EXPERIMENTAL ANALYSIS OF HEAT RECOVERY WHEEL FOR TROPICAL CLIMATE

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Abstract

This paper presented and used experimental analysis to examine design that integrates an active heat recovery wheel mechanism into a windcatcher. A rotational thermal heat recovery is incorporated into the windcatcher channel of the proposed system. An experiment was conducted to examine how the heat recovery mechanism affected the windcatcher performance, demonstrating the system ability to provide the necessary fresh air rates. A test room model, measuring 4x4x3 meters and depicting a small classroom, was integrated with the windcatcher model. Ventilation rates managed to supply sufficient ventilation even with the rotational heat recovery wheel blocked. This active recovery has the potential to lessen the demand on space heating systems in addition to providing enough ventilation. The heat in the exhaust airstreams was caught and transferred to the incoming airstream, boosting the temperature between 7-9°C depending on the indoor/outdoor conditions. This indicates that there is a great deal of room for further development of the idea, allowing for larger-scale testing and investigation of the system's heat transfer characteristics.

***Keywords**: Heat recovery, Sensible heat, Ventilation*

Abstrak

Makalah ini menyajikan analisis eksperimental untuk menguji desain yang mengintegrasikan mekanisme roda pemulihan panas aktif ke dalam penangkap angin. Pemulihan panas roda termal dimasukkan ke dalam saluran penangkap angin dari sistem yang diusulkan. Eksperimen dilakukan untuk menguji bagaimana mekanisme pemulihan panas mempengaruhi kinerja penangkap angin, kemampuan sistem untuk menyediakan laju udara segar yang diperlukan. Model ruang ujian berukuran 4x4x3 meter diintegrasikan dengan model windcatcher. Tingkat ventilasi yang cukup bahkan dengan roda pemulihan panas yang berputar terhalang. Pemulihan aktif ini berpotensi mengurangi kebutuhan sistem pemanas ruangan secara memadai selain menyediakan ventilasi. Panas dalam aliran udara buang ditangkap dan dipindahkan ke aliran udara masuk, sehingga meningkatkan suhu antara 7-9 °C tergantung pada kondisi dalam/luar ruangan. Hal ini menunjukkan bahwa banyak usaha untuk pengembangan lebih lanjut dari ide tersebut, sehingga memungkinkan pengujian dan karakteristik perpindahan panas sistem dalam skala yang lebih besar

***Kata Kunci**: Heat recovery, Sensible heat, Ventilation*

1. INTRODUCTION

Enthalpy recovery wheels are revolving air to air heat and mass exchangers found in building ventilation systems. They recover energy by transferring sensible and latent heat from supply air to exhaust air. Because enthalpy recovery wheels may recover both sensible and latent heat, they can transfer two to three times the energy of sensible heat exchangers of the same size [1]. However, a frequently stated disadvantage of the device is the carryover of airborne contaminants, such as carbon dioxide and microscopic particulate matter, from exhaust air to supply air due to the rotation of enthalpy recovery wheels between both airstreams. The persistence of air contaminants reduces the effectiveness of dilution ventilation. Therefore, more conditioned supply air needs to be used in order to maintain the proper degree of thermal comfort and indoor air quality. To reduce impurity carryover, an enthalpy recovery wheel purge section is usually included. In order to force the return air from the enthalpy recovery wheel before it cycles into the supply air stream, this purge section employs a portion of the outside air as purge air.

