Evaluation Method of Vehicle Steering Characteristics under Straight-Driving with Disturbance

Reon Suzuki[1] Masato Abe[1] Yoshio Kano[1] Masaki Yamamoto[1] Ikuo Kushiro[1] Makoto Yamakado[1] Haru Saitou[1] Kai Utsumi[1] Jun Ishio[2]

1) Kanagawa Institute of Technology, Graduate School of Engineering
1030 Shimo-Ogino, Atsugi, Kanagawa, 243-0292, Japan
2) Honda Motor Co., Ltd.
4630 Shimotakanezawa, Haga-machi, Haga-gun, Tochigi,321-3393, Japan

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The authors have previously proposed a driver model based handling quality evaluation method for lane change maneuvers using the identified driver parameter τ_L as an unified measure for the evaluation ("Lane change τ_L"). Based on the above previous method, in this study, the handling quality evaluation available for the vehicle motion due to corrective steering during a straight line driving with disturbance has been proposed ("Disturbance τ_L").

The block diagram of the driver-vehicle system during straight running is shown in Fig.1. The steering angle of the driver model δ_h is described as

$$\delta_h = -\frac{h}{1+\tau_L s}(1+\tau_h s)$$

A difference between measured steering angle δ_h^* and δ_h is

$$\delta_h^* - \delta_h = \delta_h^* + \frac{h}{1+\tau_L s}(1+\tau_h s)$$

So, a following error ε is defined:

$$\varepsilon = (1+\tau_L s)(\delta_h^* - \delta_h) = (1+\tau_L s)\delta_h^* + h(1+\tau_h s)y$$

In order to find driver parameter h, τ_L, τ_h to make the difference between δ_h^* and δ_h small as much as possible, the following criterion function is defined:

$$J = \int_0^T \varepsilon^2 dt = \int_0^T \left[(1+\tau_L s)\delta_h^* + hy + h\tau_h \frac{dy}{dt}\right]^2 dt$$

It is possible for us to find the parameters h, τ_L, τ_h which minimize J. The parameters to be found are called here the identified parameters and, as is the same in the previous method, the identified parameter τ_L is regarded as the measure of the handring quality evaluation. Larger the value of τ_L, the higher the vehicle handring quality is. Using a driving simulator, the time histories, δ_h^* and y, needed for the identification are measured in this study during the driver-vehicle running on the driving course with the pulse type of lateral force and yaw moment disturbances as shown in Fig.2.

The results of the evaluation are shown in Fig.3 by the identified τ_L for the vehicles of both good handling response and deteriorated one. The same aspects of the effect of the vehicle response characteristics on the handling quality, τ_L, are obtained by the evaluation methods of "Disturbance τ_L" as well as "Lane change τ_L". Further-more, the three cases of steering-torque and steering-angle characteristics are provided as shown in Fig.4, and the effects of the width of steering hysteresis on the vehicle handling quality of the vehicles of both standard response characteristics and deteriorated ones are investigated. The results are shown by the normalized τ_L obtained by "Disturbance τ_L" method in Fig.5. It has been shown that for the standard response characteristic vehicle, relatively large hysteresis loop characteristics of the steering system is better from the handling quality view points on the other hand, for the vehicle of deteriorated response characteristics, the hysteresis width seems better to be a little bit reduced from the handling quality points of view. This view coincides with a result of the previous study obtained by one of the authors of this study.

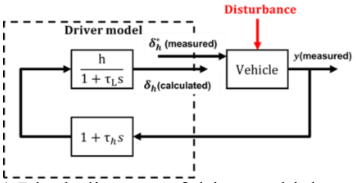

Fig.1 Block diagram of driver-vehicle system during straight running with disturbance

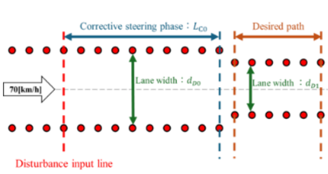

Fig.2 Driving course for evaluation tests

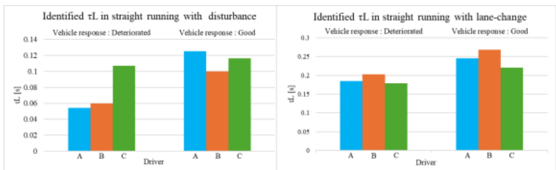

Fig.3 Identified τ_L in evaluation tests

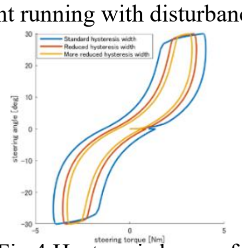

Fig.4 Hysteresis loops of steering angle to steering torque

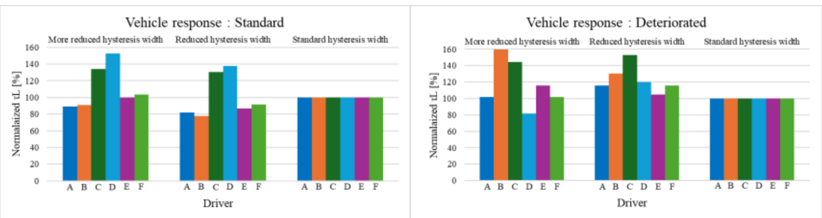

Fig.5 Normalized τ_L in evaluation tests of the effects of hysteresis width