Research Paper Environmental Science

Cycloneair Flow Field Simulation And Particle Characteristics (Pm10.0, Pm2.5) Analysis

Chih-HungHuang Ph.D. candidate of Department of Environmental Engineering and Science&National Pingtung University of Science and Technology, Pingtung, Taiwan (ROC)

Jia-TwuLee Associate Professor of Department of Environmental Engineering and Science & National Pingtung University of Science and Technology, Pingtung, Taiwan (ROC)

ABSTRACT

In real life, a good mathematical model calculations and with the appropriate simulation equations by computer fast computing power, its accuracy is pretty amazing. The development of modern science and engineering, all the innovation and invention, were intended to improve the living standards of our humanity. Since we could not avoid the dust generated in the environment, the dust collector was the life of a very important tool for dusting. How to improve this little helper, increasing further enhance the efficiency of the dust collector,was the main objective of this study.This research were bothexploratory and confirmatory studies at the same time.This study simulated cyclone air flow field, mining groups A and B to do experimental design Two experimental groups the biggest difference were that the way was the wind A group tangentially into the annular inner dust collector. Group B was the way into the wind, a non-tangential direction into the ring inside of dust collector. Respectively, inlet position of both groups(A and B) were with low, medium and high into the air to do different trials comparing. CFD software package was a powerful computing capabilities. its dynamic equations of fluid mechanics, was a self to do know how rational, logical judgment of engineering objects. After each group different attempt,simulation results showed that: (1) the way of the wind cut flush to the surface, regardless of the position in the low, which medium or high position, the resulting vortex, were smooth on the way of the wind cut flush to the surface in a non-person. (2) the way of the wind did not cut flush to the surface, regardless of the position in the low, which medium or high position, vortex generated by all the way of the wind into the ring true to cut flush to the surface of those. (3) at a fixed speed, the less were rotating scroll smoothly, the lessthe amounts of dust falling. The more vortex rotations were not smooth, the more the amounts of dust falling.After the actual operation of large cyclone separation, under the electron microscope SEM could be found that: (4) SiCparticleswerescreened to Separate out different sizes. (5)For further,This study analyzedthe changes betweenPM10.0 and PM2.5 particle. Conclusions, (6) The waysofthe windinto cyclone and a non-tangential direction into the annular internal dust collector, were dust collector with turbulent eddies of internal rotation mainly toproduce the highest position.It was that the outlet had the greatest amount of dust and dust had the best performance.

KEYWORDS Air flow field, CFD, the tangential direction, PM10.0 / PM2.5, removal efficiency of dust

INTRODUCTION

Cyclone, It was the main structure of cones. When the airflow into the entrance to the tangential direction of rotation and cones, the turning radius was small and conical barrel to form a vortex or turbulence. Dust would fall along the inner wall of the set dust bucket.Air cleaner cones were to the lower end of the rotation andthen reverse to escipe from the exit. Whether it was the air of rural, urban or industrial areas,more or less have some of our balloon floating in toxic substances. The deepest hurt for human was among polychlorinated biphenyls (PCBs) and Dai Ouxin[1].

A 2002 study published in the "Journal of the American Medical Association," It showed that PM2.5 could cause arterial plaque deposits, causing vascular inflammation and atherosclerosis, leading to heart attack or other cardiovascular problems[2]. Therefore, the more noteworthy, was the particle size of less than 2.5μm (PM2.5) because it would go into the depths of the lungs andafter the body could not naturally discharged(depending perspiration or excretion), so it having a greater injure of health. Moreover, the impact of air pollution on human health had been seriously concerned about exposure to contaminate air particles and ozone. It had been associated with respiratory, cardiovascular diseases, increased rates of hospitalization and mortality, there be a significant correlation[3].

In Spanish municipal waste incinerator(MWI), the air above the chimney, was found very high levels ofdioxinssubstance and had seriously affected the health of urban residents. Meanwhile, in the analysis of municipal solid waste, dioxins and furans Daiaoxinfu (PCDD / Fs) wouldemitte from fly ash, slag and flue exhaustautomatically[4].

Now due to odor and steam plant emissions, air pollution locomotive serious dust in the air and even toxic volatile substances, our sky became more and more dirty. Taiwan belongs island climate, warm and humid weather, and the air contains sufficient moisture. Environmental impact, easy to make these toxic dust and suspended particles, to combine with water vapor attached throughout the floats in the air, to result that the sky was always grayin a poor vision.

