Design and Development of a Smart Kitchen Chimney for Energy Saving: A Conceptual Review

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Abstract— The branch of ventilation that specializes in the treatment of air from kitchens is called as kitchen ventilation. The problems of grease, smoke and odors not usually found in other ventilation are solved by Kitchen ventilation. An extractor hood or canopy and a filtering system are used in the equipment used in kitchen ventilation. The fan which is used in the ventilation system may be fixed within the kitchen or in the duct system nearby whichever is convenient. In the present research work, academic contributions in the field of kitchen hoods are acknowledged and based on these contributions, research gaps and objectives of new research are presented.

Index Terms— Chimney, Design, Energy Saving, Hood, Kitchen Ventilation, Research Contributions, Simulation

1 Introduction

A device containing a mechanical fan that hangs above the stove or cook top in the kitchen is a kitchen chimney. It helps in removing the airborne grease, combustion products, fumes, smoke, odors, heat, and steam from the air during cooking, by evacuation of the air and filtration. Exhaust hoods are often used in combination with fire suppression devices in commercial kitchens, so that fumes from a grease fire are properly vented and the fire is put out quickly. Fresh air fans may be combined with commercial vent hoods that help in drawing in exterior air, circulating it with the cooking fumes, which are then drawn out by the hood. Present research work is devoted to academic aspects of research work and portrays details of contributions of researchers in the field of kitchen hoods and concludes with the identified gaps and objectives of new research.

2 Research Contributions in the Field of Kitchen Hoods

Following is the summary of research contributions made by different researchers in the field of kitchen hoods.

Yu et al. (2015)

A relatively low number of smokers have caused high lung cancer prevalence in females in Taiwan. Since cooking is one of the major sources of particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs) in household buildings, one of the major risk factors for lung cancer is suspected to be the exposure to air pollution from cooking (APC).

The causes for cancer risk according to many studies have demonstrated that occupational exposure (40 h per week) to APC in commercial kitchens and restaurants. However, at present the number of exposure to APC in household kitchens are relatively few in Taiwan. A health risk assessment for exposure to APC in five household kitchens in northern Taiwan was therefore conducted1 by Yu et al and was published in the paper titled "Characterization of somatic mutations in air pollution-related lung cancer" in EBioMedicine,.

Singer et al. (2017)

Singer et al in their article "Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes" published in "Building and Environment" explained after conducting an experiment in nine homes measuring of combustion pollutant concentrations was carried on during the scripted operation of natural gas cooking burners. Activities like boiling and simmering were performed on the stovetop and in the oven with range hood exhaust ventilation and without range hood exhaust ventilation or air mixing via a forced air system. And it resulted in the kitchen and bedroom area of each home after some time, concentrations of carbon dioxide (CO2), nitric oxide (NO), nitrogen oxides (NOx), nitrogen dioxide (NO2), particles with diameters of 6 nm or larger (PN), carbon monoxide (CO), and fine particulate matter (PM2.5) were found. Out of every nine homes, four had kitchen 1 h NO2 exceed the national ambient air quality standard (100 ppb). And in all homes, the highest 1 h integrated PN exceeded 2 _ 105 cm_3-h, and the highest 4 h PN exceeded 3 _ 105 cm_3-hr in the kitchen. There was a wide variance in the range hood performance, but one with a large capture volume and a measured flow of 108 L/s reduced concentrations 80e95%. When cooking the need to ventilate and a increased awareness of the need to ventilate along with building standards for minimum range hood flow rates and volume, could substantially bring down exposures to NO2 and ultrafine particles dwelling in homes.

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Zhao et al. (2017)

To ensure the provision of a healthy, comfortable and energy efficient working environment in kitchen environment, an efficient kitchen hood is preferably demanded. The design for most accurate kitchen ventilation should be based on the heat gain of the appliances. In this paper published in "Procedia Engineering" and titled as "Correction and analysis of calculation equations of the thermal plume above kitchen appliances" the authors Zhao et al have made an investigation of the calculation equations of convection plumes, above kitchen appliances. Assuming the point heat source as the heat source of cooking appliances, and the temperature and velocity distributions are assumed to match the Gaussian distribution. The convection flow of the transitional region has not yet fully developed in the kitchen environment, at the extraction point. Thus, the derived general plume equation is not accurate for the transitional region. Nevertheless, when the position of the virtual origin is individual adjusted in a practical application, the results are reasonably accurate. The calculation experience formulas of the virtual origin position of air flow rate are worked out.

