The results showed superimposed curves for the simulation case (not displayed), but exhibited a regular difference in the case of the experimental normalized kingpin torque. This difference has been assessed (negligence of friction, geometric and gain calibration), thus leading to coherent results.

**Compliant Elements Modeling**

The main elements considered are the bushings, which consist in a compliant rubber central part surrounded by inner and outer stiff metal cylinders. Their modeling is justified as they are widely used in mechanical systems, especially in automotive and rail industry and their influence on the steering performance of the vehicle is of major importance.

The results show performant identification and simulation approach with respect to the reference data. Similarly, a noise-robust improved model was implemented, thus suited for experimental data-based simulation.

**McPherson Suspension Model**

Being able to maintain a minimum computation cost, the model of the McPherson suspension considered allowed the computation of kinematic, static and dynamic behavior. The 3D visualization of the displacements, velocities and accelerations exhibit excellent coherencies.

Static elements also exhibited superimposed curves with the kingpin model, and dynamics generated coherent results (not displayed). The geometry parametric analysis highlighted the dependency of the geometric and dynamic indicators with respect to the ground level.

The important coupling highlighted the need for the study of suspension for steering dynamics, as well as for various automotive-applied control methods for steering systems.

**Conclusion**

This project has been able to provide fast and reliable models, which led to a considerable increase in terms of turning dynamics knowledge at JTEKT Co. However, in many cases, validation is only partial and remains to be completed. Nevertheless, validating and combining the results of the different models, along with further research including other elements such as tire, wishbone, torsion bar and improved spring and damper models will allow to develop JTEKT turning dynamics knowledge for product improvement, research and innovation.

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