AIR QUALITY ANALYSIS IN CLOSED-SPACE CAT CAFES TO REASSURE AIRFLOW TO MAINTAIN THE HEALTH OF THE USERS

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ABSTRACT: *The cat cafe is part of a new business strategy that has concerned the sanity issue, especially in indoor air quality. This study aims to simulate the flow of the indoor air environments including the airflow, apertures, and particles of Pet Saga and D'Meow Cat Cafe at Yogyakarta. The method of the study was through direct observation using a TVOC meter for PM 2.5, CFD simulation to assess the indoor airflow in 3 conditions of air velocity, and Air Changes per Hour calculation to assess the quality of the indoor air able to maintain the air sanitation. The results from this study show that the airflow movement inside the room depends a lot on the size of the apertures that existed along with the air velocity in the area which then has the possibility to affect the number of air micro-particles although based on the result of the calculation for the Air Changes per Hour, both of the cat cafes have surpassed the standard of air changes in restaurant according to the Indonesia National Standard for ventilation.*

Keywords: Cat Cafe, CFD, Indoor Air Quality

INTRODUCTION

The existence of companion animals inside a closed-space environment has been lingering between its benefits and risks. (Gustafsson, 1997) Especially connected with the indoor air environment, companion animals, although they have been maintained in a clean environment, can still threaten the users' health. The most common signs that are usually shown are cough, itchy throat, runny nose, and so on. Therefore, there was a study that stated, in terms of the relationship between animals and humans in an indoor area, the one that has the biggest impact on the possibility of spreading air contamination is the air tightness and the close contact with the animals (Yanagi et al., 2006). Especially in the case of a public eating area, the potential of contamination of the food prepared increases when the area itself combines humans and animals together as the contamination of food depends on the number of microorganisms in the air and the duration of exposure to air during certain technical processing steps or during storage (Moracanin et al., 2019). Therefore, it is important to keep the airflow and the quality itself to be suitable for the respiratory health of human users and the food they prepare.

Cat cafes have the possibility of having their own disease that they might carry, especially after being in contact with a lot of other cats and humans, without knowing that they carry the disease. The same goes for humans, both the visitors and the workers of the cafe. According to the Center of Disease Control and Prevention (2022), some of the diseases that have been carried by the cat might not show any physical signs, and some of the diseases are caused by scratches or fungus that happens due to the environmental condition. Therefore, considering the environmental conditions in cat cafes might still not become the priority for the culinary business as there is a lack of information on the standards or guidelines in terms of indoor quality, especially air quality.

Addressing the issues above, the main objective of this study is to analyze the airflow that happens in cat cafes by observing the chosen variables which are openings placement and size. This study will be conducted through direct observation and calculation using a device and CFD with the expected results to be able to determine the safety standards in terms of airflow to increase the comfortability of the users in doing culinary while being in the same closed-space environment with the companion animals inside. Previous studies have shown

the analysis of how airflow would affect the users' comfort, including humans and animals. But, there is still a lot of room for development on this issue considering the location of space and new phenomena and adaptation, especially for the post-pandemic era.

LITERATURE REVIEW

AIRFLOW

Airflow has always been the concern of creating a closed-space environment, especially in cat cafes where the possibility that the food be contaminated with the shedding fur from the cats, the space's opening should be designed properly. The airflow pattern must have focused variables such as the direction of the wind, objects inside the space, and most importantly the opening itself as the designer should know how many, how big, and where can it be located in the room to maximize the flow of the air. The research done by Saha et al. (2020) showed the analysis of a naturally ventilated barn for its capability to simulate the airflow inside and how the pattern of each airflow in the openings has resulted in how the distribution of the fresh air inside the barn relies a lot on the combination of the opening. As the barn is filled with livestock, the opening should be large enough to accommodate the need for fresh air inside while at the same time not disturbing the comfort of the animals. The barn that has been chosen in this research relies a lot on the door and alley to create the negative space inside the barn to control the best airflow pattern. Other than that they also make use of the sidewall opening that acts as inlet air to control the temperature for their comfort. On the other hand, similar research on a room filled with livestock has also been conducted by Bjerg et al. (2002), the discussion also finds out that the airflow will move according to the plan of the room, yet, there are also some possibilities that it will be disturbed according to existing objects in the area.

