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Air-Conditioning Systems and Indoor Air Quality Control-A Study

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ABSTRACT

With the continuous development in technology, economy enrichment of living standard of mankind paying more attention towards comfortable living, thus air-conditioning has become more essential. However, health problems due to air-conditioning systems and indoor air quality is become visible more commonly The evaluation of indoor air quality (IAQ) risks to building occupants has become a difficult and challenging matter for building occupants. The problems related to indoor air quality more attention being paid; in the presented study it is being summarized. A detailed study on air-conditioning systems and indoor air quality control for healthy and comfortable indoor air environment is required.

Keywords: Air conditioning ventilation, air quality, health, comfort

INTRODUCTION

Air-conditioning systems have been extensively used in many parts of the world for giving comfortable living atmosphere to occupants. The function of air conditioning system is to provide thermal comfort and an adequate amount of good indoor air quality (IAQ) for occupants. Now a day's each and every one research work is being paying attention on committed outdoor air system (DOAS), independent control of temperature and humidity system (ICTHS), displacement ventilation systems (CC/DV).With the up grading in living standard of occupants, they require more comfortable and healthy indoor environment. Knowledge of the indoor environment is imperfect and is of vast importance as the greater parts of people have been found to spend about 80- 90% of their time indoors in many countries. Koistinen *et al.*[1]; Scapellato *et al.*[2]; Delgado-Saborit *et al.*[3] It has been observed that Indoor environment has significant effects on human health and work efficiency. The factors responsible for indoor environment generally include temperature, humidity, air change rate, and air velocity and direction, and ventilation, particle pollutants present. Pollutants, it may be biological or gaseous Graudenz, *et al.* [4]. By Studying recent studies, Seppanen and Fisk [5] found that there was an increase in occurrence of sick building syndrome (SBS). Between 30% and 200% when compared with natural ventilation system along with air-conditioning system. The worldwide energy crisis occurred in1970swas the acknowledgment of the importance of energy saving. Reduction in energy consumption in building was the main criteria for design by designers for making air tight buildings. Thus fresh air quantity is considerably reduced in air-conditioning systems in order to reduce the energy consumption. The combination of several man-made chemicals results in high concentrations of indoor particle pollutants and volatile organic compounds (VOCs) (e.g., benzene, toluene, and formaldehyde) in association with low ventilation air flow rates is main contributor to spoil indoor air quality.

Wang *et al.* [6].However, in the past few years some comfortable and healthy air-

conditioning systems were proposed in order to control the concentration level of indoor pollutants and to improve indoor air quality(IAQ).Many researchers have studied and suggested the control methods of IAQ. In this study, recent research will be studied on air-conditioning systems and indoor air quality control for human health .In order to control the concentration level of indoor pollutants and to improve IAQ.
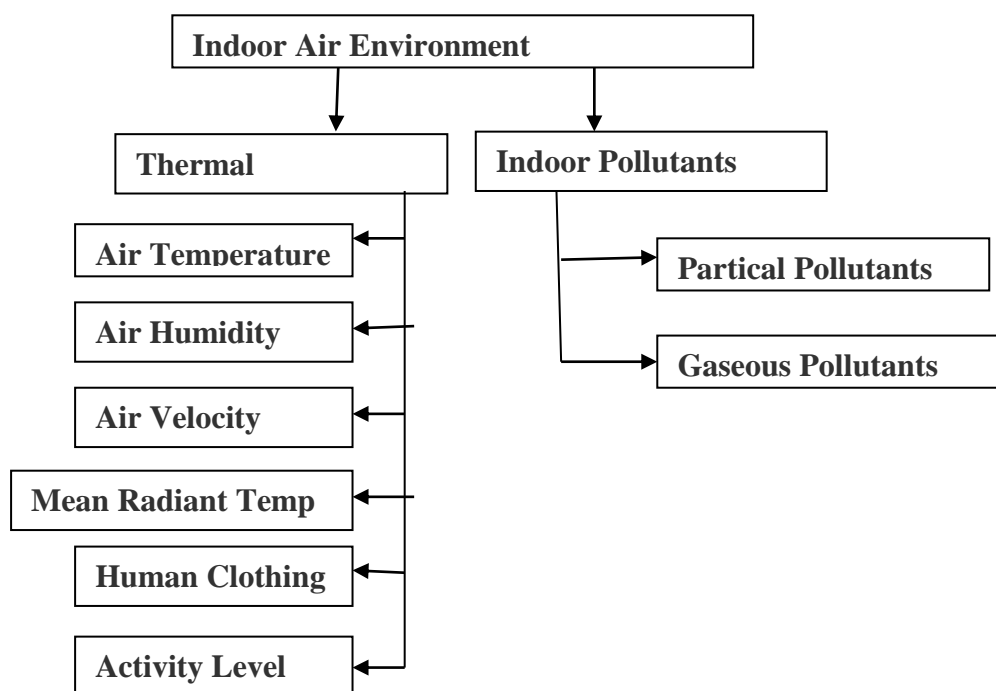
INDOOR AIR ENVIRONMENT

Fig. 1: Indoor Air Environment.

