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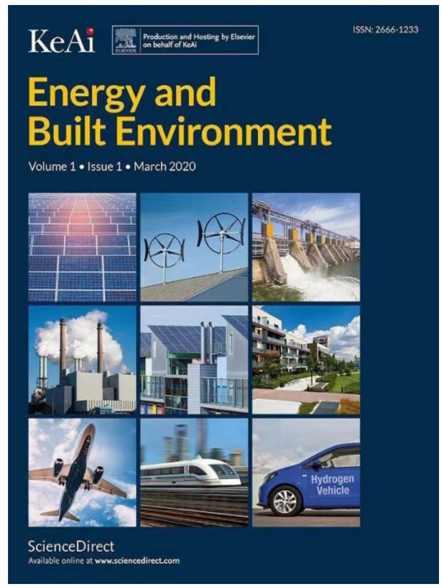
ARTICLES



- Effect of partial pit exhaust ventilation system on ammonia removal ratio and mass transfer coefficients from different emission sources in pig houses;
- Aerodynamics of railway train/tunnel system: A review of recent research;
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Effect of partial pit exhaust ventilation system on ammonia removal ratio and mass transfer coefficients from different emission sources in pig houses

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ARTICLE INFO

Keywords:
Ammonia emission
Pig house
Partial pit exhaust ventilation
CFD
Removal ratio

ABSTRACT

A partial pit exhaust ventilation (PPEV) system installed below the slatted floor has been widely used in fattening pig barns nowadays in Denmark. Experimental tests showed that annually around 50% of ammonia emissions was collected by PPEV system. However, the percent of emissions collected by PPEV system from different emission sources including slurry manure surfaces, top surfaces, bottom surfaces and side surfaces of the slatted floor has not been investigated as well as the mass transfer coefficients. This study applied CFD modeling to investigate the removal ratio of ammonia emissions from four emission surfaces including the top, side, bottom surfaces of the slatted floor and slurry manure surfaces. The CFD model was validated by experimental air speeds measured in a room equipped with two full-scale pigpens. The validated CFD model was further adopted to simulate cases under five ventilation rates (2000-4000 m^3/h), four emission sources and two locations of PPEV system exhaust. The results showed that the removal ratios of ammonia emissions by PPEV system from the four emission sources were generally higher for the cases that the PPEV exhaust was installed opposite to the air supplier than the values of those cases that the PPEV exhaust was located at the same side of side wall air supplier. The removal ratios of ammonia emissions were the highest with the emission source of slurry manure surface and generally 30% higher than the values of other cases. The mass transfer coefficients with the emission sources on the side surfaces of the slatted floor were the largest. The results indicated that the airflow patterns and locations of emission sources greatly influenced the removal ratios of ammonia emissions and ammonia mass transfer coefficients.

1. Introduction

Food Agriculture Organization (FAO) predicted that the world food production must increase by 50% within the next 20 years and 80% of that increase must come from the intensification of agricultural production. The global livestock sector is growing faster than any other agricultural sub-sectors. However, intensive livestock production can contribute largely to gaseous emissions such as ammonia, greenhouse and odor. Ammonia has been recognized as one of the important pollutant gases to accelerate fine particulate matter formation in the atmosphere and significantly contribute to the acidification and eutrophication of ecosystems and indirect emissions of nitrous oxide [1]. In order to abate ammonia emissions, cleaning techniques are required. Currently, chemical air cleaners is able to remove 90% of ammonia and biological air cleaners have efficiency of around 70% to remove ammonia and odor [2,3]. However, it is very expensive to clean the whole amount of airflow rate especially such a large amount of airflow rate in summer ventilated in livestock production houses. To reach the mitigation regulation of ammonia in Denmark, it is important to develop a technique which is economic and easy to be implemented into both existing and new buildings to be constructed in future. Driven by such a motivation, a partial pit exhaust ventilation (PPEV) system (also called point exhaust ventilation system) has been developed and widely implemented into the pig production houses now since the technique of PPEV has been nominated as one of the Best Available Techniques (BAT) in 2014 [4].

