Glossary

Semi-active Suspension

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1 Semi-active Suspension

Semi-active suspension is a type of automotive suspension systems that controls the damping force of the shock absorber in response to input from the continuously varying road surfaces. It is intended to approximately implement the active suspension (to be described later) with a damping force adjustable shock absorber (hereinafter “SA”).

Semi-active suspension may be implemented by several types of control methodologies. A generally known typical technology is Skyhook control.

Fig. 1 shows a Skyhook control model. An imaginary damper (= Skyhook damper) hung from an aerial height with its end fixed there is implemented by generating a force of the sprung (vehicle body) speed multiplied by the damping coefficient C_s. A passive (= uncontrolled) damper (C_p), which is installed in parallel with the Skyhook damper (C_s), provides a force equivalent to the SOFT damping force of the damping force adjustable SA.

When this damper model is given a random input from the road surface, the relationship between the required combined damping forces of the Skyhook and passive dampers, and the relative speed (piston speed) between the sprung and unsprung components (including tires) is shown in Fig. 2 as an example. The required damping forces appear in all of the 1st to 4th quadrants.

The damping force of SA is a resistance force against the contraction. Even the damping force adjustable SA can only deliver damping forces in the 1st and 3rd quadrants. In other words, to achieve the required damping forces in the 2nd and 4th quadrants, negative damping forces must be generated. However, this is totally impossible. Therefore, in the coordinate plane of piston speed and sprung speed shown in Fig. 3, the damping force is controlled to the required level (optimum value) for the 1st and 3rd quadrants and controlled to the minimum level for the 2nd and 4th quadrants.

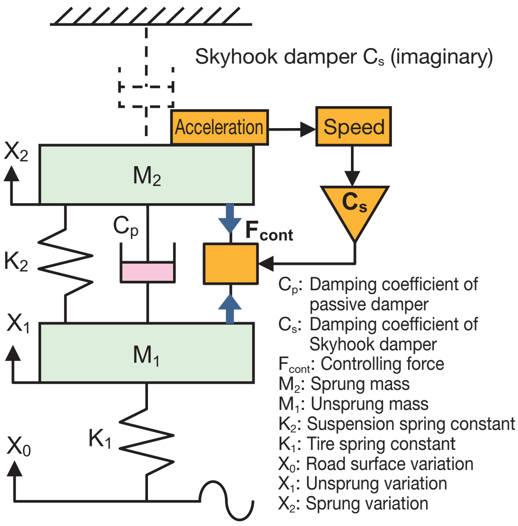

Fig. 1 Skyhook control model

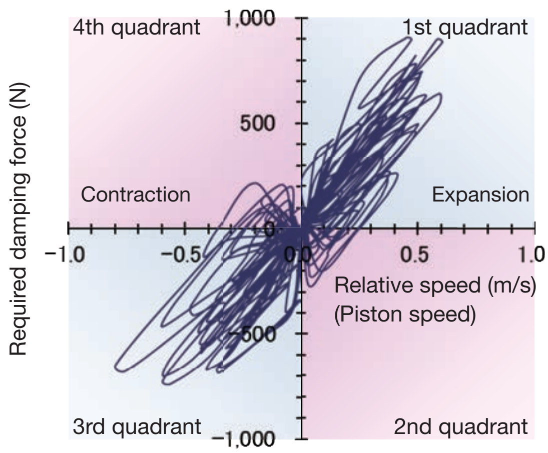

Fig. 2 Required damping force and relative speed

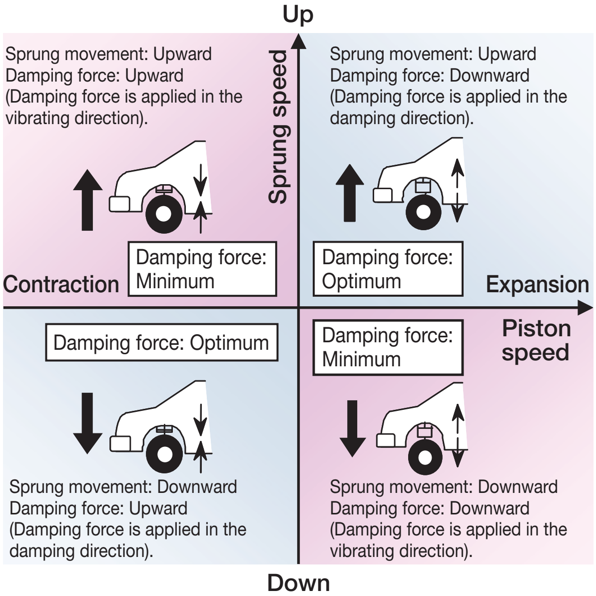

Fig. 3 Concept of semi-active control

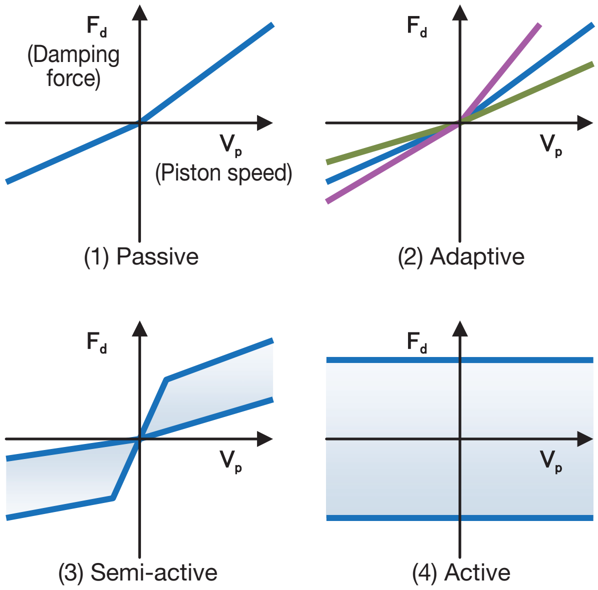

Fig.4 Potential of various systems

2 Active Suspension

Active suspension may be called ultimate suspension and provides many different functions including vibration control (Skyhook control), posture control that reduces body roll, dive and squat, steering characteristics control, and body height control.

For vibration control, active suspension can deliver desired damping forces, even in the 2nd and 4th quadrants in Fig. 2 where semi-active suspensions are unable to generate them. This difference enables active suspension to provide superior sprung damping effects.

3 Comparison Among Damping Force Control Systems

The history of damping force control systems has evolved from adaptive (adjustable), active to semi-active. These systems have their own potential, as shown in Fig. 4 when using a coordinate plane of piston speed V_p and damping force F_d.

Passive suspension using standard SA can be expressed in a single property as shown in diagram (1).

Adaptive suspension shown in (2) is the result of selection of two or more properties. Semi-active suspension shown in (3) has controllability potential in the 1st and 3rd quadrants, and active suspension in (4) has the same in all quadrants.

Active suspension can substantially reduce vibration compared to semi-active suspension with capability in the 2nd and 4th quadrants. However, this system has many drawbacks including large equipment size. Currently more and more vehicles use semi-active suspension.

References

(1) MASAMURA: History of Control Suspensions, KYB Technical Review No.47 (October 2013).