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Pre-cooling of air in centralized Air conditioner

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Abstract: Pre-Cooling of air is the concept of reducing the temperature of the air which is forced on the cooling coil so that the tonnage of refrigerant required to cool the air will get reduced effectively leading to the reduction in power consumption.
In this work optimum dimensions of nozzles are found so that the load on cooling coil to cool air is reduced which in turn leads to reduction in power required to run the Air conditioner.
Keywords: Pre-cooling , Centralized AC, modification in AHU.

I. INTRODUCTION

Air conditioning is the process of removing heat from the interior of an occupied space, to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment, typically for humans or animals. Air conditioners often use a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air) and subterraneous pipes that can distribute the heated refrigerant to the ground for cooling.
In the most general sense, air conditioning can refer to any form of technology that modifies the condition of air (heating, cooling, de-humidification, cleaning, ventilation, or air movement. In common usage, though, "air conditioning" refers air conditioning is referred to as heating, ventilation, and air conditioning.) Pre-cooling is used to reduce the temperature of air by artificial means before it is passed over the cooling coil. Pre-cooling of air is obtained by installing a set of nozzles mounted on a plate in the AHU before the cooling coil. Cooling is obtained by the principle of working of convergent nozzles. The convergent nozzles work on the principle of increase in velocity of the fluid flowing through it extent of pressure loss. This pressure loss leads to the drop in temperature across the nozzles thus obtaining the cooling of air. The purpose of pre-cooling is to reduce the tonnes of refrigeration on the cooling coil and conserve energy

II. FABRICATION

The entire setup is fabricated with Galvanized Iron (GI) sheet. The whole assembly of nozzle plate is attached to duct and exhaust fan is placed at the outlet of nozzles as shown in fig.

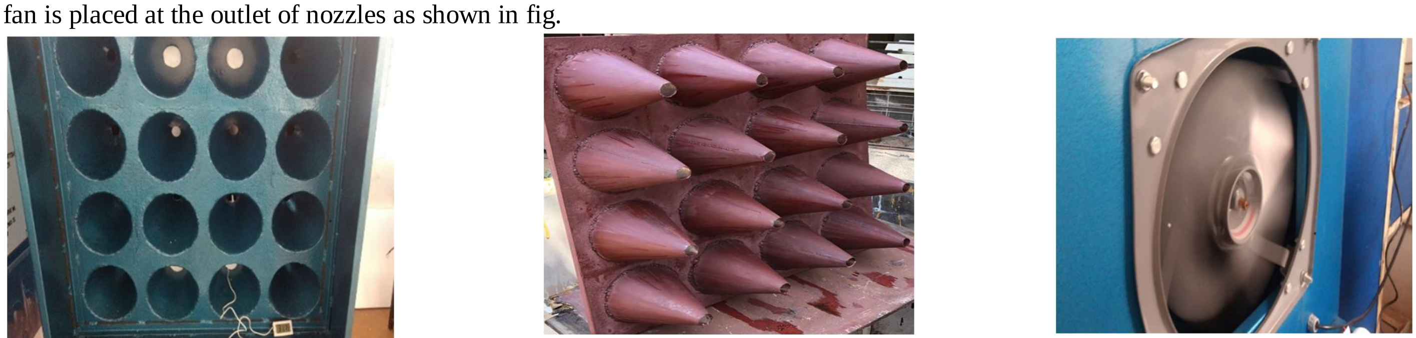

Fig.1 Experimental setup

III. SELECTION OF PARAMETERS

For designing of nozzle various factors are considered by referring Bernoulli’s equation some factors which are considered are,

A. Number of nozzles
B. Exit Diameter of nozzle

Inlet diameter, length and blower speed are kept constant. Varying number of nozzles and outer diameter various nozzles are designed and by using Bernoulli's equation theoretical results are obtained for each nozzle.
Dimensions of nozzle giving optimum results are finalized and used for experimentation.