SIZE AND LOCATION OF THE OPENING

Not only the openings will define the quality of the airflow, but also the other architectural features will have a significant impact on that as they can harness the wind force and the stack effect happening in that room (Aflaki et al., 2015). As the cat cafes chosen are located in a tropical area, Aflaki stated that building layout, size, and placement of apertures as well as building orientation and facade arrangement will also impact the airflow.

AIRBORNE POLLUTION

The airborne transmission should also be focused to be analyzed because of the condition of the post-pandemic era. Specifically in a restaurant, some environmental parameters will influence the transmission such as thermal, ventilation rate, and filtration efficiency (Liu et al., 2020). The ambient air of the room has a possibility of not only transferring the physical disturbance through airflow but also growing some viruses that are triggered by surrounding conditions. Although in business the main focus will be the human who runs the cafe, indoor air pollutants should also be eliminated as it will decrease the health of the animals due to some particles that can not be recognized (Lin et al., 2018). Especially as they only roam around the room and dwell there while meeting new people that come from outside, the respiratory disease should as well have a bigger risk of growing. According to the standard of the Meteorological, Climatological, and Geophysical Agency, Particulate Matter (PM2.5) has several standards which include 0-15.5 $\mu gr/m^3$ (good), 15.6-55.4 $\mu gr/m^3$ (average), 55.5-150.4 $\mu gr/m^3$ (unhealthy), 150.5-250.4 $\mu gr/m^3$ (very unhealthy), >250.4 $\mu gr/m^3$ (dangerous).

METHOD

This study will collect the data through direct observation, simulation, and calculation. The direct observation will be conducted in Pet Saga Yogyakarta and D'Meow Cat Cafe where the space arrangement for the cat cafe will be pretty different. The analysis of air quality conditions is proceeding through three methods, direct observation using a TVOC meter, CFD simulation, and air changes per hour calculation. CFD calculation is necessary as a way

to show the movement of air that is based on certain numbers of velocities in Yogyakarta. Meanwhile, the Ac/H calculation was used to show if the room of the cat cafe itself met the standard in SNI 03-6572-2001 which for the restaurant the minimum is supposed to be 6.

CFM x 60 / Room Volume

Minimum air changes per hour for a restaurant: 6
Standard air conditioning CFM: 350-400

The CFD Simulation is conducted 3 times including 1 m/s, 4.2 m/s, and 7 m/s, which this variable is based on the overall Yogyakarta air velocity yearly (Meteorology, Climatology, and Geophysics Agency D.I. Yogyakarta, 2019).

The Pet Saga Cafe has an aperture, which is a door with 3.2 sqm along with eight cats and some furniture consisting of seven coffee tables, one cupboard, one artificial tree, and two cat towers one of which is attached to the wall.

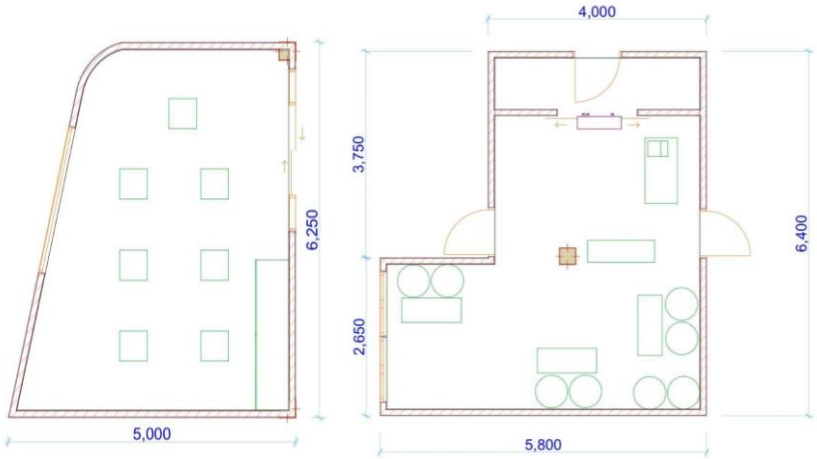


Figure 1 (left). *Petsaga Floor Plan*
Figure 2 (right). *D'Meow Floor Plan*

RESULT

Indoor Particle

Based on the direct observation, it has been found that at PET SAGA Cafe the PM 2.5 is about 13 $\mu g/m^3$. This data constantly showed around 50-60 minutes in between 0-15.5 $\mu gr/m^3$ which shows that the room had good indoor air quality.