Cicconi et al. (2017)

Energy labels as established by the European Energy Labeling Directive and displaying their energy efficiency class and other relevant information regarding the energy consumption and noise level are usually attached with kitchen hoods in Europe. New issues due to recent regulations, such as the evaluation of the energy efficiency, analysis of the energy consumption, and product lifecycle impact must be considered by the designs of cooker hoods. Therefore, eco design tools to support eco-innovation and related sustainability improvements must be used to develop the eco-driven products. To define a method and an agile and affordable platform tool that can support designers in the early estimation of product energy performance, including the calculations of energy efficiency indexes is the scope of this proposed research. The use of genetic algorithm methods to optimize the product configuration in terms of energy efficiency is also considered by this approach. The research context by the authors Cicconi et al and published in Applied Energy, Elsevier with the title "A support approach for the conceptual design of energy-efficient cooker hoods" deals with both the large and the small productions of kitchen hoods. The methodological approach within the developed tool is described in this paper. A good correlation between real efficiency values and calculated ones is shown as results. There is a description of a validation activity, and how to apply the proposed approach for the design of a new efficient product with an A-class Energy Efficiency Index is shown in the test case.

Han et al. (2010)

Han et al explained that the ventilation performance of local exhaust hoods in high-rise buildings is important in determining the distribution of pressure in the exhaust shaft which is fixed in a vertical position in their article "Correlations of control parameters determining pressure distributions in a vertical exhaust shaft" published in Building and Environment. The uneven pressure causes gap openings and through these gap openings unwanted noise is created due to insufficient exhaust airflows from hood fans and excessive infiltration. The various system parameters which affect the distribution of pressure in a vertical shaft are the height of the building, size of the shaft, characteristics of the roof fan, usage of concurrent hood fan and the outdoor temperature. To know the ventilation performance of this vertical shaft and to quantify and investigate the effects of all the above parameters numerically was the main objective of this study. And in order to complete this goal specialized simulation software was developed, which implements the principles of fluid dynamics in vertical air columns with horizontal branches. The results were obtained according to the experimental design method simulation based on a model of a 25-story apartment building. The variance was analyzed in order to investigate any correlations between the parameters. The result showed that the deviation of the pressure distribution based on a slight negative value (_30 Pa or _40 Pa) had a strong correlation when the pressure was at maximum level in the shaft. Hence, it was indicated here by using the pressure deviation as a single objective parameter was creating insufficiency and unevenness of the pressure distribution throughout the shaft. For pressure control in the vertical shaft other operational parameters like roof fan rpm and inlet damper opening, and some sensing parameters like the pressure and pressure gradient at the top-most level, and outside temperature could be used.

Saha et al. (2012)

In this work by Saha et al, published in the paper titled "Experimental and computational investigation of indoor air quality inside several community kitchens in a large campus" published in Building and Environment, kitchens in the campus of a large institute in India were selected and dealt with the experimental and computational investigation of the air quality. After a detailed initial survey of the cooking arrangement and exhaust systems in all of the kitchens in the campus four kitchens have been carefully selected. The concentrations of CO2 and CO and temperature are recorded with the help of an indoor air quality measurement device named IAQ Calc7545 for the sake of the experiment. A 1.8 m _ 1.5 m vertical area was selected in each of the four kitchens, which is perpendicular to the vertical side of a burner that faces the cooks, and measurements within this area were carried out at 72 suitable grid points. The three-dimensional fluid flow field in the kitchen of site 1 is numerically simulated by fluent for the computational part. At the outlet of the burners the volume fractions of CO2 and CO are estimated from a separate FORTRAN code for equilibrium chemical analysis and as a boundary condition for the fluent simulation are used. In Fluent, the mixture model for the multiphase flow is used for finding the distribution of the species within the flow domain. The results of CFD modeling agree well with the experiments given the complexity of the geometry and flow field considered here, validating the choice of boundary conditions, grid generation and other subtleties involved. The measured and computed values are compared with the corresponding ASHRAE standard.

