

CHAPTER 6

CONCLUSIONS

In this research work, experimental studies on improvement of electrostatic precipitator for submicron particle collection were carried out. The study was separated into 3 steps. Firstly, a lab-scale wire-cylinder ESP under negative high voltage pulse energization was tested and the collection efficiency was compared to that under a negative high voltage DC-energization. Secondly, a non-thermal plasma agglomeration technique for number particle reduction of submicron particles with a size range of 0.3-5.0 μm generated in an exhaust gas from diesel oil combustion was presented. Finally, Then a combination of a submicron particle agglomerator to pre-charge the particles before collecting in a pulse-energized ESP was carried out. The particle collection efficiency in terms of air velocity, supplied voltage and dust loading were experimentally investigated.

6.1 Pulse Corona Discharge for Electrostatic Precipitator Enhancements

Experimental studies were performed to investigate the capture of carbon particles from a soot generator between pulse and DC energizations for wire-cylinder ESP. For pulse energization, the pulse peak voltage can be set much higher than that of DC energization. It was found that high voltage pulse energizing not only used lower energy but also had higher efficiency than the DC energization. The total collection efficiency could be increased up to 92% at – 10 kV of supplied voltage and pulse frequency at 40 kHz.

6.2 Enhancement of Electrostatic Precipitator for Submicron Particle Collection by Non-Thermal Plasma Pre-charger

6.2.1 Experimental studies were performed to investigate the agglomeration characteristics and the reduction efficiency of submicron particles in a size range of 0.3 – 5.0 μm . The number particle reduction of the particles was used as an indicator

of the particle agglomeration performance under controlled conditions such as the supplied pulse peak voltages, the pulse frequencies, the dust loadings, and the mean gas flow velocity. The experimental results showed that the particle reduction efficiency increased with increasing pulse peak voltage and pulse frequency. With higher gas velocity and higher dust loading, a higher frequency of small particle collisions could be obtained, and the agglomeration of charged small particles could be achieved easily. However, at higher gas velocity, some particles were insufficiently charged. In our experiment at a peak voltage of 45 kV and a pulse frequency at 20 kHz, the efficiency increased when the gas velocity was increased from 0.5 ms⁻¹ to 1 ms⁻¹, but a lower efficiency was obtained when the speed was over 1 m/s. In this condition, the submicron particle number reduction efficiency for all particle sizes was over 90% in our non-thermal plasma ESP. A model to predict the efficiency at various operating conditions could be evaluated from the experimental data as

$$\eta_r = 91.811 \times V_{ave}^{0.039988} \times N^{-0.004392} \times U_g^{0.002238} \times d_p^{0.0053816}, (4.13)$$

$$15 \text{ kV} < V_p < 45 \text{ kV},$$

$$1 \times 10^4 \frac{\text{particle}}{\text{cm}^3} < N < 5 \times 10^5 \frac{\text{particle}}{\text{cm}^3},$$

$$0.5 \text{ m/s} < U_g < 2 \text{ m/s},$$

$$0.3 \text{ }\mu\text{m} < d_p < 5 \text{ }\mu\text{m}.$$

The results from the correlation could fit all the experimental data within 10 % deviation.

6.2.2 A NTP pre-charger was integrated with a wire-cylinder ESP to enhance the overall collection efficiency of soot particles. The ESP performance was considered under with and without NTP pre-charger. The results indicated that the overall efficiency was greater than 95% when the NTP pre-charger was on, and that was greater than 70% for tests at NTP pre-charger off mode. Moreover, under controlled conditions, such as were the supplied pulse peak voltages, the dust loadings, and the mean gas flow velocity, the experimental results showed that the overall collection efficiency increased with increasing pulse peak voltage both NTP pre-charger off and on modes. Whereas the dust loading and gas velocity also

affected, a higher particle concentration led to high rate of particle collision at the high gas velocity, and thus the small particles could be easily agglomerated, the overall collection efficiency also increased with the increase of the dust loading and gas velocity but was unlike in low dust loading. A model to predict the efficiency at various operating conditions could be evaluated from the experimental data as

$$\eta_c = 34.37 \times V_{mean}^{0.74514} \times N^{-0.021454} \times U_g^{0.094815},$$

$$6 \text{ kV} < V_{max} < 10 \text{ kV},$$

$$1 \times 10^4 \frac{\text{particle}}{\text{cm}^3} < N < 5 \times 10^5 \frac{\text{particle}}{\text{cm}^3},$$

$$0.5 \text{ m/s} < U_g < 1.5 \text{ m/s}.$$

The results from the correlation could fit all the experimental data within 10 % deviation.

6.3 Further Study

The future study should cover the task on a higher gas velocity since the collection efficiency reduces with the gas speed thus a method to enhance the system performance at this condition should be developed.

Moreover, scale-up of the system for a real practice should be carried out.