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Improvement of Air Exchanger Ventilation System with Cooling Feature

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Abstract: Ventilation is the process of 'cleaning' the air. This may be accomplished by either natural or mechanical ventilation. It is needed to provide oxygen for metabolism also used to assist in maintaining good indoor air quality by diluting and removing other pollutants emitted. Ventilation is also used for cooling purpose. So good ventilation will be a major contributor to our healthy.

Keywords: Air exchanger ventilation system, metabolism of diluting air, cooling mechanism

I. INTRODUCTION

Aviation industry has developed rapidly through the years of modernization, particularly in the improvement of aviation technology. This includes manufactured materials [1-4], aircraft parts [5-7], electrical components' development [8-11], and certainly managing aviation personnel's safety [12-15] and top-notch performances at airports and hangars [16-18].

The project is about to improve the air exchanger ventilation system. Ventilating is the process of "changing" or replacing air in any space to provide high indoor air quality and it also can control temperature, replenish oxygen, or remove moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide.

Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior room air circulating, and to prevent stagnation of the interior air. Ventilation system is a system that circulate fresh air using ducts and fans rather than relying on holes or cracks in a home wall. It is usually being used in many buildings nowadays so that the building can get a better fresh air quality.

The purpose of the project is to make a prototype of air exchanger ventilation system that are easy to install, operate and maintain. With this ventilation system people can use this system when they want to. This device will filter the air and emitted the pollutants inside the room.

Our country nowadays is very hot. It happens due to depletion of ozone layer because of the pollution make by humans. Mostly in our place such as room, bathroom, workshop etc. will be hot. So, with this air ventilation, it will make the room, bathroom, workshop more comfort and not too hot.

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II. LITERATURE REVIEW

Basics of ventilation

The Ventilation Process

Ventilation is an air exchange process that:

- Brings fresh air into the facility through planned openings.
- Thoroughly mixes incoming and inside air.
- Picks up heat, moisture, and air contaminants.
- Lowers temperature, humidity, and contamination levels.
- Exhausts moist, contaminated air from the facility.

If any section of the ventilation process is compromised, inadequate ventilation is the result. The ventilation system design should be based on animal requirements.

The Ventilation System Affects

- Air temperature.
- Moisture level.
- Air speed across animals.
- Odor and gas concentrations. Carbon dioxide, methane, etc.
- Airborne dust and disease organism levels.
- Other combustible fumes.

As the ventilating system exchanges air, it brings in oxygen to sustain life. It removes and dilutes harmful dust, gases, undesirable odors, airborne disease organisms, and moisture. Natural ventilation does not just happen naturally; it must be a properly designed system if to perform efficiently.

Types of ventilation

They are some types of ventilation that are:

Natural Ventilation

Natural ventilation is the use of wind and temperature differences to create airflows in and through buildings. There are two basic types of natural ventilation effects: buoyancy and wind. Buoyancy ventilation is more commonly referred to as temperature-induced or stack ventilation. Wind ventilation supplies air from a positive pressure through openings on the windward side of a building and exhausts air to a negative pressure on the leeward side. Airflow rate depends on the wind speed and direction as well as the size of openings. In summer, the indoor-outdoor temperature difference is not high enough to drive buoyancy ventilation, and wind is used to supply as much fresh air as possible. In winter, however, the indoor is much warmer than outdoors, providing an opportunity for buoyancy ventilation [19].

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Task Ventilation

Traditional ventilation systems supply a mixture of outside and re-circulated air in high velocity jets so that the indoor air in rooms is often well mixed. This can be an inefficient method of delivering outside air to an occupant. Task-ambient conditioning (TAC) systems are a ventilation technology with the potential for improved ventilation to the occupant. TAC systems may supply air from the floor, desk, or partitions and enable occupants to adjust the supply flow rate, direction, or temperature so that thermal conditions can be tailored to meet the individual's requirements [20].

