Designing HVAC system with and without Heat Recovery Wheel using ECO-FRESH Enthalpy wheel

SYED MUSAB AL HUSSAINI, Irfan Khan

Abstract— Implementing conservation of energy measures in structures can prolong use of finite resources while simultaneously reducing its effects on the environment. The key focus of energy saving techniques is based on air to air energy recovering concepts. The importance and desire for energy saving in structures is well understood. Also, the amount of energy required for HVAC in structures should essentially be given importance. One of the major energy efficient ability of offering cooling or heating in structures is with the use of HRW systems.A design plan of technical auditorium is taken of area 5630m^2. It consist of auditorium occupancy of 270 peoples, museum, library space, cafeteria, pray room, multipurpose hall and shops. Additionally there is a separate VIP sitting area. The technical auditorium is considered in Hyderabad region while calculating heat load calculations. The comparision is made between the technical auditorium with HRW and without HRW for energy efficient.

Index Terms— AHU, CFM, EATR, ECO-FRESH enthalpy wheel, HVAC, latent heat, OACF, packaged unit, purge section, return air, RH, sensible heat and supply air.

1 Introduction

THIS technical paper focussed on the utilization of return air using Heat Recovery Wheel, otherwise which is wasted. The return air from conditioned space is used to reduce the conditioning of fresh air from atmosphere.

ASHRAE standard-62.1 gives the minimum rates of outside air to reach the quality of air which is acceptable. This standard is followed by almost all the construction building partly or fully. According to the standards the CFM (Cubic Feet per Minute) required per person is selected for providing comfort. Almost all the owners and engineers know the benefits of more fresh air to the conditioned space but they should also consider the equipment and maintenance cost.

Approximately half of universal energy is utilize by buildings and most of heating or cooling cost is due to ventilation. Secondly, production of energy is made for the highest power demand. For the proper usage of ventilation, energy should be recovered for cost efficiency, sustainability and for the reduction of total energy consumption hence giving better indoor air quality and protecting the environment. Buildings require enormous amounts of outside air to be added in through their air flow systems. Replacing of the conditioned air with outside air is very expensive. Energy restoration can be done using the Enthalpy Wheel, which can transfer exhausting sensible energy and latent energy to the coming outside air.

Enthalpy wheel provides the precooling and dehumidification in the summer and similarly it preheat and humidify in winter season. Therefore the quantity of outside air can be increased without increasing in the cost of energy. As a result enthalpy wheel provide the solution for more fresh air at lower costs.

2 Nomenclature

AHU- Air Handling Unit, CFM- Cubic Feet per Minute, DBT- Dry Bulb Temperature, EATR- Exhaust Air Transfer Ratio, HAP- Hourly Analysis Program, HRW- Heat Recovery Wheel, HVAC- Heating Ventilation and Air Conditioning, OACF- Outside Air Correction Factor, RH- Relative Humidity.

3 Literature Review

Now-a-days demand for energy saving has increased a lot, there are different types of methods are used to store and recycle the used energy. In HVAC field the demand for green products increasing rapidly because nearly half of the global energy is utilizing by the buildings. Therefore the customers are also taking interest in green products as it is both energy-efficient and cost-efficient. The engineers are coming up with different innovative ideas and designs to fulfill the demand and reduction in energy.

Some facilities have constantly ventilated massive quantities of indoor air. But recently the facilities have increased for large amount of outside air to reach new building codes. Replacing of indoor air with the outside air may costs in the energy for heating, cooling, humidification and dehumidification.

Air to Air heat exchangers transfers the heat only, therefore a new concept was developed as heat recovery wheel or enthalpy wheel which can transfer heat and moister from air. Due to moisture content transfer ability nearly 30-50% of the cost of conditioning is saved by heat recovery wheel.

• *SYED MUSAB AL HUSSAINI is currently pursuing masters degree program in Mechanical engineering in NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING AND TECHNOLOGY, Hyderabad, Telangana, INDIA, M-8686486961. E-mail: syedmusab11@mail.com*

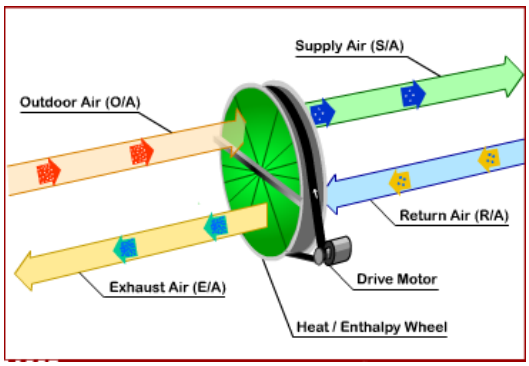

Figure 1: Rotary Air-to-Air Heat Exchanger

Heat Recovery Wheel comes under rotary air to air heat exchanger, which consist of wheel of alluminium substrate coated with desiccant which reduces the cross contaminations to minimum. The wheel comes with segmented or unsegmented options, helping easy for maintenance. The airflow across the wheel is laminar due to coating of desiccant. The wheel comes with the diameters in between 0.5m to 5m.