The PPEV was installed below the slatted floor and the ventilation rate exhausted by PPEV was 10% of maximum ventilation rate (100 m^3 h^{-1} pig^{-1}). A few articles written in English by Saha et al. [5] and Zong et al. [6,7] can be found in literature. They conducted measurements in an experimental sections with two full scale pigpens to investigate the effects of PPEV system on indoor air quality and ammonia emissions collected by PPEV system. In their studies, the PPEV was installed at either the end of the wall near resting area or near the dunging area. The results showed that PPEV system could significantly reduce the indoor ammonia concentration by 42.6% and around 47-63% of ammonia emissions (also called as ammonia removal ratio and calculated by using the ammonia emissions collected by the PPEV dividing the sum of the ammonia emissions via both room exhaust and PPEV exhaust) were collected by PPEV systems. This concept was further adapted to a naturally ventilated dairy cattle building in Denmark where a PPEV system was installed below the slatted floor to collect the ammonia and odor emissions [8,9]. Some experimental tests were also conducted in

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Aerodynamics of railway train/tunnel system: A review of recent research

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ARTICLE INFO

Keywords:
High-speed trains
Tunnel aerodynamics
Compressible flow

ABSTRACT

The coupling and complexity of railway train / tunnel system are further aggravated by increasing train speed, which produces a series of aerodynamics problems, such as aerodynamic drag, slipstream, pressure wave and micro pressure wave. Aerodynamic effects of tunnels will result in a significant increase in train energy consumption, shorten life of railway train / tunnel system, and increase maintenance cost. This paper provides a review of aerodynamics of railway train / tunnel system. Challenges in railway train / tunnel system aerodynamics and their related factors are discussed firstly. Aerodynamic performance and flow field characteristics of trains in tunnels are presented. Relationship of aerodynamic effects and parameters of railway train / tunnel system, and the control methods for reducing aerodynamic effects in tunnels are explained. A traffic safety evaluation of the train in tunnels, such as vehicle body structure, passengers' ear comfort, etc., is introduced and analysed. Finally, future outlooks and research topics are proposed.

1. Introduction

It is known that a high-speed train system is interrelated and interdependent with railway lines, the environment and airflow, which form a complex aerodynamic coupling system in high-speed railways. As shown in Fig. 1, the coupling and complexity of the system will be further aggravated by the distribution characteristics of high-speed rail lines and the complicated topography along the lines, especially tunnels. The aerodynamic effects of high-speed trains in tunnels are an important factor restricting the development of high-speed railways.

With the speed-up of trains, many engineering problems appeared and were exacerbated, such as aerodynamic drag, vehicle vibration, pressure waves, micro-pressure waves at exits of tunnels, slipstream, etc. These are major factors limiting the speed-up of train systems, particularly railway train/tunnel systems. Many countries own high-speed railway trains, such as the German Intercity Express (ICE), Japanese Shinkansen, French Train de Grande Vitesse (TGV) and Chinese China Railway High-speed train (CRH), etc. Some other countries are trying to construct high-speed railways. Because of the huge differences in railway conditions all over the world, ensuring the safety and comfort of high-speed railways is the primary task in the design, construction, operation and maintenance of the high-speed railway. With increasing train speeds, train aerodynamic effects worsen significantly, as shown in Fig. 2. When trains pass through or pass by each other in tunnels at high speeds, the vehicle structure and tunnel wall are subjected to strong transient aerodynamic impact pressures, and the pressure amplitude can be up to 6 kPa (0.6 tons/square metre).

Early research results in railway train / tunnel system aerodynamics are found in the previous studies [1–5]; and some research related to passenger comfort and pressure transients in and around tunnels is presented in references [6,7]. In this paper, progress in research on pressure waves caused by trains passing through tunnels in the past decade is reviewed, including the characteristics of the pressure wave in tunnels, the parameters influencing the pressure wave, and valuation methods and indicators for the passengers' ear comfort and the vehicle body carrying capacity, etc. The key point of this paper is to summarize the formation mechanisms and development of a pressure wave in tunnels, the relationship and rules between the pressure wave and the parameters of the railway train / tunnel system, the safety evaluation of a pressure wave caused by trains passing through tunnels, and control methods for pressure waves in tunnels.

In this paper, the Introduction mainly presents the significance and urgency of the aerodynamics of train / tunnel coupling systems. Challenges in railway train / tunnel system aerodynamics and their related factors are discussed in Section 2. Aerodynamic performance and flow field characteristics of trains in tunnels are presented in Section 3. Pressure wave in railway train / tunnel systems and micro-pressure wave at the exit of tunnel are reviewed in Sections 4 and 5. A traffic safety evaluation of the train in tunnels, such as vehicle body structure, passengers' ear comfort, etc., is shown in Section 6. Finally, some outlooks and conclusions are given in Sections 7 and 8, respectively.

