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CT6) Effects of Cone Dimension on the Cyclone Performance

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1. INTRODUCTION

Cyclones are among the oldest types of industrial particulate control equipment and air sampling device. Until now, a great number of experimental studies have been performed on cyclones. In these studies, almost all of the eight cyclone dimensions were varied and Changes in cyclone performance produced by these variations were studied. However, very little information is available on the effects of the cone bottom diameter. With regard to the effects of change in this dimension, discrepancies exist in the literature. According to Stern et al. (1955) a cone is not essential for cyclone operation, although it serves the practical purpose of delivering collected particles to the central discharge point. However, Zhu and Lee (1999) stated that the cone provides greater tangential velocities near the bottom for removal of smaller particles. Dirgo and Leith (1985) discussed the effects of the cone opening size but with uncertainty.

In this study, the effects of the cone bottom diameter on the cyclone performance were investigated and the experimental data were compared with some existing theories.

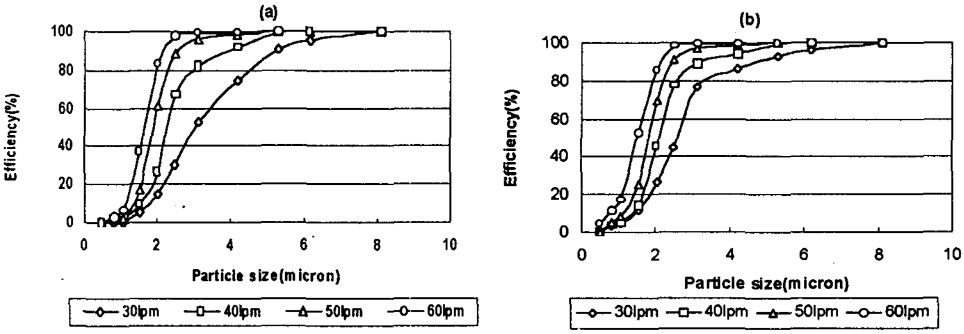
2. EXPERIMENT

Three cyclones with only difference in the cone bottom diameter were constructed out of glass in this study. The cone bottom diameters of the three cyclones are 19.4mm(cyclone-I), 15.5mm(cyclone-II) and 11.6mm(cyclone-III), respectively. To determine the grade efficiency curves of these cyclones, monodisperse PSL particles ranging in size from 0.505 to 8.1micron were used and were generated with an Atomizer. At flow rate of 30lpm, 40lpm, 50lpm and 60lpm, particle concentrations in the up- and downstream of the cyclone were measured by an Aerosizer (API Inc., Model Mach II and LD), respectively.

3. RESULTS AND DISCUSSION

Figure 1 is the measurement results for the three cyclones at different flow rates. As expected, the particle collection efficiency increases with the increasing flow rate. However, it is noted that this increase becomes less significant at the higher flow rate range. In addition, Figure 1 shows that the collection efficiency curve becomes sharper as the flow rate increases and this finding is consistent for all the three cyclones. But when the Figures 1 (a), (b) and (c) are compared for an identical condition, it is seen that the shape of the efficiency curve remains roughly the same regardless the variation in the cone dimension. Also from Figures 1 (a) through (c), it can be seen that the particle collection efficiency for a cyclone with a smaller cone opening is higher than that for a cyclone with a larger cone opening. This indicates that the gas and particles are definitely accelerated in the cone section due to the gradually reduced cross section area. The smaller the cone opening, the greater the acceleration exerted on the particles and thus higher efficiency can be obtained. For the small cone opening, the vortex may touch the cone wall, but the particle reentrainment observed by Bryant, et al. (1983) seems to be less significant than the acceleration for particles resulting from the small cone in affecting the collection efficiency.