3.1 Air Transfer between Airstreams

In the process of heat recovery wheel air moves directly between return and supply stream due to the rotation of wheel. When returning air move to the supplying air stream it is known as EATR. It is measured with the help of tracer gas in return air, supply air and outside air. When the outside air transfer to the exhaust air stream it is known as. It is measured by dividing the outside air by supply air. EATR and OACF are determined by following the ARI Standards 1060-2000.

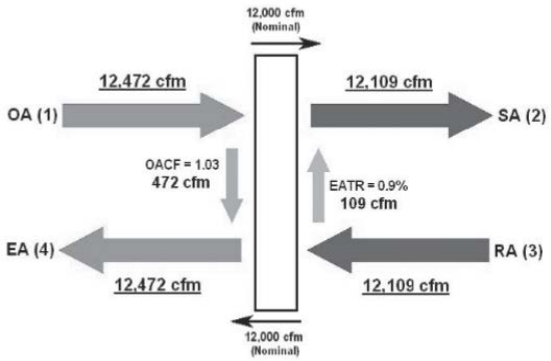

Figure 2: Example of EATR and OACF

3.2 Purge Section

Purge removes the stale air which is carried away by the rotation of the wheel from exhaust air stream to outside air stream. The pressure difference will be the driving force for the removing of stale air from outside air stream. There are basically two method of removing purge air they are

Through Matrix Purge
Mechanical Purge

In Through Matrix Purge air exchange takes place through the energy transfer matrix. It is suitable for comfort applications because of acceptable EATR i.e 4 to 6%. It is highly competitive with the mechanical purge as it is cheaper and simple for almost all applications. Effective purge have the EATR of less than 1% which can be achieve by matrix purge by making the positive static pressure from supply stream to exhaust stream on either sides of wheel.

In Mechanical Purge leakage are less which results in the usage of higher pressure applications. It uses channels for the passing of air therefore higher energy saving. A wedge shape mechanical purge is placed at the centre to minimize the carryover of air from return to supply path. The mechanical purge is movable so that EATR can be achieved to 1% or less, hence can be used for wide range of pressure applications.

3.3 Fan Location

The location of fan plays an important role for maintaining pressure difference across the wheel. If the pressure is not maintained then the efficiency of the wheel decreases. There are basically four different options for the fan placement as follows

Blowing through supply and exhaust: In this arrangement when static pressures are equal the leakage will be minimum. The leakage direction depends upon the relative static pressure.

Blowing through supply and drawing through exhaust: In this arrangement the leakage will be minimum through exhaust path. If the static pressure is not minimized then the flow transfer from supply path to return path.

Drawing through supply and drawing through exhaust: In this arrangement when static pressures are equal the leakage will be minimum. Distribution of air across the wheel is maximum comparing to other arrangement. The leakage direction depends upon the relative static pressure.

Drawing through supply and blowing through exhaust: In this arrangement the leakage is from exhaust path to supply path hence it cannot be used.

3.4 Filtration Requirements

The wheel is designed in such a way that the flow across will be laminar. As the wheel operates in two opposite direction flows therefore there is continuous reversal of air results in efficient self cleaning process. Hence minimum filtration is required to operate the wheel in any conditions.

Filter screens are provided at the intake of outside air to minimize the insects, leaves and debris entering the wheel. For the return air the filters are not required for areas like office, school etc. For the industrial return air the filters become must as it contains oil, bacteria, animal hairs etc.

3.5 Wheel Speed Control

The heat recovery wheel is rotated using variable drive motor, so that the speed is varied according to the requirement. Motor is placed at the bottom of the wheel of return air side.

The important benefit of heat recovery wheel is the ability to control the performance by varying speed of the wheel. Heat recovery wheel utilizes temperature sensors for maintaining the return air temperature.

4 ECO-FRESH Enthalpy Wheel

ECO-FRESH Enthalpy Wheel recovers both sensible heat and total heat and meeting all the necessary requirements of indoor air quality, humidity ratio and energy saving. Wheel is of alluminium substrate coated with the desiccant. The wheel takes around 20 revolutions per minute.

