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Design and CFD Analysis of Temperature Control System of Pyschrometry Room

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***Abstract*: In the recent years, computational fluid dynamics (CFD) has been widely used as method of simulating the airflow in a closed systems, studying indoor environment issues and to produce data that may be otherwise difficult to obtain through insitu measurements. These measurements gives realistic information regarding the airflow and temperature conditions in the system. A heating and cooling system for psychometric room is designed and examined for the flow patterns, temperature and pressure distribution by using CFD simulations. The wet bulb and dry bulb temperatures are obtained empirically from physical room are served as the inputs of the analysis. The entire system is modeled and boundary conditions are applied to simulate the thermal distribution. The results thus obtained are used to optimize the power consumption of the auxiliaries in the system and validate the experimental setup.**

***Keywords*: Pyschrometry Room, Computational Fluid Dynamics, Dry Bulb/ Wet Bulb Temperature, Air Conditioning, Heating, Humidity etc.**

1. Introduction

Psychrometrics is investigation of air-water vapor blends at various conditions. Psychrometrics manages the thermodynamic properties of clammy air and uses these properties to dissect conditions and procedures including soggy air. While the investigation of unadulterated psychrometrics includes various diverse perspectives, we will limit this course to the utilization of psychrometrics for use on human solace noticeable all around molding framework. In aerating and cooling framework, we utilize psychrometric properties for condition control.

India falls in the hot zone along these lines the solace aerating and cooling has dependably been felt to be a need for humankind. To accomplish comfort warm is separated from the solace locale and exchanged to the earth, which is at a higher temperature. This is finished with the assistance of refrigeration. In spite of the fact that there are numerous techniques to accomplish cooling, one process that is transcendently connected in refrigeration hardware and its application is vapor pressure cycle is in ventilating units, the all the more usually utilized one is room aeration and cooling systems, and after that comes the bundled frameworks which are utilized for higher tonnages till 50Ton. As far back as the creation of Air Conditioning as one of Refrigeration application by WH Carrier in US in prior nineteenth century, there has been a radical change in the techniques and process utilized as a part of assembling aerating and cooling gear however there is no adjustment in the standard i.e. vapor pressure framework utilized as a part of the cycle.

A. Psychometrics processes

Psychrometric processes bring about changes in air-water vapor properties. The movement of the state point on the psychrometric chart represents changes. Common processes include:

1. Sensible Heating and Cooling
2. Cooling and Dehumidification
3. Heating and Humidification
4. Evaporative Cooling
5. Air Mixing

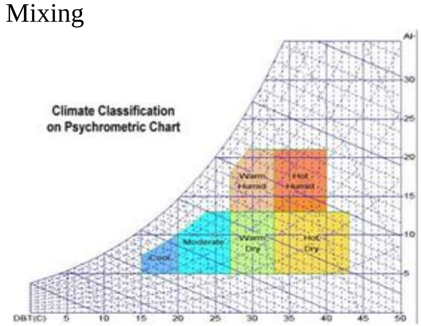

Fig. 1. Climate classification on Psychometric chart

B. CFD methodology

In all of these approaches the same basic procedure is followed.

During pre-processing

- The geometry (physical limits) of the issue is characterized.
- The volume possessed by the liquid is partitioned into discrete cells (the work). The work might be uniform or non-uniform.
- The physical displaying is characterized – for instance, the conditions of movements + enthalpy + radiation +

species protection.

- Boundary conditions are characterized. This includes determining the liquid conduct and properties at the limits of the issue. For transient issues, the underlying conditions are additionally characterized. The recreation is begun and the conditions are unraveled iteratively as a relentless state or transient.

Governing Equations

The overseeing conditions of liquid stream speak to numerical articulations of the protection laws of material science:

1. The mass of a liquid is monitored.
2. The rate of progress of energy approaches the total of the powers on a liquid molecule (Newton's second law).
3. The rate of progress of vitality is equivalent to the total of the rate of warmth expansion to and the rate of work done on a liquid molecule (first law of thermodynamics).

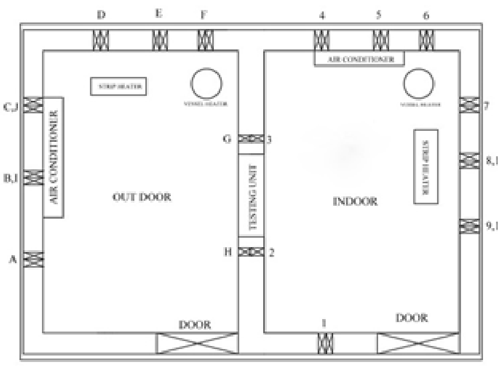

Fig. 2. 2-D View of Psychrometric Room

Table 1
Bill of Materials for Test Room

S. No.	Material used	Qty	Make
1	Plaster of Paris	-	-
2	Switch Boards	30	PVC
3	Insulating Material	-	Thermo cool

2. Components of Psychrometric Room

A. Control Panel

Fig. 3. Control panel

A control board is a level, frequently vertical, region where control or checking instruments are shown. It is a board that contains circuits and dimmers (here) for controlling the electrical gadgets which are inside the room.