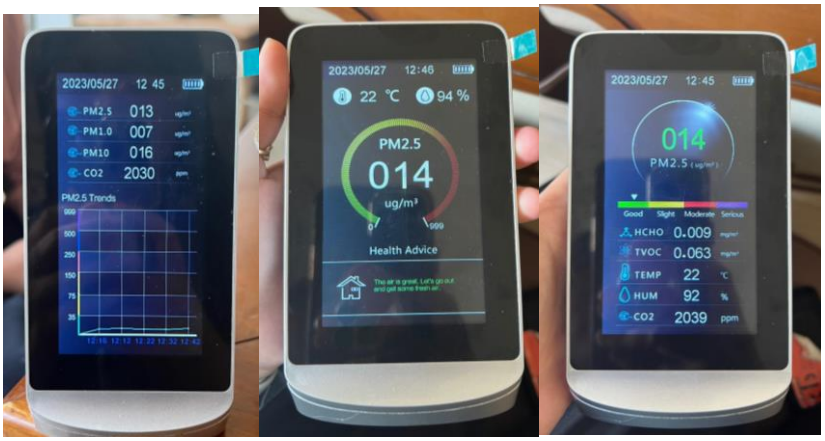
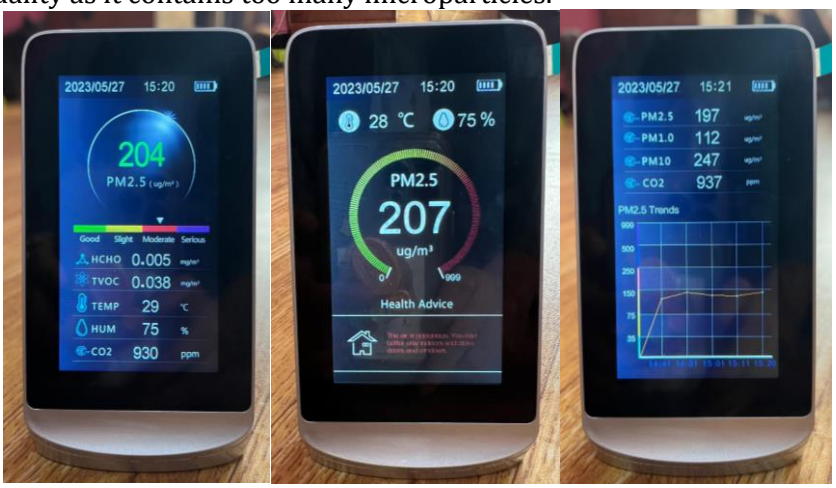


Figure 3, 4 & 5. *Pet Saga TVOC Meters Observation*

The measurement shows the constant PM 2.5 that rises up and is constant at 75-150 Trends or in between 150.5-250.4 μgr/m^3 for 50-60 minutes which shows that this room has a worse air quality as it contains too many microparticles.



Figures 8, 9 & 10. *D'Meow TVOC Meters Observation*

CFD Simulation

Based on the CFD simulation, it can be seen that the Pet Saga Cafe at 1 m/s outdoor air velocity had an indoor airflow of almost 0 m/s, which shows that the indoor environment lacked an air exchange rate. This can be seen from the figure below that the airflow is only reached surrounding the door and is unable to reach deep inside the room.