Abdullahi et al. (2013)

To assess the impact of the typical ventilation systems of four

commercial kitchens on their indoor thermal environment, an assessment of a current situation of Chinese commercial kitchen was carried out in China. This study by Abdullahi et al, in the paper "Emissions and Concentrations of Particulate matter and its specific Chemical Components from Cooking" which was published in "Atmospheric Environment" only focused on velocity field, temperature field, relative humidity field, and concentration distribution varying with following whether cooking or not in order to understand the effect of the ventilation system. We could find from the data available, for the kitchens that use the mechanical air supply system, the temperature and CO2 concentration of the non-cooking area exceeded the value of the measurement point's in spite of the use of the cooking range. The temperature and CO2 concentration was far more than the acceptable level for the middle and small scale commercial kitchens, which use the natural air supply system. The variation of relative humidity was contrary to the trend of temperature variation, in addition, which is different to the results obtained previously. The ventilation system in typical Chinese commercial kitchens couldn't remove the waste heat and impurities effectively as indicated by the measurement results. The reason is diversiform.

Gao et al. (2013)

One of the major problems of indoor air quality and indoor environmental health identified was the particulate matter generated during the cooking process. Accurate information of emission characteristics especially the size distribution is required by reliable assessment of exposure to cooking generated particles. The volume/mass-based size distribution of the fume particles at the oil heating stage for the typical Chinese-style cooking in a laboratory kitchen is characterized in this study titled "Volume-based size distribution of accumulation and coarse particles (PMO. 1-10) from cooking fume during oil heating" which was published in "Building and Environment". To measure the volume frequency of fume particles ranged from 0.1 to 10 mm, which contribute to most mass proportion in PM2.5 and PM10 we need application of a laser-diffraction size analyzer. The particle emissions have little dependence on the types of vegetable oil used but have a close relationship with the heating temperature as shown by the measurements. The volume frequency of fume particles in the range of 1.0e4.0 mm accounts for nearly 100% of PM0.1e10 with the mode diameter 2.7 mm, median diameter 2.6 mm, Sauter mean diameter 3.0 mm, DeBroukere mean diameter 3.2 mm, and distribution span 0.48 is found. To improve the assessment of indoor air quality due to PM0.1e10 in the kitchen and residential flat such information on emission characteristics obtained in this study can be possibly used.

Lim et al. (2014)

The net and integrated velocity of contaminant transport by convection and diffusion effect at a point within the room was presented by the authors Lim et al by developing a concept of ventilation efficiency called 'Net Escape Velocity' (NEV) in their publication named "Performance evaluation of contaminant removal and air quality control for local ventilation systems using the ventilation index Net Escape Velocity" published in Building and Environment. This concept (NEV) is an effective one which can be expressed by vector and scalar quantities with a velocity scale. This determines the contaminant concentration at a target point. And this was considered to be the most important characteristic of the NEV concept. And later on an expanded concept of NEV (NEV*), was proposed with an assumption that the contaminant generation is the inflow flux of a contaminant on the control volume. It was believed that the required helpful information for the design of the ventilation in order to control the contaminants could be provided by NEV and NEV* distributions. To demonstrate the advantage and contribution of NEV* to current ventilation design procedure was the main purpose of this study by using numerical analysis. Later on the evaluation was that the contaminant removal performances of local ventilation systems which are a kitchen exhaust hood in a kitchen environment, a push-pull hood in an industrial environment and an adsorptive building material in a test chamber here by the NEV*. In order to investigate contaminant leakage across the hypothetical boundaries of the control target domain of the local ventilation hood and also the contaminant concentration reduction performance of the adsorptive building materials, the analyzing of the distributions of the NEV* as vector quantities under the different flow and diffusion fields were made.

