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A Research on the Airflow Efficiency Analysis according to the Variation of the Geometry Tolerance of the Sirocco Fan Cut-off for Air Purifier

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Abstract

In this paper, we studied the flow specificity according to the variable of inner cut-off of the blower, to analyze the performance factor of sirocco fan used in air cleaner. Cut-off value of sirocco fan have an impact on interval change width and entrance according to the inner diameter, it makes discharge rate, scroll casing pressure and speed changed. Therefore, it is necessary to apply for the model turbulence analyzing, we used the model k-w which is predictable exactly flow separation, vortex property. The commercially available CFD analysis tool used SC-Tetra, as a result of analysis the blower discharge volume, pressure field, and velocity field according to the cut-off shape change of the sirocco fan, there's vortex phenomenon in blower exit, it affects to the final speed distribution.

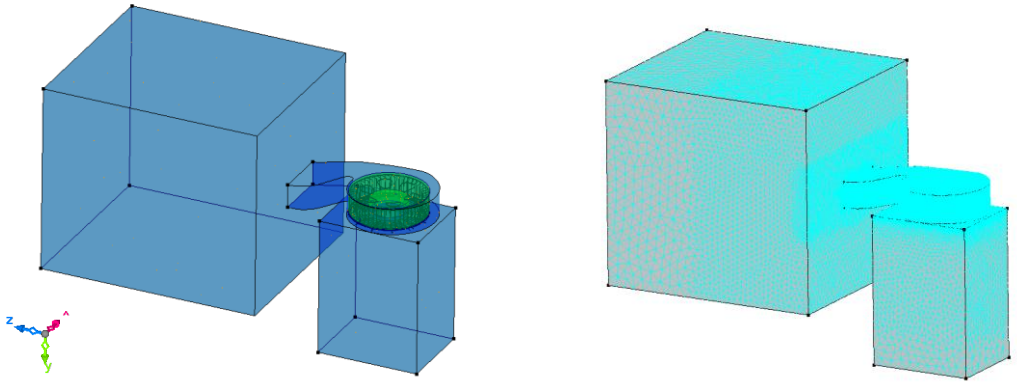
Keywords: Air Cleaner, Sirocco Fan, Cut-off, Performance, Pressure, Velocity, Computational Fluid Dynamics (CFD)

INTRODUCTION

Recently, air cleaner development and demand have been greatly increased due to interest in indoor air environment for indoor air quality along with air pollution. Air purifiers are evolving beyond simple dust collection and deodorization to products with anion, antimicrobial, antiviral and IOT technology and health care. Also, in order to satisfy consumers' desire, technology is being actively developed for upgrading the function such as product performance, noise. In this paper, we conducted the flow inside the blower, which is a centrifugal type blower, using SC / Tetra CFD, a commercial CFD [1] code, and analyze the influence of the sirocco fan on the performance of the sirocco fan according to the cut-off interval. Each flow analysis was performed on the discharge amount, the pressure field and the velocity field of the blower outlet through the change of the cut-off interval of the sirocco fan. As a factor affecting the performance of the air purifier, the blower and numerical simulation were evaluated through the flow characteristics of the internal shape. As a method of analysis, studied the flow field firstly and then the behavior and outlet velocity and pressure of the blow and internal flow in a fixed flow field were examined.