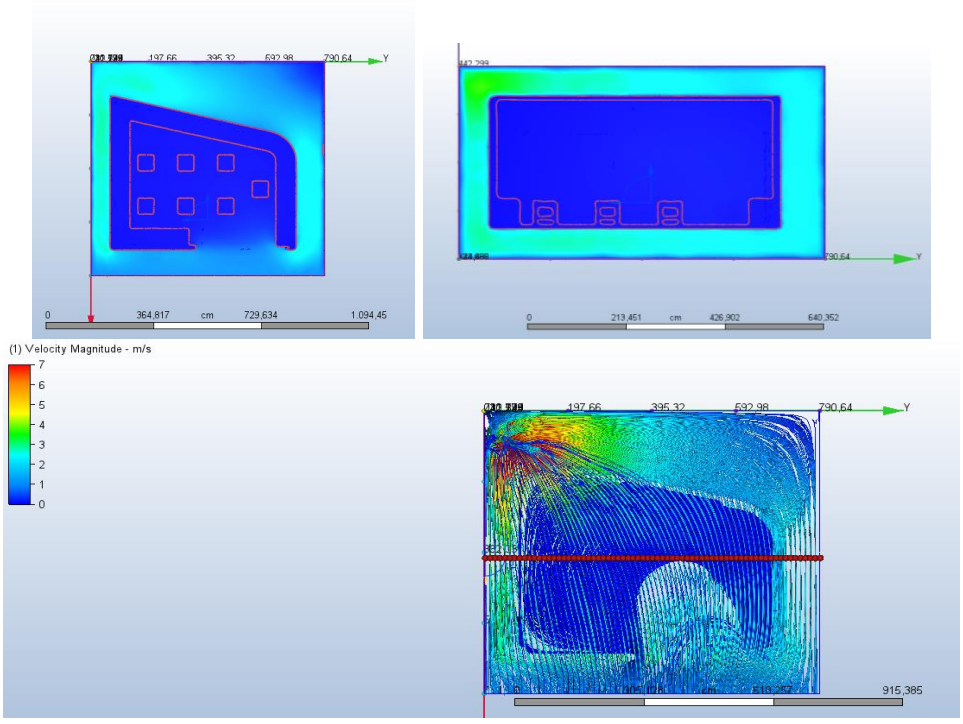


Figure 11. *Petsaga CFD Analysis (1 m/s)*

Subsequently, after the air velocity is increased to 4.2 m/s in the outdoor environment, the indoor airflow shows there is air movement, and increased the indoor air velocity up to 4 m/s. This can be seen that the indoor environment had an air exchange rate. However, the

area that can be reached by the airflow itself only surrounds the area of the door and does not go through the entire area of the room.

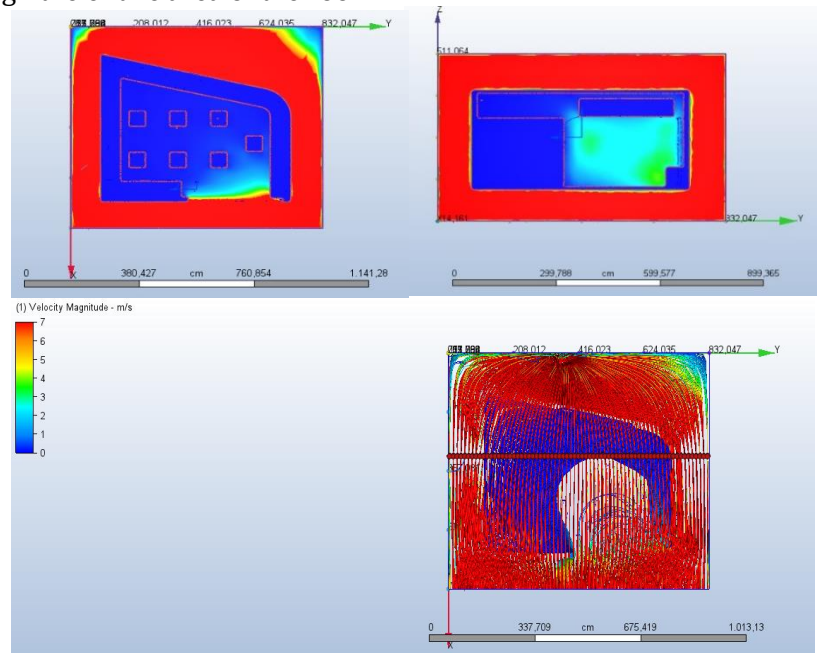


Figure 12. *Petsaga CFD Analysis (4.2 m/s)*

At last, the simulation using the greatest air velocity which is 7 m/s in the outdoor environment shows the most indoor airflow movement. The exchange rate of the airflow rose quite significantly, especially in the area surrounding the aperture and the areas of the room that are unable to be reached with lower velocity.