Indoor air surroundings must meet the required conditions of thermal comfort and improve indoor air quality (IAQ). Thermal comfort is affected by many factors, such as air temperature, air humidity, and air velocity, and mean radiant temperature, human clothing, and activity levels the widespread use of air conditioning helps to improve thermal comfort, but create health problems related with poor IAQ seen more commonly (Niu, 2004)[7].Many researchers accept as true that IAQ may be the most important and somewhat unnoticed environmental issue of their time.(Gao, 2002)[8]. Indoor pollutants may be incorporated particle pollutants or gaseous pollutants.

INDOOR POLLUTANTS
Particle Pollutants
Basically the sources of indoor particle pollutants can be separated into two category first Indoor pollution sources and second outdoor pollution sources, with the concentrations and composition of indoor particle pollutants are depending on different sources.

Particulate matter (PM) is complex mixture of inorganic and organic compounds of solid particles and liquid droplets of various sizes (range from a few nanometers to tens of micrometers) suspended in a volume of air.

$PM_{2.5}$ concentrations may be up to 3and 30 times higher than the ordinary levels during smoking and cooking, respectively He *et al.*,[9]). Several studies on indoor air quality have recognized that cooking as one of the most significant particle generating activities indoors Lai *et al.*,

[10]; Wan *et al*. [11]; Massey *et al.* [12]) The general population is exposed to cooking-related risk in spite of race, age, wealth and cultural food preferences as cooking is an important characteristic of human culture Kim *et al.* [13]

Particle pollutants can enter in human body by three ways, specifically respiration canal, skin, and alimentary canal causing danger to health. It is the risky way that particle pollutants enter human body through respiration canal Kavouras and Stephanou,[14]. The degree of harmfulness due to particle pollutants to human body is related to the chemical characteristic, diameter magnitude, and quantity.

The chemical quality of particle pollutants is the main factor because the chemical characteristic determines the degree and speed of biochemistry processes which particle pollutants contribute in the human body upsetting the cycle.

Gaseous Pollutants
Primary gaseous pollutants
Mainly gaseous pollutants mainly include CO, CO_2, SO_2, NOX (Nitrogen Oxides), O_3(Ozone) and volatile organic compound(VOCs).Volatile organic compounds (VOCs) are organic chemicals that easily produce vapors at ambient temperatures VOCs can cause many symptoms, such as headache; eye, nose, and throat irritations; dry cough; VOCs may be carcinogenic Huang and Highlight, [15] the physical and chemical characteristics of VOCs are in a center of attention for many researchers, and become a research area.

Secondary gaseous pollutants
Some unsaturated hydrocarbons are an important source of indoor secondary pollutants. Mainly include free aldehydes, ketones, alcohols, carboxylic acids. Indoor secondary pollutants have major impact on comfort and human health but the amount of impact and the frequency of occasion are uncertain at present. In addition, many secondary pollutants cannot be measured because of the intricacy of composition.

CONTROL OF IAQ
In order to provide a happy and healthy indoor air Environment, measures must be adopted to control the concentration level of indoor pollutants to improve IAQ. The current methods generally consist of control of pollution sources, ventilation and indoor air purification.

Ventilation is the process of mixing or replacing contaminated indoor air with fresh air from outside the building to minimize the level of indoor pollutants. The main types of ventilation methods used for general room ventilation are shown below, some of which are classical and some are less common.

Mixing Ventilation (MV)
The aim behind a MV system is to mix fresh air with contaminated room air to provide a fresh supply of air and lower the contaminant concentrations [16]. An air jet is normally supplied in the upper parts of the room to provide air circulation around the room. With a properly designed system, to achieve the consequential temperature and contaminant concentration in the occupied zone should be quite uniform. However, MV is known to have lower ventilation usefulness when compared to other air distribution systems.

Displacement Ventilation (DV)
DV is a new type of air supply approach and it only improves the environment in confined space but not all the spaces. Hence DV keeps better IAQ but not energy efficient. Indoor air flow pattern along with distribution pattern of temperature and pollutant concentration. DV may not provide better IAQ than MV if the pollutant sources are not associated

with heat sources, but as per Lin *et al.*, [17]; Cheong *et al.* [18], VOCs from building materials also.

