論 文 の 要 旨

題　目　Fundamental study on the improvement of the performance and durability of nonwoven filter media
（ろ布の高性能化・長寿命化のための基礎的研究）

氏　名 Mohammad Irwan Fatkhur Rozy

The filtration processes have recently received more attention to meet air pollutant emission standards, which have become stricter because of the urgent need to improve the air quality and reduce the emission of contaminants that may be harmful to human health. Thus, a filter media with high durability and excellent performance is required to overcome this problem. Polyphenylene sulfide (PPS) nonwoven fabric filters having excellent chemical, thermal, and mechanical properties are one of the promising options to meet these criteria. A brief description of each chapter in this dissertation is shown below.

Chapter 1 provides the background and the motivation for current research on the fundamental study on the improvement of the performance and durability of filter media. The description of the filter media and a review of the previous studies were presented in both experimental and numerical simulations utilizing filter media.

At first, in **Chapter 2**, this dissertation focused on the degradation of polyphenylene sulfide (PPS) nonwoven bag filter media by NO_2 gas at high-temperature conditions. The durability test was examined based on the “Test method for evaluating the degradation of characteristics of cleanable filter media” which was specified in ISO16891:2016. The exposure time was varied to investigate the degradation process on the PPS filter. It is found that NO_2 gas at high temperature reduced the tensile strength and elongation of the PPS filter in both transverse direction (TD) and machine direction (MD) with increasing exposure time. Some damage was also found in the morphological appearance of the PPS fiber which led to reduce the tensile strength of PPS filter media. A model to estimate the change in the NO_2 gas concentration in the exhaust gas and the change in the tensile strength was proposed. Our model successfully estimated the degradation of tensile strength in both MD and TD direction, regardless of NO_2 concentration in the exhaust gas.

Numerical simulation was utilized to perform the permeation of gas through a fibrous filter in **Chapter 3** by coupling computational fluid dynamics and immersed boundary method. The realistic geometry of polyphenylene sulfide (PPS) and polyimide (PI) fibrous filter were re-constructed using X-ray computed tomography (CT) images. The simulated pressure drop of each filter media was then compared with the experimental data and existing empirical equation to validate our numerical method. Our simulated pressure drops were in good agreement with the experimental and empirical equation results. Our numerical method was also useful to investigate flow characteristics in a fibrous filter, where the permeability of the PI filter was lower than the PPS filter under the same porosity conditions.

In **Chapter 4**, numerical simulation of permeation of particles through PPS fibrous filter was performed by utilizing signed distance function. We proposed a method to calculate the signed distance function around complex geometry of filter microstructure by using the Phase-field model and the Level set method. By this method, we could reasonably describe the contact behavior between particles and fiber. Our result showed that the permeation behavior of particles was significantly affected by porosity and the structure of the filter media such as the arrangement and fiber orientation. It was found that the particles tend to contact the perpendicular orientation fibers than parallel orientation fibers because the projected contact area of the perpendicular orientation fiber was larger.

General conclusions of all topics are listed in **Chapter 5**. Suggestions for further research utilizing nonwoven filter media are also proposed.