On the other hand, because of poor air quality, it waseasy to accumulate dust at home. Not only itchy eyes, but were likely to cause physical discomfort and other respiratory diseases, especially in the room with carpeted room. So, if you want a thorough cleaning, you must use the dust collector.

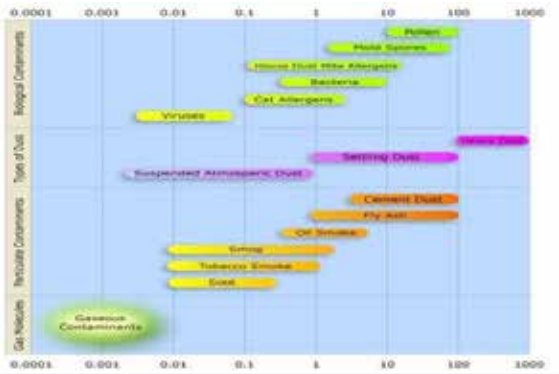

Figure 1: Comparison of various particle size, micrometers (µm). (Taken from the internet Wikipedia, 2015 [5])

Figure 1 showedwhatever the big particles or small, all had little effect on the human body (because the body could not absorb or excreted).Reallythe deepest harming to human was between the middle-sized particles, which was about 1.0 microns in size PM[5].Michigan Technological University of USA, in Las Vegas valleys,Nevada,this study appeared in the pavement when sanding, the body might inhaletiny structures of particles when setting regulations need to include asphalt respirable PM emission factors for project[6]. In 2003, South Korea, Gyeonggi rural areas, took air samples to investigate the concentration and distribution of the gas / particle from September 2001 to July 2002. It measured over 48 hours cycle gas particles with polychlorinated biphenyls (PCBs) in the concentration. The average contribution degree (%) of gas particles were about 90%, indicating that atmospheric PCBs, existing mainly in the gas phase[7].

At the same time, due to the needs of industrial upgrading, plant cleanliness of the air conditioning control was more rigorous.So cleaning air conditioning engineering, those projects weresuch as environmental control of today's semiconductor plant. With the development of air-conditioning industry, due to the different process requirements, environmental factors might be controlled temperature, wind speed, relative humidity, cleanliness, odor, noise, electrostatic and electromagnetic waves, this study would explore one related topic, how effective could the dust collector to remove dust mites life, thus improving air quality, to improve the cleanliness of the indoor environment as the main appeal.

Common type of cyclone (centrifugal) dust collector structure was simple, but compared to other types (such as filters) dust removal equipment which could be used at very low cost. we could achieve the effect of dust[8].Market to sell household cleaners (smaller dust collector) type and the principle were the use of high-speed operation of the motor. So inside the vacuum cleaner into the air, the centrifugal force, a negative pressure inside the state, could be dust, insects, small body, small trash particles through the screen filter on the suction pipe and finally reach the dust bag and complete draw dust purposes. Of course, the more cleaner horsepower was strong suction, the suction vacuum was cleaner and stronger than the average fan.So, you could absorb dust and even ants.

In order to analyze the situation of the cyclonic flow inside the flow field, this study used the market to sell the CFD (computational fluid dynamic, CFD) commercial software package, simulation experiments under different conditions and select. This Objective the study want to get was a cyclone internal flow field analysisand was tangent or tangential flow into the cyclone dust collector to optimize the pursuit, andwhich the air into was in the low, medium or high, the location of an air inlet had the best dust performance.

Experimental methods

In simulator of this study, using the air inlet with a 3.0m / s wind speed suction to create entire virtual dust collector device (Figure 2), which simulate the internal air flow field, because had a downward direction in the Z-axis gravity, acceleration of -9.8 (m / s²), to create a similar environment as the earth.The same physical principles, so analog authenticity dust collector, was quite credible. ANSYS simulation used for the construction of a model with a powerful combination of capabilities CFD pre-processor, and currently used by the US Fluent Inc.,acquisition, and added commercial CFD software package.It was treated as a general electronic computer-aided design / manufacturing / engineering analysis (CAD / CAM / CAE) mainstream system [9].

