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Development of Performance Design Method for Electric AWD Vehicle Motion Control while Acceleration/Deceleration by using a Driving Simulator and CAE

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The electric AWD, which has two independent front and rear electric motors, can control the front and rear driving force with a high flexibility and accuracy, so that the vehicle's attitude can be controlled by the driving force. This development is a new initiative for vehicle's attitude control during acceleration / deceleration by controlling the driving force of an electric AWD vehicle. The purpose of this development is to improve comfortability for the occupants. The simulation method is widely proposed to improve the development efficiency; however the performance prediction including the human subjective evaluation is limited. The reason is that the comfortability performance prediction by using simulation is not so easy; because the human subjective feeling is too complicated to make a simulation model. When the vehicle is accelerating or decelerating, several forces are excited on to the occupant such as longitudinal motion, pitch motion, and vertical motion. Understanding of, which motion is most affected to the human subjective evaluation is a key factor to make a target vehicle behavior controlled by the driving forces. But these motions are dependent on each other. Therefore it is difficult to understand how much each of these forces affects to the occupant. This is one of the roadblock to predict vehicle performance considering occupant's comfortability.

A flowchart of our proposed design method for electric AWD system is shown in the figure 1. The driving simulator, which is able to reproduce the vehicle behavior, has been installed in Nissan Motor. The subjective sensitivity analysis, which is difficult to carry out with physical vehicle test has been carried out by using this driving simulator. In order to consider the effect of vehicle behavior to occupant, developed occupant model is used for objective analysis and mechanism analysis based on driving simulator results. After determining the objective value for occupant, the controlled variables of driving forces are determined as well, by vehicle simulation. And then the driving simulator tests and physical tests are carried out to confirm whether or not the target value is valid.

As a result of subjective sensitivity analysis by driving simulator, The longitudinal jerk which is derivative of acceleration, and pitch-rate which is derivative of pitch angle are affected to comfortability feeling; and small longitudinal jerk and pitch-rate makes the occupant comfortable. Using this result, the occupant simulation has been carried out to understand the mechanism. The simulation results shows that the occupant's muscle energy cousumption is high, as longitudinal jerk and pitch-rate increases. High jerk and pitch-rate forces occupants to unwanted body motion. The target vehicle jerk and pitch-rate are determined to keep occupant comfortable based on the results of the driving simulator and human body simulations. The physical prototype tests are carried out to verify the effectiveness of this method; The results are shown in figure 2. The acceleration difference between head and vehicle when the control to improve the comfortability, is activated is shown in blue line. And the acceleration when the control is deactivated is shown in red line. The difference between the head acceleration and vehicle acceleration is smaller when the control is activated. It means that the target value which is determined by proposed method is effective to improve the human subjective test.

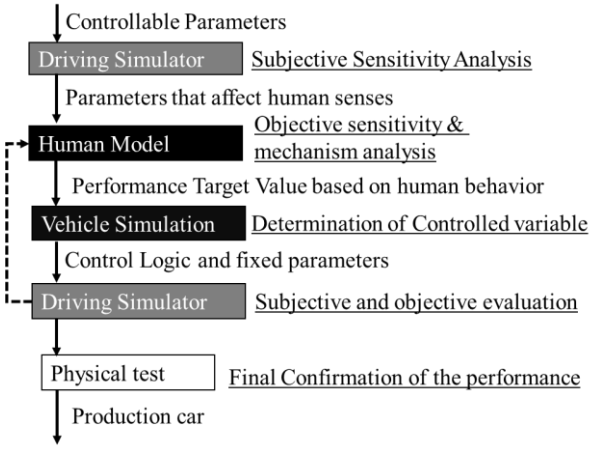

Fig.1 Performance design process

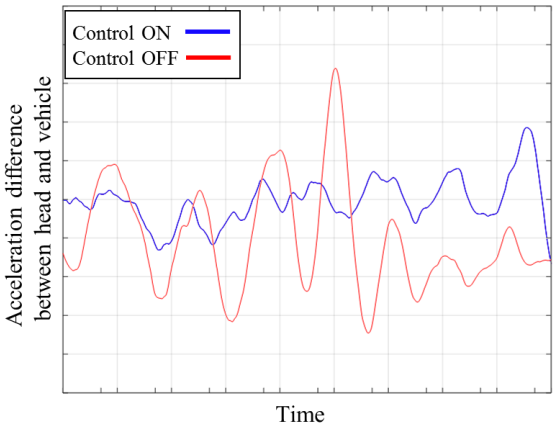

Fig. 2 The difference between head and vehicle acceleration