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Air Conditioning System using Air Cycle Machine (ACM) A Qualitative Validation

P.Sivakumar, P.Nivetha, P.K Niveka

Abstract - The work is aimed to replace conventional refrigerants used in air cooling system with Air Cycle Machine (ACM). Commercial Air-conditioners uses the refrigerants (Freon-Gas cycle) to remove the indoor air from the room. Freon leakage causes health problems such as respiratory ailments, heart attack and circulatory collapse. Air conditioning systems made based on desiccants. Refrigerant poisoning results in Throat swelling, loss of vision, blood vomiting, blood in the stool, severe abdominal pain and even death is possible. This can be overcome by using air cycle cooling process instead of Freon as a phase changing material. Air Cycle Machine is the system used in aircraft cabin pressurization and cooling system which does not uses refrigerants in the cooling process. The analytical work carried out in this paper is to study the air conditioning system using Air Cycle Machine and investigate the air flow inside the room by giving the various inlet temperatures and the inlet velocity of the Air-conditioner. ANSYS-FLUENT 16.0 is used for the analytical study. A cabin enclosure was modeled and analyzed for different inlet temperatures and velocities and out coming cool air spread nature for the given conditions have been observed. The qualitative results of this study clearly evident the usage of Air Cycle Machine (ACM) is prominently reduces the room temperature than the refrigerant system and spreads the cool air throughout the enclosed room makes a comfortable environment and this would not leads to any health hazards. Thus this study is certain to use Air Cycle Machine (ACM) for the cabin cooling system rather than refrigerants.

Index Terms: Temperature distribution, simulation, Air Cycle Machine (ACM), Air-Conditioning

I. INTRODUCTION

The Air-conditioning System is used to remove the heat from the space to be cooled. The Air Cycle Machine is used for cabin pressurisation in the gas turbine-powered aircraft machine. Air is used as a phase changing material. ACM uses air which is a free source in comparison with the Freon.
It is safe to operate and environmental friendly. It has a high cooling productivity. It is a simple design and low cost operation. ACM has no requirement of evaporator and condenser. The Air Cycle machine can be used to produce temperature less than 0°C even when the outside temperature is high. The Air-conditioning system using the air cycle machine involves the following process.

Initially the intake fan sucks the warm air from the atmosphere into the compressor. The air is compressed generating heat. The heat is removed by using the atmospheric air. By expanding the air, it becomes cooler than the ambient temperature. The CFD analysis is used to visualise the air flow in the room. It is also used to predict the velocity distribution and temperature distribution of the Air-conditioner in the room

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* Correspondence Author
Mr.P Sivakumar*, Aeronautical Department, Sri Ramakrishna Engineering College, Coimbatore - 22, India.
Ms.P.Nivetha, Aeronautical Department, Sri Ramakrishna Engineering College, Coimbatore - 22, India.
Ms.P.K. Niveka, Aeronautical Department, Sri Ramakrishna Engineering College, Coimbatore-22 , India.

II. LITERATURE SUMMARY

Aircraft air-conditioning system uses Air Cycle Machine to produce conditioned and cool air to the cabin. It is also used to maintain the pressure inside the cabin hence passenger comfort maintained [1]. It dealt with the working of Different systems of an aircraft are integrated in order to work in conditioned air atmosphere within the cabin [2]. Application of refrigeration for human comfort like storing food and medical application are evolving endlessly. It also highlights the causes of refrigerants on human health [3]. The pressurization of the aircraft cabin is a crucial process and plays vital role in passenger comfort and pressure inside the compartments. This also leads to stable flight during fly of an aircraft [4]. Simulations of the indoor air flow including numerical methods and CFD analysis describes the general procedure to validate the airflow in the enclosed cabin [5]. General Flow and Thermal Boundary Conditions in Indoor Air Flow Simulation to treat interaction between the indoor and outdoor thermal environments develop the process of airflow [6].