Calì et al. (2015)

A correct operation of the installed engineering systems like lighting, ventilation, heating and cooling can be fundamental for the detection of occupants indoors. Further, the input of stochastic models for dynamic simulation of buildings and their engineering systems can be real occupancy profiles. An algorithm for the detection of occupants in the indoor environment is presented in this work, by Cali et al, titled "CO2 based occupancy detection algorithm: Experimental analysis and validation for office and residential buildings" and published in Building and Environment validated and evaluated for different scenarios. The concentration of carbon dioxide in the indoor air is the bases for the algorithm. Both for residential and non-residential buildings are used for testing and validation: two offices one with mechanical ventilation system, and the other one without mechanical ventilation, a kitchen along with a big sleeping/living room of a residential building without mechanical ventilation have been evaluated. To permit the validation of the algorithms, volunteers recorded their presence profiles in the monitored rooms. Correct presence profile up to 95.8% of the time was provided as the results of the algorithms for the detection of occupants (whether occupants are present or not) while the exact number of occupants in the rooms is identified up to 80.6% of the time correctly.

Lai & Chen (2015)

Human health and indoor air quality are adversely affected by the airborne particles emitted in cooking process. Lai and Chen developed an Eulerian turbulence CFD model in combination with aerosol general dynamic equation (GDE) in this work, titled "Numerical study of cooking particle coagulation by using an Eulerian model "and published in Building and Environment, which is incorporated in a commercial CFD tool in order to investigate coagulation process of indoor particles.

They conducted experiments in a small scale chamber with different temperatures. Particles with a diameter range of 14e250 nm were measured in general and tests were conducted on five different coagulation mechanisms including van derWaals, viscous forces and fractal effects. A good agreement with the experimental data was shown by the simulated results. To elucidate the temperature effect on particle concentration, the coagulation coefficients with chamber temperatures of 22 _C, 42 _C, 62 _C and 82 _C were also calculated. To study water-boiling process in an environmental chamber, the validated model was applied. Boiling water was investigated for the temporal development of airflow temperatures and number or concentrations of particles emitted.

Poon et al. (2016)

The major indoor pollutant source is from cooking. To know both the exposure, inside and outside the kitchen are important. Two indoor zones and their spatial distribution of particle concentration however, have not been studied extensively. In this study, particle transport between two zones for a water boiling process under four kitchen hood operation scenarios was investigated. By using a condensation particle counter the particles were counted and the study may be considered a study of ultrafine particles since most of the particles were less than 100 nm in diameter. Poon et al published their article in Building and Environment and the title is "Experimental study of exposure to cooking emitted particles under single zone and two-zone environments". Exposures can be substantially reduced if the range hood operates during the cooking period, or both during and after the cooking period. The operation of the hood during the cooking period reduces exposure by 87e92%, compared to the no-hood operation for a single zone scenario (connecting door closed). The exposure in non-kitchen zone ranged from 30% to 54% of that near the stove, when the door between the two zones is opened and the hood is not operated. Varying concentrations at different points in the kitchen zone were the results from the strong exhaust airflow from the kitchen hood interacted with the ventilation airflow, generating complex airflow.

Zhou et al. (2016)

Occupant's health is determined by the pollutants generated from cooking process. Range hood is installed to exhaust oil fume and other pollutants for conventional residential kitchen in hot summer and cold winter region of China. Air is supplied through the insect screen in typical kitchen. However, for good indoor air quality in kitchen, this kind of air supply and exhaust system is not capable of providing air distribution. The combined scheme with air supply through slot air curtain and air exhaust through range hood is proposed in order to solve this problem, which is called as the push-pull ventilation system. To investigate the air velocity, temperature and pollutant distributions both numerical simulation and field test were carried out. During numerical simulation Orthogonal study was performed. "A pre and post evaluation of indoor air quality, ventilation, and thermal comfort in retrofitted co-operative social housing" was presented by Zhou et al and also published in Building and Environment, Six factors during the L25 (56) orthogonal test Air curtain velocity (A), air curtain angle (B, C, D, E) and exhaust velocity (F) were chosen during the L25 (56) orthogonal test. In the breathing region average CO2 concentrations of the 25 cases were compared. By using the range hood alone, oil fume generated by cooking cannot be effectively exhausted out of the kitchen was shown. The air temperature can be reduced during the summer scenario, which may improve occupant thermal comfort with application of the push-pull ventilation system. Meanwhile, with the improved air distribution, the pollutant concentration can be reduced. The sequence for effect of influencing factors on the pollutant concentration distribution more ever, is A>B>C>E>D>F. To reduce the indoor pollutant concentration in kitchen this proposal provides a scientific support to reduce the indoor pollutant concentration in kitchen.