Mechanical Ventilation

Currently, mechanical ventilation remains with the principle of supplying the flow of the much-needed air continuously with time whenever it is operational by pushing the air with kinetic energy from the fan into the duct(s). It does, however, emit more carbon dioxide [21].

Principle of ventilation

Volumetric Flow Rate

$Q = v * a$, where:
V = average air velocity, and
A = average cross-sectional area

Equation 1

The important parameter to measure is average air velocity.

Pressure Measurement

At any point in the exhaust system, three air pressures exist:

$Tp = sp + vp$, where:
Tp = total pressure in “wg”
Sp = static pressure in “wg”
Vp =velocity pressure in “wg”

Equation 2

Static Pressure

- Pressure which tends to burst or collapse a duct
- Positive when > atmospheric
- Negative when < atmospheric

Instruments Used for Measurements

- Simple piezometer
- Simple u-tube manometer filled with oil or appropriate liquid
- Water gauge
- Reading pressure gauge
- Inclined manometer gives increased accuracy and permits reading of lower values of velocities

Introduction of air-cooling system

Air cooling is one of a method dissipating heat. It works by making the object to be cooled have a larger surface area or have an increased flow of air over its surface, or both.

Air cooling is ideal with components that have a larger mass and bigger surface area. Air cooling can be used by lowering air temperature for comfort, process control, or food preservation. Air and water vapor occur together in the atmosphere [22].

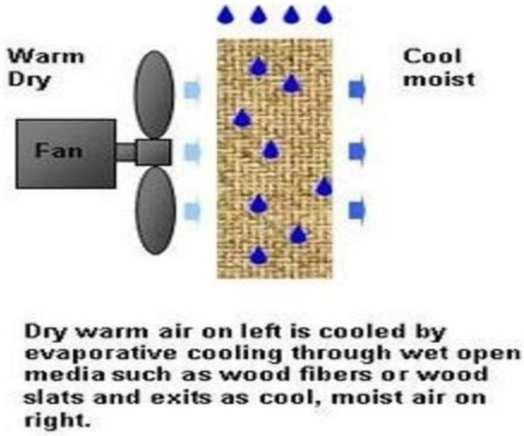

Fig. 1 Working Principle

Radiator cooling

Radiator cooling is the most common type of closed cooling system, providing a self-contained system that is both simple and practical for most installations. Cooling of the engine parts is accomplished by keeping the coolant circulating and in contact with the metal surfaces to be cooled [23].

For cooling systems with additional volume due to plumbing or additional components, the expansion tank may need to be enlarged to allow for the expansion of the additional volume of the system. The top tank is fitted with a pressure cap. This cap allows coolant level to be checked and replenished as necessary. The cap also seals the cooling system and limits its pressure with a spring-loaded disc valve [24].

III. METHODOLOGY

In this method, we have designed the air exchanger ventilation system prototype by using computer aided design software. The measurement is based on the box that we have buy. So below is the design of the prototype.

Fig. 2 Final Product

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IV. ANALYSIS

Introduction

The air exchanger ventilation system with cooling feature prototype will be tested in a room label as Room A. There will be three result regarding on this test. Firstly, we will test the prototype by running the prototype normally secondly by using water and thirdly by using ice.

Room A: result and analysis

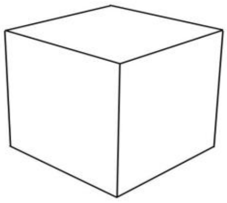

Fig. 3 Room A Measurement in Meter

Room Width: 2.3 m
Room Length: 2.8 m
Room Height: 3.0 m
Wall Area: 32.6 m2
Floor Area: 6.2 m2
Perimeter: 10.0 m
Room Volume: 19.32 m3

Air change rate - air changes per hour

$$n = 3600\, q / V$$

Where n = air changes per hour,

q = fresh air flow through the room (m3/s),

V = volume of the room (m3),

$$n = \frac{3600 \times 0.039\text{m3/s}}{19.32\text{m3}}$$

$$= 7.26\ \text{h-1}$$

Equation 3

So, the air change rate in the Room A is 7.26 h-1. The value of the fresh air that flow through the room is 0.039 m3/s where the speed of the fan is 2.71 m/s times 0.0144 m2 which is the area of the ducting. After we got the value of the fresh air that flow through the room, we use the equation above where 3600 seconds air change per hour times 0.039 m3/s and the value is 140.4 m3/s. Then, we divided with 19.32m3 which is value for volume of the room. Lastly, we got the value of the air change rate for the room.