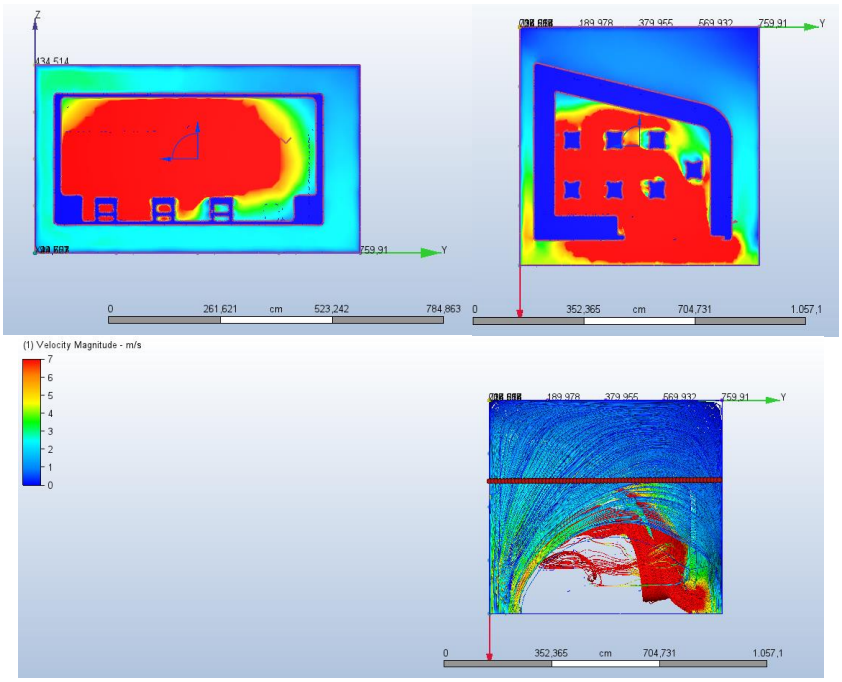


Figure 13. *Petsaga CFD Analysis (7 m/s)*

D'Meow Cat Cafe CFD analysis

According to the simulation result, the indoor airflow that can be seen at D'Meow Cat Cafe starts from 0 m/s until 2 m/s by using 1 m/s outdoor air velocity. Although the indoor

environment shows the air exchange rate almost reached the medium level, the room is still considered to lack air exchange. From the figures below, areas of the room achieved better airflow only in the area near the apertures and became less as it went further.