Netherlands and Canada in 2011 scholars, the researchers for the tricky urban pollutantsand PMwere in turbulence model simulation and validation experiments,wanting to know how the diffusion? When identify issues related to prevention, found to be very suitable for the micro-scale atmospheric diffusion to simulate situations[10]. Studies of Islamic Azad University, Mechanical Engineering Section,Tehran, Iran, H. Safikhani et. al.noted that in a circulating fluidized bed (CFB) of the industry when you wanted to introduce some major equipment problems, such as bulky traditional (round) cyclone and the time required to raise the cyclone. Now this problem wasovercame by changing design to produce a square cyclone[11].

Figure 2 showed that the synthesis of the entire virtual dust collector unit mesh interior space and graphics, ANSYS simulation software to map out the entire interior space of the virtual dust collector system configuration diagram. To renderfaithfully the entire virtual simulated space dust collector device and dust flowing field inside case, the researchers designed two separate analog entity, to form the entire virtual dust collector means, which were named Fluid1 and Fluid2, shus as Figure 3 and Figure 4.The two entities shared a common wall (WALL). The dust collector inlet aperture fixed 16cm (r = 8cm), cylinder diameter 80cm (r = 40cm), length 130m (including the bottom of the vertebral body part), the duct height was 80cm. Into the outlet position was designedto low, medium, high three modes. There were six types of combinations to do more. A total of 247,576 grid entire graph.

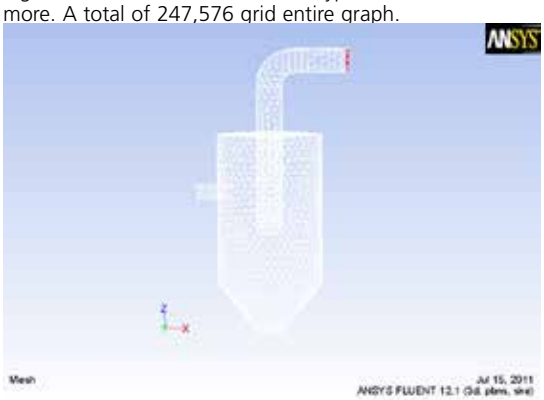

Figure 2: The entire virtual dust collection device with synthetic mesh interior space

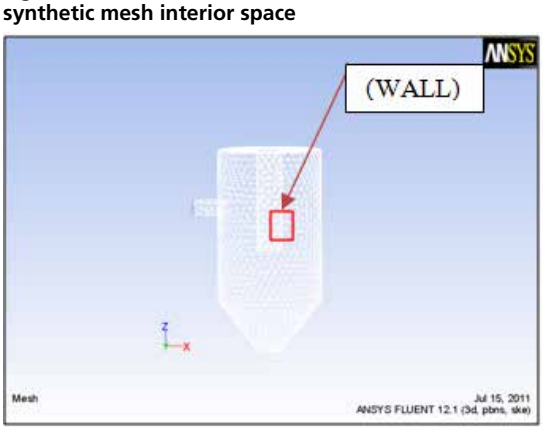

Figure 3: The virtual entity Fluid 1 mesh interior space,

andhad common wallbetween Fluid 1 and Fluid 2(WALL)

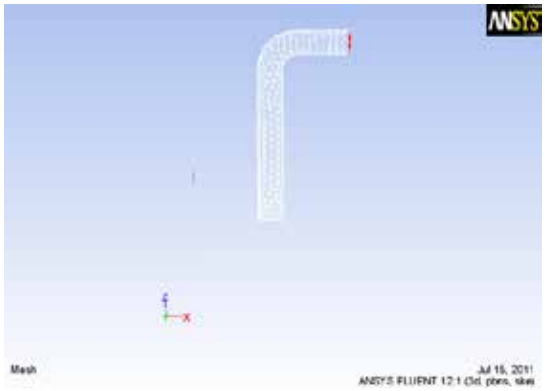

Figure 4: The virtual entity Fluid 2 interior space with mesh

Boundary conditions and initial conditions were set: (1) In the gas flow into the air inlet was a boundary face setting (inlet), for a given air flow into the wind speed was fixed to (3.0m / s). (2) At the outlet side was to the outlet boundary (outlet). (3)Wall boundary condition (WALL, WALL-1 & WALL-2) was in the flow field of the most common boundary of the set condition. For a fluid having viscosity of, the use of adhesion conditions were not sliding, while the wall of the fluid was the same rate of speed and at near the wall. Generally speaking, it wasmore difficult being given the export conditions in the analysis of a viscous fluid problem. One solution was to export the flow surface (outlet) placed in the appropriate position, so that a variety of physical changesin the department's relatively was the smallest[12]. The simulation experimental devicedid not modifiersbecause the outlet flow surface had been fixed set on top of the dust collector, so did not do this experiment set export borders. Other parameter values were not specifically mentioned, the begin of the software's default parameter values based.

