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Abstract
As people stay indoors most of the time, how to operate the Heating, Ventilation and Air-Conditioning (HVAC) systems as well as building facilities to reduce airborne infections have become hot research topics. This paper presents a systematic review on HVAC systems and the indoor environment. It reviews the research on the improvement of ventilation, heating and air-conditioning systems which is install in commercial building, hotels, hospitals etc. and various indoor environment improvement measures to minimize airborne spread, such as building envelope design, physical barriers and vent position arrangement.

Keyword: HVAC, Indoor environment, Humidity, Patient room, Computational Fluid Dynamics, Heat transfer coefficient, etc.

Introduction

A. HVAC (heating, ventilation and air conditioning)

Ventilation, Heating, and Air Conditioning is an abbreviation for such systems. Enterprise data centers require HVAC systems to be planned for and managed alongside the other data center components like servers, storage, networking, security, and power. These systems regulate the "data center's ambient environment", which includes humidity, temperature, air flow, and air filtration.[1] Almost all pieces of IT gear have certain temperature & humidity requirements. Product specifications and physical planning guidelines often detail these needs. The safety, security, fire, and environmental issues of all of the equipment in the data center must be taken into consideration while designing HVAC system.[2]

This is why proper forethought, installation, and upkeep of an HVAC system are essential. In addition, emergency planning has to be included. A data center may, for instance, use HVAC redundancy, stockpile replacement parts, and store portable cooling units as backups.[3]

B. The importance of HVAC systems in hospitals

The heating, ventilation, and air conditioning systems in hospitals are performing a crucial function by keeping the buildings at a healthy temperature and humidity level and by keeping the air clean and free of germs. Due to these variables, particular consideration must be given in design of the hospital air conditioning systems to a number of criteria that are also relevant in other industries.[4]

In a healthcare setting, air conditioning does much more than just keep people comfortable. In order to work properly, the medical equipment used in hospitals and other healthcare institutions is very temperature and humidity sensitive. However, the design of such structures is made more complicated by the fact that hospitals must have rooms with quite distinct uses.[5] It's important to have a well-defined plan for how each area will be used. Some patients in a hospital could be exposed to the "infectious-contagious diseases", necessitating a degree of isolation; similarly, patients with suppressed or the weak immune systems (in intensive care units, neonatal wards, operating theaters, etc.) need to be protected from the plethora of pathogens that thrive in hospitals.[6] Because of the high concentration of the pathogens in hospitals, and because most of these chemicals travel in air currents, the air conditioning devices in hospitals is particularly vulnerable to the accumulation of large quantities of the empathogens and can even serve as areas for their cultivation, posing a risk to health of those who use it. All of this may be prevented if the buildings are planned properly to prevent patients, staff, and visitors from being exposed to harmful bacteria and viruses.[7]

Zoning in over-pressure & depression is especially important, so consistency when designing zoning of every space to be air-conditioned is crucial. Similarly, designing with the elements which maintain the correct degree of the water tightness, but are at same time accessible and built with the clean materials, is essential.[8] Furthermore, it is crucial to incorporate a sufficient amount of outside air supply, often significantly higher than in the other types of the installations, and a more exhaustive level of the filtration to enable maximum retention of micro-particles that help fungi, bacteria, and viruses that cause diseases settle.[9]

1.1 Potential for Natural Ventilation and Operable Windows

Natural ventilation through operable windows could be the efficient and cost-effective way to "supplement HVAC systems" in areas of country where the climate allows for it to provide outside cooling, air ventilation, and thermal comfort when the conditions permit (such as humidity, temperature, precipitation, outdoor air pollution levels). Having operable windows may make people feel more at ease and in charge of their surroundings. They are also useful for providing supplementary exhaust ventilation during construction projects that may generate indoor air pollution.[10]

A structure with moveable windows may have higher indoor air quality (IAQ), but the sealed building with a well-planned and run HVAC system may have even better IAQ. Ventilation with unrestricted access to external air may let in pollutants that would otherwise be caught by filters, throw off the mechanical ventilation system's equilibrium, and let in too much moisture.[11]

Wind-driven cross-ventilation & stack ventilation, which utilizes the difference in the air densities to create air flow across a space, are examples of "natural ventilation strategies". Convective flows are essential to both forms of the natural ventilation and need careful engineering. There must be no obstructions (such closed perimeter rooms) to the free movement of air from the entering point to the exit.[12]

