Comprehensive analysis of thermal utilization of solar wall system

Qintai Jiao[1] ,Kun Qin[1] ,Wenjing Qiao[2] ,Shuhuai Wang[3] ,Daojing Xu[1]

[1] Jiangsu sunrain solar energy Co.,Ltd.,Lianyugang(China)

[2] Xi`an Technological university,Xi`an(China)

[3] Beijing micoe solar energy technology Co.,Ltd.,Lianyugang(China)

Abstract

This paper introduces a energy saving solar wall ventilation heating system.We measure the temperature of each part of the system and analyze the performance of the system.Results indicate that,Under the same conditions, the solar wall system has a high efficiency in the high volume of air delivery, while in the case of low air supply, the heating efficiency is lower;The air volume of the system is inversely proportional to the temperature rise.;The solar wall system has good energy saving effect and good economic benefit.

Keywords：Solar wall system，Energy conservation，Economy

1.Introduction

With the rapid development of the economy ,the energy and environmental pressure which people are facing is increasing.Solar energy as an ideal renewable energy is applied in the construction field.Solar wall system is effective integration of solar air heating technology and building integration,which provides an ecnonmic and applicable solution for heating and ventilation,and is with such prominent advantages as low cost,low energy consumption,low maintenance cost and high air quality.The paper investigate the thermal performance in actual building,application results and benefit analysis by experimental research and theoretical analysis.

2.Overview of solar wall research system

2.1. System introduction

The solar wall ventilation heating system studied in this paper is located in lianyungang, jiangsu province(Fig.1), which is the office of sunrain solar energy Co.,Ltd.The office heating area is 97.5m^2, office wall toward the south, with 25m^2 to install solar wall system, metope is exposed.

Fig.1 solar wall testing system

Fig.2 90°irradiation

Fig.3 wind speed and ambient temperature

doi:10.18086/swc.2017.09.01 Available at http://proceedings.ises.org

2.2. Principle of system operation

The system adopts the automatic control mode, when the cavity temperature reaches the set temperature , then the fan is started, and the air supply air temperature is set at 20℃

2.3. Data collection and testing methods

2.3.1. Measurement of irradiation strength

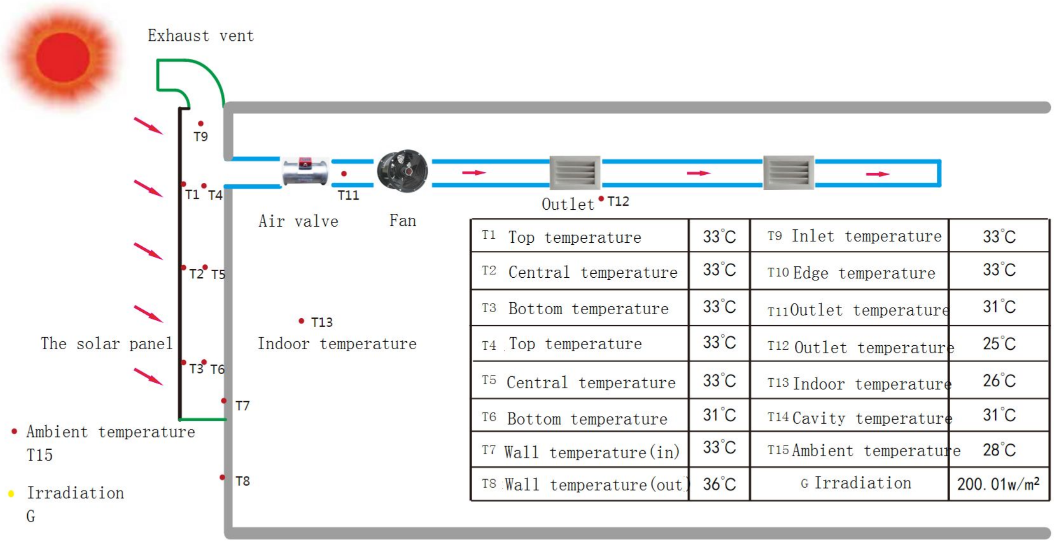
TBQ - 2 to measure Solar radiation(Fig.2).

