De-NOx SCR Catalyst Coating with Strong Adhesion to Metal Honeycomb Substrate

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Introduction

Most of De-NOx SCR catalysts for stationary applications are ceramic monolith type with honeycomb structure consisting of V2O5/TiO2 catalyst with a large number of parallel channels. The channel diameter affects pressure drop across the catalyst as well as NOx conversion efficiency on the catalyst. The SCR catalyst monolith for marine applications is required to have high strength to support its self-weight and to sustain against vibration in engine room. The wall thickness of the catalytic ceramic monolith, therefore, needs to be very thick (sub- to a few millimeters). The space requirement for the SCR system in the engine room is considerable and the SCR catalyst also require a lot of space, so it needs to make the SCR system as compact as possible.

De-NOx SCR catalysts for automobile applications, on the other hand, have been developed mostly with zeolite-based catalyst coated mainly on ceramic honeycomb substrate made of cordierite ceramic. For marine applications demanding high mechanical strength, good resistance against vibration, low pressure drop of the exhaust gas, low catalyst volume, and good thermal management, however, metallic substrates present several advantageous properties such as higher mechanical resistance and thermal conductivity, thinner walls with thickness less than 100 μm allowing higher cell densities, low substrate volume, and lower pressure drop. But the ceramic-based catalyst coating on flat metal surfaces could be less durable because the bonding property between ceramic and metallic materials is basically not good.

Recently, we reported the fabrication of TiO2 photocatalytic films by vacuum-assisted room temperature powder spray coating at room temperature [1]. The TiO2 catalytic coatings showed strong adhesion strength to the substrate without any binder and very rough surface [2]. SCR catalyst coatings on costly effective metallic substrate such as STS444 foil using the technique for potential marine and automobile applications, and their De-NOx performance and catalyst adhesion property with microstructural observation will be presented.

Materials and Methods

Fe-ZSM5 catalysts for De-NOx SCR were coated on thin stainless steel STS-444 foil with thickness of 50 or 100 μm using the vacuum-assisted room temperature powder spray coating and conventional slurry coating methods. The thickness of the coat layers were in the range of a few μm to 50 μm. The catalysts coat layers were observed using SEM to check their cross-sectional microstructure and adhesion property of the catalysts were compared using a sonicator filled with water. Core samples with 1 inch diameter and 360 cpsi were also made using the two coating methods and their De-NOx SCR performance was measured using a lab bench reactor equipped with automatic mass flow controller and Horiba gas analyzers controlled by a lab view program. Both the standard and fast NH3-SCR reactions were tested.

Core samples made of the STS-444 foil with or without TiO2 layer coated by the vacuum-assisted room temperature powder spray coating were made and vanadia/TiO2 catalysts were washcoated on the cores. Their adhesion property and De-NOx SCR performance were compared before and after the adhesion tests.

Results and Discussion

Both catalyst samples coated by the conventional and powder spray coating methods showed similar SEM microstructures and De-NOx performance for both standard and fast reactions. The sample prepared by the powder spray coating, however, showed much better adhesion strength than the sample coated by the slurry coating. The core samples with TiO2 layer coated by the powder spray coating also showed better catalyst adhesion strength than the samples without TiO2 layer. The excellent adhesion property of the samples is probably originated from intrinsic coating and adhesion mechanism of the vacuum-assisted room temperature powder spray coating and this will be discussed during presentation also.

Significance

The samples coated by the vacuum-assisted room temperature powder spray coating have excellent mechanical durability even with very high catalyst loading showing very strong adhesion strength to the metal substrate.

Figure 1. Microstructures of the catalysts layers coated by the vacuum-assisted room temperature powder spray coating and conventional slurry coating methods

References