Heat transfer table and graph with normal condition

Table. 1 Measurement of time and temperature

Time (Minute)	Temperature (°C)
0	31.0
5	30.2
10	29.8
15	29.6
20	29.4
25	29.2

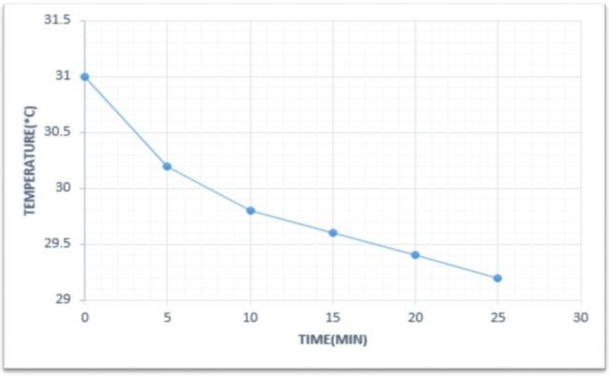

Fig. 4 Heat Transfer Graph with Normal Condition

From the table and graph above shows the heat transfer with normal condition. The prototype of air exchanger ventilation system is operated for 25 minute and in every 5 minutes the temperature change will be recorded. The horizontal axis represents the time in minutes and the vertical axis show the temperature in Celsius. The initial temperature is 31°C, then for the first 5 minute the temperature gradually decreases to 30.2°C. Then in 10 minutes, the temperature decreases slightly drop from the first 5 minutes which is 29.8°C. For the 15, 20 and 25 minutes, the temperature starts to decrease slowly. Then, the temperature decreases from 29.6°C to 29.4°C and last decrease slightly to 29.2°C for the 25 minutes.

Heat transfer rate for normal condition

Heat transfer rate can be calculated using this equation:

(Temperature 2 - Temperature 1) / (Time 2 - Time 1)

=___ºC per minute

Equation 4

Point 1 and Point 2
= (30.2-31) ºC / (5-0) min
= -0.16ºC min-1

Point 2 and Point 3
= (29.8-30.2) ºC / (10-5) min
= -0.08ºC min-1

Point 3 and Point 4
= (29.6-29.8) ºC / (15-10) min
= -0.04ºC min-1

Point 4 and Point 5
= (29.4-29.6) ºC / (20-15) min
= -0.04ºC min-1

Point 5 and Point 6
= (29.2-29.4) ºC / (25-20) min
= -0.04ºC min-1

Calculation 1

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Table. 2 Heat Transfer Rate for Normal Condition

Temperature Different	Heat Transfer Rate (°C min-1)
30.2-31	-0.16
29.8-30.2	-0.08
29.6-29.8	-0.04
29.4-29.6	-0.04
29.2-29.4	-0.04

The heat transfer rate is calculated from the curve between 2 points. The heat transfer rate for the first curve is about -0.16°C per minute, and the heat transfer rate for the second curve is about -0.08°C and for third curve the heat transfer rate about -0.04°C. Then, the heat transfer rates in the fourth was the same as the third curve about -0.04°C per minute. For the last curves, the heat transfer rate was unchanged that are -0.04°C per minute.