2.3.2. Measurement of wind speed and ambient temperature

EC-1A to measure wind speed and pt100 to ambient temperature(Fig.3).

2.3.3. Solar wall system temperature measurement

The internal wall temperature and indoor temperature were tested respectively(Fig.4).



T1 Top temperature	33°C	T9 Inlet temperature	33°C
T2 Central temperature	33°C	T10 Edge temperature	33°C
T3 Bottom temperature	33°C	T11 Outlet temperature	31°C
T4 Top temperature	33°C	T12 Outlet temperature	25°C
T5 Central temperature	33°C	T13 Indoor temperature	26°C
T6 Bottom temperature	31°C	T14 Cavity temperature	31°C
T7 Wall temperature(in)	33°C	T15 Ambient temperature	28°C
T8 Wall temperature(out)	36°C	G Irradiation	200.01w/m²

Fig.4 Temperature distribution of solar wall test system

3.Thermal performance of solar wall test system

3.1. Solar panel and cavity temperature

Figure 5 shows the change of cavity temperature and the surface temperature of solar wall panel during the solar wall system operation.From the diagram, the temperature of the solar panel and the temperature of the cavity are consistent with the variation of solar radiation.When the solar radiation intensity is greatest at noon, the temperature of the solar wall panel and the cavity temperature reach the maximum.In the morning and evening, the temperature of the cavity is low due to the small amount of solar radiation.During the operation of the system, the temperature of the cavity is up to 40℃, which is 30℃ higher than the outdoor environment, and the effect of temperature rise is obvious.

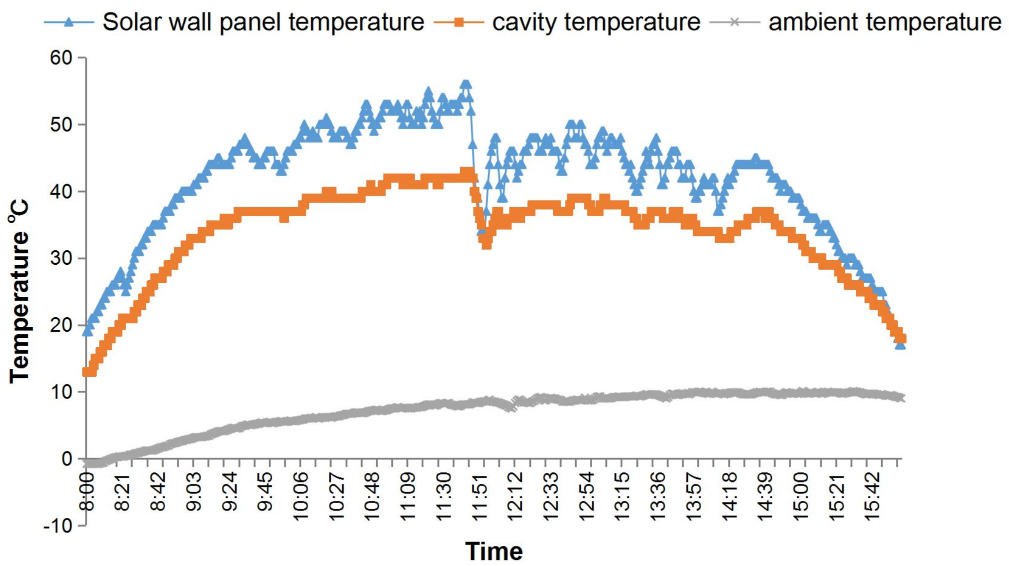


Fig.5 cavity temperature and the surface temperature of solar wall

3.2. Deliver temperature

Figure 6 shows the change of deliver temperature during the operation of the solar wall system in local heating period(Nov 14, 2016 ~Mar 27, 2017, total 134 days [1]).Figure illustrates the deliver temperature up to 48℃ during work, and the average working time from 8:30 ~ 16:00, with an average of seven hours.The results show that the solar wall heating system is stable and reliable in the better working conditions.