They are found in processing plants to screen and control machines or creation lines and in spots, for example, atomic power plants, boats, airplane and centralized computer PCs. More established control boards are frequently outfitted with push catches and simple instruments, though these days as a rule contact screens are utilized for checking and control purposes.

Table 2
Bill of Materials of Control Panel

S. No.	Material used	Qty	Make
1	M.S Angle Rods		M.S
2	Wooden Plank	2	-
3	Dimmer stat	3	-
4	Voltmeter	1	-
5	Ammeter	1	-
6	Wattmeter	1	-
7	Frequency Indicator	1	-
8	Temperature Indicators	4	-
9	MCB	24	Legrand
10	Wiring		Finolex
11	Bolts & Nuts	40	C.I

3. Experimental Analysis of Psychrometric Room

The trial test had been directed with calorimeter test for air conditioning and cooling and vapor pressure cycle execution test, the calorimeter has the office to lead from little ventilation systems unit to huge chillers.

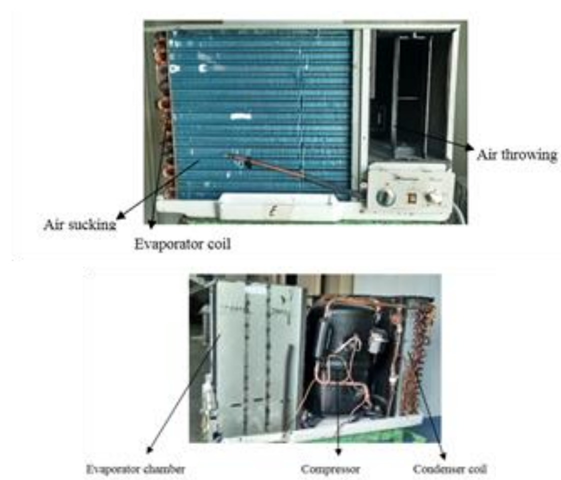

Fig. 4. Front and side views of the test AC

Cooling capacity conditions

Area, Ai = ((22/7*4)*SQRT (48.66/1000)) + ((22/7*4)*SQRT (99.43/1000))

= 0.00962 m2Cubic flow per minute,

Cfm = Ci*Yi*Ai*SQRT ((2*Dp)/D_{le})*3600*0.5885

= 0.985*0.998*0.00962*SQRT ((2*445)/1.2138)*3600* 0.5885

Table 3
Observations made with psychrometric room

	T_1	T_2	T_3	T_4
Receiver gas	24.9	17.9	17.2	16.3
Discharge gas	24.9	71.7	75.1	75.3
Liquid line	25.7	55.3	57.7	56.9
Shell top	25.7	29.8	31.5	31.4
Shell bottom	25.4	40.5	44.1	45.0
Evaporator entry	24.7	17.3	17.1	16.5
Evaporator exit	25.0	10.2	10.2	9.4
Evaporator middle	25.0	15.0	14.6	14.2
Ambient	24.3	26.8	28.7	29.5
Condenser middle	24.7	60.1	61.4	62.7

= 542.56 or 543

Volume flow rate, Qva = Cfm/2118.88
= 543/2118.88
= 0.2562 m3/sec

Enthalpy difference, $D_h = h_{en}-h_{le}$
= 48.53 - 30.60
= 17.93 kj/kg

Mass flow rate, Ma = Volume flow rate (Q_{va})/Specific volume of leaving air (V_{le})
= 0.2562/0.8238
= 0.3109 kg/sec

Cooling capacity in KW = Mass flow rate (Ma)*Enthalpy difference (D_h)
= 0.3109*17.93
= 5.5744 kw

Cooling capacity in Btu/hr = cooling capacity in kw * 3412.14
= 5.5744 *3412.14
= 19020.75 Btu/hr

Energy efficiency ratio, EER = (cooling capacity in Btu/hr) / (Input power in watts)
= 19020/2240
= 8.491 Btu/W-hr

Therefore calibration factor for Psychrometric room is 19020/21032.43 = 0.904
Which is nothing but 1.096

Computational Fluid Dynamics Simulation Setup

Problem Description

- The Air conditioner condenser efficiency is evaluated by performing a CFD simulation of the condenser chamber.
- The necessary inputs such as convective heat transfer coefficient (air side) is determined by CFD analysis.

