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Quantification of Air Flow Pattern in Air Conditioned Room – A Review

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Abstract : *This configuration has many advantages from the point of view of comfort and medical assistance, but it implies an important restriction as far as ventilation is concerned. Numerical model solves mass, momentum and mean age of air equations assuming isothermal and stationary flow. Ventilation is evaluated analyzing the age of air and the velocity fields inside the room. The results with the initial architectural design of the room show very deficient ventilation at the occupant's site. Alternative configurations have been studied, allowing for correct ventilation without renouncing to the assistance advantages. Finally, the optimum configuration of the room is provided, regarding both the comfort of the occupants and the cost of execution.*

The present work focuses on the room air flow pattern in terms of temperature and velocity along with thermal comfort quantification by varying clothing index cfd study. Room air flow pattern in the two test rooms, University conference hall and RAC Lab are studied under four conditions; natural, only fan, only AC, fan with AC. Effect of air conditioner position on the room air flow pattern is also studied. Thermal comfort is quantified using standard ASHRAE sensational equation based on the feelings of the four B. Tech students at various clothing index and exposure period. The contour of the flow patterns are plotted using ORIGIN 6.1 software.

Keywords*- Air Flow Pattern, Quantification of Air Flow, Air Velocity Temperature Distribution.*

I. INTRODUCTION

It is well known that indoor environment is an important factor not only for occupants' comfort as a whole, but also for their health and productivity. Air distribution achieves the acceptable levels of temperature, humidity, cleanliness and air motion in the occupied zone of conditioned area. All this is done in such a manner that the occupant does not experience any draft. Airflow and transport phenomena play an important role in air quality, thermal comfort and energy consumption in buildings. Air movement is one of the six main variables determining human thermal comfort.

It is advisable to operate the ceiling fan at moderate speed with air conditioner to get the uniform flow pattern with respect to temperature and velocity which leads to saving in energy. Air flow pattern depends on the location of the air conditioner. Thermal comfort depends on the clothing resistance and activity level.

1.1 Ceiling Fan and Space Air Diffuser

Ceiling fans are used to make a breeze for the occupants in various kinds of buildings. Yoshihisa ,[1] propose to use ceiling fans not only to make a breeze but also to controlee the airflow pattern in a room. This study shows that it is possible to predict airflow patterns and temperature distributions in large rooms with ceiling fans with CFD analysis, using the measurement data of the airflow from the ceiling fan as boundary conditions. the results indicate that from the energy conservation point of view, it is desirable to stop the rotation of the ceiling fans, but to prevent cold draft, it is useful to generate an upward flow.

When horizontal supply openings are used to cool the room in summer, the cold air drops down to the occupied zone directly. Therefore ceiling fans can be used as complementary devices for air-distribution to prevent the horizontal jets from falling and make air circulation in the room. in this way ceiling fans can improve thermal comfort in the occupied zone.

Space air diffusion distributes the conditioned air containing outdoor air to the occupied zone (or a given enclosure) in a conditioned space according to the occupants' requirements. Satisfactory space air diffusion evenly distributes the conditioned and outdoor air to provide a healthful, and comfortable indoor environment for the occupants, or the appropriate environment for a specific manufacturing process, at optimum cost.

Because space air diffusion is the last process of air conditioning and takes place entirely within the conditioned space, it directly affects the effectiveness of air conditioning. Because diffused and ambient air are transparent, space air diffusion is also difficult to trace.

The objective of air distribution is to achieve the acceptable levels of temperature, humidity, cleanliness and air motion in the occupied zone of conditioned area. All this is done in such a manner that the occupant does not experience any draft. Correct air diffusion and the proper quantity of conditioned air are essential for comfortable conditions in forced-ventilation systems. Three different kinds of air diffusion models are studied for summer cooling conditions.

UP to 90% of a typical person's time is spent indoors and a large fraction of that time is spent in a residential or commercial environment. People therefore expect the indoor environment to be as comfortable as possible. Thermal comfort is generally defined as that condition of mind which expresses satisfaction with the thermal environment. Dissatisfaction may be caused by the body being too warm or too cold as a whole, or by unwanted heating or cooling of a particular part of the body.k.c.chung [2]. Study of room air distribution is important in many applications, including commercial and residential rooms, clean room manufacturing, electronic and computer rooms, biomedical research, hospital disease control, and greenhouse and animal agriculture. The perceived comfort equation and thermal comfort equation are applied to evaluate local indoor air quality and draft conditions in an indoor environment under three different air diffusion models. The distributions of air velocity, temperature, and thermal comfort are investigated numerically using three different air diffusion models.

