CHAPTER 6

Conclusion and Recommendations

This final Chapter presents concluding remarks for the air conditioning inlet section, the particle charging section, the particle size selector, the particle size classification-Faraday cup and cage, an electrometer circuit, flow system, power system, data acquisition and processing, as well as field tests with standard detectors.

6.1 Conclusion

In this study, the multi-channel airborne PM detector by electrical technique (the PMx detector) was developed. The PMx detector had seven important parts, consisting of the air conditioning inlet section, the particle charging section, the particle size classifier-Faraday cup and cage, the electrometer circuit, flow system, power system and data acquisition and processing. The sampling head was designed to use for 15 L/min air flow rate for getting an airborne PM. The air conditioning inlet was used silica gel to reduce the humidity from airborne continuously. The laboratory test indicated that the diffusion dryer had 45% efficiency in absorbing the humidity (80% RH to 45%RH and 64%RH to 35%RH). It had a low temperature effect for inlet and outlet that less than 1 ^{o}C in different (or ±2%). The CPC used to measure nano-particles in the diffusion dryer and was found to be about 16.67% maximum loss for particles less than 50 nm in diameter at 1.5 L/min flow rate. For the particle charging section, the charger can generate ion number concentration about 10^{16} ions/m^3 and had 75 % ion penetration at 2.7 kV in positive corona and 15 L/min in flow rate. The result from laboratory test indicated that the temperature less than 50 ^{o}C had low effect for this charger. In addition, the $N_i t$ product was high between 2.6 - 2.7 kV positive corona voltage corresponding to a maximum high ion penetration at 75% (15 L/min air flow rate). The numerical results showed that this charger can generate about 3.4×10^6 V/m in electric field strength. The inertia impactor was used at 5 L/min flow rate in each channel for classifying PM10, PM2.5 and PM1.0. The classification efficiency was validated from analytical and numerical analyses. It was recheck by the NaCl and the combustion particles for SEM analysis. The HEPA filter inside the Faraday cup was used for collecting the PM sample and electric charge. LMC6032 opamp circuit can detect and convert low level current between 20 fA to 10 pA that corresponding between 2.72×10^{5} to 1.36×10^{8}, 3.73×10^{6} to 1.87×10^{9} and 1.93×10^{7} to 9.65×10^{9} particles/m^3 in particle number concentration for PM10, PM2.5, and PM1.0 detectors, respectively. The voltage output results were shown to have high accuracy between 0.488 to 5.55% and 0.11 to 7.0%. Flow system used Rotameter for controlling and monitoring particle flow and was calibrated with Dwyer mass flow controller series GFC. The electric power system used to drives the charging section, vacuum pump, electrometer circuit, and data acquisition system. This system based on 220VAC system and had 12 VDC battery section for emergency case. Data acquisition used ADAM-4017 and UCON-485 to convert measuring data from the PMx detector to the PC. PM data were recorded to the PC and crown system of Drobox. The system can be remoted control by other PC or smartphone.

The PMx detector system can be measured PM10, PM2.5 and PM1.0 together. It was compared with standard detectors, including the TEOM, the Beta and laser technique for several months during 2013 to 2016. First of the field test was compared between charging current from the PMx detector and mass concentration from standard detector. Second, the power regression model between current and mass were used to compare a PM mass from the PMx detector with mass from standard detector. The average data of 1-min, 1 h and 24 h were compared and high regression coefficient (R^2) between 0.89 to 0.98 of all field tests. The PMx detector can be measured PM continuously and fast reported in units of the particle mass concentration and the particle number concentration. In addition, it has high performance equivalent standard detectors and appropriate to continuous PM monitor.

6.2 Recommendations for Future Works

6.2.1 The particle charge number was dependent on the particle diameter, the ion concentration, and charging time. It was related to the electric intensity and flow velocity in the charger. So for future study, numerical and laboratory test are needed for motion characteristic and the particle- ion collisions under the electric and flow field in the charger.

6.2.2 This thesis has tested the effect of temperature for the particle charger only. Temperature has effect to semiconductor, which it need to validate the temperature effect in the electrometer circuit inside the Faraday cage for study further

6.2.3 This measuring technique uses the electric charge on particle accumulated on the HEPA filter in the Faraday cup. So, this accumulated particles may resist the electric charge flow. This topic should be studied further.

6.2.4 In the future, measurement and warning system for air pollution may be developed. Further study and update may be needed for the database system, wireless communication, alarm system, the embedded system, intelligent software, including with data processing.