Results and discussion:

The simulation used two sets A and B do experimental design. Two experimental groups the biggest difference was that the way the wind A group tangentially cut flush into the dust collector inside the ring.The way of the wind was group B, in order to non-tangential direction trimming enter the ring inside the dust collector. The two groups were respectively provided with air inlet low, medium and high winds into position, so there would be a total of 2 × 3 = 6 different inlet location for comparison test.As were shown in Figure 5-10. Finally, throughout the experimental device, selecting tangentially cut flush into the ring inside the dust collector to the outlet position, was a set of examples in the middle, adding 0.001g / s quality of PM, taking a look at this set of experiments dust device.The overall air flow field flow PM diffusion and distribution situation were in cyclone internal turbulence. Fluent solver was used to substitution calculation that:

(A)The tangential direction of the dust was cut flush into the internal design:

1. Into the air in the middle position, settinga fixed wind speed 3.0 m/s, was presented by Fluent graphical ilk field flow chart shows.The wind speed into the dust collector from the middle position, the centrifugal force was at the beginning of the fastest appear while immediately the wind was into the vortex state.Due to the influence of gravity, most of the air flow had been down into the bottom of the rotation.A small part of the air circling was upward, then still pull of gravity falling.The two streams in the bottom of the intersection, squeezed upward direction to exit effluent gas stream from the geometric vector illustration- direction of the arrow. As was shown in Figure 5.

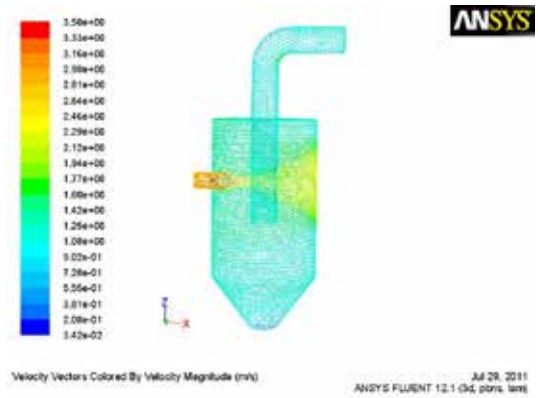

Figure 5: The air inlet in the middle of a cyclone geometry of the flow field velocity vector

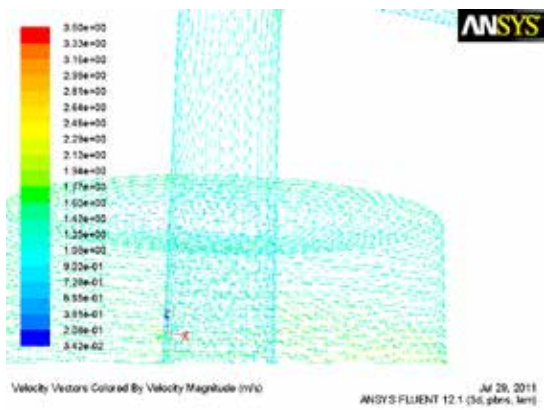

Figure 6: The air inlet in the middle of a cyclone the flow field velocity partial enlarged view

2.Into the outlet position at the top, setting a fixed wind speed 3.0m/s was presented by Fluent graphical flow chart described ilk field. entering the dust collector from the top position of the wind speed, the centrifugal force was at the beginning of the fastest appear while immediately the wind was into the vortex state. Due to the influence of gravity into two airflow around, most of the preceding flow had been down into the bottom of the rotation. After only a very small segment within the airflow along the top edge (fluid1) rotation, was also subject to the pull of gravity to fall. After two streams in the bottom of the intersection squeezed upward direction towards the outlet (fluid2) effluent gas stream from the geometric vector illustration-direction of the arrow, as was shown in Figure 7.