III. CONCEPTUAL BACKGROUND

A. Geometry

The work has been done by using the CFD Fluent 16.0. The Air-conditioning dimensions of 6 faces, 8 vertices, surface area of 613.35 square-meter, volume of 783.66 cubic meter, the geometry type is design modular. The inlet and outlet of the Air-conditioner are defined. The facers other than inlet and outlet are defined as wall 1. The length and width of the room are 50m and 30m respectively and are defined as a wall 2.

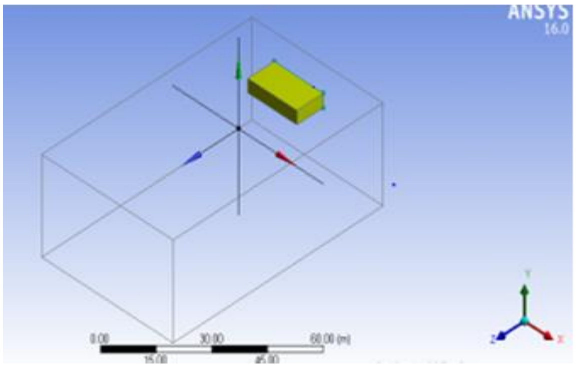

Fig.1. Design Model of the Air-conditioner

B. Meshing

Meshing the model is carried out by using the fluent solver. The Dimension of the body in X, Y and Z are 50m, 30m and 80 m. Under statistics, the number of Nodes are 14013. The number of elements are 70592. Under sizing the maximum face size is 2m and the maximum edge length is 4.2 m.

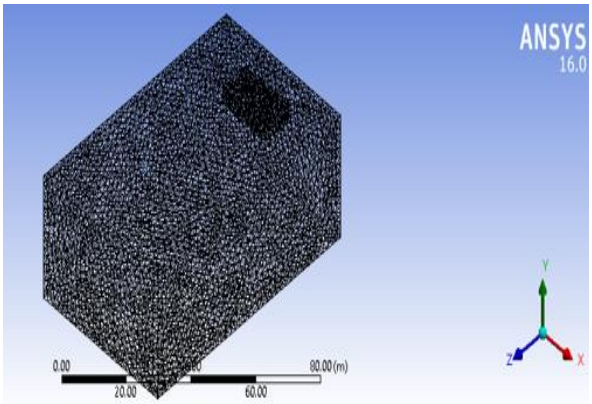

Fig.2. Meshing of the Air-conditioner model

C. Boundary conditions

The following boundary conditions of the Air-conditioning model are the velocity inlet is 3m/s,2m/z and 1m/s respectively, interior solid, pressure outlet, room is defined as a wall 2, are 3D space, Absolute velocity formulation, Steady time, Pressure-based type, Energy equation is enabled, material used is air, k-epsilon (2 equation) viscous model is used.