Many studied enthalpy recovery wheels or dehumidifier wheels in attempt to better understand heat and mass transportation using mathematical models. In the 1970s, analytical models were developed using various simplifying assumptions. The literature [2,3] predicted the performance of a regenerative exchanger by using the similar theory that Banks [4], Close, and Banks [5] developed. Van Den Bulck et al. [6,7] developed a regenerator-operating chart for the dehumidifier wheel and an effectiveness number of transfer units (e-NTU) approach. This method was also used to optimize the regeneration air mass flow rate and the wheel rotation speed [8]. Numerical models have also been created during the 1990s. A one-dimensional transient model was developed by Zheng and Worek [9] to simulate the coupled heat and mass transmission in the solid desiccant dehumidifier. The axial heat conduction and mass diffusion in the desiccant were assumed to be negligible, and an implicit finite difference technique was applied. Axial heat conduction in the supporting materials and in the desiccant were both taken into consideration by Simonson and Besant [10,11]. However, radial heat conduction and axial and radial mass dispersion of the desiccant were still ignored. A two-dimensional model was developed by Zhang and Niu [12] and Sphaier and Worek [13] to take mass diffusion and axial and radial heat conduction into account. These two-dimensional models were used to do parametric research on the enthalpy recovery and dehumidifier wheels. Sphaier and Worek [14] contrasted the two- and one-dimensional models and discussed possible applications for these models, including enthalpy recovery wheels and dehumidifiers. The phenomena of condensation are noted. According to experimental findings, a condensation ratio higher than 20% might lead to less effective moisture recovery. On the other hand, heat recovery efficiency may reach 82% and the overall performance of heat recovery is independent of the condensation ratio. To replicate the process of heat and mass transfer and to characterize the parameter distribution, a mathematical model of the enthalpy wheel is constructed. It is anticipated where condensation will occur inside the enthalpy wheel. The properties of the incoming air have a substantial relationship with the condensation ratio. Although it only slightly affects the condensation ratio, rotation speed is a major determinant in both moisture recovery and heat recovery efficiency [15].

2. METHODOLOGY

Experimental testing

A heat wheel, also known as a rotary heat exchanger, or air-to-air enthalpy rotary wheel, or heat recovery wheel, is a type of energy heat recovery exchanger placed in the air supply stream and exhaust air handling system, or flue gas in industrial processes, to recover heat energy. Other variants include enthalpy wheels and drying wheels. In the cooling process the hot wheel is sometimes called the Kyoto wheel.

The heat recovery wheel is made of a honeycomb structure made of aluminum foil sheet with a central hole for the position of the rotating shaft. The rotor is mounted on a reinforced iron frame divided into two parts, and allowed to rotate on two bearings. The rotor diameter is 70 cm, length 36.5 cm, and weight 63 kg. Aluminum is used as the matrix material with a thickness of 0.75 mm. The density of the matrix which is defined as the heat transfer area to volume is approximately 3600 m^2/m^3. The regenerator housing and seal spin like a dehumidifier wheel. It should be noted that aluminum has been commonly used as a matrix material in spin regenerators. Here aluminum is used with a thermal conductivity value of 237 W/m^{o}C. Estimated air flow speed 3.7 m/s, air volume 380 m^3/hour. The heat recovery wheel used in this system is EcoFresh-BryAir type HRW 500-MS 270. The inlet air temperature in this test is 40^{o}C with a relative humidity of 30%, the air temperature for the regeneration process is 50^{o}C with a maximum relative humidity of 25%. The rotation speed

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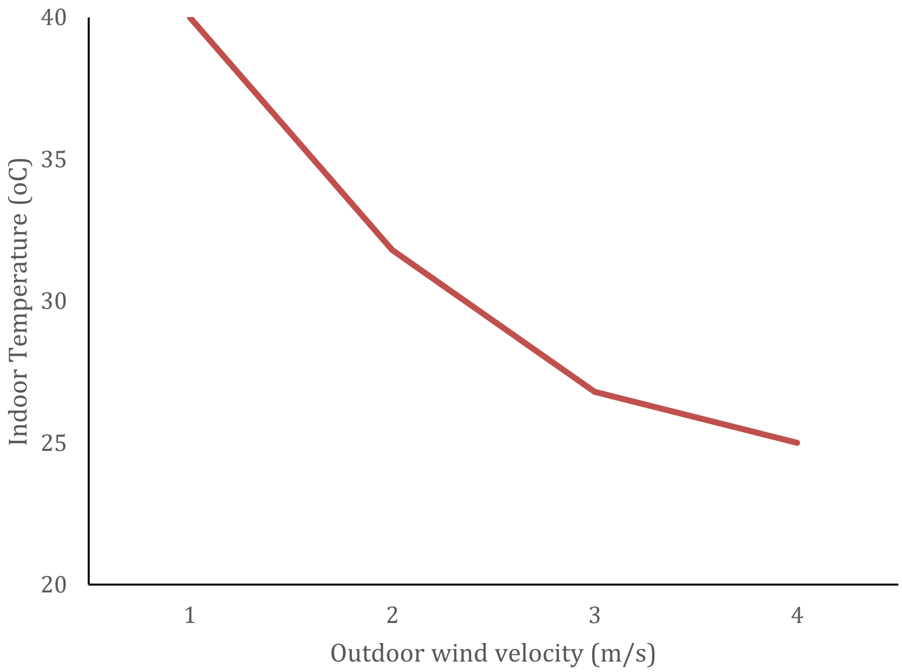
of this wheel can be controlled or changed by controlling the rotation speed using a transformer by setting a frequency of 5 Hz to 60 Hz as in Figure 1.