1.2 Human Thermal Load as a Comfort Index

Men of today are facing a variety of issues such as Global Warming and Urban Heat Island. Solving such problems attracts lots of attention. Street plantings, highly reflective materials, and water retentive materials are considered to be useful for decreasing sensible heat load and creating comfortable space. As a matter of fact, the definition of 'comfortable space' is obscurity, and in this paper predictive method for human thermal comfort is judged by human feeling. Human thermal feeling is mixed senses of air temperature, humidity, radiant temperature, wind speed, metabolism, and clothing insulation. Human thermal load proposed by authors (Yasuhiri Shimazaki, 2009)[3] is an index which can express human thermal feeling. Therefore, some countermeasures were valued by human thermal load.

Any heat gain or loss from thermally neutral state is considered as hot or cold sensation of discomfort. The amount of heat was focused on base on the idea, and the human thermal load was examined its effectiveness. The amount of physiology also needs to be included in the thermal comfort index which aims at application on the outdoors in the suitable form as well as the weather parameter peculiar to the outdoors, such as solar radiation and wind velocity. The human thermal load Q is calculated from Equation 1 as a remaining amount of each energy balance items. It is objective and actually by the basis of the energy balance formula about the human body incorporating the amount of physiology.

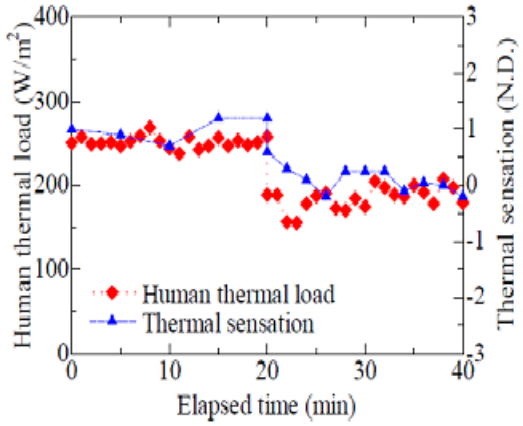
$$Q = M - W + R_{net} - E - C \qquad (1)$$

Where M is metabolism [W/m2], W is workload [W/m2], Rnet is net radiation [W/m2], E is latent heat loss [W/m2] and C is sensible heat loss [W/m2], respectively.

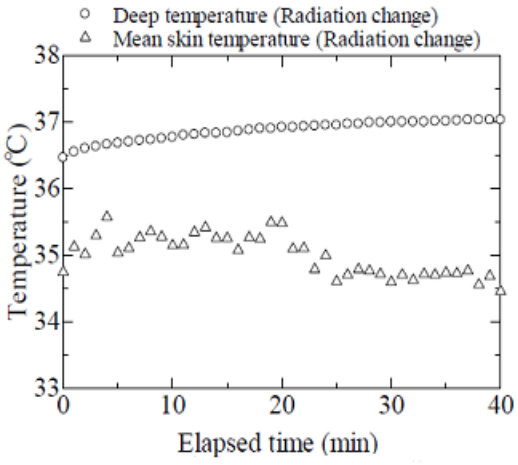
In order to grasp the effectiveness of human thermal load, the subject experiments were carried out and the physiological reaction and mental action of human body in the outdoors were observed. The surrounding weather factors and the physiological amounts of human body were measured.

1.3 Effect of Radiation

Solar radiation is dominant especially in outdoor. The effect of solar radiation on human thermal comfort was examined. Some of the results are shown in Figure. Because the amount of solar radiation which human received changed, human thermal load dramatically changed after 20 minute. And the mean skin temperature decreased gradually after 20 minute when radiation change occurred, however deep temperature gradually increased through the experiment because of exposure in outdoor. In this way, radiation's strong effect on human thermal comfort was confirmed.



"***Figure 1. Temp change of human thermal load and thermal sensation.***"



"***Figure 2. Temp changes of skin temp***"

1.4 Optimization study

The aim of this study is to optimize the ventilation flow pattern in the room, that is, to find a feasible design that achieves efficient ventilation. To do so, the flow pattern of the initial configuration is analyzed and, from this analysis, possible modifications in the geometry and location of the air inlets and outlets are deduced. These changes substantially maintain the architectural design and, simultaneously, are feasible from the point of view of economics and manufacturing.