Figures 2 through Figure 4 compare the experimental efficiency curves at a flow rate of 50lpm with those generated from the revised Leith-Licht theory by Clift, et al. (1991), Barth's theory (1956) and the logistic equation proposed by Iozia and Leith (1990). Obviously, although the revised Leith-Licht theory improves the original model greatly, it still underestimates the cyclone performance. Further, the theory predicts that the collection efficiency decreases with the reduced cone size, which is completely opposite to the experimentally observed trend. Figure 3 and Figure 4 shows that the theoretical efficiency curves based on Barth's and Iozia and Leith's theories are very close to the experimental curves. However, none of the two theories can predict the effects of the change in the cone opening properly and sufficiently. Note that in Figure 3 the predicted curves for cyclone-I and II are identical. Similarly, Iozia and Leith's theory gives an identical curve for all the three cyclones in Figure 4.



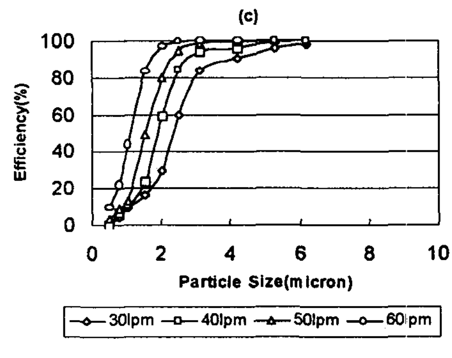


Fig. 1. Particle collection efficiency as a function of particle size (a) cyclone-I B=19.4mm (b) cyclone-II B=15.5mm (c) cyclone-III B=11.6mm

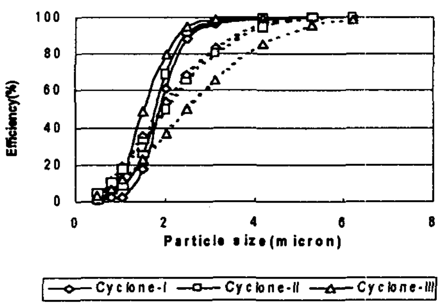


Fig. 2. Comparison of experimental data with Revised Leith's theory for three cyclones at a flow rate of 50lpm. Dotted lines represent the theory.

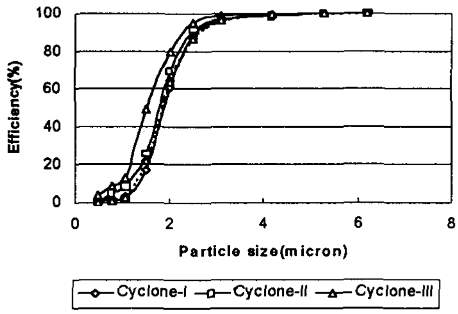


Fig. 3. Comparison of experimental data with Barth's theory for three cyclones at a flow rate of 50lpm. Dotted lines represent the theory.

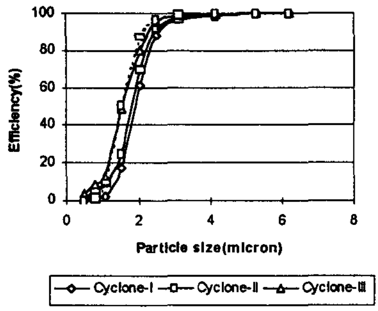


Fig. 4. Comparison of experimental data with Iozia and Leith's theory for three cyclones at a flow rate of 50lpm. Dotted line represents the theory.

4. CONCLUSION

Efficiency data were obtained for three cyclones with different cone sizes at four different flow rates in this study. For a particular cyclone, the efficiency curve is sharper at a higher flow rate. However, the change in the cone size doesn't alter the shape of the efficiency curve if other parameters are kept the same. By comparing the efficiency curves for the three cyclones, it was found that the collection efficiency increases with the reduced cone bottom size. The comparison of the experimental data with existing theories indicates that the Barth's and Iozia and Leith's theory have good ability to predict cyclone performance. However, all the three theories assessed in this study failed to predict the effects of cone size satisfactorily.

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