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Development of Thermal Management and Noise/Vibration Control Material Model Technology by Model-Based Research (MBR) (2nd report)

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To efficiently develop innovative multifunctional materials, we are developing simultaneous control modeling techniques to establish multiple functions with high performance based on the concept of Model-Based Research (Fig. 1). Model-Based Research is a research method that efficiently develops materials by backcasting from necessary functions. Phenomena occurring inside the microstructure of material are modeled using mathematical formulas based on their mechanisms to identify micro-level structural factors that control macroscopic performance and function.

Focusing on porous materials, this research aims to develop material control model technology that achieve high levels of sound absorption/heat insulation/vibration isolation functions. So far, we have developed technologies for sound absorption and heat insulation functions. In this study, we developed a microscopic structural design model technology for porous materials to control the vibration isolation function in order to improve quiet and ride comfort performance in cabin. Two types of vibration were targeted for control. One is the linear vibration related to quietness that occurs in vehicle body panels and other components. We constructed a model that takes into account the coupling of skeleton and fluid in porous material by homogenization method and showed that resonance frequency, which is important for vibration isolation design, cannot be accurately predicted without taking the coupling into account (Fig. 3(a)). The other is the vibration propagated when a large load is applied and nonlinear deformation occurs, as in the case of a seat. We constructed a large deformation and contact analysis model and showed that if the material is not designed to have appropriate elasticity in the targeted load range, the resonance frequency may change significantly (Fig. 3(b)).

In the future, we will combine this model with the previously developed models to build a simultaneous control model for sound absorption, heat insulation, and vibration isolation functions, and use it to develop innovative porous materials with multiple functions at a high level while satisfying mass, space, and cost requirements.

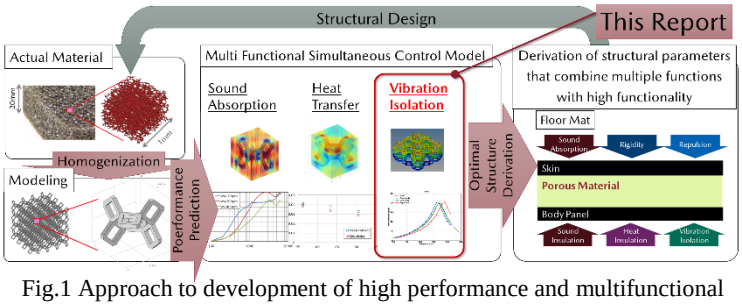
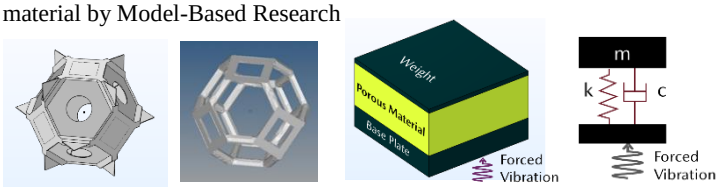


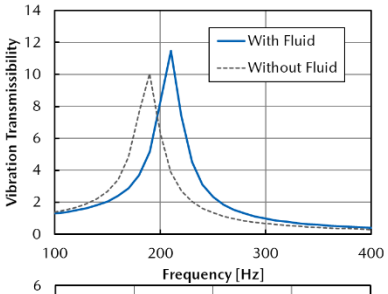
Fig.1 Approach to development of high performance and multifunctional material by Model-Based Research



Micro scale model (Kelvin cell) Macro scale model

Fig.2 Analysis model of vibration transmissibility

(a) Comparison of characteristics with/ without fluid (For linear micro-deformation)



(b) Comparison of characteristics under different loads (For large non-linear deformations)

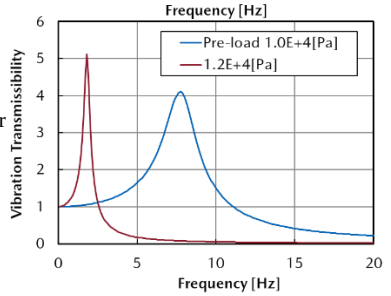


Fig.3 Analysis results of vibration transmissibility