The wheel in the air handling unit is placed in such a way that it divides into two equal portions for outside air stream and exhaust air stream. Wheel rotates and the air in two streams flows simultaneously. The warmer region temperature is transferred to the colder region hence recovering sensible heat. Similarly the desiccant coating adsorbs the moisture from high humidity ratio region and releases to the lower humidity ratio region hence recovering latent heat.

4.1 Benefits of ECO-FRESH Enthalpy Wheel

- Pre conditioned outside air.
- It can install easily in new/existing ventilation systems.
- Deliver outside fresh air throughout the year.
- Meet ventilation standard at no additional cost.
- Overall system capacity is reduced by 30-65%.

5 Building Details and Calculations

A plan of Technical Auditorium is considered which consist of different spaces. While designing, the plan is considered in Hyderabad. Therefore weather properties of Hyderabad are selected during heat load calculation. Area of Technical Auditorium is 4488 m2. Most of the area is covered by the auditorium, museum and gallery sections.

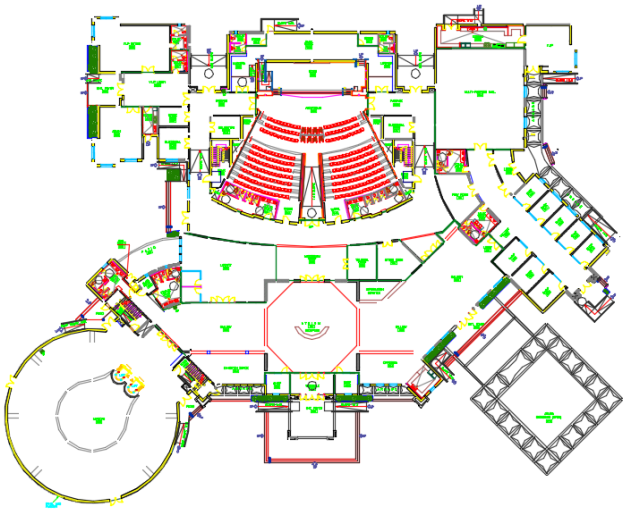

Figure 3: Technical Auditorium Plan

Auditorium has a fixed occupancy of 270 persons in which 8 occupants are dignities. The occupancy for the other spaces of Technical Auditorium is taken from the ASHRAE Standard 62.1-2004.

In this paper the equipments are selected as 1-Packaged unit and 6-AHU's. The cooling medium required for AHU's is from air cooled chillers. Chillers are selected in such a way that it has one standby. For example if there are 3-chillers then 2-chillers will be working and 1-chiller will be standby. Number of chillers is selected by the diversity factor. In this paper diversity factor is taken as 66% therefore 3-chillers are selected of each capacity 84TR.

5.1 HEAT LOAD CALCULATIONS (without HRW)

Heat load calculation are the most important stage in the designing of HVAC (Heating Ventilation and Air conditioning) systems. There are different methods through which heating loads are calculated they are General method, E-20 method and HAP (Hourly Analysis Program) method. In this paper HAP (Hourly Analysis Program) method is considered.

5.2 HEAT LOAD CALCULATIONS (with HRW)

For calculating heat load with HRW (Heat Recovery Wheel) firstly the normal heat load should be calculated because heat load with HRW (Heat Recovery Wheel) is the further step of normal heat load calculations. Heat load calculation using HRW (Heat Recovery Wheel) can be carried out using ECO-FRESH enthalpy wheel software.

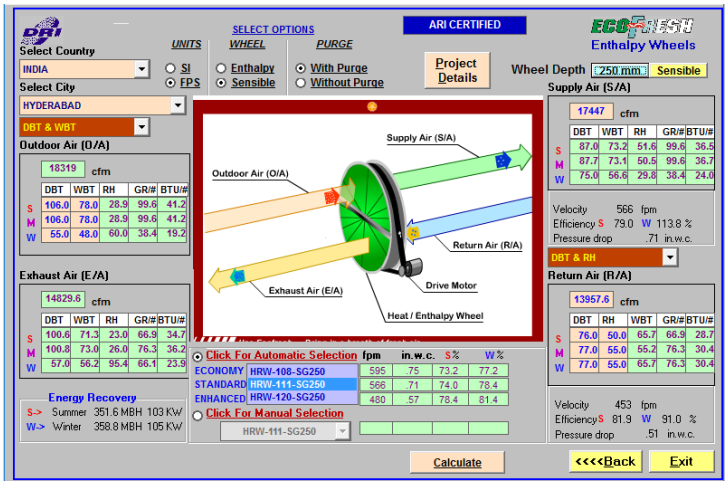

Figure 4: ECO-FRESH Enthalpy Wheel

ECO-FRESH enthalpy wheel uses the data from the normal heat load calculations to find the heat load with HRW (Heat Recovery Wheel). It has two constraints for selecting the wheel

one is the enthalpy and other is sensible. In the enthalpy wheel both sensible and latent heat is recovered while in case of sensible wheel only sensible heat is recovered. ECO-FRESH wheel comes in two types with and without purge section.