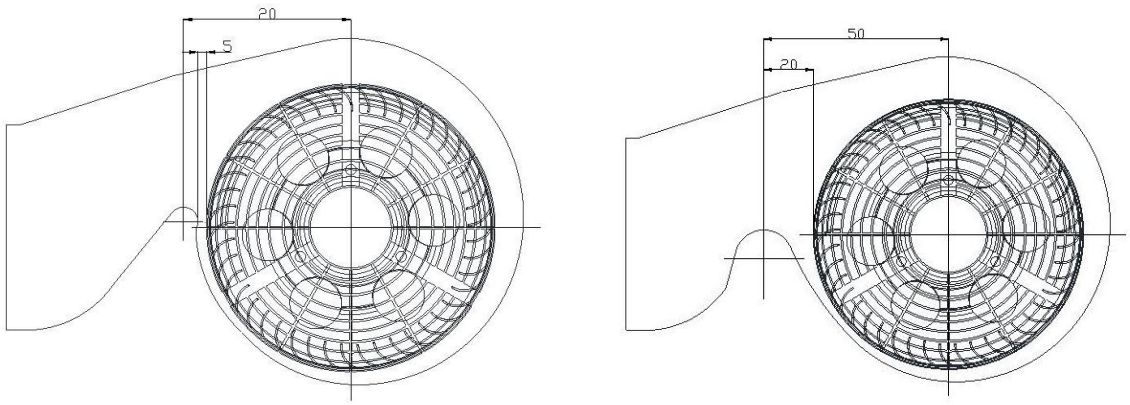
BOUNDARY CONDITION

In this paper, we mainly used SC / Tetra CFD, which is a commercial analysis code for turbo machine flow analysis. For the analysis of compressive turbulent motion, three-dimensional Nabier-Stokes are equally applied and discretized by volumetric method derived from governing



(a) Simple Model for CFD (b) Meshing

Figure 1. Geometry of CFD Model



(a) Original Drawing(Cut-off) (b) Modified drawings(Cut-off)

Figure 2. Detail Drawing of Cut-off

We used the Shear Stress Transport k-w model, which is accurately predictable of the phenomena such as flow separation, as a high resolution scheme with more than second dimension accuracy. In this paper, the sirocco fan model for analysis is a bilateral suction type fan which 3D Full model analysis has been proceed to improve reliability of it.

The boundary conditions were 25 ° C internal fluid temperature, natural suction at the inlet, and atmospheric pressure at the outlet, in actual experiments, the number of revolutions of the sirocco fan blades is changed as the characteristics of the motors, but in the analysis, the conditions are set to rotate at 750 RPM. In addition, Sirocco fan meshing was performed with a sliding lattice, and detailed lattice calculations were is consist of the tip, front and back sides of the sirocco fan where complicated flow separation and reattachment occurred in the flow inside the sirocco fan.

The distribution of pressure of the outlet of the blower and the pressure field and the velocity field along the cut-off interval of 23 mm, 10 mm, and 50 mm and 10 mm, respectively, of the center axis of the sirocco fan were analyzed. Figure 1 (a) shows the simple model for the flow analysis, and (b) shows the model with the hybrid mesh [2]. Figure 2 (a) shows the conventional blower cutoff interval plot, and Figure 2 (b) shows the changed blower cutoff interval plot [3].

