CORK INSTITUTE OF TECHNOLOGY

INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Novaerus (Ireland) Ltd Innovation Voucher

NV950 Flow Investigation

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1 Introduction

The aim of this study is to investigate the performance of an NV950 unit in a standard room size. The unit is typically recommended to be wall hung centrally on a main wall and has two outlets and one main inlet. The device intakes air from the room through the inlet and internally treats the air before emitting clean air back into the room via the outlets.

Computational Fluid Dynamics (CFD) simulation was identified as a cost and time effective method by which this investigation could be carried out and so a numerical simulation was undertaken on the NV950 device placed in an 800 ft^3 square shaped room with standard 8ft ceilings. Transient models were developed to simulate the unit's two speed settings and plot the percentage of treated air in the room over time. Once these simulations were completed, flow visualization tools were also employed to assess the aerodynamic behaviour of the fluid within the domain which may be informative from a device operation perspective.

This initial study is completed at the request of Novareus (Ireland) Ltd and carried out by Dr Andrew Cashman, Cork Institute of Technology funded under Innovation Voucher, IV-2016-0021-T.

2 Numerical Simulation - Procedure

The domain was created based on a square shaped 100 ft^2 room with standard 8 ft high ceilings having a total volume of 800 ft^3. The unit was placed centrally on the back wall at the mid height position. The domain was initialised with 100% air type 1, which will be used to represent the untreated fluid. The outlet vents of the unit were then set as velocity inlet boundaries which were inputting air type 2 (representing the cleaned air) into the room at the desired volumetric flow rates. Concurrently, the circular inlet to the fan was modelled as a velocity outlet which was removing air mixture from the room, simulating the air being sucked into the unit. The volumetric flow rates into and out of the domain were monitored to ensure conservation of mass was preserved. ANSYS Fluent 16.0 was used to carry out the simulation.
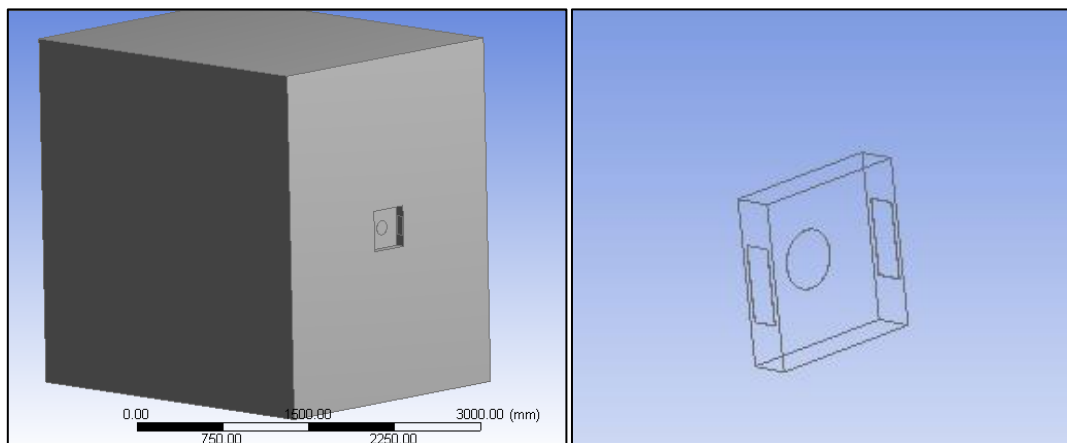

Figure 1 Computational Domain

As this simulation required a transient analysis, time step size and number of iterations per time step were critical to the accuracy of the results. A small step size of 0.1s was selected while initial maximum number of iterations of 20 per time step was also utilised. Residuals were monitored and required to drop 3 orders of magnitude before a converged solution was obtained. After various runs, it was found that the maximum number of iterations per time step could be reduced to 8 in order to reduce the computational expense while not affecting the accuracy of the simulations.

Calculations would suggest that at the lower fan speed of 912 rpm where Q=136 m^3/hr, with perfect mixing the unit would take approximately 10 minutes at this setting in order to exchange 100% of the air in a room of size 800 ft^3. Therefore, initial models were expected to run for a minimum of 6000 time steps. Due to this computational demand, it was found that models were required to run on parallel processors for several days in order to model complete air exchange in the domain.