IV. THEORETICAL CALCULATION

Bernoulli's equation is used to get outlet pressure at exit of nozzle. We first determined inlet conditions of nozzle by calculating pressure, velocity and temperature.
Bernoulli's equation for real fluid,

$$\frac{P2}{\rho g}+\frac{V2^2}{2g}+z_2=\frac{P1}{\rho g}+\frac{V1^2}{2g}+z_1+h_l+p_l$$

From the above equation pressure drop at outlet section of nozzle is determined.
After calculating pressure drop, ideal gas equation for constant volume flow rate of air is used for each nozzle present on plate considering all inlet conditions. Ideal gas law,

$$\frac{P_1}{T_1}=\frac{P_2}{T_2}$$

V. EXPERIMENTATION

Applying Bernoulli's equation,

$$\frac{P2}{\rho g}+\frac{V2^2}{2g}+z_2=\frac{P1}{\rho g}+\frac{V1^2}{2g}+z_1+h_l+p_l$$

For D_2=20 mm,
Full factorial method is implemented to find combinations of parameters like number of nozzles, inlet diameter and outlet diameter and for each combination of parameters temperature drop across nozzle is determined.
Experimentation involves the measurement of temperatures at the inlet and the exit of the nozzles and thus the drop in temperature across the nozzle. Digital thermometer is used to measure the temperature at the inlet and outlet. These temperatures are helpful in determining the drop across the plate for various combination of nozzles. Experimentation is done on the pre-cooling setup available at the Heat Power Lab of Finolex Academy of Management and Technology, Ratnagiri. Volume flow rate of air flowing through the cabinet is 0.45 m^3/s. The cross sectional area of plate is 0.645 m * 0.645 m .The plate is fitted into cabinet. Thermometer is placed in cabinet which gives the temperature of air.
D_1=120mm and D_2= 20mm with number of nozzles=16 is optimum set of combination of parameters temperature drop for this set of combination is 0.8^{0}C. Also by considering time factor in account it is found that by experimentation, for maximum temperature drop maximum time required is 1.46 minutes.

VI. EXPERIMENTAL RESULTS

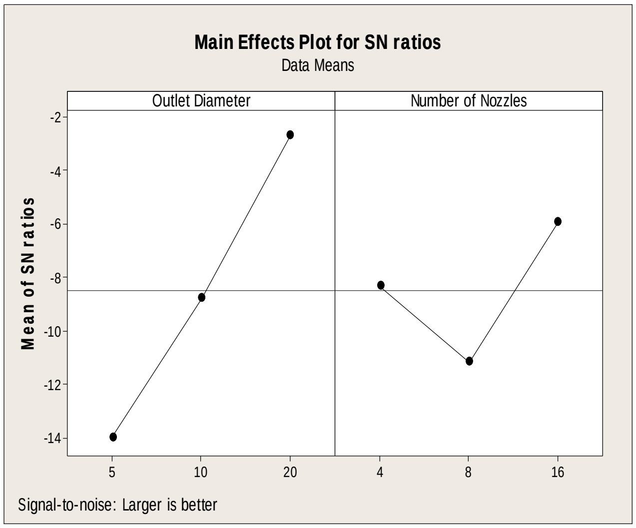

Fig 2. Graph of Outlet Diameter & Number of nozzles VS Temperature drop

VII. CONCLUSION

This paper has attempted to reduce the load on cooling coil considering all the aspects of centralized air conditioner. Study includes the actual dimensions of nozzles and number of nozzles required to obtain reduction in temperature of air. Paper includes the calculations required to find nozzle dimensions considering factors affecting it.

From the theoretical result it is seen that the combination of 16 nozzles can be used to obtain the objective of pre-cooling the air which is further verified by experimentation. Thickness of the nozzles does not contribute to the temperature drop. Angle of nozzle is important factor which affects the temperature drop across the plate.

VIII. ACKNOWLEDGMENT

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