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Evaluation of Motor In-wheel Behavior in Loss-of-contact Scenarios and Analysis of Potential Measures for Performance Improvement

Javier Cuadrado*, David Vilela*, Alberto Luaces*, Francisco Mouzo*, Adrián Martín#, Iñaki Iglesias#, Alberto Peña#

* Laboratorio de Ingeniería Mecánica
University of La Coruña
Mendizábal s/n, 15403 Ferrol, Spain
javicuad@cdf.udc.es

Industry and Transport Division
Tecnalia Research and Innovation
Edif. 202, 48170 Zamudio, Spain
alberto.pena@tecnalia.com

Abstract

Motor in-wheel (MiW) configuration presents advantages for electric-powered vehicles over conventional standalone motor configuration, like improved modularity when designing different drivetrains (FWD, RWD, AWD) and increased usable interior space of the vehicle. However, the increased unsprung mass can lead to drawbacks in ride and/or handling behavior and represents a challenge for suspension designers since no previous similar data are available.

In a previous work [1], the authors modeled a typical B-segment car, a Fiat Punto, featuring a MiW configuration with front wheel drive lay out, which was subject to three simulated tests -sine sweep, obstacle avoidance and constant radius- so as to obtain indicators of ride and handling performances. Results revealed that handling characteristics of MiW configuration were similar to those of the conventional one, while ride was slightly degraded, particularly at high frequencies of excitation.

In this work, the authors address a study (already announced as future research in the previous work), which consists of evaluating the behavior of the MiW configuration when wheels lose contact with the ground, i.e. in the presence of bumps or holes combined with high speed cornering, and analyzing potential alternatives for improvement in case relevant degradation is demonstrated.

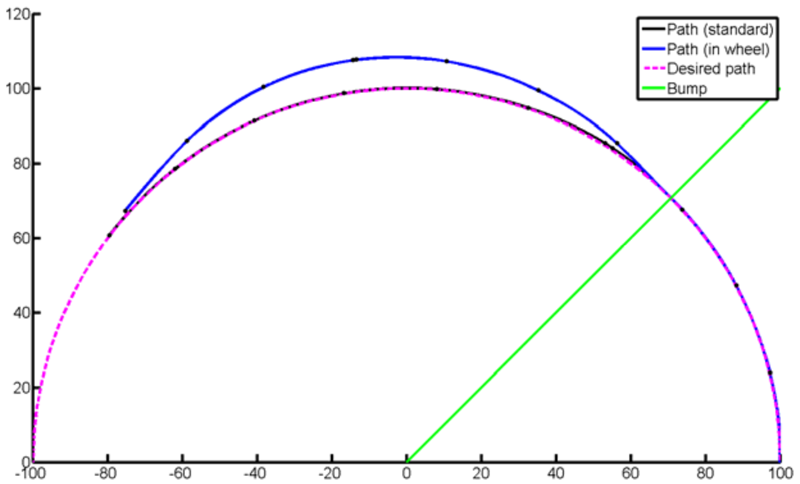

Figure 1: Trajectories of MiW and conventional configurations at 25 m/s.

In order to carry out the mentioned objective, the same computational multibody model of the car as that described in [1] is used. The car must follow a circular trajectory of radius 100 m, finding a transversal bump when at 45º of the circular arc. The bump is represented as a green line in Figure 1, and its shape corresponds to the upper 10 cm of a circle of radius 1 m, as illustrated in Figure 2.

Figure 2: Bump shape.

A smart driver is implemented to so as to mimic the average driver's behavior. Simulations are run for the car performing the maneuver at different speeds, ranging from 20 m/s to the vicinity of the critical speed, which is 28.014 m/s for the given trajectory, assuming a friction coefficient of 0.8. The trajectories of MiW and conventional configurations for 10-second simulations at a speed of 25 m/s are drawn in Figure 1. As it can be observed, MiW suffers a much higher drift from the desired trajectory after passing over the bump, thus pinpointing the worse behavior of that option in loss-of-contact scenarios. Figure 3 shows, as comparison, the superposed images of the two configurations after some instants from passing over the bump, where the understeer behavior can be clearly seen. Additionally, the effect of having the motors installed at the rear wheels combined with this demanding case is evaluated as well.

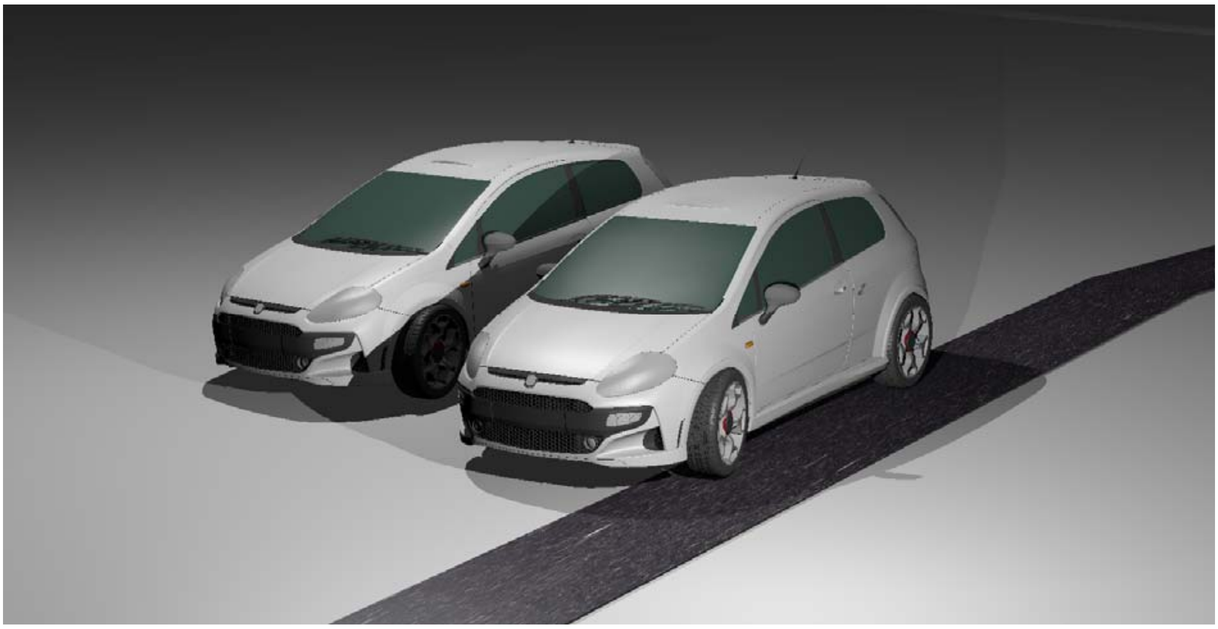

Figure 3: A picture of MiW and conventional configurations after passing over the bump.

At the view of the degraded behavior of the MiW configuration, some measures for compensation are analyzed in the work. First, the suspension parameters are set to different values, corresponding to standard and sport driving configurations, and their effect on the car behavior is studied. Then, an adaptive suspension system is also tested. Finally, different strategies of torque control are implemented, as independent braking or torque vectoring. Such compensation measures are likely to be included in future MiW vehicles, not requiring expensive equipment in vehicle or excessive complexity.

References

[1] Cuadrado, J.; Vilela, D.; Iglesias, I.; Martin, A.; Peña, A.: A Multibody Model to Assess the Effect of Automotive Motor In-wheel Configuration on Vehicle Stability and Comfort. In Proceedings of ECCOMAS Thematic Conference Multibody Dynamics 2013, Zagreb, Croatia, 1-4 July, 2013.