3   Results

The following graph shows the volume fraction of air type 2 (treated air) in the domain versus time. It is observed that at the lower fan speed setting of 912 RPM, 24 minutes were required before the domain was completely filled with treated air. 90% was achieved after 17 minutes, however the rate of change after this point is seen to reduce substantially. In comparison, the larger fan speed setting of 1072 RPM (Q=167 m^3/hr), 21 minutes were required for full exchange while a 90% exchange was achieved in 15 minutes.
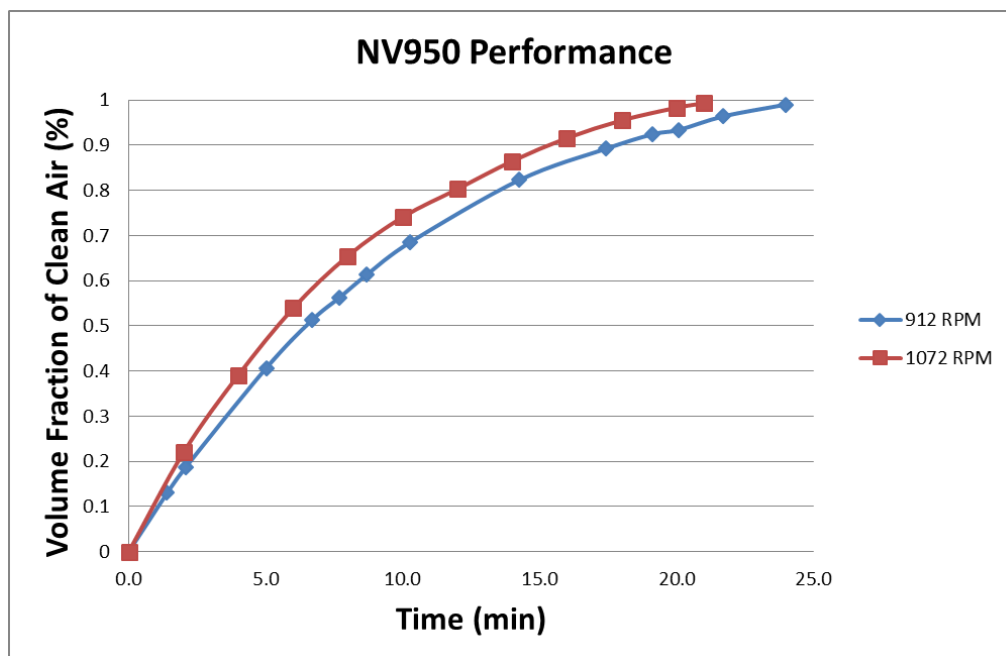

Figure 2 Air Exchange History

The flow pattern within the room was plotted after various time steps in order to examine and understand the nature of mixing of both air phases in the model. The design of the unit clearly promotes an excellent mixing pattern as the fan inlet draws air in centrally, while the outlet vents release treated air perpendicularly to this. This creates a flow of clean air out to the extremities of the room and down along the back wall before filling "from outside to in", while untreated air is constantly drawn in from a central channel.
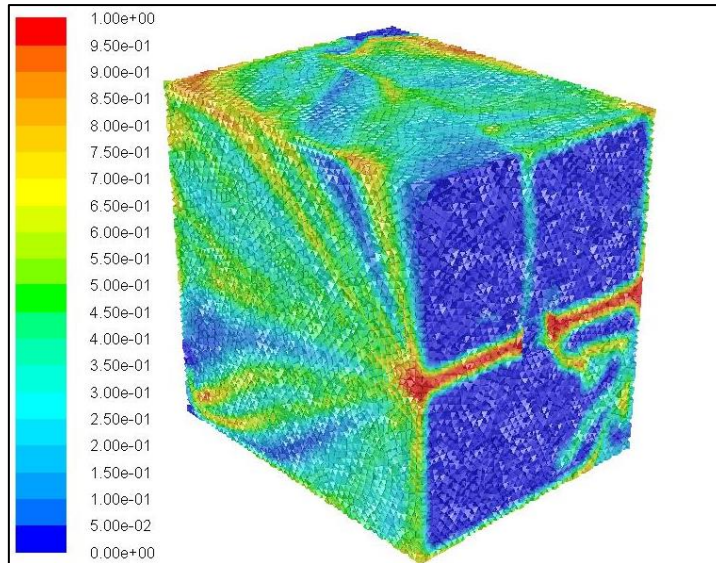
Figure 3 Volume fraction of clean air, t=64s

Shown above, the horizontal flow from the outlet vents on the unit track uniformly across the room until the column of air hits the side walls. This then causes the uniform column to disperse and spread down along the wall towards the opposite end of the room. In the meantime, the fan inlet draws air down a central axis which promotes the cleaned air to circulate from the back wall.