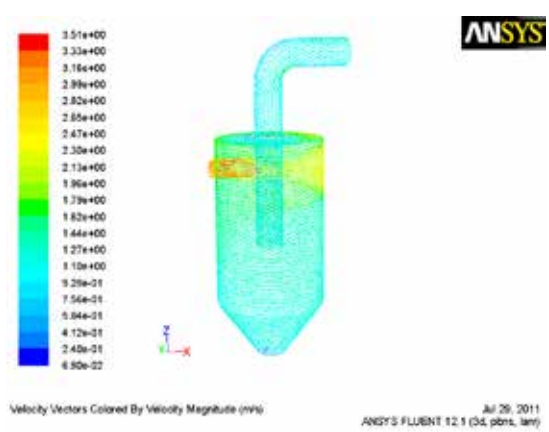

Figure 7: The air inlet at the top, cyclone geometry of the flow field velocity vector

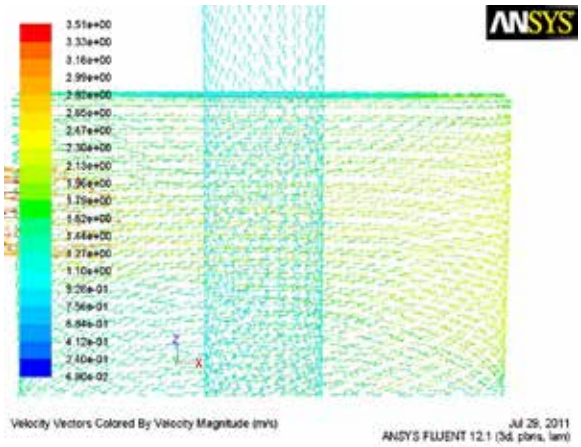

Figure 8: The air inlet at the top, inside the cyclone flow field velocity partial expansion

3.Into the air intake at the bottom position, wind speed setting fixed 3.0m/s was presented by Fluent graphical ilk field velocity diagram.It showed the wind speed into the dust collector from the lower position was the centrifugal force fastestwhile immediately entering the vortex state.Due to the influence of gravity, itwas divided into two sections. After the airflow into a small part of the front air flow down into the bottom of the rotation, most of the flow along the inner side of the edge segment(fluid1) rotation, rushed inside the top edge, was also subject to gravity the pull to fall.Before the two streams in the bottom of the intersection, was squeezed upward direction towards the outlet (fluid2) effluent gas stream from the geometric vector illustration-direction of the arrow, as was shown in Figure 9.

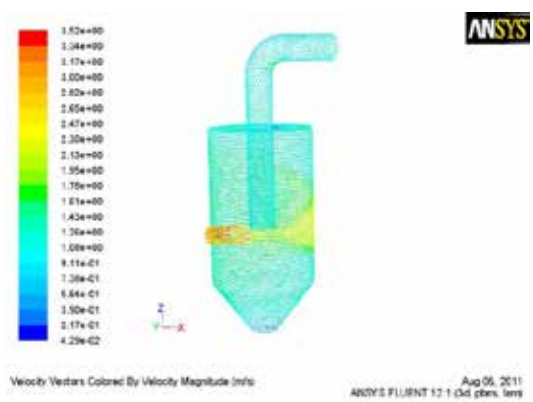

Figure 9: The air intake at the bottom, cyclone geometry of the flow field velocity vector

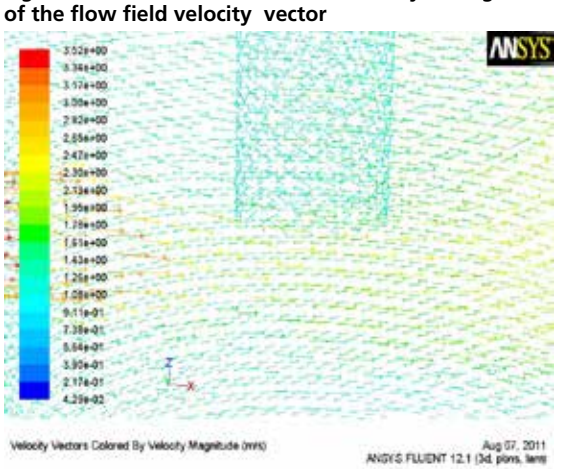

Figure 10: The air intake at the bottom, inside the cyclone flow field velocity partial enlarged view

(B) A non-tangential directionwas into the ring inside the dust collector design:

1.The air inlet in the middle position,setting a fixed wind speed 3.0 m/s, the graphics was presented by Fluent ilk field velocity diagram shows and the wind speed into the dust collector from the neutral position, and by the tangential direction into the dust collector inside design (Figure 5). Compared with each other, which flow field velocity was significantly slower although the flow rate slows down. The air entering the dust collector interior, still natural vortex state was formed.Due to the influence of gravity, after the gas flow was divided into two sections, the majority of front flow directly had been down into the bottom of the rotation after a small part of the air flow within the segment along the side edges (fluid1) rotation.Then circlling up, rushed inside the top edge, still under the pull of gravity and to fall.Finally, at the bottom of the intersection of two streams after squeezing up to the exit direction (fluid2) effluent gas stream from the geometric vector illustration-direction of the arrow, as was shown in Figure 11.