Broderick et al. (2017)

The indoor air quality and its energy upgrades with regards to the assessment and the impact and the comfort in the occupant has received little attention in comparison to building energy performance. During the 2015 and 2016 winter periods the author monitored the indoor air concentrations in fifteen, three bed semi-detached co-operative social dwellings and that too before an upgrade and after an energy upgrade. He selected seven cavity wall (CW) dwellings and eight hollow block (HB) wall dwellings from the fifteen dwellings already selected. Measurement of thermal parameters including temperature and relative humidity and indoor air pollutants concentrations including CO, PM2.5, CO2, TVOCs, formaldehyde, BTEX, NO2 was done before and after the energy upgrade in the main living area and main bedroom. And a decrease was observed in building air tightness from pre retrofit values of 9.26e10.00m3/(h.m2) @ 50 Pato an average of 5.53 m3/(h.m2) @ 50 Pa and 8.61m3/(h.m2) @ 50 Pa post retrofit (CW group and HB group, respectively). The concentration had a significant change in CO2, TVOC, and PM2.5 and post-retrofit, with an increase in post retrofit in both dwelling groups (CW; p ¼ 0.014; p ¼ 0.009; p ¼ 0.005) (HB; p ¼ 0.003; p ¼ 0.032; p ¼ 0.008). After the retrofit, increases in pollutant concentrations were correlated with lower building air exchange rates. The energy retrofit had a positive impact on occupant comfort and building temperature was suggested by this study; however, it was found that there was an increase following the retrofit in concentrations of some pollutants. To ensure improved health outcomes for building occupants post retrofit, the study highlights the importance of characterizing indoor air quality post energy retrofits within the overall building energy performance and Broderick et al have published this in the article "A pre and post evaluation of indoor air quality, ventilation, and thermal comfort in retrofitted co-operative social housing" published in Building and Environment.

Lim & Lee (2008)

The flow characteristic of kitchen hood system with using 3D numerical analysis method and improving the system to expel pollutes more efficiently is aimed by deriving analysis in this study. This study by Lim & Lee in their paper "Performance evaluation of contaminant removal and air quality control for local ventilation systems using the ventilation index Net Escape Velocity" and published in Building and Environment

only focuses on velocity field, temperature field, and concentration field varying with followings whether separation plate is set or not and the shapes of separation plates in order to understand the flow characteristics of four models. The constant values here are the quantity of air, speed of exhaust fan and temperature and concentration of heating source. Three models with different shapes have one exhaust port and the model which has the vent at the closest position to where pollutes are generated is discovered to be the most efficient model. Compared to the initial model having no separation plate was 1.40–1.90% more efficient at temperature distribution and 9.40–11.90% more at CO2 concentration distribution.

Wang et al. (2017)

The paper proposed a highly efficient solution for both thermal compensation of ground-coupled heat pump systems and kitchen exhaust air waste heat recovery (KHR-GCHP) in cold climatic regions. A new analysis and calculation method was developed for non-finned coil heat exchangers of KHR-GCHP systems. The two indexes were defined to evaluate KHR-GCHP and other relevant systems: the thermal compensation capacity per unit energy consumption (TEC) and the system specific net energy saving (S-SNES). Thus concluded that the KHR-GCHP system has higher energy efficiency with TEC up to 36.78 kWh/kWh, significantly higher than that of normal boiler-GCHP systems (0.90 kWh/kWh) or frequently-used hybrid solar-GCHP systems (15.73 kWh/kWh). Furthermore, the S-SNES of the KHR system reached 2.37 Wh/m3, which was at least 1.86 times as high as common kitchen exhaust air waste heat recovery systems (ranging from 0.85–1.27 W • h/m3) through comparing and analyzing TRNSYS simulation results and experimental data,. Additionally, a simplified criterion was developed to facilitate KHR-GCHP's wide application, for both circumstances where air-water temperature difference (Td) was higher than 9.43◦C (current project; suitable for the hybrid solar-GCHP system) or higher than 3.99◦C (other projects), the KHR-GCHP system demonstrated advantages over other systems16. And this was presented in "A highly efficient solution for thermal compensation of ground-coupled heat pump systems and waste heat recovery of kitchen exhaust air "work by Wang et al and published in Energy and Buildings.