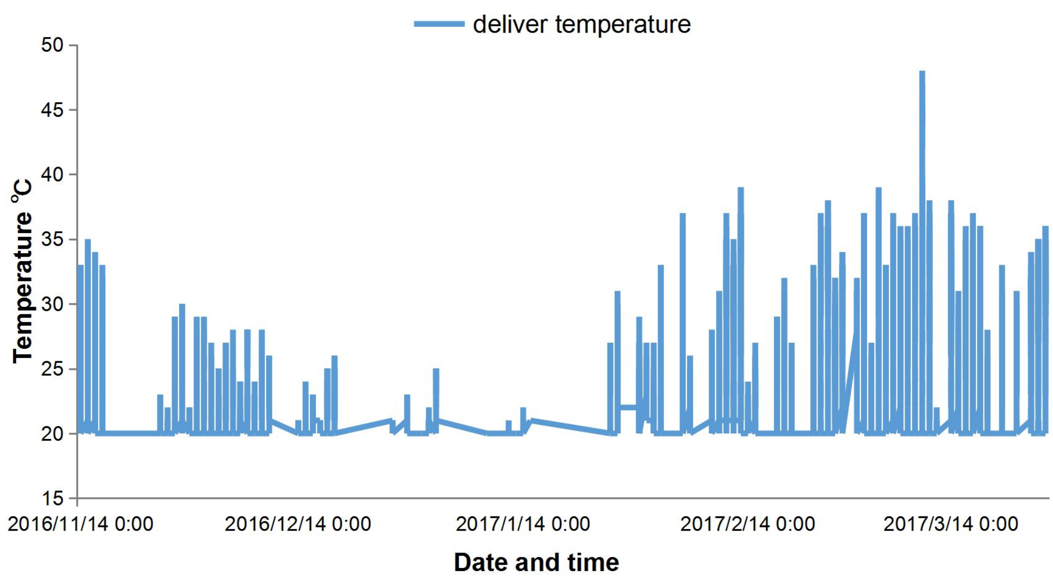


Fig.6 deliver temperature during heating period

3.3. Performance analysis

The save energy Q refers to the heat provided by the solar wall during a heating period

The heat provided by solar wall system in unit time：

$$Q = c * \rho * mv * \Delta T \text{ (eq. 1)}$$

The heating efficiency of solar wall heating system in unit time is calculated by

$$\eta = \frac{Q}{A * H} \text{ (eq. 2)}$$

As shown in figure 7, when the radiation is high, the instantaneous heat efficiency of the system decreases, and when the radiation intensity decreases, the instantaneous heat efficiency of the system is increased.Because the heat efficiency is proportional to the temperature rise and inversely proportional to the radiation intensity,When the magnitude of the decrease of radiation is greater than that of temperature rise, the efficiency will be increased. While when the amplitude of radiation rise is greater than that of temperature rise, the efficiency will decrease.