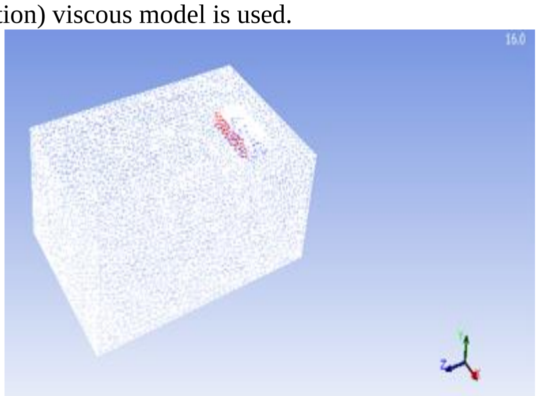

Fig.3. Iterations and Calculations of the Air-conditioner Model

Inlet velocity (m/s)	Inlet temperature (K)
3	300
2	302
1	302

Table-1 Varying the Inlet Temperature of the Air-conditioner

IV. RESULTS

A. Temperature Distribution of the Air-conditioner at inlet velocity = 3m/s

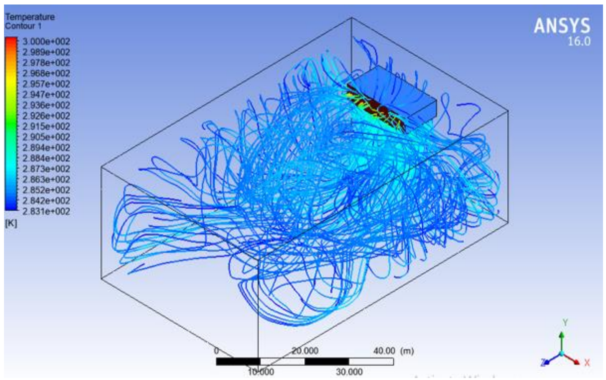

Fig.4. Temperature Distribution of Airconditioner at inlet velocity is 3m/s

B. Temperature Distribution of the Air-conditioner at inlet velocity = 2 m/s

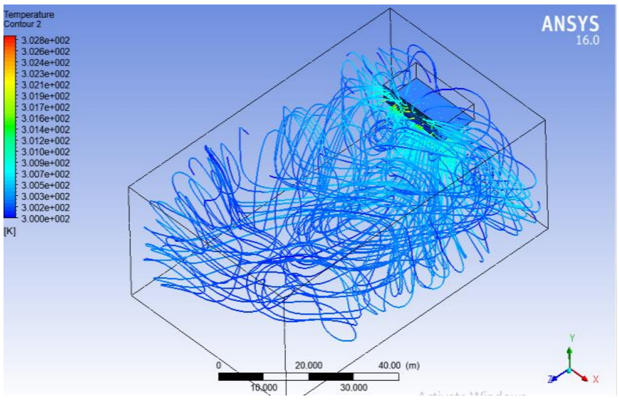

Fig.5. Temperature Distribution of the Air-conditioner at inlet velocity is 2m/s

C. Temperature Distribution of the Air-conditioner at inlet velocity = 1m/s

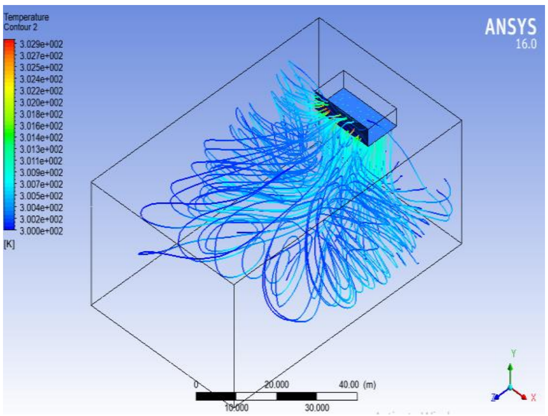

Fig.6. Temperature Distribution of the Air-conditioner at inlet velocity is 1m/s

Experiment Results

Inlet velocity in (m/s)	Inlet temperature (K)	Outlet temperature (K)
3	300	283
2	302	300
1	302	300

Table-2 Temperature distributions with respect to their inlet velocities

V. CONCLUSION

From the results of the analysis it can be observed that the inlet velocity at 3m/s is reducing temperature from 300K to 283K and the cool air flow distribution inside the room is at high rate compared to flow distribution in the inlet velocity at 1m/s and 2m/s. From the results we conclude that the inlet velocity at 3m/s is reducing to 17°C to obtain the required comfort condition of the room. Continuous flow patterns in the results evident the spread nature of the cool air flow throughout the enclosed room cabin.

FURURE WORK

1. Fabrication of the Experimental model
2. Comparison of the analytical and experimental results
3. Automated experimented model is to be done to overcome the existing problems
4. Alternative phase change gases to be used

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Authors Profile

Mr. P. Sivakumar, Assistant Professor at Sri Ramakrishna Engineering College, Coimbatore since 2014. His interest domains are High Speed Aerodynamics, Boundary Layer studies, Propulsion and Vibrations.

Ms.P. Nivetha, doing 3rd year B.E Aeronautical Engineering,Sri Ramakrishna Engineering College, Coimbatore, India. Her areas of interest are Aerodynamics and Propulsion

Ms.P.K Niveka, doing 3rd year B.E Aeronautical Engineering,Sri Ramakrishna Engineering College, Coimbatore, India. Her areas of interest are Aerodynamics and Propulsion