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Development of Evaporation and Drying Modeling Techniques for High-Performance Coating Materials

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Polymer–inorganic composite coatings with high filler content are widely applied; however, solvent evaporation behavior during the drying process has a significant influence on surface roughness and void formation, thereby directly affecting coating functionality and durability. In this study, an evaporation and drying model was developed using a heat-insulating coating material for engine combustion chambers as the model material to predict the temporal evolution of the coating state from the initial wet film stage to the completion of drying.

As a result, the following findings were obtained.

(1) The proposed evaporation and drying model incorporated the coupled relationship between time-dependent filler configuration and solvent behavior in the wet film (Fig. 1), thereby reproducing the temporal evolution of solvent concentration during drying. The predictions showed good agreement with the experimental data (Fig. 2).

(2) The developed model enabled quantitative evaluation of surface roughness after drying and successfully predicted void formation behavior, as characterized by the C* values (Fig. 3).

(3) By applying coating conditions derived from the model, surface roughness was reduced while void formation was simultaneously suppressed (Fig. 4).

These results indicate that the proposed evaporation and drying modeling techniques are effective for high-filler-content coating materials and useful for efficiently deriving appropriate coating conditions.

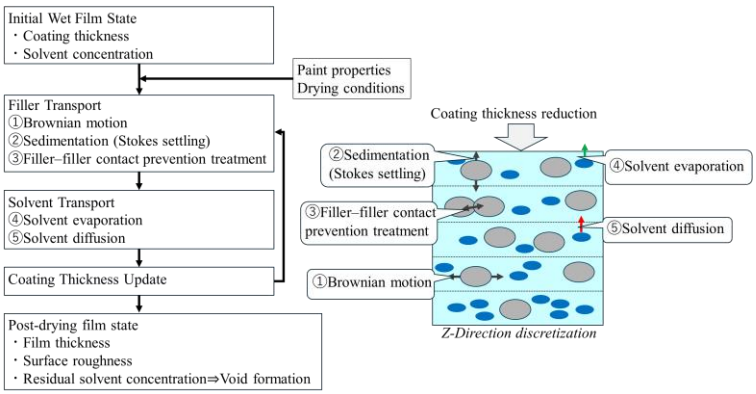

Fig.1 Schematic of the Evaporation and Drying Model

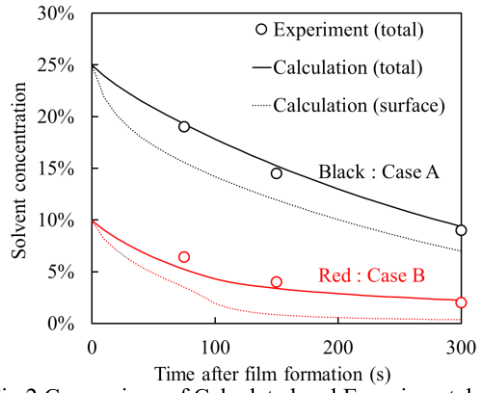

Fig.2 Comparison of Calculated and Experimental Solvent Concentration during Drying

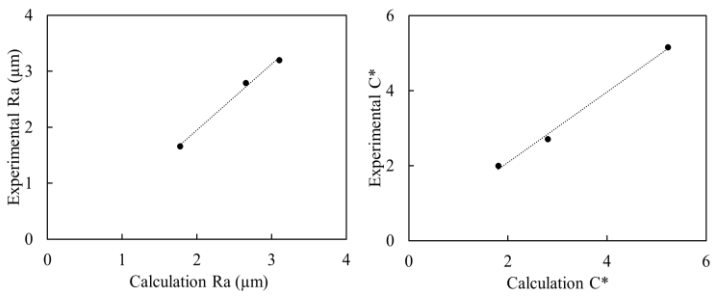

Fig.3 Comparison of Calculated and Experimental Surface Roughness (Ra) and Void Content (C*)

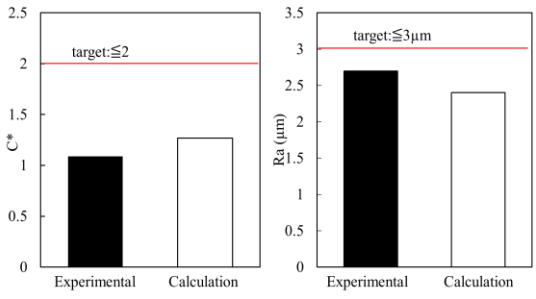

Fig.4 Reduction of Surface Roughness and Void Formation by Applying Model-Derived Coating Conditions