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OBJECTIVE EVALUATIOM METHOD OF RIDE COMFORT

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The dynamic comfort of the vehicle is divided into the subjective evaluation method and the objective evaluation method which shows the quantitation value by measuring the vibration signal. The results of subjective evaluation have disadvantages not only on the reproducibility and objectivity but also the difficulty in designing directions for improvement of comfort. On the other hand, the objective evaluation method considering the characteristics of the human body and the vibration signal generated in the vehicle is consistent. By analyzing the characteristics of the vibration signal, it can be used as important information to identify the cause of hindrance of comfort. In this study, we propose a new objective riding evaluation index that replace the subjective evaluation result and verify it through correlation analysis between the subjective evaluation and the objective evaluation index obtained from the actual vehicle test.
Keywords: Ride Comfort, Vehicle Dynamics, Objective Evaluation, Correlation

1. Introduction

The riding comfort is defined as satisfaction of the vehicle body vibration caused by the excitation force generated form the engine or the road surface in the running process of the vehicle, and comfort that the rider feels. Research is underway to improve the comfort of the vehicle as the demand level of consumers gradually increases. As it`s criteria are subjective, it should be performed by combining the experimental results of various people. This subjective evaluation test has the disadvantage that there are variables due to the external conditions, and that much expense and time are consumed in the test. [1] To solve these drawbacks, RMS (root mean square), VDV (vibration dose value), and MS (mean square) [2] have been used to date, but they do not represent well the subjective evaluation. In this study, we introduce a new method that could represent evaluation based on MS, finds correlation with subjective evaluation of actual vehicle test and verifies the validity of this method by comparing with the existing method.

2. Proposal of new ride comfort index

We refer to the study of katrin strandemar for MS index, and based on this, we propose a new riding comfort index that better represents the subjective evaluation. Since the objective riding comfort evaluation index should be able to represent the subjective evaluation well, representative values of vibration for all axes were obtained to better represent subjective evaluation. The calculated vibration representative value is used to express the level of ride comfort by applying the dB scale. The procedure for obtaining the new riding comfort evaluation index overall MSL is as follows.

First, the MS index is calculated for each of nine axes (seat, backrest, footrest – X, Y, Z). Next, the overall MS index is defined by the following equation and is used as the representative value of vibration for all axes.

$$overall\ MS = (\sum MS\ of\ each\ axis^2)^{\frac{1}{2}}. \tag{1}$$

Finally, the overall MSL is calculated by the following equation as an index that evaluates ride comfort in dB scale.

$$overall\ MSL = 20 * log_{10}\left(\frac{\mathrm{A_{MS}}}{\mathrm{A}_{ref}}\right). \quad (2)$$

A_{MS} is the MS acceleration, and A_{ref} is the reference acceleration. $A_{ref} = 10^{-6}(m/s^2)^2$.

3. Experiment and correlation analysis

3.1 Emotion vibration measurement

In order to make an index for a vehicle vibration, it is necessary to measure the various vibration. In this study, a total of 9vehicles were used and idle vibration was measured using SCADAS Mobile SCM05 and Test lab of LMS. Figure 1 shows the location where vibration is measured. To reproduce the vibration of the actual vehicle, a vibration was measured while the occupant with 70kg was seated in the driver`s seat. In accordance with ISO2631-1, the vibration of the driver`s seat, the backrest and footrest was measured using a three-axis acceleration sensor, and the vibration was measured under four condition (n_off, n_on, d_off, d_on – (gear _air conditioner on/ off)). The query language was defined as “uncomfortable / comfortable” and the emotion vibration evaluation was conducted.