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Impact of residential building heating on natural gas consumption in the south of China: Taking Wuhan city as example

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ARTICLE INFO

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South of China
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NG consumption forecasting

ABSTRACT

With the development of social economy, heating in the south of China has been concerned widely. As one of the energy sources of decentralized heating, natural gas (NG) has been used more and more popularly. This paper aimed to study the impact of residential building heating on NG consumption, and took Wuhan city, the representative city needing heating in winter of the south of China due to its location and climate, as an example. Firstly, a typical residential building model was established through DeST software. The heating load was simulated, and the corresponding NG consumption index was calculated. Secondly, appropriate methods were used to forecast the basic data of Wuhan city in 2020, including households and per capita gross national product (GDP), etc. Thirdly, the NG consumption of residential buildings with and without heating were predicted. Finally, the impact of residential building heating on NG consumption was analyzed. The results showed that the average annual household heating consumption of residential building in Wuhan city in 2020 was 2100 kWh/ household, and the NG consumption using for residential building heating was 295 Nm^3/household. In addition, the NG consumption of residential building generated by space heating with 100% heating rate was 2.82 times the NG consumption generated by the stove and water heater, showing that residential building heating had a large impact on NG consumption. This study can contribute to choosing appropriate heating method in the southern cities of China, and further planning the gas pipe network in these cities.

1. Introduction

With the development of social economy, the requirement for building thermal comfort has been raised rapidly. In the south of China with a climate of hot summer and cold winter, the lack of central heating in winter leads to poor indoor thermal environment. Therefore, the requirement for heating becomes more and more urgent in this area. According to a survey, 91% of residential people in the south of China want heating in winter [1]. Considering the small heating load and intermittent significance in the south of China, decentralized heating is the main method. As one kind of clean energy, natural gas (NG) has become one of the main heating sources.

Over the years, many scholars have investigated the heating methods in the south of China. Long [2] analyzed the characteristics of residential heating in hot summer and cold winter areas, and concluded that decentralized heating was the mainstream. Chen [3] studied the range and methods of southern heating, and indicated that more attention should be focused on heating mode, energy saving, heat source, terminal and system, etc. Jin [4] introduced eight kinds of southern heating methods, and conducted the economic comparison for the most representative ones. The results showed that low-temperature floor radiation heating was the most economical, followed by heat pump, wall-mounted furnace, and electric heating. Li [5] compared the applicability of central heating, district centralized heating and decentralized heating for the south of China, and the results showed that small-scale district centralized heating and various decentralized heating could be used, and further the widespread application of wall-mounted furnace in decentralized heating would become popular. Zhang [6] made an economic comparison between coal-fired boilers, oil-fired boilers, single-unit heating for wall-mounted furnaces, single-family heating and electric heating. It concluded that central heating of coal-fired boilers was the most economical, but from the perspective of environmental protection and energy, NG heating was more promising. Qian [7] analyzed the economics of household wall-mounted furnace, and predicted NG heating

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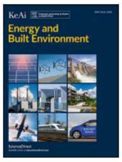

An Expandable, Contextualized and Data-Driven Indoor Thermal Comfort Model

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ARTICLE INFO

Keywords:
Fuzzy Logic
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ABSTRACT

Continuous discrepancies in building performance predictions creates an ongoing inclination to link contextualized, real-time inputs and users' feedback for not only building control systems but also for simulation tools. It is now seeming necessary to develop a model that can record, find meaningful relationship and predict more holistic human interactions in buildings. Such model could create capacity for feedback and control with a level of intelligence. Fuzzy Logic Systems (FLSs) are known as robust tools in decision making and developing models in an efficient manner. Considering this capability, in this paper, FLSs is implemented to make a thermal comfort model in an educational building in the UK. Such implementation has an ability to respond to some identified desires of developers and performance assessors in addressing uncertainty in thermal comfort models. The results demonstrate the proposed method is practical to simulate the value of comfort level based on the input data.

1. Introduction

In the UK, non-domestic buildings are accountable for approximately 12% of carbon emissions and 17% of overall energy consumption. Even though considerable effort has been made on new low energy buildings, but the existing building stock dominant energy use in the country [1]. Numerous building regulations are introduced to facilitate low carbon design but they only focused on regulated energy loads, which created a challenge of building performance gap. As a result, researchers are now switching their attention to occupant behaviour and many efforts have been made in studying responsible energy usage in office buildings. However, there is still limited understanding of energy use during building operation.

