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Converter Model for PM Oxidation Catalytic Activity

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Experiments by powder catalyst are insufficient to evaluate the PM oxidation performance of catalytic DPFs directly unless experiments of DPFs fabrication which are prepared and coated with CeO2 catalyst are performed using real DPF substrate. In addition, the DPF after deposited by PM must be submitted for regeneration test at high temperatures. There are many issues such as experimental costs and catalyst support techniques if we use novel powder catalysts as real coat layers on DPF parts. Therefore, few studies have conducted detailed verification and evaluation of the PM oxidation performance of catalyst-loaded DPFs, and their performance is not yet clear. This study aimed to accelerate the development of a novel PM oxidation catalyst by using our short-path technique of converter model which can predict the PM purification performance of a DPF coated with a powder catalyst. In this work, by evaluating PM oxidation performance using nano-CeO2 in powder form, a model was developed to convert the catalytic reaction activity of catalyzed DPF from powder data. This model can obtain the fundamental catalytic activity and behavior when the catalyst is loaded in the DPF, not doing a laboratory-scale fabrication procedure of DPF. Our model will give preliminary knowledge on whether the powder catalyst is useful or not when a novel PM catalyst is reported.

In this study, an attempt was made to build a model that can quantify the entire process from the properties of the nanomaterial catalyst powder to its behavior when the DPF is used. The results are as follows.

1. frequency factors of PM oxidation in DPFs

SEM observations showed that the contact state of CeO2 and PM was different between samples in which CeO2 and PM were mixed in powder form and samples in which PM was deposited dropwise onto a CeO2 substrate, suggesting that the frequency factor of the PM oxidation reaction is lower inside the DPF. Therefore, the difference in the frequency factor due to the difference in the contact area between CeO2 and PM was modelled numerically, and a conversion equation was developed to obtain the frequency factor inside the DPF. The frequency factor values obtained by the conversion equation and the experimental values were in close agreement, indicating that the conversion equation was highly valid.

2.PM purification performance of CeO2-coated DPFs

The PM purification performance of the CeO2 catalyst-coated DPF was evaluated by model calculation using the conversion equation and the frequency factor of the PM oxidation reaction inside the DPF obtained from the TG measurements. It was predicted that sufficient PM purification performance could be achieved even when the amount of catalyst to be coated was reduced. It was also shown that the PM purification performance could be achieved even when the oxidation temperature was lowered by 50 °C from 600 °C to 550 °C.

The conversion (converter) model obtained in this study has the advantage that even if a high performance powder catalyst is found, it can be used as a preliminary study prior to DPF fabrication to obtain an indication of the PM purification performance when the DPF is expected to be used.

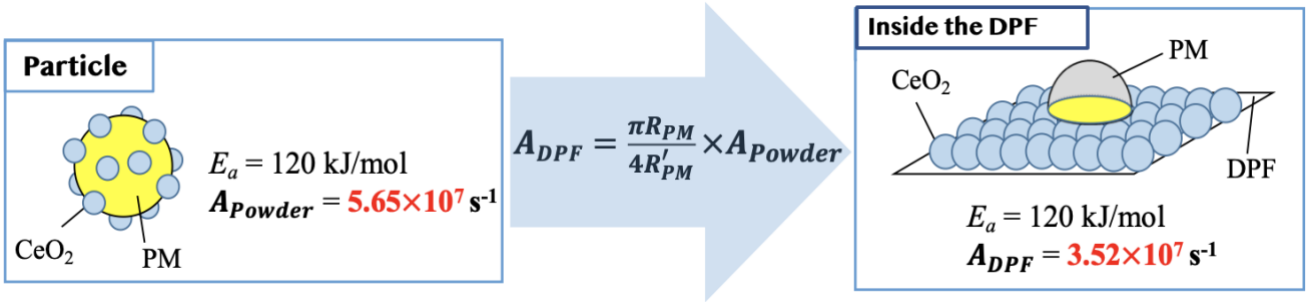

Fig. Conversion of frequency factors inside the DPF.