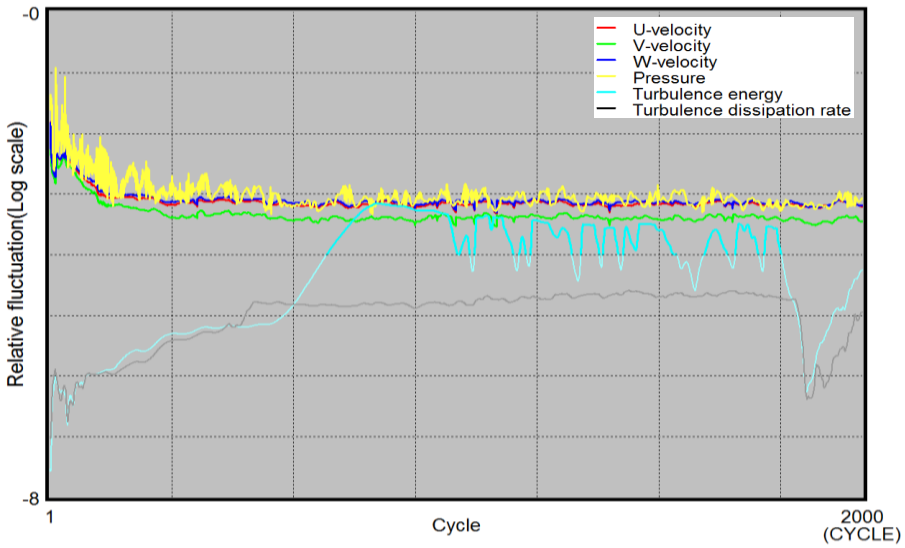


Figure 3. Convergence status of CFD Analysis

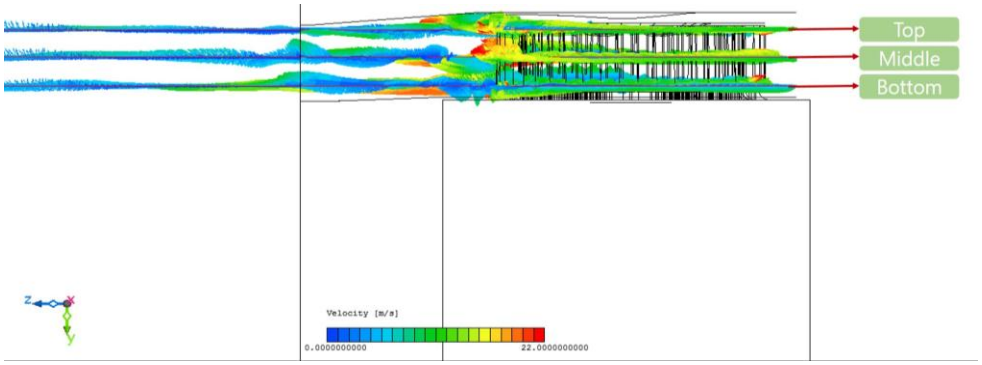
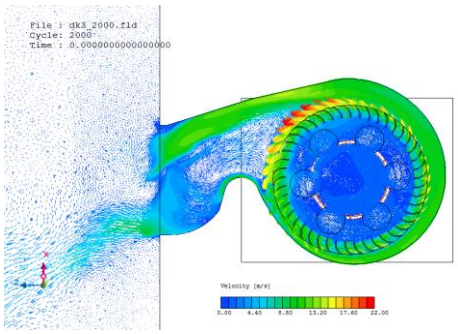


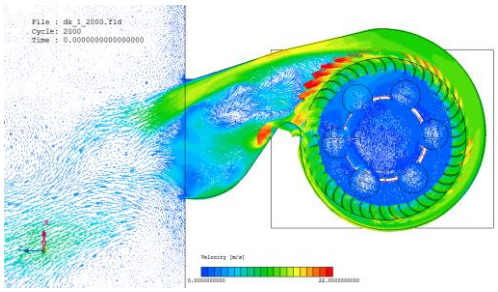
Figure 4. Section Plan of CFD Results (Top, Middle, Bottom)

RESULT OF COMPUTATIONAL FLUID DYNAMICS

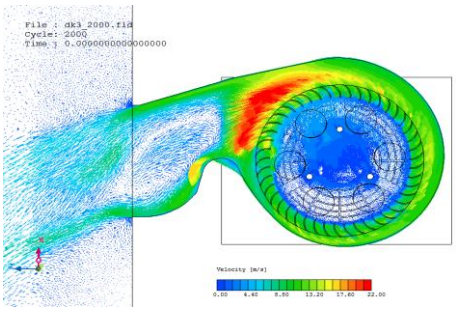
The flow analysis carried out at 2,000 cycle and showed a constant convergence result as shown in Figure 3. It can be seen that turbulence generation due to the generation of sound pressure in the Sirocco fan appears to be somewhat unstable. Velocity vector distribution, velocity, and pressure fields were analyzed by dividing Top, Middle, and bottom plan according to the cutoff radius of the Sirocco fan. Figure 4 shows the results of the velocity vector analysis for the three part aspects according to the cutoff interval variation, and Figure 5 shows the velocity field flow according to the cut-off interval variation. Figure 6 shows the results of the pressure field. Figure 7 shows the discharge speed of outlet at the cutoff interval variation [4]. From the results, it can be seen that the difference of the discharge speeds is 1.47 m/s according to the change of the cutoff interval of the sirocco fan. As a result, the inner pressure is reduced due to the reduction of the sirocco fan and the blower for the change of the cutoff radius, as the speed increases [5], the flow rate of air discharged from the outlet increases and the average speed of the outlet increases compared to the average area of the outlet. Table 1 shows the analytical results according to the change of the cutoff interval of the sirocco fan.