The inputs for ECO-FRESH enthalpy wheel are the country with city, supply air CFM (Cubic Feet Per Minute) and return air CFM (Cubic Feet Per Minute). Supply air CFM is known from the HAP (Hourly Analysis Program) final report and the return air CFM should be 80% of supply air CFM according to ECO-FRESH wheel principle as shown in fig-5.

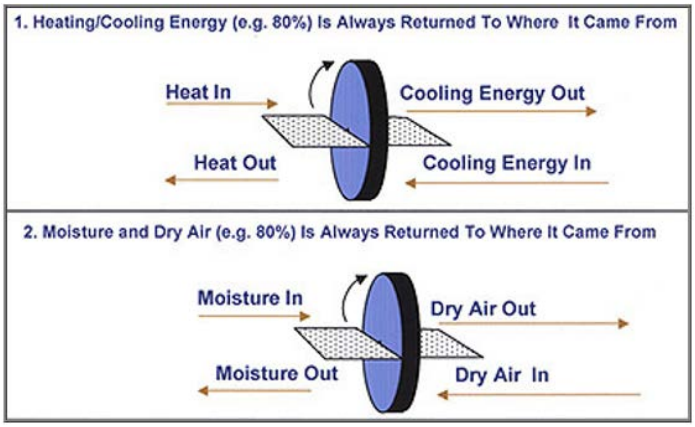

Figure 5: ECO-FRESH Wheel Principle

In this paper Sensible energy is recovered using ECO-FRESH wheel using the supply air CFM from the HAP final report and 80% return air CFM with 50%relative humidity.

6 Comparision of Results

Comparision of heat load calculations with and without heat recovery wheel are shown below

Table 1: Comparision of Ton of Refrigeration with and without Heat Recovery Wheel

EQUIPMENT	HAP (TR)	ECO-FRESH (TR)	ENERGY RECOVERED(%)
AHU-1	54.9	29.91	45.5
AHU-2	48.6	26.78	44.89
AHU-3	45.5	23.64	48.0
AHU-4	45.5	21.93	51.8
AHU-5	24.5	15.09	38.4
AHU-6	32.7	18.51	43.39
TOTAL	**251.7**	**135.86**	**46.02**

From the above comparision it is clear that using heat recovery wheel 46.02% of energy is recovered.

7 Conclusion

The purpose of this paper is to compare the heat load calculations with heat recovery wheel and without heat recovery wheel for energy efficient. The purpose of this paper has been accomplished, by using ECO-FRESH enthalpy wheel software to calculate the load calculation with heat recovery wheel and HAP (Hourly Analysis Program) to calculate load calculation without heat recovery wheel. Using HRW (Heat Recovery Wheel) sensible heat is recovered and the total reduction in the ton of refrigeration reduces to 46.02%. Hence using HRW (Heat Recovery Wheel) nearly half of the energy can be saved.

References

[1] Energy Information Agency, 2001. Commercial Buildings Energy Consumption Survey. Washington, DC: U.S. Department of Energy.

[2] ASHRAE. 2000. ASHRAE Handbook - 2000 HVAC Systems & Equipment, chapter 44. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

[3] ASHRAE. 2001. ASHRAE Handbook - 2001 Fundamentals, chapter 27. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

[4] Besant, Robert W., and Simonson, Carey J. "Air-ToAir Energy Recovery." ASHRAE Journal, Volume 42, Number 5, May 2000 - pp. 31 - 42.

[5] Eurovent 10/1 (1986) – 'Heat Recovery Devices – Specifications, Terminology, Classification and Functional Characteristics'.

[6] ASHRAE Handbook (2007) - ' Heating, Ventilating and Air-Conditioning – Applications'.

[7] NPTEL "Inside And Outside Design Conditions", Version 1 ME, IIT Kharagpur.

[8] NPTEL "Selection Of Air Conditioning Systems", Version 1 ME, IIT Kharagpur.