Literature review

(Aulia et al., 2923)[13] The standard for temperature quality in inpatient rooms is the temperature parameter 22-23°C. This study uses an HVAC system with variations in geometry, duct position, and cooling time to measure the temperature in the inpatient room. The results showed that if the model of the inpatient room at Bitung Hospital without a partition, using the geometry of 4 of 5 variations in the geometry of the duct position, and the location of the inlet and outlet diffuser must be on the upper side wall, so that it can overcome the temperature of the inpatient room in the hospital. Bitung Hospital that does not meet the requirements. Thus, an alternative solution is produced that can increase the maximum thermal comfort for patients at Bitung Hospital.

(Torres et al., 2020)[14] With the rising demands for quality, visitor comfort, and rate level standards, the hospitality industry has become a major consumer of energy. Even amongst hotels in the same general area, there may be as much as a 114 kWh/m2/year variance in energy use, and this is only for a four-star establishment. This study discusses the design, service type, operation, operating point, occupancy patterns, and HVAC efficiency in hotels, which account for 30–50% of total energy consumption. Photovoltaic projects and other non-traditional energy resource implementations were also examined as potential solutions to the problems of fuel reliance and high-power prices. Where electricity savings may reach 30% & gas savings can reach 60%. However, these facilities need to take into account new features, which might be expensive and take a long time to pay for themselves.

(Becchio et al., 2017) [15] The European standards for the high-performing buildings constitute a significant challenge for the renovation of existing building stock, especially for historical structures. The study's goal is to

determine the best efficient HVAC setup for renovating Mediterranean-area hotels of historical significance in order to cut down on their energy bills. The goal of this study was to identify the most energy-efficient HVAC solution by simulating the "historical hotel's Reference Building" across "five Mediterranean cities using Energy Plus software" and the set of the tools designed to mimic the energy behaviour of "specific HVAC technologies".

(Liang et al., 2023)[16] This research compared and contrasted the standards for high-biocontainment facilities developed in China and other countries, with a focus on technical points and necessities of Heating, Ventilating, and Air Conditioning" (HVAC) systems in various series of standards. The interior characteristics, ventilation system, integrity test, filter design, airflow pattern, fan standby, and system dependability were all elaborated upon, as were their verification in design process. Input on the design, building, and potential future change of Chinese national standards for biosafety facilities is sought for this research.

(Jahanbin & Semprini, 2022)[17] This study analyzed the differences and similarities between the series of standards for the high-biocontainment buildings produced in China and other countries, paying special attention to the technical details and requirements of the HVAC systems. Detailing and verifying the ventilation system, interior characteristics, filter design, integrity test, fan standby, airflow pattern, and system reliability. This study seeks input on the planning, construction, and possible future modification of "Chinese national standards" for the biosafety facilities.

Conclusion

This paper presents a review on the relevant research on HVAC system and indoor environment, including ventilation system, air filtration device, HVAC system, building envelope design, and vent location arrangement, etc. Also, it is a sector that consumes large amounts of electricity and energy, the HVAC system has an important participation. However, in the hospital sector it is important to maintain a comforting concept and environment for its patient and employees. The hospital facilities are composed of few fundamental areas: room areas, public areas, and operation rooms; each one has different requirements for comfort environment according to international standards. The following conclusions can be made:

- Natural ventilation with auxiliary equipment can help improve indoor air quality and maintain a healthy environment. However, 100% fresh air supply leads to increased building energy consumption. Future research should focus on how to provide enough fresh air through the combination of reasonable natural ventilation and efficient air purification to achieve a low infection risk while maintaining low energy consumption during the pandemic.
- Research focuses on the increase of fresh air to stop/mitigate virus spread, as well as heat recovery and new air-conditioning system to reduce the energy consumption caused by increased ventilation rate.
- Future studies could focus on how to design HVAC system that can both work in normal conditions and during a pandemic with low energy consumption while maintaining a healthy indoor environment.
- Vent location, physical barrier, building envelope design, and flow deflector can all play a role in preventing virus spread. Future research can explore the impact of building layout and the synergistic effects of combining these improvement measures with HVAC operations to effectively minimize the risk of infection.

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