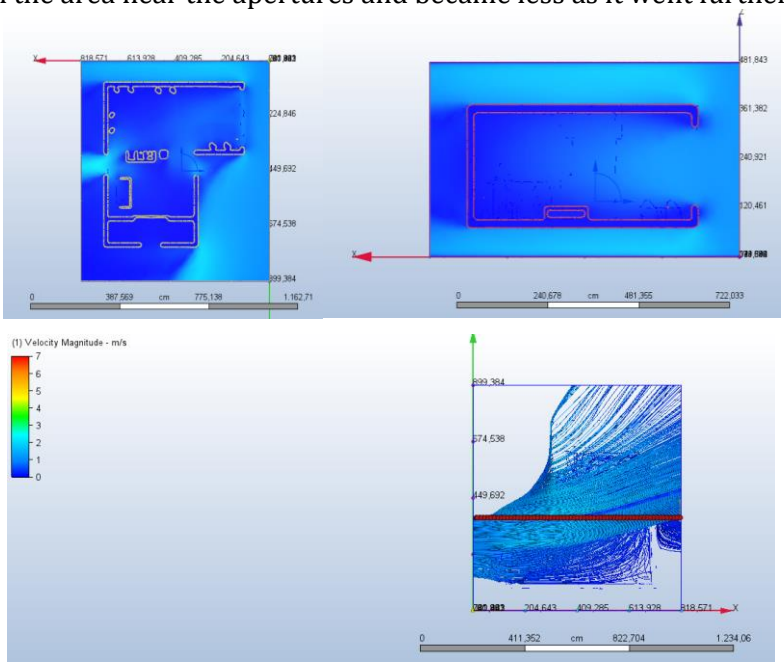


Figure 14. *D'Meow CFD Analysis (1 m/s)*

Furthermore, by using the CFD simulation at 4.2 m/s outdoor air velocity, the indoor airflow at D'Meow Cat Cafe rose up two times bigger than in the previous simulation which reached 4 m/s for the air exchange rate. The airflow reached the middle area of the room even though it was not yet able to reach the edges.

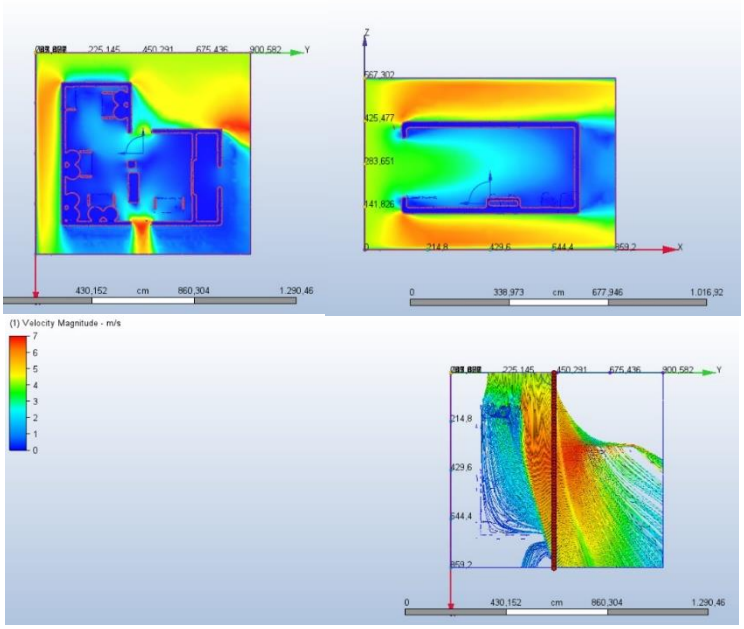


Figure 15. *D'Meow CFD Analysis (4.2 m/s)*

CFD simulation with the greatest outdoor air velocity at 7 m/s, the indoor airflow at D'Meow Cat Cafe rose up two times bigger than in the previous simulation which reached 4 m/s for the air exchange rate. The airflow reached the middle area of the room even though it was not yet able to reach the edges.