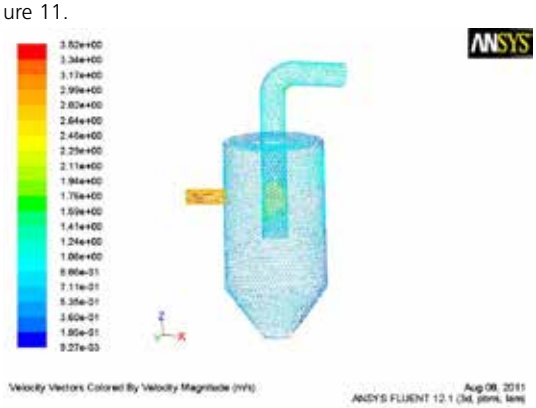

Figure 11: The air inlet in the middle, velocity vector geometry

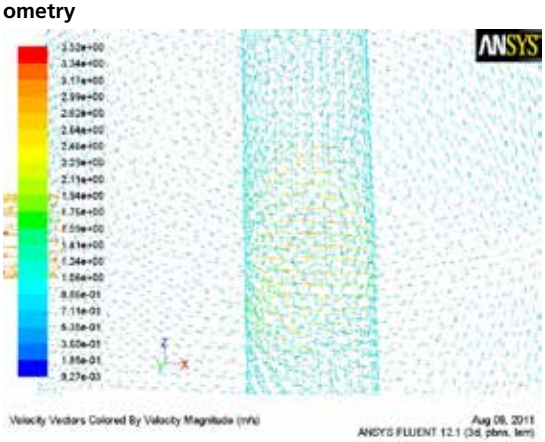

Figure 12: a gas inlet in the middle, the flow rate of a partial enlarged view

2. The inlet position at the top, setting a fixed wind speed 3.0m/s, the graphics was presented by Fluent ilk field velocity diagram shows and the wind speed into the dust collector from the top position, and by the tangential direction into the dust collector inside design (Figure 6).Compared with each other, which flow field velocity was significantly slower although the flow rate slows down.The air entering the dust collector interior, still natural vortex state was formed. Due to the influence of gravity,after the gas flow was divided into two sections, the majority of front flow directly had been down into the bottom of the rotation after a very small section of the air flow along the inner edge of the sides (fluid1) rotation. Then circlling up in the top of the rim, The pull of gravity was later but still to fall. Finally, at the bottom of the intersection of two streams after squeezing up to the exit direction (fluid2) effluent gas stream from the geometric vector

illustration-direction of the arrow, as was shown in Figure 13.