Personalized Ventilation (PV)

PV is a special DV system. PV is able to endow with occupants with better IAQ, thermal comfort and individual control of the micro-environment.

PeV aims to provide fresh air directly to the breathing zone of every occupant in the space to improve the air quality and increase occupants' satisfaction Melikov AK [19]. However, this type of system is not for general application through adjusting the personalized airflow rate, direction, and temperature and turbulence intensity

Under-Floor Air Distribution (UFAD)

UFAD system is a new type of air supply mode with the advantages of superior relasticity energy saving and improvement of IAQ Webster *et al.*, [20]. Now it has been functional in Europe, Hong Kong, Japan, South Africa and America.

At present, the studies on UFAD are paying attention on its airflow characteristics, IAQ, thermal comfort, thermal characteristics of under-floor plenum, and energy consumption of the system. UFAD requires further developments in a number of aspects: Like individual control of thermal comfort, thermal characteristics of under-floor plenum, development of new types of diffusers, the recent research on ventilation has been described .Control of pollution sources. It is a most economical and successful approach in improving IAQ to eliminate or reduce indoor pollution sources Guo *et al.* [21]the best ways of controlling indoor air pollution are to use pollution-free or low-pollution materials and to take up the design and maintenance measures that avoid producing indoor pollutants.

INDOOR AIR PURIFICATION

Indoor air purification is an important method of removing indoor pollutants and improving IAQ under the situation that the ventilation and the control of pollution sources are not possible. The major methods of indoor air purification mainly filtration, adsorption, photo catalytic oxidation (PCO), Negative air ions (NAIs) and non-thermal plasma (NTP).

Filtration

Filtration is a reasonably economical and capable method of improving IAQ. Filters are vital components in all AC systems. It has been found that AC filters can remove ozone appreciably at steady state Hyttinen *et al.*, [22, 23]; Beko *et al.* [24, 25] Zhao *et al.* [26] measured the ozone removal efficiencies of clean filters and field-loaded residential and commercial filters in a Maintained laboratory environment where air temperature 22–26°C, with 45–60% RH. In the steady-state environment ozone removal efficiency varied from 0% to 9% for clean filters. The mean steady-state ozone removal efficiencies for laden residential and commercial filters were established in between 10% and 41%, respectively. From the results above it can be seen that the particles accumulated on the filters can increase the ozone removal efficiencies regardless of the fact that air filtration systems correspond to a good solution for the improvement of IAQ.

Adsorption Technology

At present, the main types of adsorption treatment materials available are activated carbon, activated carbon fibers, and zeolites. Activated carbon is a porous carbonaceous material with a well-developed micro porous structure and a large specific surface area.

It consists of many types of carbon-based substances that have adsorption capability and can absorb many chemical substances on the surface, and has been widely used.

Activated carbon has a good purifying effect on VOCS when a concentration of about 100 mg/m^3. It can be used for more than 1000h, and the purification effect will decrease with the prolonged use.

Catalytic Conversion Technology

Photo catalytic degradation is a photochemical effect using nano-semiconductor materials as a catalyst. The photo catalytic degradation catalyst is often known as photo catalyst. Photo catalysts, a kind of semi-conductor, mainly include TiO_2, SnO_2, ZnO, CdS, Fe_2O_3, WO_3 and MnO_2. Photo catalysts absorb specific wavelengths of ultraviolet light to motivate electrons, generate electron-hole pairs, and rapidly move to photo catalysts.

The activated oxygen and moisture adsorbed on the surface of the photo catalyst to produce active hydroxyl radical OH and superoxide anion radical O_2-with exceptionally strong oxidizing power, which can oxidize and decompose organic compounds into harmless H_2O and CO_2.

CONCLUSION

A comfortable and healthy indoor air environment is always favorable to occupants. In recent years, indoor thermal comfort has been improved to a great extent due to the development of air-conditioning systems. However, health problems associated to poor IAQ appear more frequently, and it is the indoor pollutants that lead to poor. IAQ Many researchers have widely studied the composition of indoor pollutants, their sources, physical and chemical properties, and their effects on human health. If these problems of pollutants are resolved, then indoor air environment can be controlled accurately and reasonably. People should strengthen their understanding of indoor air pollution, strengthen their wakefulness of prevention, simplify their beautification and accept more green building materials. Therefore there is a need for assessing established methods of building ventilation and developing new ventilation systems that should be capable of providing good IAQ and energy saving routine to make building occupants happy and, at the same time, in line with new building energy regulations. At the same time, we must make good use of the developments and achievements of modern science and technology to use such technologies as adsorption, catalytic conversion, can successfully prevent indoor air pollution, and improves indoor air quality, and guarantee that people have a good living and working environment.

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