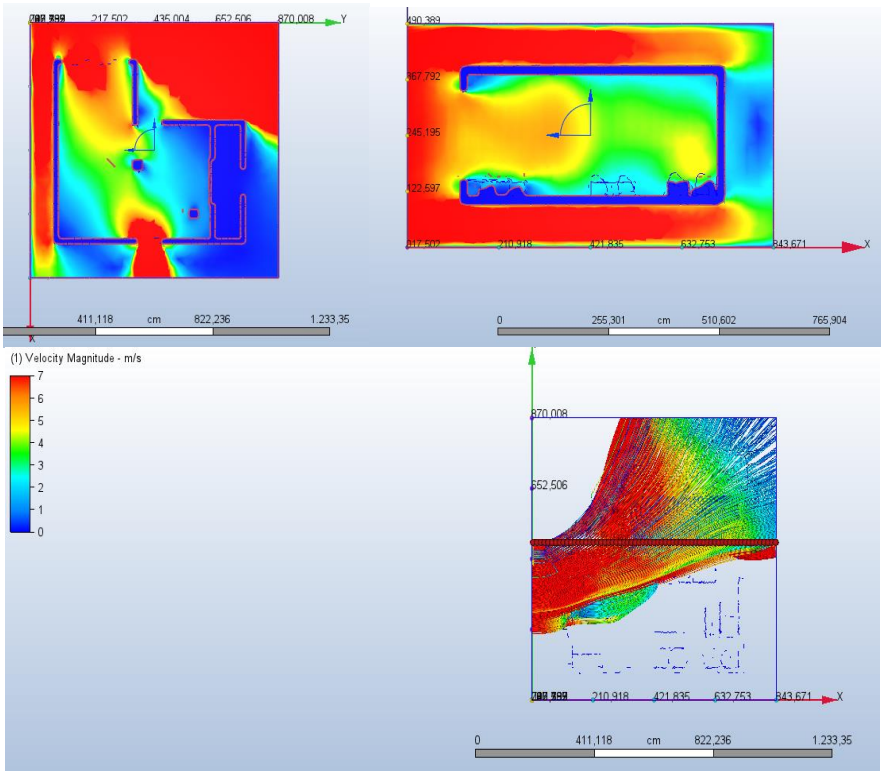


Figure 16. *D'Meow CFD Analysis (7 m/s)*

Air Changing per Hour Calculation

Petsaga

ACH= CFM x 60 / Room Volume

= 350 x 60 / 93.75 (**3310 cubic feet**)

= 21,000 / 3310

= 6.3

D'Meow

ACH= CFM x 60 / Room Volume

= 350 x 60 / 97.2 (**3432 cubic feet**)

= 21,000 / 3432

= 6.1

DISCUSSION

SIZE AND LOCATION OF THE OPENING

Based on the result of the CFD simulation proves the theory of Aflaki (2015) about the size of the openings. According to the velocity and intensity of the wind in Yogyakarta, the bigger the opening size and velocity of the wind the wind easier to reach all areas inside the room. The size of the opening should be able to fit with the room size to give the best air movement through the whole part of the room. As seen from the simulation, Pet Saga Yogyakarta, which only has one aperture, nicely complemented the area for visitors to get a good air exchange as the size and placement of the aperture are closely connected to the outdoor environment. But, due to the limited movement of air inside the room, the air that comes from the outside mostly only reaches the area near the door if the velocity of the wind itself is quite weak. The condition also applies to D'Meow Cat Cafe for 1-4.2 m/s wind velocity. Meanwhile, the difference is that D'Meow has evenly spread apertures inside the room, which allows the air to exchange near each of the apertures on every side of the room even though the velocity is weak. This data shows that the location of apertures is also important to make sure an even air exchange inside the room.

AIRFLOW

The limitation of airflow inside the cat cafe also depends on the furniture or other objects inside the room that might possibly block the airflow movement, as based on the theory of

Bjerg et al., (2002). As can be seen from the simulation, there are some objects that are located near the area of the apertures such as tables, cat towers, and so on. Although not entirely blocking the airflow, these objects tend to slow the velocity of the wind which causes the airflow to only stop around those areas.

AIRBORNE POLLUTION

On the other hand, based on the calculations of Ac/H which are based on SNI 03-6572-2001 which shows the restaurant Ac/H minimum standard is supposed to be 6, both cat cafes have surpassed the standard. This shows that according to the size, amount, and placement of the openings, the airflow from both cat cafes was supposed to be able to let the air condition be changed into a better one and let the particles move or disappear to achieve a good state of room air conditions. The air exchange rate inside the room will also affect the Particle Matter (PM2.5). The result of the TVOC meter observation shows a big difference between Pet Saga and D'Meow Although both of them contain main objects which are cats and human visitors, this means that D'Meow cat cafe possibly contain other micro-particles that are not coming from the cats. For example, the microparticles can come from dust or other electrical devices that produce microparticles such as humidifiers.

CONCLUSION

Based on the observation and simulation, it has been proved that the existence of cats inside a room combined with humans does not show threats to human health, especially the respiratory system as long as the air exchange rate is at least met the standard. From the observation of the disturbance, microparticles did not merely come from the cats, another object installed inside the room that spread microparticle components to the air such as a humidifier will also affect the result of the observation. But, they are possibly solved by making sure that the airflow of the cat cafes is arranged nicely to make sure that the outdoor air is able to be exchanged with indoor air.

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