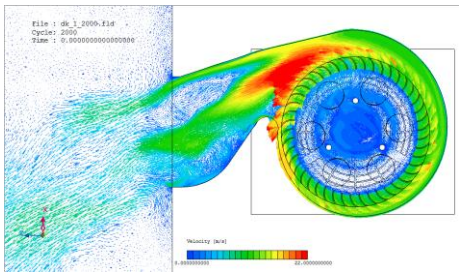
(a) Section of Top Plan (Cut-off 23mm)



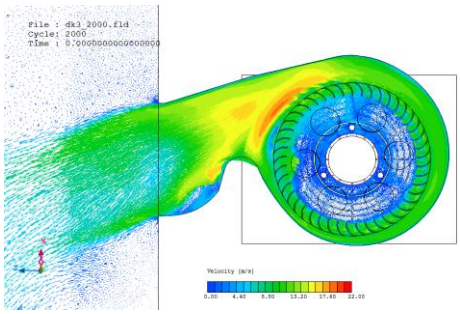
(b) Section of Top Plan (Cut-off 10mm)



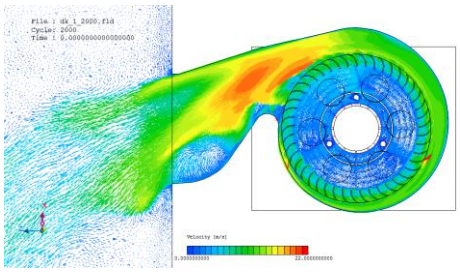
(c) Section of Middle Plan (Cut-off 23mm)



(d) Section of Middle Plan (Cut-off 10mm)



(e) Section of Bottom Plan (Cut-off 23mm)

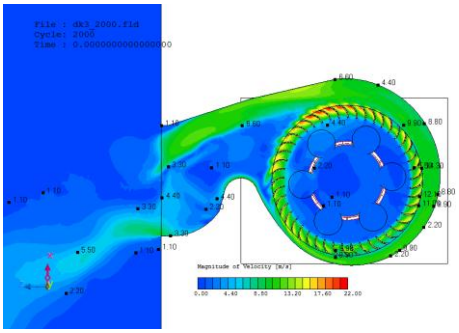


(f) Section of Bottom Plan (Cut-off 10mm)

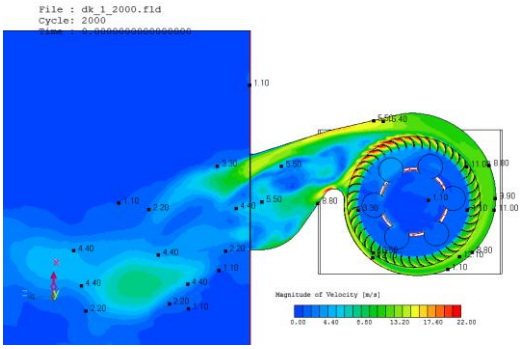
Figure 5. Results of Velocity Vector

Table 1. Results of CFD Analysis for according to cut-off

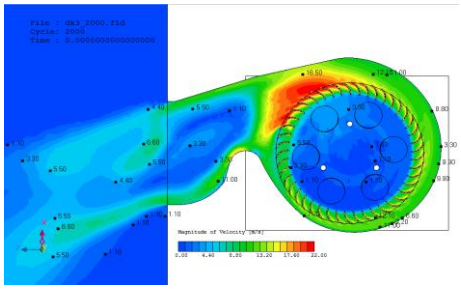
No	Cut-off [mm]	Outlet Area [m^3]	Outlet Velocity [m/s]	CMS [m^3/s]1	CMM [m^3/min]	CMH [m^3/hr]
1	23	0.016896	6.581	0.111	6.671	400.29
2	10	0.016896	8.05	0.136	8.161	489.64



