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論　文　要　旨(博士)

論文題目	Indoor Air Cleaning with Corona Discharge using Electrostatic Flocking Electrode (静電植毛電極を用いるコロナ放電による室内空気浄化に関する研究)

本論文は室内空気浄化から産業施設の換気装置まで幅広く利用されている電気集じん装置においてサブミクロン粒子の集じん率を向上させるために集じん電極表面にナイロンパイルを静電植毛した。この静電植毛電極を用いることで、以下の二つの効果が期待される。(1) パイル先端部に電界が集中するため、集じんされた微粒子がグレーディエント力によって押さえつけられ、再飛散を起こしにくくなる。(2)集じん電極の表面積が増加することや、その表面に形成される微細な空間の中での空気の流れが穏やかになるため、微粒子を機械的に保持しやすくなる。この電気集じん装置を用いてサブミクロン粒子の集じん性能及び集じんされた粒子の状態または気流中における粒子挙動を実験的に検討した。さらに、湿式静電植毛電極を設置した湿式電気集じん装置を用いることでガス状汚染物質と粒子状汚染物質の同時除去の可能性を検討したものである。また、電気集じん装置内のオゾン発生の抑制や除去のため、カーボンフィルタ集じん電極の利用を検討した。第１章は序論であり、論文の背景及び目的を述べている。第２章は電気集じん装置やグレーディエント力、静電植毛の理論を述べている。第３章と４章は申請者らが開発した静電植毛集じん電極を用いることでサムミクロン粒子の集じん性能および凝集効果を示した。第５章は電気集じん装置内部のガス流れの可視化や PIV(Particle Image Velocimetry)測定の結果を示した。第６章は湿式電気集じん装置を用いたガス状汚染物質と粒子状汚染物質の同時除去の効果を示した。第７章は本論文の結論である。

これらの研究を通じて開発した静電植毛電気集じん装置は、サブミクロン粒子の捕集性能の改善や悪臭、VOC などのガス状汚染物質の除去、一般的な電気集じん装置が持っている異常再飛散及び逆電離現象を抑制することができることを示した。特に、これらの技術を室内空気調和に用いることで、室内空気環境の改善に大きい貢献できると考えられる。

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ABSTRACT (DOCTOR OF ENGINEERING)

Title	Indoor Air Cleaning with Corona Discharge using Electrostatic Flocking Electrode (静電植毛電極を用いるコロナ放電による室内空気浄化に関する研究)

Electrostatic precipitator (ESP) has been widely used to remove particulate matter in industrial and indoor air cleaning. Recently, environmental concern is directed towards controlling the emission of fine particles (from 0.1 to 1.0 ㎛). Purpose of this study is to improve overall performance of a conventional ESP by enhancing collection efficiency for fine particles and suppressing re-entrainment precipitated particles, in addition, treatment feasibility for gaseous pollutants such as acetaldehyde was tested.

From above viewpoints, a new type ESP using coated electrode with nylon fibers was proposed. This collecting electrode was made of electrostatic flocking technique. It is based on increasing surface area of the collecting plate and on producing gradient force at the tip of fibers to suppress re-entrainment. Using the ESP equipped with electrostatic flocking electrode (E.F.Electrode) collection efficiency for fluorescent fine particles or tobacco smoke was achieved 95% or 98.9% at dc –9kV with short residence time (0.06s) respectively, and these values were higher than those of a conventional plate electrode.

Through flow visualization in vicinity of the collecting electrode and particle image velocimetry (PIV) measurement, it was noticed that not only suppression of backward gas flow, which is caused by ionic wind, by fibers friction and narrow space betweens them but also possibility to transport particles towards collecting electrode, and the surface properties of collecting electrode can be used in order to control the behavior of ionic wind. And also through the electron microscopic observation on the surface of collecting electrode, most of the inlet particles is mainly captured and agglomerated at the tip of fibers, due to converged electric field at the tip that caused gradient force to keep the particles at the tip of the fibers, and then become larger particles. These results also indicate that the ESP can be used for an agglomerator prior to mechanical particle collector such as air filters and cyclones.

Furthermore, in order to examine the performance of simultaneous removal of gaseous pollutants and particulate matters, the wet-type ESP with a wet electrostatic flocking electrode has been employed. And carbon fabric plate as a collecting electrode was experimentally studied to suppress ozone generation by dc corona discharge in ESPs. As a result, removal efficiency of acetaldehyde (CH3CHO) using the wet-type ESP alone was about 68.2% at 8.4W of input power with residence time of 2.1s and the collection performance of wet E.F.Electrode for submicron particles (0.3-0.5mm in diameter) was higher than that of dry type one. In case of wet E.F.Electrode collection efficiency was achieved 94.2% at –dc 7kV. The process using the combination of corona discharge and carbon fabric plate is effectively applicable not only to suppress ozone but also to achieve high collection efficiency for submicron particles.

From these results, the wet-type ESP and the combined system have a potential of the simultaneous removal of gaseous and particulate pollutants and can cope with the well-known problems of ESPs, such as abnormal re-entrainment of particles with low resistivity and back corona for high resistivity particles