Geometry of Indoor and Outdoor Assembly

Geometry of entire physical setup of pyschrometry room is modelled in the CAD package. The final geometry files are exported to the Ansys workbench using the neutral file format. The geometry is cleaned as per the convenience for meshing and fluent solving.

Mesh Model

CFD mesh for the simulation is generated using Ansys Workbench Mechanical Modeller. Fine mesh is generated near the fins and tubing, whereas coarse mesh is generated in remaining location, since the area of study is concentrated at fins and tube. Hex dominant meshing method is utilised to generate mesh.

Fig. 5. Indoor unit geometry and Outdoor unit geometry

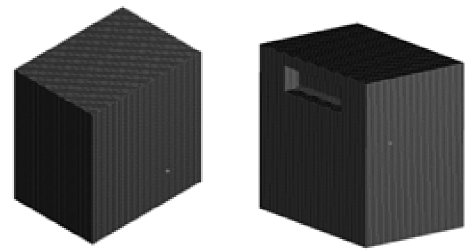

Fig. 6. Indoor Mesh model and Outdoor Mesh model

Boundary Conditions

The named selections are assigned to the geometry for the ease of the assigning the boundary conditions.

Fig. 7. Inlet naming conditions of indoor unit (suction and blowing)

Fig. 8. Inlet and outlet boundary conditions for Outdoor unit (AC suction and blowing, test specimen condenser out)

Fluent:

The fluent package is used for the flow simulation in the condenser:

Fig. 9. General settings of the solver

Step 1: Fluent Setup
Step 2: Equation models

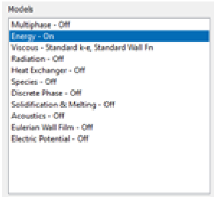

Fig. 10. Equation models for analysis

Step 3: Material specification
The air is considered as the material for the geometry.

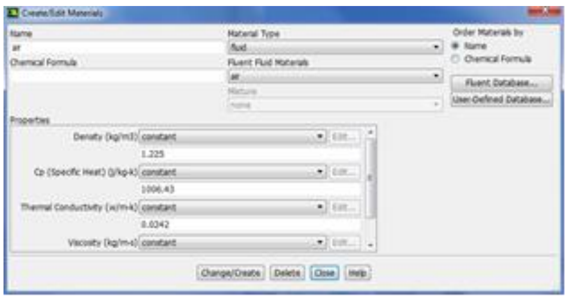

Fig. 11. Material assigning for the flow

Step 4: Boundary conditions
In the present case to simulate the real time flow of AC, recirculation boundary conditions are considered for the geometric entities. To initiate the recirculation boundary condition a special TUI code has to be executed in the FLUENT terminal.

```
> (rpsetvar 'icepak? #t)
icepak?

> (models-changed)
#f
```

Fig. 12. TUI code for recirculation

For air inlet: The recirculation inlet has been assigned to the inlet and its outlet pair is also mentioned in the inputs.
For Air outlet: The recirculation outlet has been selected for the outlet and mass flow rate is assigned for the outlet.
For the Condenser of test specimen outlet: It is considered as the normal velocity inlet with the temperature measured by probe.
For the Temperature: The temperature gradient (found by the probes) is given in the inlet recirculation condition.

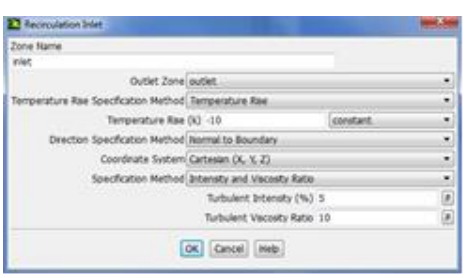

Fig. 13. Inlet boundary (Suction) condition for the Outdoor unit AC

The air flow rate is calculated by considering the velocity from the AC outlet, area of the outlet and the density of the air.
Mass flow rate = $\rho * v * A = 0.36$ kg/s

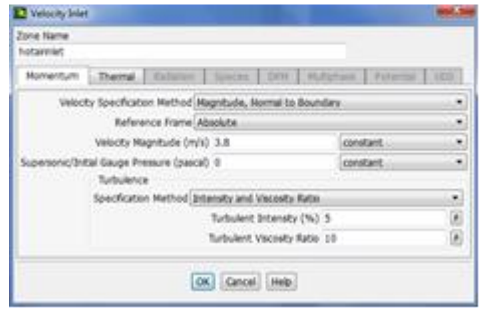

Fig. 14. Inlet boundary condition of air entering into unit from condenser

The velocities are found out by using anemometer.