Widely used simulation programs generally evaluate the heat flux, HVAC system loads and demands and lighting, on the basis of standards like ASHRAE55 for thermal comfort. Weather data, the geometry of buildings and materials as well as setpoints for temperatures are the inputs of such programs. Heating or cooling setpoints data are not always available, requiring researchers to use an estimate, which may not be always accurate and a true reflection of the occupants' comfort level. Therefore, there is a growing concern about a discrepancy between the predicted energy performance of buildings and actual measured performance, widely known as building performance gap (BPG). BPG is not only limited to energy efficiency but also likely to be on indoor air quality, acoustic performance and daylighting levels.

The importance of addressing the BPG issue lies on the fact that there is an increased pressure on the construction industry to reduce carbon emissions from heating and hot water substantially above 20% by 2030, with a further reduction to complete decarbonisation by 2050. This is due to legally-binding targets set by UK Parliament in the Climate Change Act [2]. Furthermore, under a system of the Fifth carbon budgets which run until 2032, if construction industry fails to achieve carbon reduction target then the UK will have to increase pressure on other sectors to achieve corresponding falls [3]. Therefore, a mismatch between designing and delivering could affect other sectors.

Bridging the performance gap can be achieve by designing a decision-making stage to deliver (i) higher quality homes with lower costs to meet the quantified targets, such as zero carbon Buildings, (ii) buildings that are robust towards arguably warmer conditions with considering growing concern of changing climate and health risk [4,5]. It is also a key requirement for building delivery and facility management, enabling the feasibility of concepts such as performance-driven buildings.

BPG can be controlled by an organised, multidisciplinary approach that incorporates improvement in data collection for simulations [6,7], data validation [8] and change of industry practice to minimise workmanship errors [9]. Therefore, the objective of this research is to address BPG challenge by make a contextualised thermal comfort model to address uncertainty in building energy management tools. Neural networks, clustering methods, data mining techniques, fuzzy logic systems

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Experimental study on the flow field and economic characteristics of parallel push-pull ventilation system

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A R T I C L E I N F O

Keywords:
Push-pull ventilation system
Economic characteristics
Flow field
Parallel flow

A B S T R A C T

Push-pull ventilation systems provide excellent control of contaminants and harmful gases. However, since both a push inlet and a pull outlet are used in the push-pull ventilation system, the flow rate required by the system is large. In that case, the energy consumption of the system is large. The purpose of this paper is to study the flow field and economic characteristics of a parallel push-pull ventilation system by reducing the flow rate of the exhaust outlet, which will be achieved by reducing the size of the exhaust hood. The three commonly used push-pull ventilation systems were analyzed: a high velocity push-pull system with high air supply velocity, a low velocity push-pull system with wide airflow and small velocity, and a parallel push-pull system with wide airflow and uniform air supply velocity. Results showed that the parallel push-pull ventilation system was the only one in which the flow rate of the exhaust outlet could be reduced, reducing the overall energy consumption. Under conditions of the parallel air supply jet, the diffusion range of contaminants in the push-pull flow field was the smallest and reducing the exhaust air flow rate did not affect the capture efficiency of pollutants. These results may be useful in guiding the design of push-pull ventilation system and optimize economic constraints.

1. Introduction

During different industrial production processes, contaminants such as dust and steam may be produced. In order to effectively protect the working environment of workers, local ventilation can be used [1–6]. A widely used local ventilation method in industrial applications is the push-pull ventilation system, which has good pollution control [7–9]. The system is composed of two parts: an air supply inlet and an exhaust outlet, which uses an air supply jet as the power to transport contaminants to the exhaust outlet [10–13]. Depending on the type of air supply used, push-pull ventilation systems can be divided into high velocity push-pull ventilation system, low velocity push-pull ventilation system and parallel push-pull ventilation system. A High velocity push-pull ventilation system uses a high velocity supply jet to mix and transport contaminants [14,15]. A low velocity push-pull ventilation system uses low velocity and wide air flow to control workspace contaminants [16]. A parallel push-pull ventilation system uses a low turbulence intensity, uniform, and wide air flow with good directionality to push the contaminants into the exhaust outlet [13,17,18].

Initial research on push-pull ventilation systems was based on the high velocity system [19,20]. Betta et al. explored the capture of pollutants with different particle sizes [21]. Marzal et al. studied the effect of the geometric size of the air supply on capture efficiency and observed flow field characteristics by using airflow visualization [22,23]. Robinson et al. explored the flow field distribution and developed design recommendations for a push-pull ventilation system [24,25]. Rota et al. tested the impact of different factors on contaminant capture and proposed corresponding design suggestions [26]. Enrique Gonzalez et al. studied the effect of different sizes of exhaust hood on capture efficiency [27].