II. LITERATURE REVIEW

Most important prospect in designing, sensitive area equipment, storage enclosures, hospitals, offices like other sensitive areas is to ensure a uniform targeted temperature and humidity in the relevant enclosures. Sempey et al.[2] has obtained the methodology for temperature distribution in air conditioned rooms focusing on to test the feasibility of the approach. Simple numerical study of turbulent flow is done by yongson et al.[3], over an enclosed air conditioning system, the better comfort analysis of occupants in the room is noted by different locations of blower placement. "state numerical analysis in a room heated by two-panel radiators", the three dimensional study had done by Sevilgen Gokan et al. [4] , his results showed that, by using better insulated outer wall materials and windows, the energy consumption can be significantly reduced while increasing the thermal comfort. Ozcan and vranken [5] had measured the trajectory of a non-isothermal air jet in a building with a single or multiple air inlet(s) and developed an airflow pattern sensor. Air velocity and temperature distribution in a refrigerated warehouse presented by Ho. Son H. et al.[6] according to him, better cooling effectiveness and uniformity of temperature in the refrigerated space could be achieved by using higher blowing.

Air velocity and/or locating the cooling units lower and closer toward the arrays of product packages. Kosonen Risto et al. [7] conducted the experiment in a mock-up of an office room to study the air velocities in the occupied spaces. With the extremely high heat gain of 164 W/m2 the maximum air velocity measured was still below 0.25 m/s.

Thermal comfort aspects were studied by Myhren Jonn Are et al.[8] for different heating systems and their position effect on the indoor climate in an exhaust ventilated office under swedish winter conditions, for investigating possible cold draught problems, air speed levels and energy consumption, differences in vertical temperature gradients, he used computational fluid dynamics (CFD) simulations. In order to achieve the thermal comfort of the occupant Nielsen [9] had work on velocity distribution, further he simulated and concluded the airflow from an air terminal device influences the occupant's thermal comfort. for a person standing in a room with an inlet and an outlet for air conditioning and a ceiling fan, thermal comfort analysis is performed by Ho Son H. et al [10]. He found, as the normal air speed from the fan increases, thermal comfort significantly shifts toward the cooler scale to allow higher supply air temperature or higher heat load in the room while maintaining the same comfort level.

The field study on thermal comfort in the capital city of jakarta indonesia had done by Karyono Tri Harso [11], the study with 596 office workers in seven multi-storey office building had conducted. Human feeling temperature is focusing on and human thermal load was proposed as an index by Yasuhiro Shimazaki et al [12] by using this human

thermal load index countermeasure techniques for severe thermal environment were evaluated from the perspective of human feeling. Zhang et al. [13] proposed the investigation on a personal chair arm rest-embedded air system the system delivers conditioned, outside air directly to the breathing zone of a passenger, the system is robust to prevent the contaminants released at any height to the passengers breathing region was found by combining the under-aisle air supply with the personal supply at the chair armrests. Sekhar S.C. et al[14] measured the characteristics of thermal comfort and indoor air quality (IAQ), during sleeping period in 12 naturally/mechanically ventilated (NMV) and 12 AC bedrooms over a period of 2 months in hot and humid climate, it was found that NMV bedrooms was a better sleeping environment.

A systematic multi-phase and solution oriented approach through which thermal comfort problems can be assessed was presented by Budaiwi Ismail M.[15] identified and treated in a systematic way without utilizing unnecessary resources and time has been introduced. An index was proposed by Yasuhiro Shimazaki et al[16] about human feeling temperature is focusing on and human thermal load, by using this index, countermeasure techniques for sever thermal environment were evaluated from the perspective of human feeling.

III. CONCLUSION

In terms of temperature and velocity for achieving a uniform flow distribution, mostly higher blowing velocity and location of the cooling units at different places were suggested depends on the situation. Much less work has focused on the validation of fanger's draught model, in comparison to fanger's PMV model. Hence the objective of present review work is to characterization of the room air flow pattern with respect to temperature and velocity, cfd study with the help of experimental data and the quantification of the thermal comfort.

The present work is focused on the cfd analysis based the characteristics of room air flow pattern in terms of temperature and velocity with thermal comfort quantification by varying the clothing index.

IV. SCOPE OF WORK

Proper room air flow distribution and thermal comfort are the important aspects of the air-conditioning. The primary objective of the air-conditioning is to create thermal comfort environment which is largely depends on the IAQ and room air flow pattern. Further, room air flow patter in a conditioned space is situation dependent and cannot be generalized. In view of this fact the proposed review work involves the experimental and CFD study to visualize and analysis the room air flow pattern under different conditions. Further, thermal comfort is also quantified.

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