Air change rate by using water (using Equation 3)

So, the air change rate in the Room A is 7.26 h-1. The value of the fresh air that flow through the room is 0.039 m3/s where the speed of the fan is 2.71 m/s times 0.0144 m2 which is the area of the ducting. After we got the value of the fresh air that flow through the room, we use the equation above where 3600 seconds air change per hour times 0.039 m3/s and the value is 140.4 m3/s. Then, we divided with 19.32m3 which is value for volume of the room. Lastly, we got the value of the air change rate of the room.

Heat transfer table and graph by using water

Table. 3 Measurement of time and temperature

Time (Minute)	Temperature (°C)
0	31.0
5	29.3
10	28.7
15	28.3
20	28.1
25	28.1

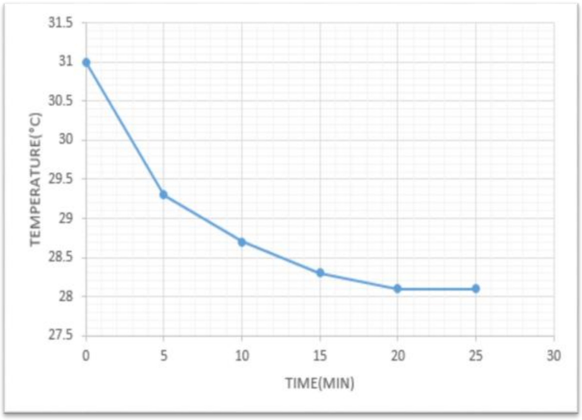

Fig. 5 Heat Transfer Table by using Water

From the table and graph above shows the heat transfer by using water. The prototype of air exchanger ventilation system is operated for 25 minute and in every 5 minutes the temperature change will be recorded. The horizontal axis represents the time in minutes and the vertical axis show the temperature in Celsius. The initial temperature is 31°C, then for the first 5 minute the temperature gradually decreases to 29.3°C. Then in 10 minutes, the temperature decreases slightly drop from the first 5 minutes which is 28.7°C. For the 15, 20 and 25 minutes, the temperature starts to decrease slowly. Then, the temperature decreases from 28.3°C to 28.1°C and last decrease slightly to 28.1°C for the 25 minutes.

Air change rate by using ice using (Equation 3)

So, the air change rate in the Room A is 7.26 h-1. The value of the fresh air that flow through the room is 0.039 m3/s where the speed of the fan is 2.71 m/s times 0.0144 m2 which is the area of the ducting. After we got the value of the fresh air that flow through the room, we use the equation above where 3600 seconds air change per hour times 0.039 m3/s and the value is 140.4 m3/s. Then, we divided with 19.32m3 which is value for volume of the room. Lastly, we got the value of the air change rate of the room

Table. 4 Measurement of time and temperature

Time (Minute)	Temperature (°C)
0	31.0
5	28.3
10	26.8
15	25.4
20	25.0
25	24.2

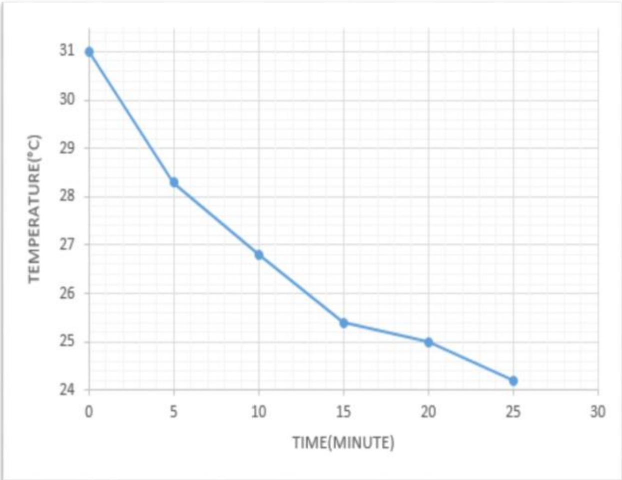

Fig. 6 Heat Transfer Table by using Ice

From the table and graph above shows the heat transfer with normal condition. The prototype of air exchanger ventilation system is operated for 25 minute and in every 5 minutes the temperature change will be recorded. The horizontal axis represents the time in minutes and the vertical axis show the temperature in Celsius. The initial temperature is 31°C, then for the first 5 minute the temperature gradually decreases to 28.3°C. Then in 10 minutes, the temperature decreases slightly drop from the first 5 minutes which is 26.8°C. For the 15, 20 and 25 minutes, the temperature starts to decrease slowly. Then, the temperature decreases from 25.4°C to 25.0°C and last decrease slightly to 24.2°C for the 25 minutes.