Li et al. (2017)

Due to the incensement of worldwide population in countries like China, United States and India, the residential buildings are usually the high-rise buildings of multi-dwelling units. And in these buildings most of the cooking exhaust shafts are in the form of central exhaust system. The performance of kitchen hoods comes down due to the mal-distribution of exhaust flow in central exhaust system and it often leads to oil fumes reflux and odor migration. This study was conducted by Li et al. in a 32-storey residential building which employed central exhaust system. The central exhaust shaft was investigated with uniform cross section of velocity distribution and static pressure. And Computational Fluid Dynamics was adopted to analyze flow characteristics and later on validated by comparing the simulation results with experimental data. The effects of temperature differences and equally spaced operating rates of kitchen hoods on flow characteristics in central exhaust shaft were emphasized here. When the temperature difference varies from −12◦C to 30◦C, the locations of maximum static pressure gradually moved downwards and presented a low-high-low distribution as per the results. The maximum was in the middle-low storey under different operating rates. This paper titled "Field test and CFD modeling for flow characteristics in central cooking exhaust shaft of a high-rise residential building" was published in Energy and Buildings. This was of great value for the HVAC engineers in improving the design of central cooking exhaust shafts fixed in high-rise residential buildings, and the mal-distribution problems of exhaust flow in central exhaust systems was solved.

Liu et al. (2014)

Experiment carried out earlier in a room calorimeter to study cooking oil kitchen fires with multiple fire sources under natural ventilation with burning characteristics observed. Fire and air temperatures inside the room and heat release rates were measured before. Average heat release rate, burning time and average oil mass flux were investigated in this paper by analytical studies together with those experiments. Average heat release rate, burning time and average oil mass loss rate for 2 woks, 4 woks and 6woks were compared. Three typical burning conditions were identified and analyzed. Rapid burning rate in the experiments was observed. A mathematical model on the heat transfer from the flame to the pan surfaces was developed. Analytical results were justified by the earlier experimental observations. Then compare the results better with 2 woks, 4 woks and 6 woks. Each pan was placed at different distances away from the door in the calorimeter. The mass loss rate of kitchen oil, the burning process and burning time are different. Hence only the average values were used to get more reasonable results18. Liu et al in their article "Numerical studies on kitchen fire hazards with multiple burning sources" presented this issue and the same was published in Building Simulation.

Previdi et al. (2014)

By using piezoelectric actuators, Prevedi et al in the paper "Active Vibration Control over the Flexible Structure of a Kitchen Hood" presents the kitchen hood after analyzing it fully and developing the system completely for mechanical vibration reduction. This paper was published in "Mechatronics" Journal. A single acceleration sensor collocated with the actuator was important as the action of the feedback controller depends on this and the control system is based on this feedback controller. The hood with a model of the actuator-sensor pair mounted on it and a model of the disturbance is provided. A Minimum Variance (MV) controller in order to reduce the noise is able to provide the theoretically best performance. In order to maintaining the stability of the system a singletones Minimum Variance controller (resonant controller) provides quasi-optimal performance. Two resonant control laws were designed differently. One law operates without the information of the hood motor velocity and the other being a more sophisticated controller exploits the velocity information. Both of these controllers reduce the mechanical vibration with performances which is more effective and is achiev-

able with an MV controller. The best performances are guaranteed with an 85% vibration reduction by the motor velocity's information. The best compromise with performances (75% of reduction) and complexity of the implemented system is by the resonant control system without the motor velocity information. Tests were conducted in an anechoic chamber have shown the vibration reduction's influence upon the acoustic noise.

Claeys et al. (2015)
In large industrial kitchens air curtain assisted range hoods are very customary. An increase in the capture efficiency of the range hood with a decrease in the net exhaust flow rate is allowed. It is noticed a lack of data on the performance of air curtain assisted range hoods, as well as a lack of information on the required settings and boundary conditions for applications in residential settings to come to the successful application of air curtain assisted range hoods. Claeys et al present the results from an experimental test campaign in this paper titled "Capture efficiency of air curtain assisted residential range hoods" in which they investigated the capture efficiency of a residential air curtain assisted range hood in comparison to a regular range hood, as well as the sensitivity of the capture efficiency to boundary conditions such as net exhaust flow rate, height above the range, enclosure etc. The results indicates that air curtain assisted range hoods are more efficient at lower flow rates, especially in non-enclosed settings, confirming the performance known from industrial kitchens, but are sensitive to higher mounting and on-going cooking activities.

