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Review on Passive Ventilation system for Improved Indoor Environment

Jitendra Raghuwanshi[1*], V. N. Bartaria[2]

[1,2] Department of Mechanical Engineering, LNCT University, Bhopal, India,

Email: jitendrar@lnct.ac.in, Contact No- 9300751991

Abstract - Passive systems ventilation systems are gaining its popularity over mechanical ventilation systems due to its inherent characteristics which help in reducing cost during operation, lower requirement of power/energy as well as reduced emission of carbon dioxide. Various types of ventilation systems are available which utilizes solar energy and wind energy and as well as its combination are also used. The present study gives the systematic review of the passive ventilation systems for achieving indoor environment thermal comfort. Variety of passive systems which can deliver thermal comfort. Both experimental and CFD simulation both are rigorously utilized by the researchers for analysis of various passive ventilation systems.CFD simulation ventilation systems are devised by various researchers i.e. wind driven, solar driven and hybrid found to be an effective tool to design earth -to-air heat exchanger (EAHE).It can be also conclude that hybrid systems which contains solar chimney, wind tower as well as underground systems can yield indoor environment.

Keywords - passive, ventilation, wind, solar,CFD simulation.

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INTRODUCTION

Passive systems ventilation systems are gaining its popularity over mechanical ventilation systems due to its inherent characteristics which help in reducing cost during operation, lower requirement of power/energy as well as reduced emission of carbon dioxide. Various types of ventilation systems are available which utilizes solar energy and wind energy and as well as its combination are also used. Many researchers in the past worked and employed passive ventilation systems for obtaining thermal comfort. Connor et al. [1] employed rotary thermal wheel which amplifies the rate of air supply within the building and rooms. Turner et al. [2] found that both passive and hybrid systems provide better exhaust system of pollutants as compared to mechanical ventilation systems. Sanij et al. [3] recommended the usage of transparent materials in wind towers for increment in rate of building which is an example of passive ventilation system which can be incorporated with solar chimney in the direction of maximum wind speed. Han et al. [4] employed active-passive ventilation wall with storage capability of latent heat that can be integrated with greenhouse back wall and found that this wall system can store 5.36 MJ/m^2.day of solar energy in the city of Beijing.Cakyova et al. [5]implementeda new idea of ventilation in Southern European climatic conditions during summer season, which involves the ventilation through window during night time and greatly helped in reduction of overheating as well as in carbon dioxide concentration. Obeidatet al. [6] found through simulation that wind tower can be utilized for reduction in temperature by 6.164˚C and can be filled with ample quantity of fresh air.Nguyen and Nguyen[7] focused on coupled approach of ventilation by combining a solar chimney to and Earth-to-Air Heat exchanger and found that thermal comfort can be achieved for natural and force ventilation effectively. Rasliet al.[8] devised a slotted type wooden window panel for circulation of passive ventilation system in building wall as well for expelling out of air present inside room. Lopez et al.[9] implemented various ventilation and shading strategies to counteract the overheating issues during summer season in a Passivhaus certified residential tower. Piotr Michala[10] worked on passive commercial office building and found that the floor surface temperature lies in the range of 20.6 to 26.2 ^{O}C.Rieseret al.[11] presented a review for ventilation systems employed in buildings and shown the significance of ventilation for making it energy efficient buildings as well as to maintain quality of interior of the buildings. Serageldin et al. [12] found through experiments and CFD simulation that Earth-to –air heat exchanger pipe

diameter is most vital parameter in design of passive ventilation systems by integrating it to the solar chimney.Calautit et al. [13] employed such a passive ventilation heat recovery device in the windcather, through which exhaust stream is transferred to the incoming airstream which not serves the purpose of ventilation but also aids in energy savings. Vivian et al. [14] observed passive ventilation system to be more effective to sense the changes in wind as compared to effect of buoyancy. Cuce et al. [15] found stack ventilation system to be effective to achieve thermal comfort with reduction in indoor air temperature as well as increment in air exchange rate by 40 %.Chen et al. [16] implemented phase change material in wall to form an active –passive ventilation system and found that irradiated surface temperature has raised by 20.1 -2.67 ^{0}C during nighttime and 0.98-1.04 ^{0}C for ventilation during daytime. Simonett et al. [17] worked on the low pressure flat plate heat exchangers for passive ventilation systems and found through CFD simulation is employed for optimization of flow-mixing device inside the heat exchanger which will eventually reduce the usage of fans. Connor et al. [18] developed new design of desiccant rotary wheel with 28 silica gel coated radial blades which can improve the quality of incoming air and can result in energy savings too. Kinnane et al. [19] evaluated the application of passive ventilation systems in domestic housing retrofits and observed different air change rates by prescribing vents without reference to building air-tightness. Hviid and Svendsen[20] also worked on low pressure heat exchanger for passive ventilation through analytically and experimentally. Alfano et al. [21] proposed the usage of passive ventilation grilles for naturally ventilation buildings with an aim for improved quality of air as well as energy saving requirements. Khan et al. [22] performed an extensive review work on the different wind driven ventilation techniques. Khanaland Lei have done an exhaustive review of applications of solar chimney for passive ventilation system.

