Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

CFD Analysis of Velocity & Temperature Under Variable Flow Condition in an Air Distribution of Air Conditining

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***Abstract*— Human comfort and commercial needs for controlled thermal environment are increasing rapidly. It is needed for the better performance of the man power apart from domestic comfort need and to protect the goods and food material from being deteriorating. The air in an air conditioned space is maintained at certain desired condition with controlled temperature, humidity and velocity of flow. This paper presents the work done by the various researchers in air conditioning and distribution technology and the effect of various parameters of air distribution on indoor environment. It is reflected from the literature that more attention of researchers and designers of air conditioning equipments is needed to work on this least focused but important field of engineering and technology. Many other aspects of air conditioning such as alternative air conditioning methods, alternative refrigerants and savings in energy consumption are being focused by the researchers. Since indoor thermal environment is affected by the air distribution and human comfort can be ensured by the proper air distribution in the spaces .It is found in the literature that many alternative technologies of air distribution are being developed by the researchers to improve indoor environment and savings in energy consumption. Many researchers are working using the mathematical and experimental methods to get the useful results. Computational Fluid Dynamics (CFD) tool is gaining importance among the researchers as a modern tool capable of providing useful engineering solutions to the problems particularly involving fluid flow and heat transfer with the saving of cost and time.**

Keywords—Computational Fluid Dynamics (CFD) Temperature Counter, Velocity Counter, Air Distribution.

I. INTRODUCTION

Most people spend a great part of their lifetime staying indoors and they need a comfortable physical environment for their better living and performing activities. Temperature among other factors in providing suitable physical environment is controlled by the air conditioning for both the living and non living beings. Air velocity, purity, humidity and pressure are the other factors of indoor environment. Any space has variations in these parameters throughout the year in various combinations. The thermal environment involving temperature is the most important factor in the comfort conditions. The human comfort is obtained when the temperature and other physical parameters in a space are controlled. Thermal comfort is defined as the condition of mind of the human being expressing satisfaction with thermal environment [1]. This thermal comfort has two personal factors with four environmental factors. The human activity level and thermal insulation of clothing are the personal factors while the environmental factors include temperature, velocity and humidity of the air. To provide comfortable environment in indoor spaces all these factors are needed to be controlled.

Air Distribution

Air distribution is the process of transferring conditioned air into the conditioned spaces. The required amount of the conditioned air is supplied into the conditioned space through supply air diffusers or supply air vents in order to distribute it properly so that required thermal environment could be established in the conditioned space. The design of the air distribution system is needed to fulfill the following requirements:

A proper combination of temperature, humidity and velocity or air motion is needed for the comfortable thermal indoor environment in the occupied zone. The occupied zone is defined as the space in the conditioned zone that is from the floor to a height of 1.8 m and about 30 cm from the walls. In the occupied zone, the maximum variation in temperature should be less than 1o C and the air velocity should be in the range of 0.15 m/s to 0.36 m/s.

Draft in the occupied zone is not required and it is defined as the localized feeling of cooling or warmth. Draft is measured above or below the controlled room condition of 24.4 oC and an air velocity of 0.15 m/s at the center of the room.

The research in design of air distribution system is needed to find the ways and system providing comfortable indoor environment at a lower cost and better efficiency as evident in the literature available. Thermal comfort has been achieved by the indoor air movement [2] and temperatures of the air in the conditioned space. However, several factors are responsible for the air movement within a room [3]. Movement of air is caused due to the forced convective airflow [4]. Natural convection and the temperature difference causes the air movement as the conditioned air and the walls of the conditioned space and air movement caused by a differential pressure across the indoor structure are the factors affecting air motion. The cause of air movement in the conditioned space also includes the existence of the doorways and apertures

International Journal of Engineering Research & Technology (IJERT)
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inside a room which could have great impact on the indoor air movement [5]. The opening and closing of doors coupled with people's movement may also have important influence on the indoor air distribution [6]. Several numerical studies are therefore being done by the designers and researchers to achieve the thermal comfort, finding of alternative air conditioning technology, alternative refrigerants and design of various parts of air conditioning.

