International Journal of Automotive Technology, Vol. 8, No. 6, pp. 745−752 (2007)

1229−9138/2007/037−09

EFFECT OF THE FLEXIBILITY OF AUTOMOTIVE SUSPENSION COMPONENTS IN MULTIBODY DYNAMICS SIMULATIONS

J.-Y. LIM, W.-J. KANG*, D.-S. KIM and G.-H. KIM

Structural Durability Research Center, Korea Automotive Technology Institute, 74 Yongjeong-ri, Pungse-myeon, Cheonan-si, Chungnam 330-912, Korea

(Received 23 February 2007; Revised 19 October 2007)

ABSTRACT−In this study, the effects of flexible bodies in vehicle suspension components were investigated to enhance the accuracy of multibody dynamic simulation results. Front and rear suspension components were investigated. Sub-frames, a stabilizer bar, a tie rod, a front lower control arm, a front knuckle, and front struts were selected. Reverse engineering techniques were used to construct a virtual vehicle model. Hard points and inertia data of the components were measured with surface scanning equipment. The mechanical characteristics of bushings and dampers were obtained from experiments. Reaction forces calculated from the multibody dynamics simulations were compared with test results at the ball joint of the lower control arm in both time-history and range-pair counting plots. Simulation results showed that the flexibility of the strut component had considerable influence on the lateral reaction force. Among the suspension components, the flexibility of the sub-frame, steering knuckle and upper strut resulted in better correlations with test results while the other flexible bodies could be neglected.

KEY WORDS : Multibody dynamics simulation, Virtual testing laboratory (VTL), Flexibility, Suspension

1. INTRODUCTION

Virtual engineering is one of the powerful design methodologies in the automotive industry because it reduces the cost and period of vehicle development. The multibody dynamics model of a vehicle has much utility in the virtual design process. Although it can be applied to the design of crashworthy structures, ride-handling and durability are the major fields of applications (Dias and Pereira, 2004; Kim *et al*., 1996; Yi, 2000). The reaction force on each component can be evaluated under various driving conditions and, hence, it is possible to predict the durability of automotive parts at a very early design stage. However, a more rigorous and accurate reaction force should be guaranteed for the durability evaluation than the one for the ride and handling analysis since the amplitude of the load history is very sensitive to the fatigue life of an automotive part; see Ellyn (1997). The multibody dynamics model of a vehicle consists of rigid bodies connected to each other with non-linear force elements and joint constraints that limit the motion of the rigid bodies. The proper mechanical characteristics of the force elements, such as dampers and elastomeric bushings, need to be taken into account in the model. Cho and Choi (2007) analyzed the ride quality according to the non-linearities of suspension parameters and found the effect of the dynamic viscosity of oil.

Virtual technology in a point of vehicle durability can be divided into two categories: Virtual Testing Laboratory (VTL) and Virtual Proving Ground (VPG). The primary difference between the two is the method for the generation of wheel forces in the vehicle model. The former needs the direct input of wheel forces acquired from driving tests while the latter calculates the wheel forces at the contact interfaces between the tires and road. Although the VTL concept has the disadvantage of measuring or estimating wheel forces, the results are much more reliable than that of the VPG concept, which needs an accurate tire model as well as road surfaces. Mousseau *et al*. (1999) coupled the multibody dynamics model of a vehicle with a finite element tire model by a parallel processing algorithm for the VPG. Figure 1 shows examples of the two methodologies.

For fast computation as well as fast modeling of a virtual vehicle, it is generally useful to consider suspension components as rigid bodies since the elastic deformations of the components are small in comparison with elastomeric components. However, some errors can possibly be imposed on the simulation results if elastic bodies are taken as rigid bodies which have no elastic deformations and vibrations.

**Corresponding author.* e-mail: wjkang@katech.re.kr