4. Results

A. *Indoor Unit*

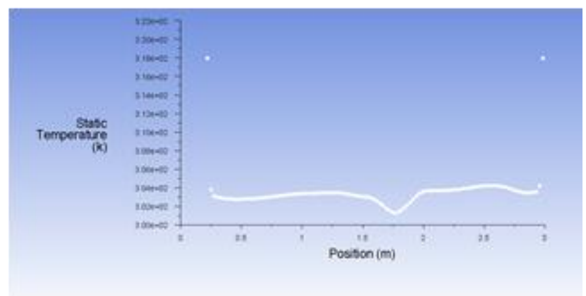

Fig. 15. Temperature profile at centre of the indoor unit 180 Seconds

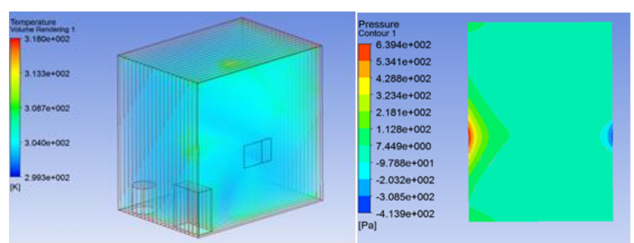

Fig. 16. Temperature distribution in K and pressure contours the Indoor unit after 180 Seconds

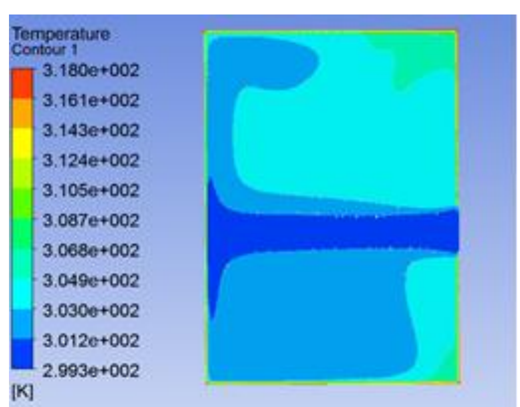

Fig. 17. Temperature contours in K the Indoor unit after 180 Seconds

B. Outdoor Unit

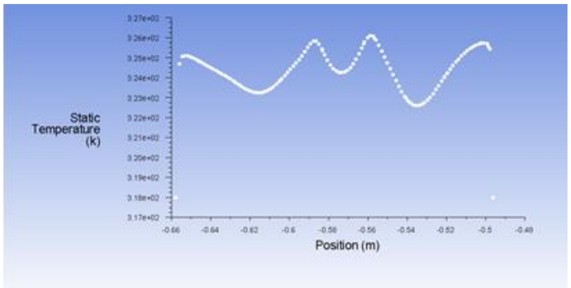

Fig. 18. Temperature profile at centre of the outdoor unit after 180 seconds

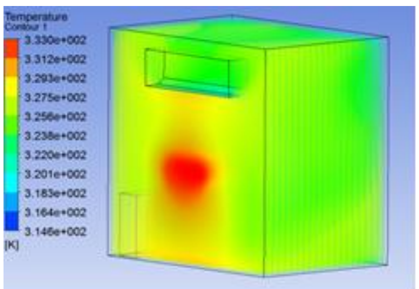

Fig. 19. Temperature distribution in K and pressure contours the outdoor unit after 180 Seconds

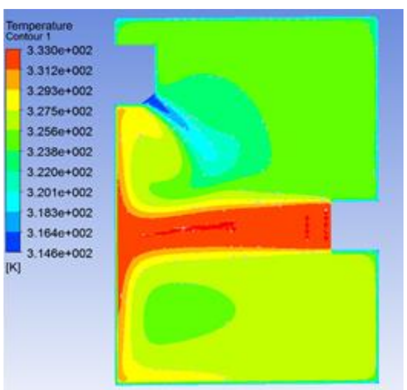

Fig. 20. Temperature contours in K the outdoor unit after 180 Seconds

5. Conclusion

Psychrometric room has been designed and simulated on ANSYS using workbench 18.1. The simulation of psychrometric room and behavior of airflow and temperature variations have been shown in this experimental design analysis.

Acknowledgement

Acknowledge Sreyas Institute of Engineering & Technology for R&AC lab facilities for psychometric testing of AC, Akella Systems Pvt. Ltd., for Assembling the prototype model and Uniscient Engineering Pvt. Ltd. For computational Fluid Dynamics work. These and the Reference headings are in bold but have no numbers. Text below continues as normal.

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