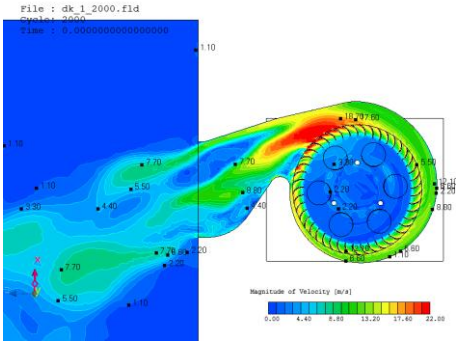
(a) Section of Top Plan (Cut-off 23mm)



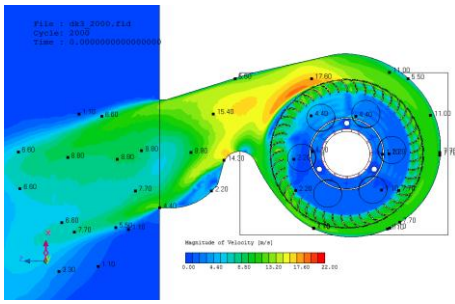
(b) Section of Top Plan (Cut-off 10mm)



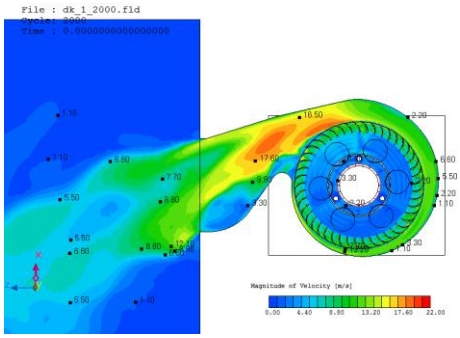
(c) Section of Middle Plan (Cut-off 23mm)



(d) Section of Middle Plan (Cut-off 10mm)

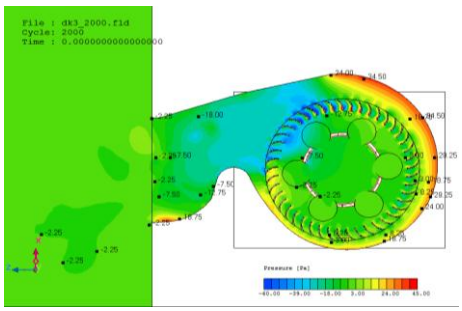


(e) Section of Bottom Plan (Cut-off 23mm)

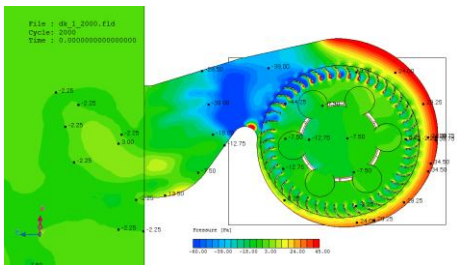


(f) Section of Bottom Plan (Cut-off 10mm)

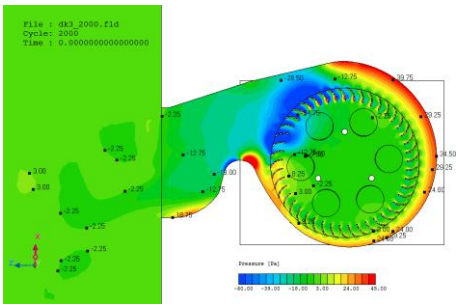
Figure 6: Results of Velocity Contours



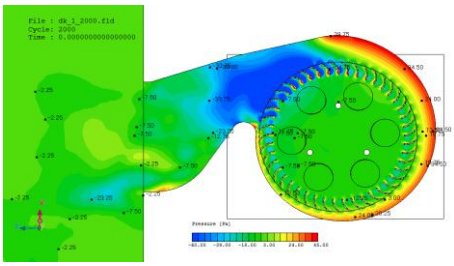
(a) Section of Top Plan (Cut-off 23mm)