Figure 1. Heat Recovery Wheel

3. RESULT AND DISCUSSION

Figure 2a shows the effect of varying the outdoor wind speed on the indoor air temperature for standard windcatcher and windcatcher with heat recovery. As expected, the higher the outdoor wind speed, the lower resultant air temperature inside the room. The rate at which the internal temperature falls as the inlet velocity increases was of significance. A more substantial temperature increase was seen from 2 m/s to 3 m/s (6 - 8ºC) supply air temperature reduction) outdoor wind speed, than from 3 m/s to 5 m/s (7- 9ºC) supply air temperature reduction). Figure 6b shows the effect of varying the outdoor wind speed on the average indoor air velocity.



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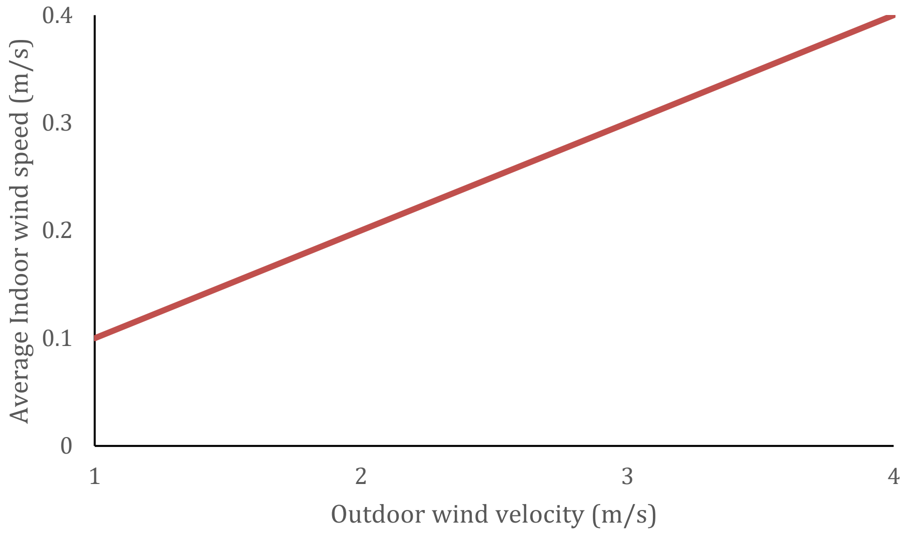

Figure 2. Effect Of Varying External Wind Speeds on Average (a) Indoor Temperature (b) Indoor Velocity

4. CONCLUSION AND FUTURE WORK

In this study, the air flow through a windcatcher with a rotary heat recovery wheel was investigated using experimental. It has been shown in previous work that windcatchers are capable of delivering the guideline levels of ventilation into a room, therefore the rotary wheel should not reduce the air supply rate to unsuitable levels to provide adequate ventilation to be an effective system. The numerical modelling necessary to validated against experimental models tested in a closed-loop wind tunnel. Results showed that the addition of heat recovery had a positive effect on the indoor air temperature, raising the temperature between 7- 9^{o}C depending on the outdoor wind conditions, a recovery of 8^{o}C from the exhaust stream to the inlet stream. This shows that the concept has significant potential to be developed further, whereby the heat transfer properties of the system can be investigated and tested on a larger scale.

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