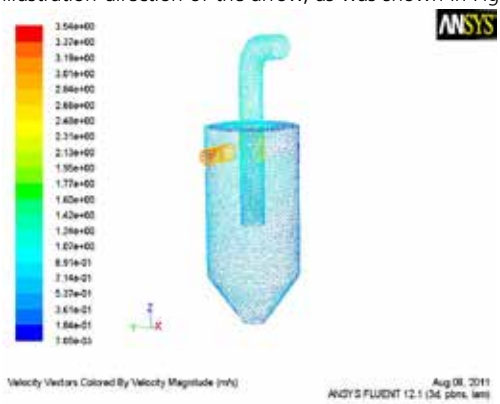

Figure 13: The air inlet at the top, velocity vector geometry

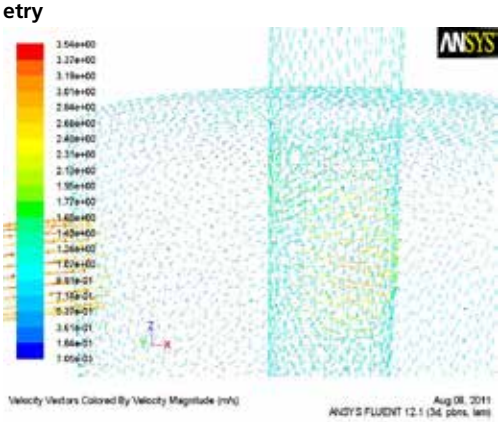

Figure 14: Local expansion of the air inlet at thetop, the flow rate

3.Into the air intake at the bottom position, wind speed setting fixed 3.0m/s,was presented by Fluent graphical ilk field velocity diagram shows.The wind speed into the dust collector from the lower position, was dust from entering the inside of the tangential direction design (Figure 15).Compared with each other, the flow rate of the flow field significantly was slower more.The air entering the dust collector interior, natural vortex state was formed.Due to the influence of gravity, it was divided into two sections. Front air flow into a small number of straight, hadbeen down into the bottom of the rotation after the segment within the airflow.Becomes large part along the side edges (fluid1) rotation, It rushed inside the top edge.Then still it was under the pull of gravity and to fall. Finally, the two streams at the bottom after the fair, were squeezed upward direction towards the outlet (fluid2) effluent gas stream from the geometric vector illustration-direction of the arrow, as was shown in Figure 15.

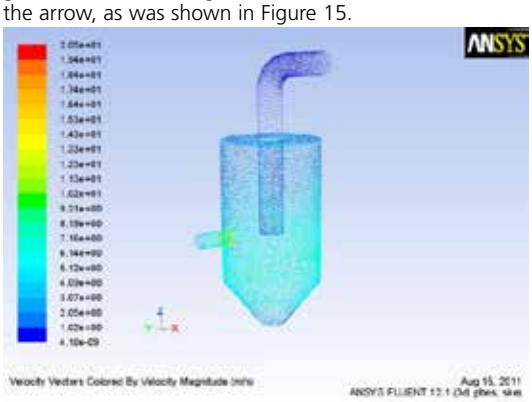

Figure 15: the intake port in the bottom, a flow rate of geometrical vector

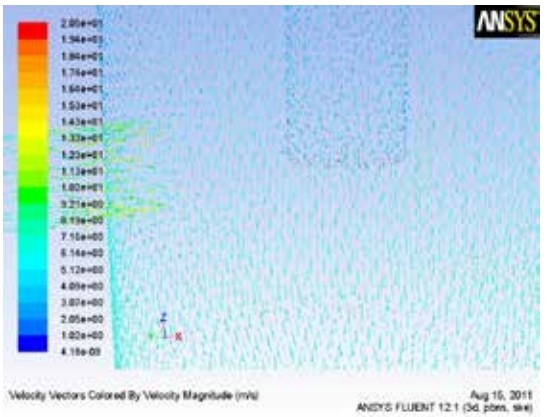

Figure 16: the intake port in the bottom, a flow rate of a partial enlarged view

(C) The actual screening after the cyclone, was particle size comparison scenario:

1. Represented the purity of 99% SiC PM, which had presented the appearance of a pale green color.
2. Represented purity of 85% to 90% of SiC PM, which had presented the appearance of gray-brown color.
3. Represented the purity of only 50% to 60% of SiC PM, which had appeared black exterior color, because it mingled with oil and waterand other impurities.

Figure 17: After a cyclone filter, compare different purity granular particles

(D) PM10.0 granular features were introduction under SEM:

1.After the actual operation of a cyclone separator, SiC with oilandwater was high viscosity, be observedits contour.

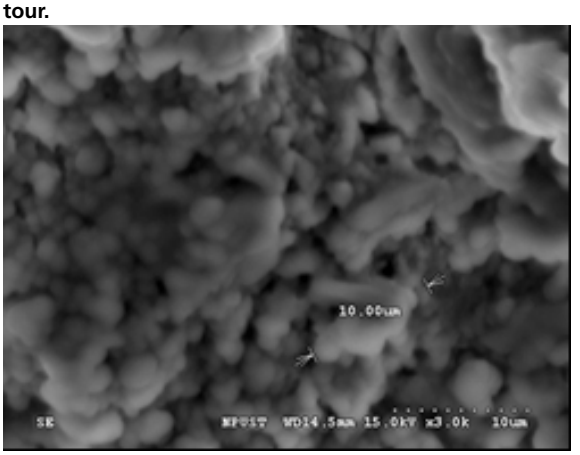

Figure 18: In the SEM, the cyclone had not been isolated before running PM10.0 of granular characteristics situation

2.After the actual operation of the cyclonic separation device, SiC with no oil and water, the particles under SEM were the granular clear outline.