Wei et al. (2017)
In the research field, the study of thermal comfort in the non-uniform environment has become a hot topic with the universal existence of non-uniform environment in the living space and Wei et al in their article published in Procedia Engineering with the title "Study on Thermal Comfort under Non-uniform Thermal Environment Condition in Domestic Kitchen". The thermal environment in kitchen is always not uniform likewise, as there are heat source and external window in domestic kitchen fan. The occupant's health may be affected and influence the cooking thermal sensation and occupants in the kitchen will feel uncomfortable. Therefore, to study the thermal comfort in domestic kitchen is necessary. The thermal comfort studies in non-uniform thermal environment were carried out as a review. Moreover, in a domestic kitchen which is located in Nanjing Tech University a study about the thermal comfort under winter condition was conducted. After obtaining the thermal environment characteristics in the kitchen and the thermal comfort law of people, the corresponding improvement measures for domestic kitchen thermal environment under winter condition are put forward.

Zhang et al. (2017)
To assess the impact of ventilation systems on the indoor air quality an assessment of Chinese charcoal barbecue restaurants was carried out. The temperature field was focused in this study, by Zhang et al along with relative humidity field and concentration distribution. Same was presented in the paper "Measurement of Indoor Air Quality in Chinese Charcoal Barbecue Restaurants"and was published in Procedia Engineering. The fuel of heat sources and the mechanical exhaust system, especially the local exhaust system were related to the indoor environments of the sampled restaurants. CO2 values did not exceed the acceptable level for most of time. The main contaminant of this kind of charcoal barbecue restaurants is CO. We could find restaurant C3 produced the largest amount of CO (38.5 PPM) in cooking mode from the data available due to natural air supply. While the largest amount of CO (42.6 PPM) was generated from restaurant C2 in idle mode because of the temporary use of exhaust hood. Between the mean temperatures and relative humidity before and after dinner there was a little difference.

Xu et al. (2017)
A combination of traditional closed kitchen and living space is an open kitchen. During cooking however, the open kitchen cooking fumes generated spread serious damage to the indoor air quality of rest area (including living room, bedroom, etc.). The cause of indoor pollution to endanger people's health can be improper ventilation which cannot quickly and effectively remove pollutants. Application of CFD numerical simulation to analyze the temperature and pollutant diffusion in the open kitchen was set up in this study by making a physical model by Xu et al and published in Procedia Engineering, the article titled "Numerical Simulation Analysis of Temperature and Pollutant Concentration Diffusion in the Open Kitchen Cooking Area". The distribution of temperature and pollutant concentration in several different ventilation conditions in the kitchen and adjacent rooms was done. The optimal control method of oil fume pollutants in open kitchen was obtained by carrying out the comparative analysis of different cases.

Zhang et al. (2017)
Where cooking takes place appreciable particles can be generated within the area, which is the main cause of adversely affecting human health and the indoor air quality as explained by Zhang et al in his article titled "Measurement of Indoor Air Quality in Chinese Charcoal Barbecue Restaurants" published in Procedia Engineering. A Lagrangian approach based on CFD was established in this work. On the distribution and motion of particles in the kitchen the influence of different exhaust air rates and heating methods were analyzed.

3 Gaps in the Research and Objectives of the New Research

Based on survey of available literature following gaps in the research are being identified.
There is almost nil research available which tells about optimal parameters of kitchen hood for commercial kitchens; and
There is almost nil research made by the researchers which highlights Indian commercial scenarios.
Considering these research gaps objectives of the research work are being decided. Following are the objectives of the Research.

- Identification of mostly adopted type of kitchen hood;

- Simulation of kitchen hood under different geometrical and operating conditions; and
- Identification of optimal combination of geometrical and operating conditions for best energy saving value.

4 CONCLUSION

Present research work tells about the academic contributions made by different researchers in the field of kitchen hoods. It also portrays the research gaps identified and objectives of the new research. On the basis of these gaps and objectives a new research work shall be initiated as an attempt in the direction of making kitchen chimneys perfect.

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