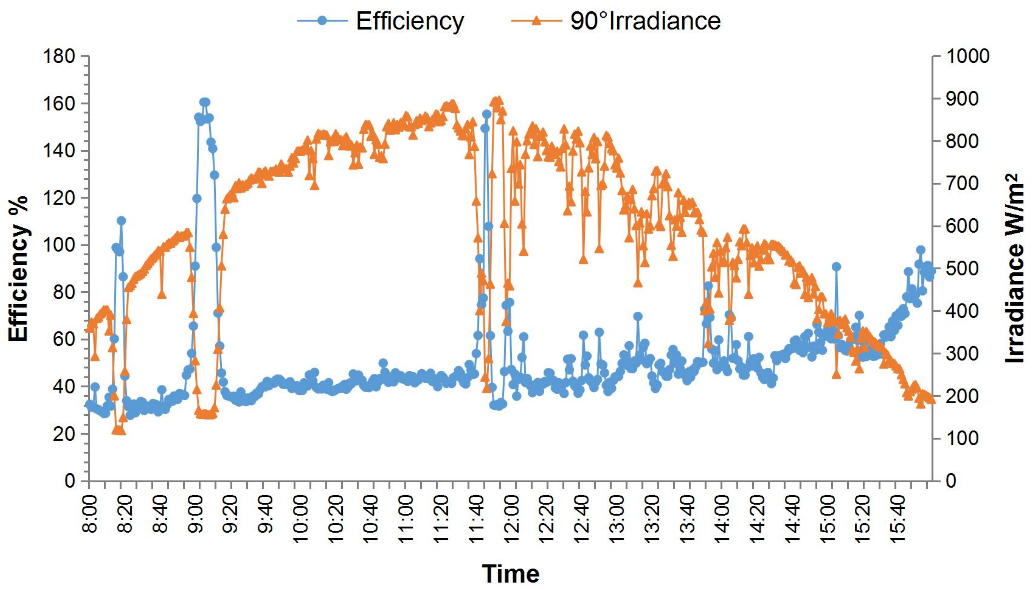


Fig.7 Efficiency and Irradiance

3.4. The effect of air flow on the system

It can be seen from figure 8 that under certain conditions, the heat efficiency is high in high air flow and low heat efficiency in low air flow.This result is consistent with figure 9.In this way, we can use the efficiency curve to calculate the energy of the section through irradiation