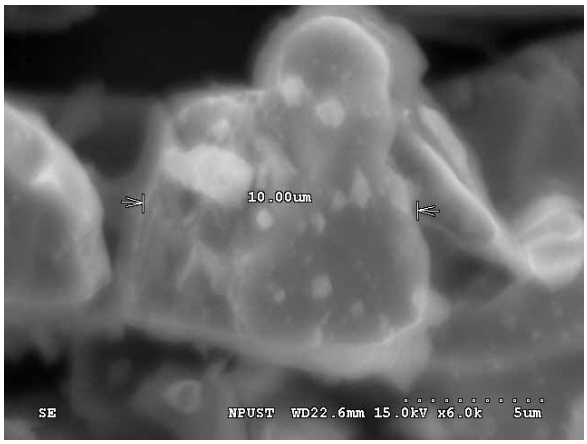

Figure 19: Under SEM, after the operation of a cyclone separator of particulate characteristics PM10.0 case

(E) PM2.5 granular features were introduction under SEM: 1.After the actual operation of a cyclone separator, SiCwith oil and water was high viscosity, be observed its contour.

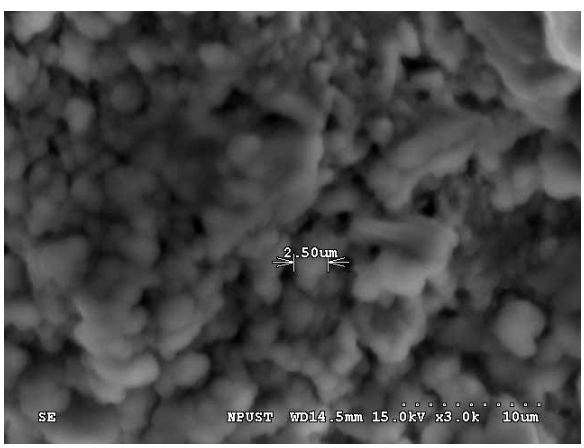

Figure 20: In the SEM,the cyclone had not been in operation after cyclone separation granular characteristics PM2.5 case

2.After the actual operation of the cyclonic separation device, SiC with no oil and water, the particles under SEM were the granular clear outline.

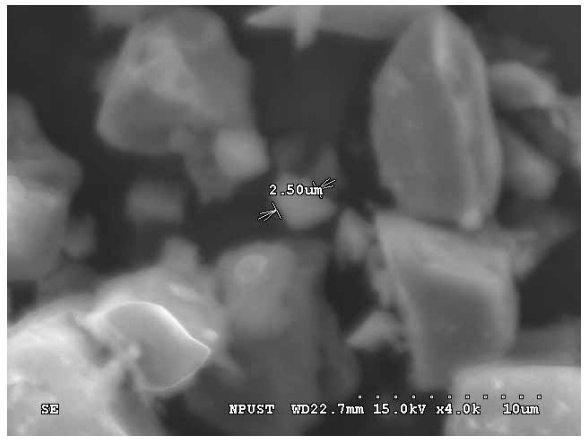

Figure 21: Under SEM, after the operation of a cyclone separator of particulate characteristics PM2.5 case

conclusion:

1.The conclusions were as follows:

1. The way of the wind cut flush to the surface, which of the position in the low, medium andhigh position, the resulting vortex were smooth on the way into the wind in a non-cut flush to thesurface.
2. The way of the wind did not cut flush to the surface, which of the position in the low,medium and high position, the vortex were generated by the wind all the way to cut flush to the surface.
3. At a fixed speed, rotating scroll more smoothly, the less the vortexrotation was smooth, the more the amount of dust be collected.

The operation of large cyclone was experience after actual operation,

1. Under SEM, we could find that SiC particles be screened to show different sizes.

2. For further analysis, PM10.0 of the Shape had no changes with PM2.5 under SEM.

3. Cyclone way into the wind, a non-tangential direction into the annular internal dust collector, dust collector was with turbulent eddies internal rotation, mainly to the highest position of theoutlet,to produce the greatest amount of dust and dust having the best performance.

2. it was recommended:

Cyclone inside velocity was an important factor in influence of the dust amount, and theamount of dust would affect the amount of dust removal efficiency of the dust collector,andtherefore at the time of purchase, we should pay the attention to its internal velocity and dustremoval efficiency.

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