

論文 / 著書情報
Article / Book Information

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著者(和文)	讃井涼子
Author(English)	ryoko sanui
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻： 機械制御システム 専攻
Department of
学生氏名： 讃井 涼子
Student's Name

申請学位 (専攻分野)： 博士 (工学)
Academic Degree Requested Doctor of
指導教員 (主)： 花村 克悟 教授
Academic Advisor(main)
指導教員 (副)：
Academic Advisor(sub)

要旨 (英文 800 語程度)
Thesis Summary (approx.800 English Words)

Diesel particulate filters (DPFs) are an important technology to remove a harmful particulate matter (PM) from exhaust gases of diesel engines. DPFs are generally made of ceramic materials with a micro-porous structure. Accumulated PM on the DPF is regularly burned to maintain the performance of the filter as a process called regeneration, where additional fuel is consumed to increase the DPF temperature to 600 °C. The timing of the regeneration process must be optimized in terms of fuel consumption. For that, a PM accumulated mass is generally estimated from the pressure drop through the DPF.

This thesis consists of seven chapters with an aim to intensively investigate the PM trapping process inside DPF walls. PM particle-scale visualization helped for better understanding of the relationship between PM trapping phenomena and pressure drop increase, and contributed to an improvement upon current accumulated PM mass estimation models and the optimization of DPF design.

In Chapter 1, the current DPF technology is presented. It is shown that a better understand of the PM trapping process is necessary to meet current strict legislation limiting PM emissions.

In Chapter 2, the PM trapping process was visualized at a pore-scale using scanning electron microscopy (SEM), relating visual observations to the pressure drop through a DPF. In the visualization experiments, the short time PM trapping process and SEM observation was repeated at specific locations on a DPF. In close-up images of the same locations for each observation, serial time-lapse images for specific fields allowed visualization of a dynamic PM trapping process on a DPF. This visualization revealed that a drastic increase in pressure drop at the beginning of the PM trapping process was caused by PM accumulation inside the porous walls of the DPF, where the flow rate was accelerated due to decreased porosity.

In Chapter 3, PM trapping initiation was highlighted and visualized at a particle-scale using field-emission SEM (FE-SEM). PM particle-scale visualization revealed that PM bridging initiates PM trapping inside a porous DPF wall. The bridge is formed by a dendritic growth of PM at constricted areas in porous channels. Most of flow volume avoids a

growing PM dendrite because of high flow resistance inside the PM structure. This accelerates PM deposits atop of dendrite structures towards the center of pore closing the porous channel perpendicular to the stream line. After bridge formation, PM accumulated on the bridge structure, and no further PM deposition downstream of the bridge was observed, thus the location of bridge formation plays a significant role to determine the PM accumulation mass inside wall.

In Chapter 4, a simplified model of bridge formation by trapped PM inside a porous wall was proposed based on the details of the process observed through the visualization presented in Chapters 2 and 3. In the new model, a porous channel is regarded as a cylinder where PM accumulated and decreased the diameter of the channel with PM deposition. The model presented here focuses only on bridge formation, which is the initiation of PM trapping in one porous channel. This should be integrated into the present PM mass estimation models for the whole PM trapping process in a DPF. The number of PM particles introduced until bridge formation was compared to that obtained experimentally and a similar tendency was found that related flow velocity and PM size.

In Chapter 5, an experimental parametric study was conducted to investigate the impacts of the parameters such as flow velocity, PM size distribution and porous structure, on the PM penetration depth. Determination of penetration depth is necessary to characterize the drastic increase in pressure drop. The PM packing fraction distribution was obtained via post-observation of the wall cross-section for each condition. While the location of the bridge formation strongly depended on the porous configuration, the amount of PM accumulated inside of a porous wall was determined by the efficiency of the bridge formation as a function of flow velocity and PM size, since the different timings of bridge formations occurred at various constricted area in a porous structure of a DPF.

In Chapter 6, two solutions were proposed and validated experimentally to model PM trapping with a lower pressure drop. One employed a submicron membrane filter and the other used a DPF with a uniform porosity.

In Chapter 7, the relationship between pressure drop and PM accumulation obtained through visualization is summarized. The determining factor for PM accumulations is also summarized focusing on the two factors: the timing and the location of bridge formation inside the porous channels which depends on the efficiency of bridge formation and on the porous configuration, respectively.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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