A Model of Two Types of Leveling Valve

Kazuyuki SHIMOZAWA
Senior Researcher, Vehicle Dynamics, Vehicle Structure Technology Division

The automatic leveling valve (LV) is one of the components of the air spring system which automatically maintains the floor height of a railway vehicle at a certain level. Two types of leveling valves, called LV-4 and LV-7, are used in Japan. The LV-4 has the neutral zone and a time lag. The LV-7 has a throttled air flow around the neutral position. In order to investigate the dynamics of a vehicle passing through a curve at low speed, it is necessary to consider a model of the leveling valve.

To create a model, the functions of the mechanical structure and the air flow have to be separated. A spring with the initial load and a single action damper featuring a time lag are built into the LV-4. Using the indicator, the mechanical structure of the LV-4 is as shown in Fig. 1. When the indicator moves away from the neutral position, the damper takes effect. The delay time is defined as the time from the air spring exceeding the neutral zone to the moment when the leveling valve starts to work. When the air spring moves slowly, the delay time is about 10 msec without the initial load. But there is no delay time when the initial load is applied. On the other hand, if the air spring moves quickly and the displacement of the air spring is the same as the height when the time lag is measured, the delay time converges towards the time lag. However, if the displacement of the air spring is shorter than the height when the time lag is measured, the delay time is longer than the time lag. The mechanical structure of the LV-7 is a simple model as shown in Fig. 2, because there is no time lag.

It is assumed that the characteristic of the air flow rate through the leveling valve is the same as the orifice. After the end of the time lag and when the indicator has passed the neutral zone, the characteristic of the flow rate of the LV-4 rises sharply, forming a step shape. Thinking about the pressure condition when the leveling valve works, the flow rate through the LV-4 is proportional to the pressure of the upstream air flow. The characteristic of the flow rate of the LV-7 is proportional to the displacement of the air spring, because it has a throttled air flow and no time lag.

Using two models of these leveling valves, a simulation of the vehicle running through a sharp curve at low speed was carried out. The roll angle of the vehicle on the curve became constant, because the LV-4 worked only in the start of the transition curve. And on the straight section of line after the train had passed through the curve, the vehicle tilted by an angle of a few degrees because of the neutral zone. The roll angle of the vehicle on the curve changed, because the LV-7 worked when the train was traversing the curve. Moreover, on the straight section of line after the curve the roll angle of the vehicle decreased gradually, because the LV-7 works continuously.

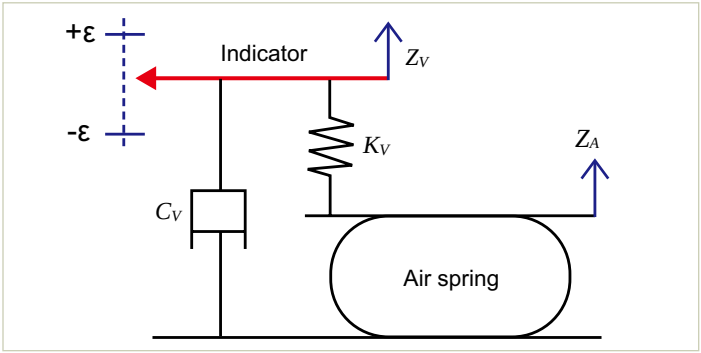

Fig. 1 The mechanical structure of LV-4

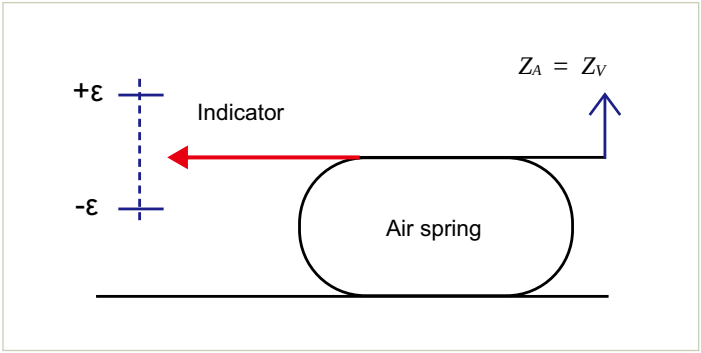

Fig. 2 The mechanical structure of LV-7