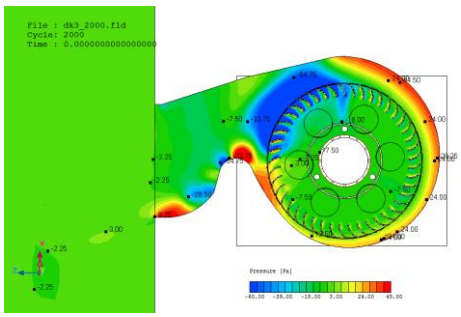
(b) Section of Top Plan (Cut-off 10mm)



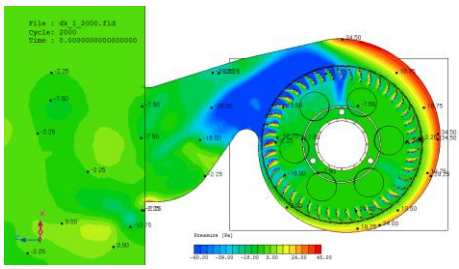
(c) Section of Middle Plan (Cut-off 23mm)



(d) Section of Middle Plan (Cut-off 10mm)



(e) Section of Bottom Plan (Cut-off 23mm)



(f) Section of Bottom Plan (Cut-off 10mm)

Figure 7. Results of Pressure Contours

In order to confirm the reliability of the flow analysis, it is necessary to analyze the value of the test result with respect to the actual model, first, basically, the analytical results may differ depending on the analysis conditions such as turbulence model, lattice, and discretization technique of CFD. In the analysis, it is assumed that the entire blur including the scroll casing is modeled and the inlet area is analyzed as the virtual inlet condition using the expansion volume.

Therefore, the flow condition is similar to the experimental value of the real model, can be minimized. As shown in Figure 5, the velocity vector is formed smoothly at the entrance area and the constant velocity distribution is shown at the exit area. The velocity vector distribution is unstably distributed in the middle plan when the cutoff interval of the Sirocco fan is 23 mm, when the cutoff is 23 mm and 10 mm, the velocity vector of the bottom plan shows a relatively stable distribution.

Figure 6~7 show the velocity field and the pressure field according to the cut-off interval variation. As shown in Figure 6, the velocity distribution is proceeding toward the exit direction when the cutoff interval is 10 mm. As can be seen in Figure 7, the wall pressure of the scroll casing is high at the cutoff interval of 23 mm, the flow is not smoothly discharged toward the outlet due to the flow separation phenomenon in the cutoff region. When the cutoff distance is 10 mm, the pressure drop on the wall of the scroll casing decreases as the flow separation phenomenon decreases, and it is confirmed that the discharge of the flow is on the progress.

CONCLUSION

In this paper, a comparative analysis of the flow rate at the exit of the blower according to the cutoff interval of the sirocco fan is described. Once the cut-off interval of the existing Sirocco fan was 23 mm, the speed of the blower outlet was about 6.6 m/s and the flow rate was about 6.7 CMM, as a result of reducing the cutoff interval to 10 mm, the velocity of the blower outlet increased to about 8.1 m/s and the flow rate increased to about 8.2 CMM.

This is because the sirocco fan cutoff interval is reduced to eliminate the internal flow separation phenomenon, and the flow rate is normally discharged to the outlet side. Therefore, it is considered that the airflow efficiency of the sirocco fan is increased by a value within the cutoff interval of 10 mm than the cutoff interval of 23 mm. In the future, we will carry out the study goes on the improvement of the sirocco fan efficiency by optimizing the scroll casing wall pressure and the blade airfoil.

ACKNOWLEDGMENTS

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