Design of System

The system of air distribution is designed with the prime objective of choosing the location of the supply air diffuser the type of diffuser and the location of the return air vent or grill and the type of return air vent or grill. The effect of the type and location of the supply air diffuser and return air duct is on the temperature and velocity of conditioned air at any given point of the space to be conditioned. The common parameters which affect the room air temperature and velocity are as under:

Velocity of the conditioned air which is supplied at
the inlet of the diffuser. Room air temperature and the supply air temperature difference.
Type and location of the supply air diffuser.
Type and location of the return air grill or vent.

Indoor Air Quality

Conditioned environment and air quality in the conditioned room needs mainly the two requirements to be fulfilled which includes indoor. Breathing in the room should not cause health risk to the occupants one requirement and other is occupants should perceive air in the room as fresh and pleasant air when occupied in the conditioned space. **[7]**

II. LITERATURE REVIEW

Air conditioning [Ajay Kumar1& Dr. V. N. Bartaria, 2016] of spaces requires the air to be supplied in the conditioned space of desired thermal quality and at flow rate of specific requirement. It is essential in providing human comfort in commercial and residential spaces to have the desired characteristics of the supplied air. The main characteristics of the air among others are the supply air temperature and its flow velocity. The objective of air conditioning of spaces is that, the conditioned air provided comfort to the occupants of the spaces and goods are protected from being deteriorate. The conditioned air is required to be maintained at certain desired physical condition with defined temperature, humidity and velocity of flow. The objective of this paper is to present the numerical simulation of the temperature and velocity variation in an air conditioned space. Three cases have been taken into consideration for three different locations of the return air vent. The conditioned air is supplied through one of the wall of the room through an opening. The air is returned through the return air vent placed on the opposite side of the wall. Temperature and velocity distribution for three cases of return air vent locations have been presented. The numerical results show that the supply air vent at a position near the ceiling provides the more uniform temperature and velocity distribution and thus the comfort.

III. NUMERICAL SIMULATION

With the rapid increase in computational power in the last 20 years CFD has gained significant popularity and modeling is often considered more illuminating and cost effective than lab or field experiments [8]. The present work is divided into two parts, in one part the model of the computational field will be developed using FLUENT software. Meshing of the model and boundaries will be set with required boundary conditions [9]. For the analysis and solution of the problem in second part commercial CFD codes of FLUENT will be used. The results will be obtained in the forms of temperature and velocity contours. The temperature and the velocity distribution in the conditioned space will be plotted in the form of two dimensional plots for the various test locations in the computational domain. Now using governing equation in air conditioning system.

$$\frac{\partial v}{\partial t} + v.\nabla v = F - \frac{1}{\rho}\nabla p \quad Euler's\ Equation$$

$$v = -\nabla\phi \quad and \quad \nabla \times v = 0 \qquad irrotational\ velocity$$

$$F = -\nabla\Omega \ conservative\ forces$$

$$\rho = const. \quad incompressible\ fluid$$

$$\frac{\partial}{\partial t}(-\nabla\phi) + \nabla\phi.\nabla\nabla\phi = -\nabla\Omega - \frac{1}{\rho}\nabla p$$

$$\nabla\left[-\frac{\partial\phi}{\partial t} + \frac{v^2}{2} + \Omega + \frac{p}{\rho}\right] = 0$$

$$-\frac{\partial\phi}{\partial t} + \frac{v^2}{2} + \Omega + \frac{p}{\rho} = const.$$

$$\frac{v^2}{2} + \Omega + \frac{p}{\rho} = const. \quad Bernoulli's\ Equation$$

IV. CONCLUSION

The design and development of air conditioning equipment needs data and results of the research on the thermal comfort and performance parameters of the system to be designed. These parameters are evaluated from the numerical and experimental studies. Thermal comfort and air distribution have close relation with each other. The literature shows that the air distribution is gaining importance in the development of better air conditioning effect and thermal comfort. Apart from the experimental methods, numerical methods are being used by the researchers for being the effective and low cost technology analysis and simulation. The role of air motion and temperature as the main parameters of the air conditioning needs to be optimized for the physical conditions of the conditioned space and the air distribution method.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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