Analysis of a Variable Geometry Active Suspension

Willem-Jan Evers**, Albert van der Knaap*, Igo Besselink*, Henk Nijmeijer*

* University of Technology, Eindhoven, The Netherlands
Fax: +31 402461418
Email: W.J.E.Evers@tue.nl
Email: H.Nijmeijer@tue.nl

** Corresponding author.

Abstract

The use of actuators in vehicle suspensions is not very common. When looking at passenger cars, it can be seen that the majority uses suspensions with passive spring and damper elements. However, the benefits of active suspension systems over passive systems are clear, [1]. They can be used to both increase the driver comfort and handling behavior of the vehicle.

In this study a model is presented of the variable geometry force actuator as described in [3]. Furthermore, the concept of the variable geometry force actuator is evaluated with respect to power consumption and disturbance reduction properties. Hereto, a comparison is given with a passive spring-damper suspension; a spring-damper suspension with either a hydraulic or electric actuator parallel; and a spring-damper suspension with either a hydraulic or electric actuator in series with the spring. Similar results as those presented here can be obtained using a quarter car model (two mass-spring-damper system). However, a single suspended mass is chosen here for simplicity.

The variable geometry force actuator under consideration is inspired by the Delft Active Suspension [4], with the modification that it has a fixed spring [3], see Fig. 1. The benefits of this configuration over the conventional system with rotating spring include a higher achievable bandwidth (due to the lower inertia) and better packaging (more compact system). The actuator uses a spring with stiffness $c_a$ and a certain pre-tension $F_0$. The force within this spring gives rise to a force $F_{act}$ at the end of the wishbone. This is the actuator force, which varies for different values of $\alpha$ and $\gamma$. Herein, $\alpha$ can be seen as the suspension deflection and $\gamma$ is the controlled orientation of the actuator arm with length $l_b$.

The direction of motion of the electric motor, $\gamma$, lies perpendicular to the direction of force. As such, a fictional cone is created with height $h_0$ and radius $l_b$, similar to that obtained by the Delft Active Suspension [4]. The advantage of this concept lies in the fact that with a limited amount of power (acceleration of the electric motor) a large actuator force variation can be obtained. However, this only holds as long as the wishbone (with length $l$) remains horizontal. For any $\alpha \neq 0$ a disturbance moment induced by the spring force acts on the electric motor.

The (idealized) simulation results, using a skyhook control strategy as proposed in [2] on a stochastic road, show that the performance increase with variable geometry force actuator is about the same as that of the active benchmark systems. However, the peak required power is significantly lower. As such, it is expected that the variable force actuator is (by far) more energy efficient than the active reference systems.

References