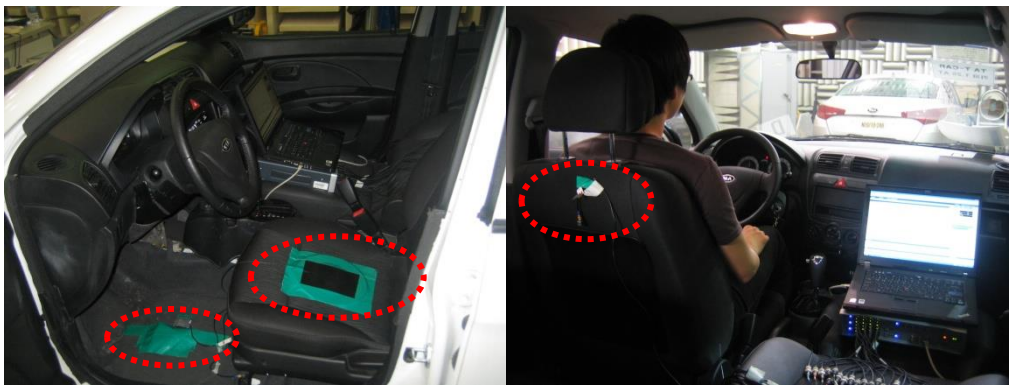

Figure 1: Location of sensors and condition to measure the acceleration of a car

3.2 Evaluation method

Table 1 results of subjective evaluation

	Subjective evaluation			
	Test 1	Test 2	Test 3	Test 4
car A	1.633	1.333		
car B	1.367	1.3	1.3	1.067
car C	2.1	2.033	1.833	1.767
car D	3.633	3.633	3.133	3
car E	2.8	2.367	3.167	3.067
car F	2.967	2.933	2.933	2.767
car G	4.433	4.567	4.867	4.8
car H	3.767	3.867	4	3.867
car I	4.1	3.967	3.1	3.733

Subjective evaluation was performed using the rating method. Subjective evaluation was performed by 26males and 4 females. Rating method was rated from 1 to 5 with Very uncomfortable, somewhat, uncomfortable, neither, somewhat comfortable and very comfortable. Table 1 shows the

subjective evaluation mean values for the comfort sense query in four conditions. In tests 3 and 4, car A is a manual gear, so subjective evaluation is excluded.

3.3 Correlation analysis

Figure 2 shows the results of the correlation analysis between the vibration element (PTP, RMS), MS and overall MSL. RMS, PTP and MS use footrest Z-axis vibration data, and the overall MSL is calculated using all measurement positions and directions. The MS and overall MSL are divided into a transient part and a stationary part. In this experiment, the vibration was measured in idle state, so the correlation was obtained using the value of the stationary part.

MS showed correlation of 71.65%, 93.94%, 67.61% and 75.78% for the four conditions. Test 2 showed high correlation but low correlation for other values. On the other hand, overall MSL showed 84.8%, 95.32%, 94.95 and 95.65% correlation. As a whole, it showed high correlation with the subjective evaluation and 11.03%, 31.5%, 15.61% improvement in the test 1, 3 and 4, compared with the vibration elements. Through this, it was verified that the overall MSL is an index that better represents subjective evaluation of various vehicle conditions than the existing vibration elements.

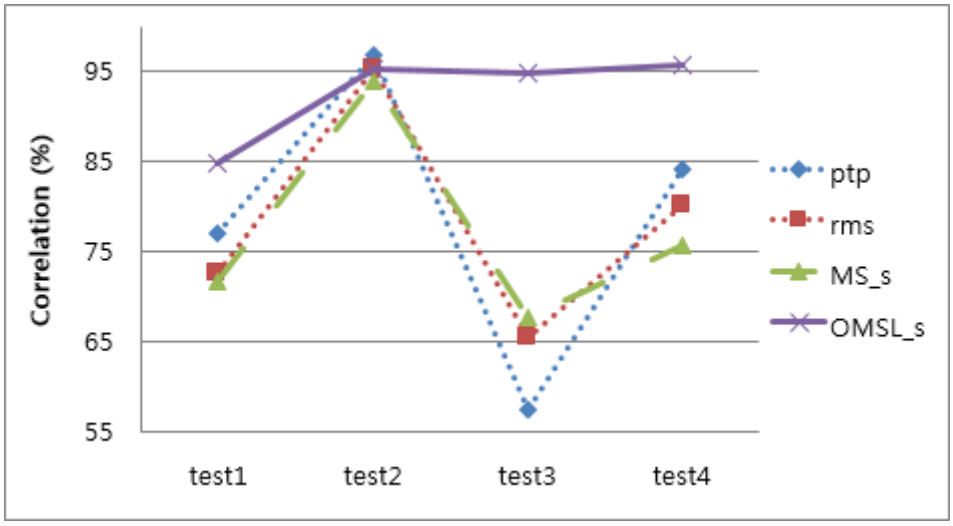

Figure 2: Correlation analysis

4. Conclusion

In this study, we proposed a new evaluation method which represents the subjective evaluation based on the MS index. The vibration of idle state was measured for four conditions. In order to evaluate the vibration of the vehicle, the query language was defined as comfort. The correlation between the subjective evaluation and the objective evaluation result was analysed. The validity of the overall MSL was confirmed by comparing with the existing riding index. Future research will evaluate and analyse ride comfort by applying overall MSL to various surface vehicles.

5. Acknowledgement

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