However, excessive air supply velocity at the push inlet can damage the workpiece surface [16,17]. A large number of studies indicate that initial conditions of the air supply jet, such as air supply uniformity, directivity, and turbulence intensity have an important impact on the performance of push-pull ventilation systems [28–30]. Based on these findings, a low momentum system was proposed. There are two types of low momentum system: a low velocity push-pull system that supplies air as slowly as possible but with enough velocity to reach the exhaust outlet and to control the polluted airflow [16], and a parallel push-pull system with uniform air supply velocity, good directivity, and low turbulence density [16].

Low velocity and parallel flow system have developed rapidly in recent years [16,17,31–34]. Hayashi advised that to improve the push-pull system, parallel jets, low velocity, good directionality and a uniform air

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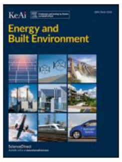

Experimental study on PM2.5 removal by magnetic polyimide loaded with cobalt ferrate

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ARTICLE INFO

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Magnetic polyimide
Cobalt ferrite
PM2.5
Filtration performance

ABSTRACT

A novel functional magnetic polyimide loaded with cobalt ferrite nanoparticles by coprecipitation method was proposed, and XRD, FTIR, SEM technologies were employed to study their physicochemical properties. The filtration performance of non-magnetic and magnetic polyimide were examined by experimental system. The effects of dust resistance, filtration velocity and initial dust concentration on the filtration performance of magnetic polyimide were investigated under different dust loadings. The results revealed that presence of ρ-π conjugation between the cobalt ferrite and polyimide fiber resulted in easily load on the fiber surface for cobalt ferrite nanoparticles. The magnetic polyimide exhibited good filtration efficiency especially in the range of particle size less than 2 μm. The filtration efficiency of magnetic polyimide filter materials increased by nearly 20% compared with the primary polyimide. Due to the loading of cobalt ferrite, the resistance of the magnetic polyimide increased, while the resistance growth rate decreased from 100% to 29% with increased filtration velocity from 0.5 m/min to 2.5 m/min.

1. Introduction

One of the key parameters of dust emission control in steel industry is PM2.5. In particular, a lot of ferromagnetic particles are discharged during raw material transportation, treatment and stacking of iron making, steel-making, rolling, fly ash and steel slag [1–3]. Bag filters have been widely employed in metallurgy, chemical engineering and steel industries with the characteristics of high dust removal efficiency [4]. The core of bag filter is fiber filter materials. At present, in order to improve the dust collection efficiency of fiber filter materials, most researchers have prepared fiber composites by needling, spunlacing or film covering method to improve the collection efficiency of particles. Due to the limitation of single nonwoven fiber filter, the filtration efficiency with less than 2.5um particle size is very low [5–7]. The PTFE (Polytetrafluoroethylene) film has been commonly covered onto the nonwoven fiber filter by adhesive under high temperature to improve the collection efficiency of PM2.5, but it is also easy to be damaged after long-term usage [8–9]. Functional filter media probably can be a potential alternative for PM2.5 collection given above limitations.

The high collection efficiency for PM2.5 can be achieved by traditional functional fiber filters with film covering. However, PPS (Phenylene sulfide), PTFE (polytetrafluoroethylene), aramid and other functional fiber filter materials have poor temperature resistance and expensive cost [10–13]. Polyimide filter materials have excellent high temperature and corrosion resistance [14]. Particles deposit well on the filter surface under high temperature during the dust removal. However, polyimide is limited to capture ferromagnetic particles with particle size less than 2.5 μm. So it is of great significance to investigate functional polyimide filters for the removal of magnetic particles in steel industries.

Based on magnetic coalescence technology, PM2.5 can be agglomerated into large particles in the magnetic field, which will be captured easily [15–16]. Li et al. [17] prepared PAA (Acrylic acid Polymers) @Fe_3O_4 composite by electrospinning, which showed that the composite exhibited good magnetism and Fe_3O_4 nanoparticles were evenly dispersed in the material. Dong [18] prepared the polyimide PI@Fe_3O_4 fiber membrane composite by introducing Fe_3O_4 magnetic nanoparticles onto it. The results revealed that magnetic Fe_3O_4 nanoparticles did not destroy the chemical structure of PI (polyimide) molecule, and the fiber membrane composite had obvious magnetism. Cobalt ferrite as a kind of magnetic material has the advantage of high remanence compared with the above magnetic materials. Ji [19] studied the influence of various synthesis processes on the magnetization of cobalt ferrite. The cobalt ferrite loaded with other metals with higher magnetic properties was obtained by Sih and Shi [20–21]. In the study on PM2.5 removal with magnetic field, the methods by laying wires outside the filter material have been employed to generate magnetic field [16]. This method is limited by the facilities space. In addition, most of the magnetic functional materials are produced by electrospinning, which have higher