PASSIVE VENTILATION SYSTEMS

In passive ventilation systems, passive grilles are one of the strategies which involves the pressure decrement between indoor and outdoor. It also provides the pressure drop through grille also. Passive ventilation grilles can be classified into various sub-categories such as simple, self-regulating, humidity-sensitive [21]. Table 1 shows the details of wind driven ventilation techniques [22].Solar chimney is also an effective passive ventilation strategy which can be used even for hot windless days as well as when stack ventilation is very reduced due to very less temperature difference between inside and outside temperature of building.

Table 1*:* Techniques employed for ventilation through wind energy [22]

S.NO.	Ventilation through wind energy	Feature/application	Typical flow rate
1	Natural ventilation	Wind passes through opening which creates pressure difference	It is separate method for ventilation.
2	Chambers and yards	Aesthetic appearance is required in buildings especially in hot temperatures	NA
3	Oblique retaining wall	Wind pressure plays vital role for achieving natural ventilation in buildings.	The share of wind speed i.e. resides outside is 40 %.
4	Passages and chimney	Chimneys are usually placed on the top of the buildings to facilitate ventilation	This can be applied as per the capacity and size of building

RESULTS & DISCUSSION

Experimental analysis

Various types of experimental strategies were employed by previous researchers for practical application of passive ventilation systems. One of such application is quite advanced and hybrid system for future application of passive ventilation systems is shown in fig. It consists of wind tower as well as of subterranean canal. Such types of systems surely help in solving problems of energy crisis and global warming.

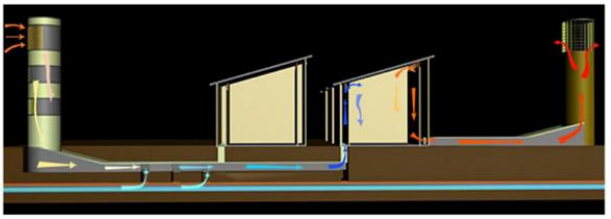

Figure 1: Air moves in a building through wind tower, underground canal and solar chimney [3]

CFD analysis for passive ventilation systems

CFD analysis is one of the powerful techniques to assess the suitability of thermal comfort developed by employing passive ventilation systems.

In one of the case studies, CFD analyses were performed for earth-to-air heat exchanger (EAHE) by employing passive ventilation systems. Fig.2 shows the contour plots of temperature and velocity by following horizontal and vertical plans. The temperature of air increases by 2 K by passing it through earth-to-air heat exchanger as shown in Fig.2a. Fig 2.b shows the influence of air which is passing near underground tubes which near to walls. It is important to note here that air now enters with higher temperature as compared to ambient temperature. It is seen that temperature increases in the y-direction. In addition to this, it is observed that air flows with high acceleration near

to the walls and therefore the path of air is in upright direction as per Fig .2.c. According to fig. d the velocity contour plots on same plane the air enters with an average velocity of 0.1 m/s. [12]

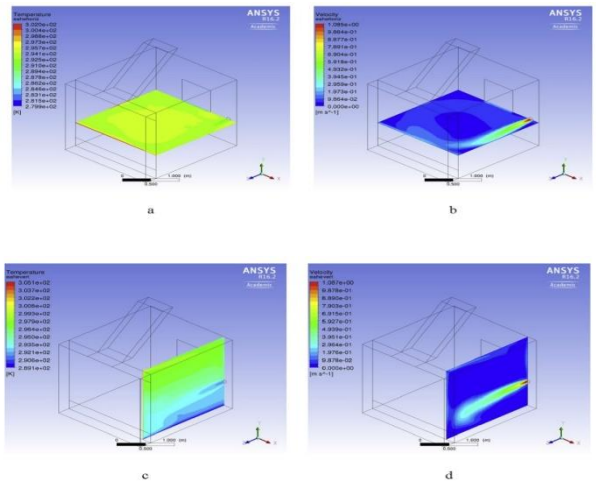

Figure 2: Horizontal and vertical plans at the EAHE inlet level at 10:00 A.M. (a) Horizontal temperature contours (b) Horizontal velocity contours (c) Vertical temperature contours (d) Vertical velocity contours [12]

CONCLUSIONS

The present study gives the systematic review of the passive ventilation systems for achieving indoor environment thermal comfort. Variety of passive ventilation systems are devised by various researchers i.e. wind driven, solar driven and hybrid systems which can deliver thermal comfort. Both experimental and CFD simulation both are rigorously utilized by the researchers for analysis of various passive ventilation systems.CFD simulation found to be an effective tool to design earth -to-air heat exchanger (EAHE).It can be also conclude that hybrid systems which contains solar chimney, wind tower as well as underground systems can yield indoor environment .

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Corresponding Author

Jitendra Raghuwanshi*

Department of Mechanical Engineering, LNCT University, Bhopal, India

Email: jitendrar@lnct.ac.in