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Development of Method for Predicting Dynamic Behavior of Rubber Hose in Engine Compartment

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Recently, in vehicle development process, it is required to reducing the waste of resources, environmentally friendly and shortening the development term. As one of means to deal with this, reducing the number of actual vehicle test with utilize digital engineering is expected. We encourage utilization of digital engineering for development of engine compartment arrangement. Rubber hoses in engine compartment have to be designed not to interfere with other parts even when vehicle is running and the rubber hose is vibrated. However we depend on actual vehicle test to confirm it, thus we developed method that enable to predict the hose behavior by the Multi Body Dynamics.

First, we measured the relationship between load and displacement of rubber hose to figure out the stiffness and damping characteristic of it. Fig.1 shows that load – displacement graph is nonlinear. Besides, the rigidity calculated by the load and the displacement at (a) in Fig.1 have non-linear tend with decreasing as the strain increase. The nonlinearity of the rigidity affects the hose dynamic behavior. As amplitude of the rubber hose is larger, the strain becomes larger, the stiffness becomes smaller, and consequently resonance frequency of the hose vibration becomes lower. The same result can be measured by rubber hose bench vibration test. At (b) in Fig.1, the curve shows hysteresis, which means the rubber hose has damping characteristic. Therefore, it is necessary to consider both nonlinearity of stiffness and damping characteristic in analysis of rubber hose.

Fig.2 is schematic illustration of hose analysis model. In the analysis, we adopt spring-mass model to express the hose, and uses engine behavior as the analysis conditions. To reproduce the nonlinearity, the spring is given the stiffness and the damping characteristic of hose by applying viscoelastic model.

We verified accuracy of the dynamic analysis of rubber hose behavior by analyzing the CAE model using the actual vehicle engine behavior. In order to make clear the superiority of dynamic analysis, we conducted quasi-static analysis using the same model as used in dynamic analysis. Fig.3 shows the comparison of static analysis, dynamic analysis and measured maximum displacement of waved road test. The result of dynamic analysis is closer to of measured than of quasi-static analysis. In this verification, dynamic analysis and measured have almost equal maximum displacement. From this, it can be assumed that dynamic analysis of rubber hose can reproduce rubber hose behavior with higher accuracy. Therefore, the method of the dynamics analysis is valid to predict dynamic behavior of rubber hose.

We developed the analysis method for predicting dynamic behavior of rubber hose in engine compartment. The results of analysis can be presented by not only coordinates but animation or envelope surface of the hose behavior and it can be utilized to detect the interference with other parts even without actual vehicle test. In future, it is expected to be applied dynamic analysis of rubber hose behavior to vehicle development process.

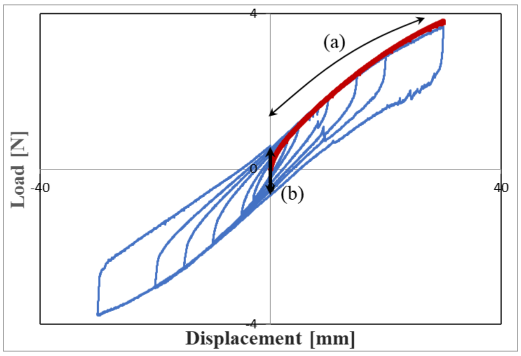

Fig.1 Load Displacement Curve of Rubber Hose in Engine Compartment

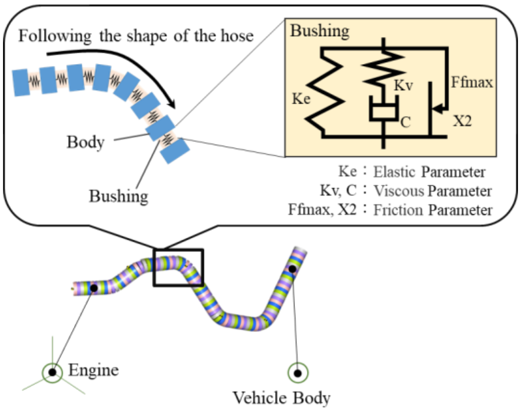

Fig.2 Schematic Illustration of Hose Analysis Model

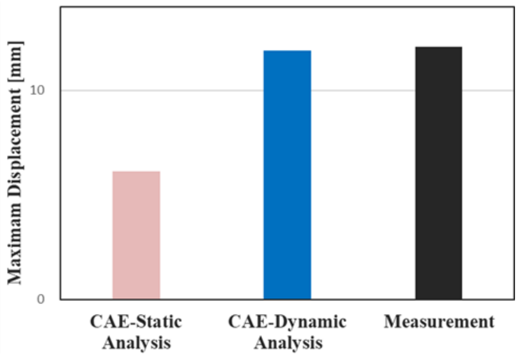

Fig.3 Comparison of Static Analysis, Dynamic Analysis and Measured Maximum Displacement of Waved Road Test