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Synthesis and thermal properties of nanoencapsulation of paraffin as phase change material for latent heat thermal energy storage

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A R T I C L E I N F O

Keywords:
Nanoencapsulted PCMs
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A B S T R A C T

In this work, a series of nanoencapsulated phase change materials (NanoPCMs) with paraffin wax (PW) as core and melamine-formaldehyde (MF) as shell were synthesized by the in-situ polymerization method. The morphology, chemical structure and thermal properties of prepared NanoPCMs were characterized by scanning electron microscope, Fourier transform infrared, differential scanning calorimetry and thermogravimertic analyzer. The results show that the PW is successfully encapsulated in the MF without chemical interaction, and the NanoPCMs present regular spherical shape with the average diameter of 260–450 nm. The encapsulation efficiency of the NanoPCMs increases with the augment of the supplied amount of core material. The maximum encapsulation efficiency of the NanoPCMs can reach up to approximately 75%. The NanoPCMs can maintain excellent thermal reliability and stability after 2000 thermal cycling. The prepared NanoPCMs can be well applied in the latent heat thermal energy storage and thermal management systems due to their remarkable encapsulation efficiency and thermal properties enable them to.

1. Introduction

Increasing the energy utilization efficiency is reckoned as an effective way to solve the issues of fossil energy shortage and environment pollution in the recent years, which can be feasibly realized by using phase change materials (PCMs) to store and release the thermal energy circularly [1,2]. PCMs can absorb and release a large amount of thermal energy during their melting and freezing process, with outstanding advantages of storing or releasing the thermal energy at a constant temperature or with a narrow temperature range [3,4]. They have attracted much attention in developing the new applications and technologies due to such excellent performance [5].

According to the chemical component, PCMs can be classified as inorganic and organic PCMs. As a typical organic PCM, paraffin wax (PW) obtains many merits like safety, reliability, high heat of fusion, chemically inert and stability, no toxicity, no phase segregation and commercial availability, etc. However, it also has some undesirable properties such as low thermal conductivity, poor mechanical property and liquid leakage during the phase change process [6]. Microencapsulation and nanoencapsulation technology are feasible choices to solve the inherent drawbacks of PCMs [7]. The microencapsulated PCMs (MicroPCMs) and nanoencapsulated PCMs (NanoPCMs) are small core-shell particles of PCMs coated by inorganic materials or polymer [8]. By encapsulating PCMs into the shell materials, it can greatly enlarge the heat transfer area of PCMs, increase their heat transfer efficiency, make liquid PCMs easy to be handled when the phase change occurs without extra encapsulation, and decrease the volume change during the solid-liquid phase transition of PCMs [9].

The generally methods descried in the literatures to prepare the MicroPCMs and NanoPCMs are complex coacervation [10], interfacial polycondensation [11], emulsion polymerization [12], suspension polymerization [13] and in-situ polymerization [14]. Among the above methods, the in-situ polymerization method, as one of the most feasible and widely used techniques to encapsulate PCMs, is a simple and desirable technology for industrial manufacturing. The distinguishing characteristic of in-situ polymerization method is that there is no chemical reaction in the core material [15]. Due to the good chemical stability and mechanical strength, urea-formaldehyde (UF) and melamine-formaldehyde (MF) had been widely used as the shell materials in the in-situ polymerization [16]. Fang et al. [17] prepared a series of nanocapslues by using in-situ polymerization with n-tetradecane as core, urea-formaldehyde resin as shell material, sodium dodecyl sulfate as emulsifier and resorcin as system modifier. The results showed that the nanocapsules had general size about 100 nm and the mass content of n-tetradecane was up to 60%. The nanocapsules could be applied for thermal energy storage and heat transfer enhancement. Fan et al.

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Deviation of design air-conditioning load based on weather database of reference weather year and actual weather year

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ABSTRACT

In Japan, in order to determine the capacity of air-conditioning equipment, designers usually use the weather database of Reference Weather Year (RWY) to obtain the design air-conditioning load by using software such as New HASP/ACLD and Building Energy Simulation Tool (BEST) that are often used in Japan. In recent years, with the global warming due to climate change, the weather database used to calculate air conditioning load also changes. Thus, in order to determine an appropriate capacity of air-conditioning equipment for energy conservation of buildings, the deviation of design air-conditioning load calculated using the weather database of RWY and Actual Weather Year (AWY) should be discussed.