Figure 4 shows the profile after 10 minutes of the fan running at this setting and again, it is evident that the outer walls have mixed with clean air. It is noted that complex flow is developing around the fan unit itself and this is clearly one of the last sections of unclean air in the domain to be replaced.
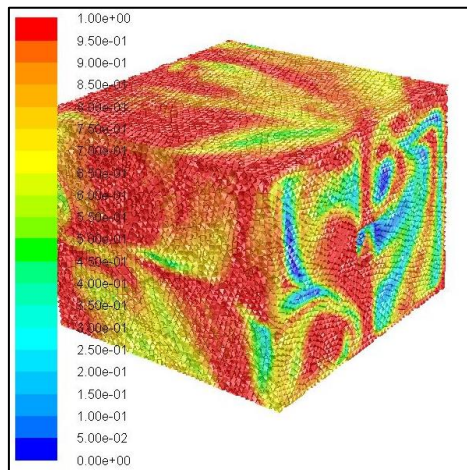

Figure 4 Volume fraction of clean air, t=10 min

Towards the end of the simulation, the entire domain is clearly mixed, as shown in Figure 5 below.
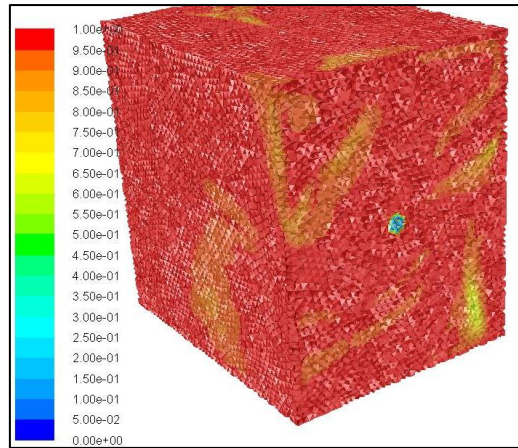
Figure 5 Final volume fraction of clean air

Placement of the device centrally on one end wall is certainly shown to be a positive influence on the mixing performance of the unit in a room. The pathlines shown below in Figure 6 help to demonstrate the initial flow trajectory from the device and it is clear that the central column of air being sucked into the unit creates a mixing as the clean air column hits the side wall and moves in a parallel direction to the intake column. When the two outlet vents from the NV950 unit expel clean air, the mass travels in a uniform column laterally until they strike the side walls of the room. This column then disperses and spreads out along these walls in a more dispersed manner. With that, it is clear that one of the last areas of the room to become mixed is above and below
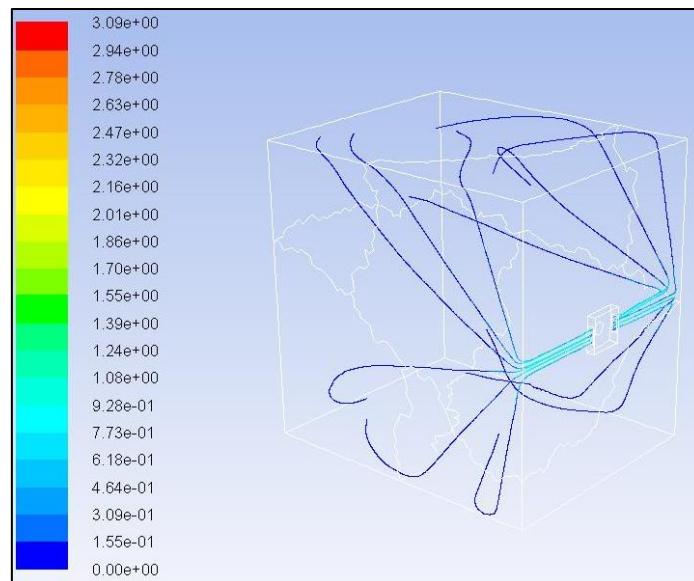
While the results of the numerical model certainly provide a good insight into the operation of the device and flow patterns within the room, it should be noted that the flow here is highly irregular after a small period of time. This fact, coupled with the normal error associated with any numerical model, should be kept in mind when analysing specific results from the study.

4   Conclusions

➢ Following this analysis, the unit operating at the lower speed setting can be said to take 24 minutes to clean 100% of the air in a room of 800 ft^3 in volume

➢ The larger operating speed of 1072 RPM is shown to take 21 minutes for full air exchange

➢ 90% exchange of air is complete after 17 minutes at 912RPM and 15 minutes at 1072 RPM.

➢ The placement of the device on a wall centrally is an excellent standard procedure to assign to the operation of the unit as the flow patterns into and out of the device promote good mixing patterns in the room.