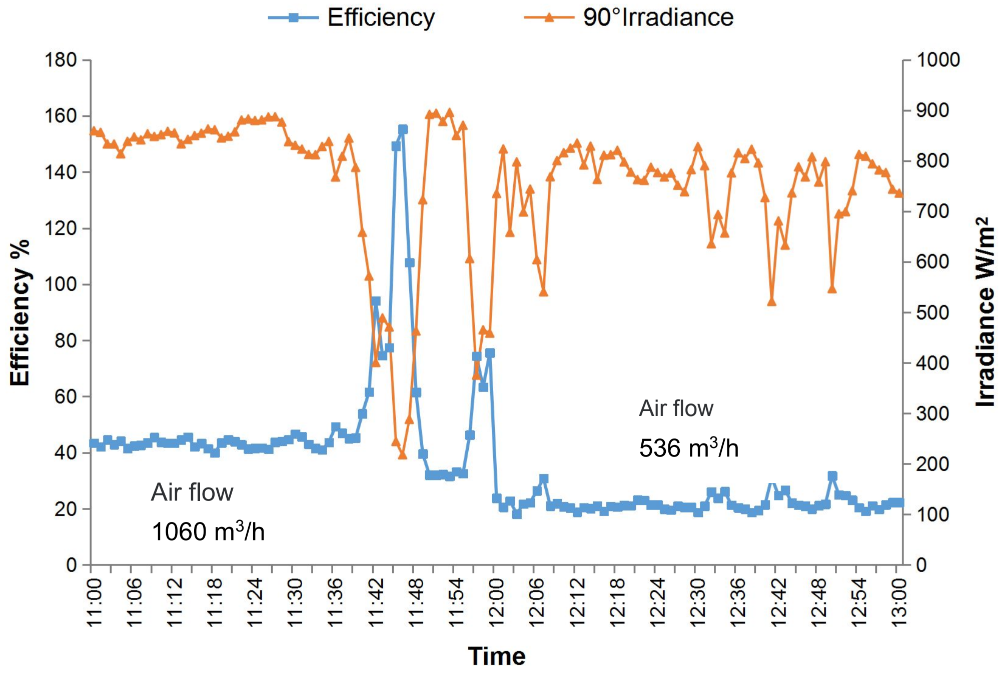


Fig.8 Efficiency for solarwall at various wind speeds

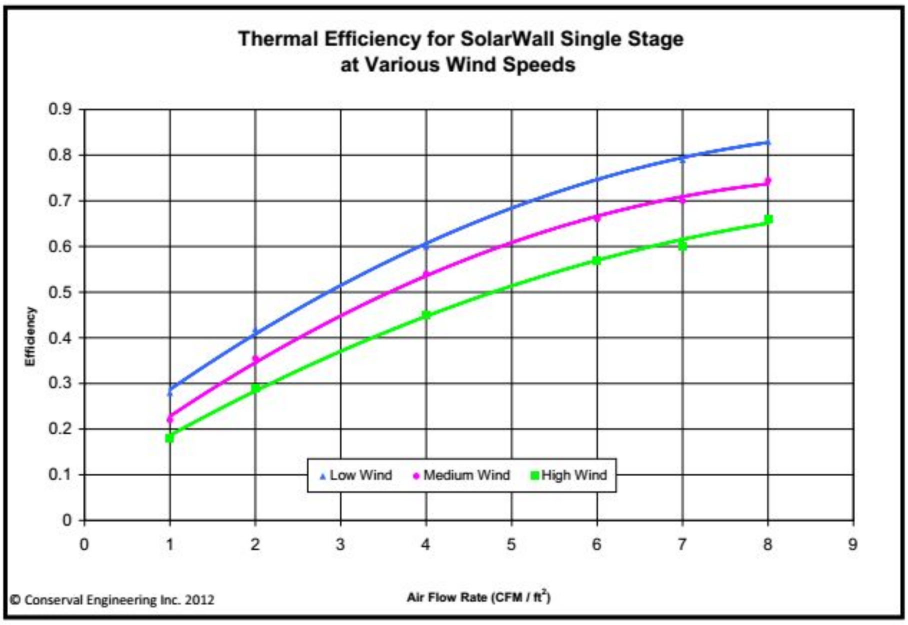


Fig.9 Efficiency for solarwall at various wind speeds[2]

According to the figure 10 analysis, under certain conditions, the solar wall system under the condition of high air flow, the deliver temperature rise is smaller, and under the condition of low air flow, the deliver temperature rise is larger. You can compare the temperature rise certification curve, as shown in figure 11.