In this paper, New HASP/ACLD was used to calculate the building heat loads of eight major Japanese cities over 30 years (1981–2010) between RWY and AWY. The heat load at an exceedance probability of 2.5% is defined as the design air-conditioning load in this paper. Comparing the design air-conditioning load obtained from RWY and AWY, it is shown that it is not necessarily the most appropriate when using the RWY to calculate the design air-conditioning load, especially for heating load in winter. Additionally, it is also shown that the annual heating load time ratio has decreased and the annual cooling load time ratio has increased over the 30 years.

1. Introduction

In the past, it was difficult to evaluate the heat loads of buildings due to the lack of weather data and computer performance. In order to evaluate heat loads of buildings and prevent the evaluated values from getting too larger or too small that may lead to excessive or small air-conditioning capacity selection, the Reference Weather Year (RWY) has been designed to calculate the design air-conditioning load [1,2]. In EU and US, it is also called "Typical Meteorological Year (TMY)" [3].

Up to now, Expanded Automated Meteorological Data Acquisition System (AMeDAS) weather data from 1981 to 2010 were developed for 842 locations in Japan [4,5], and each location has three types of RWY weather data, that are the period from 1981 to 1995 (RWY_1), the period from 1991 to 2000 (RWY_2), and the period from 2001 to 2010 (RWY_3).

Currently, with the global warming due to climate change, the design air-conditioning load for building energy savings is also changing. Under the call of environmental improvement and energy conservation, the accuracy of the design air-conditioning load calculation from RWY needs to be improved. There are several methods to calculate the design air-conditioning load [6–9], and the method which is choosing the 2.5% exceedance probability heat load as the reference standard is selected in this study [10].

In order to evaluate the effect of climate change on design air-conditioning load of buildings in Japan [11], the deviation of design air-conditioning load based on the weather database of RWY and Actual Weather Year (AWY), and the change in annual cooling and heating load time ratio over 30 years (1981–2010) is analyzed using the program "New HASP/ACLD" [12,13] in this paper.

2. Reference weather year

Japan has been producing and using RWY to calculate heat load of buildings since 1970. So far, there have been two main methods of making RWY, one is the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan (SHASE) method, and the other is the Expanded AMeDAS (EA) method [14,15]. SHASE method is almost same as International Standard (ISO15927-4: 2005) [16], and it chose the candidate month from statistics determined by using three elements; dry bulb temperature, absolute humidity, and horizontal global solar irradiation. The deviation of these three elements times weight coefficient determined by data of building monthly names "DM" is calculated at first, then the

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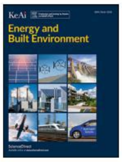

Investigation of transient and heterogeneous micro-climate around a human body in an enclosed personalized work environment

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A R T I C L E I N F O

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A B S T R A C T

Heterogeneous distribution of indoor environmental quality is known to have a great impact on human health, comfort, and productivity. A personalized work environment, that creates a localized and independent environment with capsules or partitions, is being developed worldwide to provide workers with a space that enables undisturbed concentration on studying and working. However, the minimized interior space of a personalized work environment can immediately cause adverse health impacts for occupant if the air quality and thermal environment in the personalized work environment is not controlled appropriately. Particularly, constant breathing can sharply increase the CO_2 concentrations in an interior space with an insufficient ventilation rate. In order to design a healthy and comfortable indoor environment, especially in a personalized work environment, it is important to predict precisely and comprehensively the transient and heterogeneous structure of the indoor environment formed around a human body. With this background, we have developed an *in silico* human model that integrates a computational human model (virtual manikin combined with thermoregulation models) and respiratory model (virtual airway) for estimating indoor environmental quality, targeting the microclimate around a human body and breathing zone with high accuracy.

In this study, we report the applicability of a comprehensive *in silico* human model to estimate the environmental quality in a personalized work environment. A coupled analysis of heat and contaminant transfer with computational fluid dynamics was conducted targeting the space around the *in silico* human model installed in a virtual personalized work environment. The informative data including human thermal comfort and breathing air quality were obtained, potentially forming the basis for the development of a digital twin of the personalized work environment and contributing to the design of a healthy, comfortable, and productive personalized work environment.

