ECOFRESH: FOR BETTER INDOOR AIR QUALITY

Dr. Ajoy Kumar

Principal

Chhatrapati Shivaji Maharaj Institute of Technology

Panvel , University of Mumbai , India.

drajoyk@gmail.com

Abstract- People are more bothered about outdoor pollution and remaining inside the buildings gives them a false sense of security because a growing body of scientific evidence proves that the air within our air- conditioned workspaces can be more seriously polluted than the outdoor air even in the largest and most industrialized cities. Research shows that people spend 80% to 90% of their time indoor. Research also indicates about the detrimental effects of poor indoor environment on the productivity of an office and on the health of its occupants. Thus, for most people health problems may be more due to indoor air pollution rather than outdoors. This paper deals with the indoor air quality, its causes and the efforts made to revive the standards as required for a person. This paper highlights about the device made called ECO-FRESHENER and its testing under normal outdoor conditions. Result shows of 83.02% as air supply efficiency and 84.32% as exhaust air efficiency with 1.157 ton of refrigeration(TR). Total operating cost of the eco-freshener in one month (8 hours a day) comes out to be Rs. 532.44. It reduces the size of air conditioning systems used in hotels, supermarkets, offices etc. and saves the energy cost as well.

Key words: IAQ, enthalpy recovery wheel, Eco fresh, cmm, HVAC, Tonnage, Supply air efficiency,

1. INTRODUCTION

The very fast rate of development in urban areas and industry over the last few decades has led to the rise of countless buildings. These buildings, houses numerous offices, educational institutions, shopping complexes, hospitals, hotels, theaters etc.are largely air conditioned. Unknowingly, these structures of stone and cement have become an integral part of our lives, as we spend the greater portion of our productive hours within the four walls of ‘closed’ space.

Air conditioned buildings create an environment inside the closed space. The technocrats are satisfied after getting control over temperature, humidity and maintenance of ventilation (sufficient to overcome human odor). But what is the reason behind these astounding findings? Why our places of work proving to be health hazards? The answer is INDOOR AIR POLLUTION which is turn leads to poor INDOOR AIR QUALITY (IAQ i.e. the nature of the air that circulates within the areas where we work) [1, 2, and 3].

2. INDOOR AIR QUALITY

Pure air comprises of oxygen, carbon dioxide, nitrogen and water. All these components together help in the perpetuation of life on earth. Besides these other substances also occupy space in air due to both natural processes and human activities such as pollen, fungal spores, bacteria, viruses, dust particles and gasses from combustion processes (i.e. smoking and others). The type and proportion of substances may vary in the air over time and from place to place. In heart patients, it causes chest pain. At high levels, it results in impaired vision and co-ordination, headaches, dizziness, confusion, nausea and respiratory irritation. These symptoms disappear with the removal of the source.

Growing concern for the deteriorating indoor air quality and extravagant energy cost has forced ASHRAE to revise standards [4, 6, 7 and 12] for IAQ. In 1983 it laid down 5cfm (cubic feet per minute) of fresh air intake per person as its standard. This standard was revised due to decrease in indoor air quality. The current ASHRAE STD. (standard 62-1989) for ventilation is a minimum of 15cfm to 20cfm of fresh air intake per person in a conditioned room. But what measures are being taken to follow and maintain this standard? Do we really believe that the ventilation system fitted in the air-conditioners is sufficient to control indoor air pollution and maintain a good IAQ? How can we provide for a better IAQ without increasing energy costs? These are some of the questions which will be discussed here.

3. CAUSES FOR POOR IAQ

Following factors have been identified:

(a) Presence of indoor air pollution sources materials which are supposed to be essential requirements for an office, create inside air pollution. Depending upon the type of substance, its exposure time and concentration the effect (long or short term) may be felt by individuals. Shorts terms effect include phellmonia, respiratory infections and allergic asthma. Long terms effects of indoor air pollution include cancer, birth defects, immunological problems, nerve damage. Asbestos is one of them which is widely used as roofing material, floors and tiles. After getting damaged or disintegrated, its microscopic fibers are released into the indoor air causing long term effects such are chest and abdominal cancer and lung infections. Smokers are at a greater risk of developing asbestos.

(b) Poorly designed and maintained ventilation systems:

Proper circulation of fresh air from outside to inside and polluted air from inside to outside makes the room as a cool environment and pollution free.

In normal working of window air- conditioning which is designed for minimum or no fresh air intake, the inside air gets laden with hazardous pollutants which play with the occupant's health. The growing concern for the deteriorating indoor air quality and extravagant energy costs has forced ASHRAE to revise standards for IAQ.

IAQ Enhancers

Source control:

Source control eliminates air pollutants before they enter inside our air-conditioned space. Although source control is the most effective way of dealing with an air quality problem, it's usually not the cheapest way and it's often impractical.