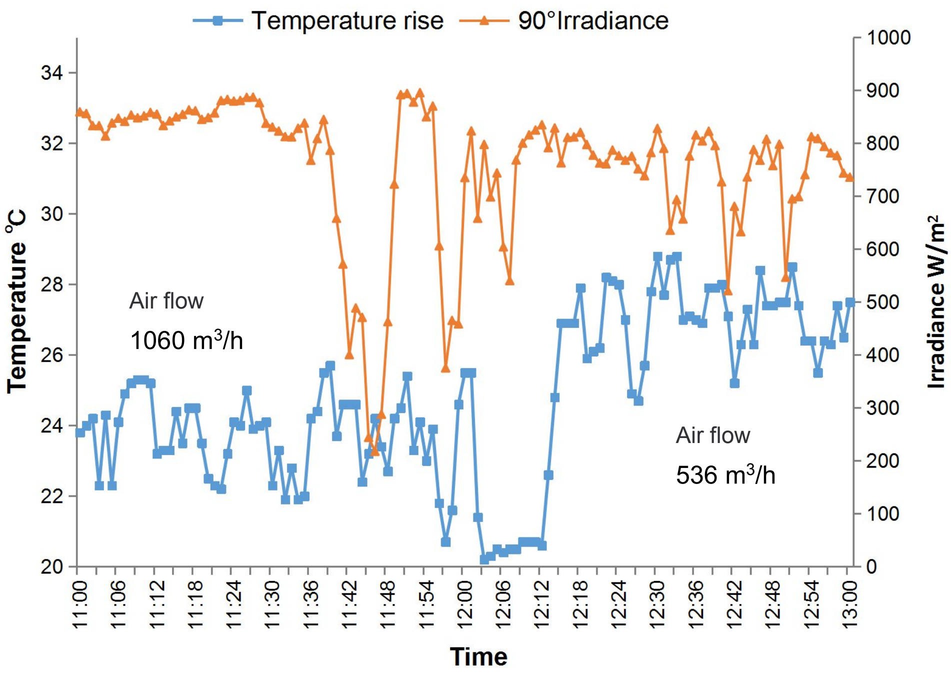


Fig.10 Temperature performance for solarwall wint wind variance

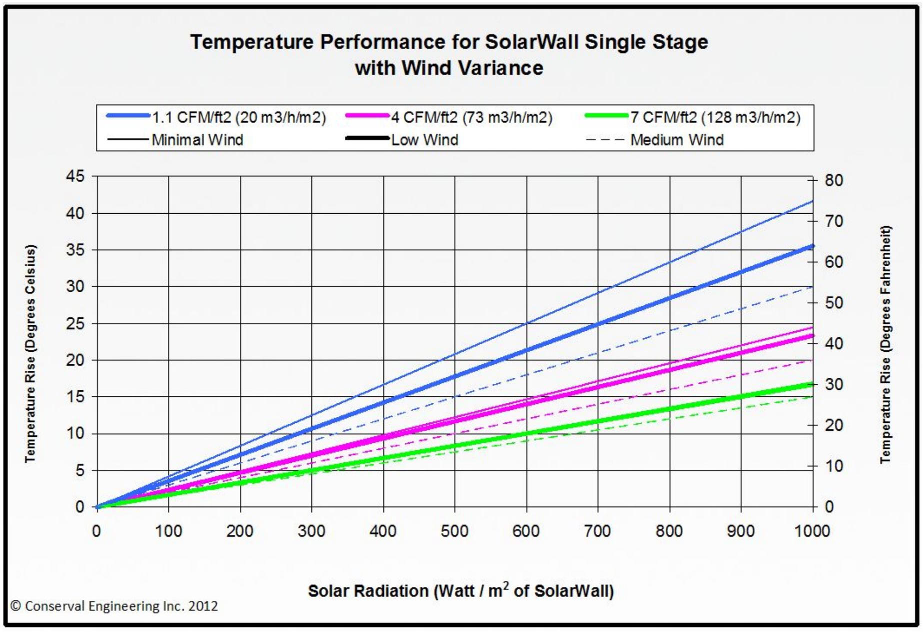


Fig.11 Temperature performance for solarwall wint wind variance[2]

Practical application can not blindly pursue high efficiency and increase the air volume, it will lead to the deliver temperature is low, thereby reducing the body's comfort, so in the later application according to different types of engineering deal with the relationship between air flow and temperature rise, maximize the benefits.

4.economy evaluation

The economic evaluation index of solar wall system includes the fund saving in life span and the payback time N[3].The two methods are calculated as follows：

$$SAV = PI * (\Delta Q_{SAV} * C_C - A * DJ) - A \quad \text{(eq. 3)}$$

$$PI = \frac{1}{d-e}\left[1-\left(\frac{1+e}{1+\mathrm{d}}\right)^n\right] \quad \text{(eq. 4)}$$

payback time N，That is, when the formula SAV is equal to zero, the value of N,the calculation formula is as follows:

$$N = \frac{\ln\left[1 - \frac{A(\mathrm{d}-e)}{\Delta Qsav - A \bullet DJ}\right]}{\ln\left(\frac{1+\mathrm{e}}{1+\mathrm{d}}\right)} \quad \text{(eq. 5)}$$

The above formula can be used to calculate the payback time N=2.3 years.

5.Conclusion

This paper studies the solar wall system in lianyungang,the following conclusions can be obtained by statistical analysis of the application of solar wall system

1.The solar wall system has good thermal performance, and system efficiency is inversely proportional to irradiation;The air flow is proportional to the efficiency, inversely proportional to the temperature rise.

2.The solar wall heating system can provide 48℃ heating air in the heating season, with an average working time of 7 hours per day, and 13640MJ energy in the heating season.

3.This solar wall heating system has good economic benefits and the payback time is two to three years.

References

[1] GB 50736-2012,Civil building heating ventilation and air conditioning design specification[S].

[2] SAHWIA.SLOAR AIR COLLECTOR CERTIFICATE 1001[EB/OL].http://sahwia.org/solar-a-mark/view-certifications/,2012-07-31.

[3] Ruicheng.ZHENG.Technical manual for solar heating and heating engineering[M].china building industry press，2012：240-247.

Nomenclature

Quantity	Symbol	Unit
Specific heat	*c*	J kg^{-1} K^{-1}
Density	ρ	kg m^{-3}
Air flow	*mv*	m3/s
Temperature difference	ΔT	K^{-1}
Area	*A*	m^2
Heat	*Q*	J
Irradiance	*E, H*	W m^{-2}
Efficiency	η	
Total energy saving cost	SAV	yuan
discount factor	PI	
discount rate	d	
fuel cost escalation rate	e	
project life	n	
heating delived	△Qsav	J
Fuel cost	Cc	Yuan J^{-1}
Total initial costs	*Aa*	yuan
O&M expense ratio	DJ	