1. Introduction

With the sophistication of the control methods of indoor environmental quality, there is a strong demand for the development of a fundamental technology that can precisely predict and evaluate the comprehensive interaction between occupants and the environment, which is the basis of indoor environmental design [1,2]. In a modern society where people spend a majority of their time in indoors, indoor environmental quality has a tremendous effect on the human body. Therefore, it is important to understand the short-term and long-term effects on the human body from the viewpoint of health, comfort, and productivity [3,4]. In particular, evaluating the indoor thermal and air quality environment based on comprehensive numerical analyses that integrate non-uniform flow, temperature, and pollutant concentration distributions in a room using computational fluid dynamics (CFD) with a computer-simulated person would be an essential and promising technique for achieving high quality indoor environmental design [5–9].

There have been numerous reports on the effects of indoor environmental quality on the health, comfort, and performance of office workers [10–13]. In some developed countries, increasing worker productivity has become an urgent social issue with the decline in population and strict total working hour regulations. In order to optimize human capital, designing an office space that enhances the performance and productivity of workers is an important issue [14,15]. Notably, because the effects of indoor environmental quality on worker performance and productivity will vary from person to person, it might not be possible to bring out the maximum potential of an individual in an existing homogeneous workspace environment. In other words, because workers prefer diverse indoor environments for maximizing their performance and pro-

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Decomposing the drivers of residential space cooling energy consumption in EU-28 countries using a panel data approach

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ABSTRACT

While space cooling currently represents less than 1% of final energy use in the residential sector of the European Union (EU-28), it was the fastest growing end-use during the 2000-15 period with a mean annual growth rate of 6% per year. Currently, little is known about factors which have driven regional air-conditioning (AC) energy consumption over time, since the literature is limited to cross-sectional studies that lack differentiation between climatic and non-climatic influences. Future projections for the EU's electricity sector may therefore neglect the potential implications of rapidly growing AC demand. We develop a novel decomposition framework, which breaks down residential space cooling energy consumption in EU-28 countries into the effect of different components from 2000 to 2015. Decomposition is extended to panel data models identifying specific drivers of space cooling's climate-sensitive components. Finally, we explore scenarios of residential AC energy consumption up to 2050 and evaluate their impact on summer time peak loads. AC diffusion was found to be the key driver of space cooling energy consumption, but this effect was partly counterbalanced by efficiency gains. While weather influences AC equipment ownership rate in EU-28 households, personal income has a larger marginal effect. In baseline scenarios, AC diffusion saturates by 2050, while modestly increasing sectoral final energy use. Still, our range of scenario values for space cooling energy consumption in 2050 exceed the majority of those originating from recently published projections. In a future renewables-driven electricity system, energy security risks may emerge from a scenario of fast AC up-take in new and renovated buildings, especially for colder European countries where modelled peak cooling electricity demand is shown to outgrow the projected expansion of solar capacity. These findings have important implications for the EU's strategy to decarbonise energy supply.

1. Introduction

Global energy consumption for space cooling has increased three-fold between 1990 and 2016 and has been accompanied by a tremendous growth in air-conditioning (AC) sales [1,2]. The diffusion and use of air-conditioning across the globe has been strongly linked to changing climatic and economic conditions [3]. In the European Union (EU-28), while residential space cooling currently forms a minor share of sectoral final energy use (0.6% in 2015) it was the fastest growing household end-use during the time period 2000-15, recording an average consumption growth rate of 6.3% per year (Fig. 1) [4]. Residential air-conditioning also has an enormous future growth potential in the EU-28 as less than 10% of household floor area is currently cooled [5]. Since space cooling in EU-28 households is usually supplied through electric room air-conditioners (RACs) [6], the expected growth of residential AC markets across Europe [7] will intensify pressure on national electricity sectors. This translates into a need for additional generating capacity and more effective management of summer time peak loads; issues which are already evident in Mediterranean EU-28 countries [8].

In the absence of granular household end-use consumption data, studies analysing the EU's current space cooling energy use involve estimates obtained mostly through bottom-up technology-based energy models. These in turn depend on technical parameters gathered over tiny time frames, overlooking past variation of AC use [5,9]. These models provide limited value to the policy making process as they do not facilitate a broader discussion about the relative importance of the various factors driving air-conditioning use in different EU Member States. These historical estimates are subsequently mixed with crude assumptions about the future development of modelled parameters, such as a 100% AC technology saturation rate [10,11] or using current diffusion data from United States as a proxy [12,13], to define ceiling values for EU-28 space cooling energy consumption. The adoption of such simplified methodologies limits understanding about the potential trajectories residential AC markets could follow in the near-future and how different

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