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Heat transfer rate by using ice (using Equation 4)

Point 1 and Point 2
= (28.3-31.0) ºC / (5-0) min
= -0.54ºC min-1

Point 2 and Point 3
= (26.8-28.3) ºC / (10-5) min
= -0.30ºC min-1

Point 3 and Point 4
= (25.4-26.8) ºC / (15-10) min
= -0.28ºC min-1

Point 4 and Point 5
= (24.2-25.0) ºC / (20-15) min
= -0.08ºC min-1

Point 5 and Point 6
= (25.-25.4) ºC / (25-20) min
= -0.16ºC min-1

Calculation 2

Table. 5 Heat Transfer Rate by using Ice

Temperature Different	Heat Transfer Rate (ºC min-1)
28.3-31.0	-0.54
26.8-28.3	-0.30
25.4-26.8	-0.28
25.0-25.4	-0.08
24.2-25.0	-0.16

The table above is about the rate of heat transfer in Room A by using ice that has been take from the graph. The heat transfer rate is calculated from the curve between 2 points. The heat transfer rate for the first curve is about 0.54°C per minute, and the heat transfer rate for the second curve is about 0.30°C and for third curve the heat transfer rate is about -0.28°C. Then, the heat transfer rates in the fourth was about -0.08°C per minute. For the last curves, the heat transfer rate increases slightly to -0.16°C per minute.

Differential between heat transfer rates of each condition

Points (ºC min-1)	Normal	Water	Ice
Point 1 and Point 2	-0.16	-0.34	-0.54
Point 2 and Point 3	-0.08	-0.12	-0.3
Point 3 and Point 4	-0.04	-0.04	-0.28
Point 4 and Point 5	-0.04	-0.04	-0.08
Point 5 and Point 6	-0.04	-0.00	-0.16
Average	-0.072	-0.054	-0.272

As we can see from the table above, the differential between heat transfer rates of each room is different because of the cooling feature that was used. The average for normal condition is about -0.072 (ºC min-1) and by using water is about -0.540(ºC min-1) and by using ice is about -0.272(ºC min-1). Ice is the fastest heat transfer rate as it degrades very fast rather than normal condition and using water. For normal condition, from point 1 to point 2 is about -0.16. From point 2 to point 3 is about -0.08. From point 3 to point 4 is about -0.04 same as point 4 to point 5 and point 5 to point 6. Secondly for the water condition, from point 1 to point 2 is about -0.34 and from point 2 to point 3 is about -0.12. From point 3 to point 4 is about -0.04 same as from point 4 to point 5. While for point 5 to point 6 there is no change. For the ice condition, from point 1 to point 2 is about -0.54. From point 2 to point 3 is about -0.30. From point 3 to point 4 is about -0.28 and from point 5 to point 5 is about -0.08 and from point 5 to point 6 is about -0.16.

V. CONCLUSION

Summary

For the conclusion, this project has achieved its objective to develop a prototype of air exchanger ventilation system with cooling feature and to control the air condition in the room.

The test has been carried out by three different conditions and in the same size of room. The test by using ice to cool the room is the best one as the degrade of temperature is the highest compare to the other two. Although it is the best, but still by running in normal condition and using normal water still can cool the temperature but it takes a longer time compare to ice. Lastly, the humidity also effects on the environment of the room. So, with ventilation system the humidity will be higher.

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