Filtration:

Air filters arid air cleaners actually remove particulates found in our indoor air.

Central system air- filters or air- cleaners are installed in return air duct work, just ahead of the heating and cooling equipment. Whenever the blower motor runs, dirty air is pulled into the return air ducts and passes through the air cleaner before it's heated or cooled. In the process, a portion of airborne particulates is removed.

Ventilation/Dilution:

Sometimes it's not enough to simply clean the indoor air. If the air-conditioned space is well insulated, we need to replace the stale air inside with fresh air.

Today, new buildings are built energy-tight out of necessity. Many are sealed up to save on energy costs, with one air exchange in ten hours not uncommon. The result is greatly reduced the air exchange, stale air and humidity trapped inside. In the optimum health range of 40 to 50 percent relative humidity, bacteria and fungi are eliminated and viruses, dust mites, respiratory infections, allergic reactions and asthma are significantly reduced. Optimum humidity levels also go a long way towards reducing the effects of various chemical interactions.

The ventilation system extracts stale air from indoor spaces and replaces it with fresh outdoor air. In the process, it recovers most of the energy used to heat or cool the air being exhausted. Combined with an efficient air cleaner, it's an excellent way to ensure a continuous supply of fresh and clean indoor air.

4. ENERGY RECOVERY PROCESS

Two types of energy recovery systems are available:

(a) Sensible energy recovery.

(b) Total energy (enthalpy) recovery

Sensible Energy:

In this process, only sensible heat is removed. Two different streams of air are passed through an air to air heat exchanger. Due to temperature difference the heat flows from hotter air to cooler air. The heat transferred depends upon the effectiveness/efficiency of the heat exchanger.

Enthalpy recovery:

In this process, total energy transfer takes place. Generally, a rotating wheel is used. One stream of air passes through one half of the wheel and other stream passes through another half.

Process happens in two stages. Sensible heat is transferred through metallic substrata and latent heat by condensation of moisture on an adsorbing media. The heat transfer depends upon the effectiveness/ efficiency of the heat exchanger.

5. RECOVERY DEVICES

ASHRAE equipment handbooks refer to six types of air to air heat exchange devices. Distinction is made between the sensible heat only and the total heat exchangers. These devices are given as below:

1. Rotary energy exchangers

2. Coil energy recovery loop

3. Twin-tower enthalpy recovery loop

4. Heat pipe heat exchangers

5. Fixed pipe heat exchangers

6. Thermosyphon heat exchangers.

Because of their ability to transfer both sensible and latent heat, the enthalpy devices are more effective in energy recovery. It is found that under summer design conditions, the total heat device typically recovers nearly three times as much energy as the sensible heat device. Under winter conditions, it recovers over 25% more.

After getting compared, it is found that the enthalpy wheel has the highest effectiveness and the least pressure drop at any face velocity. In other enthalpy device, the twin tower loop- has the highest pressure drop for the same effectiveness. Since it uses a liquid heat transfer medium (a halogen salt solution, usually lithium chloride) velocities need to be kept low, usually below 400 fpm, and the equipment tends to be large and cumbersome. The technology has therefore, gone into disuse, leaving the enthalpy wheel as the most appropriate choice for energy recovery in comfort ventilation. This paper deals with the details of enthalpy wheel.

Enthalpy wheel

Fig. 1(a), (b) shows the photograph of the experimental setup of the eco-freshener used. Fig.2 gives the structural diagram of enthalpy wheel which is usually 10 to 25 cm deep packed with a heat transfer medium that has numerous small air passages, or flutes which are parallel to the direction of air flow. The flutes are triangular or semi-circular in cross section. The structure, commonly referred to as the honeycomb matrix, is produced by interleaving flat and corrugated layers of a high conductivity material, usually aluminium, surfaced with a desiccant. Stainless steel, ceramic, and synthetic materials may be used, instead of aluminium, in specific applications. The flutes in most wheels' measure between 1.5 mm to 2.0 mm in height. The surface area exposed to air flow in a wheel lies between1570 to 3150 sq.m/cu.m depending on configuration. In a typical installation as shown in Fig.1, the wheel is positioned in a duct system such that it is divided into two sections. The eco-freshener with wheel can be mounted either on ceiling or on wall. Its principle of operation is shown in Fig3.

Pore openings in this sieve allow only molecules smaller than 3A in diameter, 5000 times smaller than that of a human air, to pass into the fresh air supply. Water molecules 2.8A in diameter, can enter and exit the sieve, but pollutants larger in size are excluded. Only eco-fresh provides strict separation of the air flows, preventing carry-over of bacteria and dust particles from the exhaust air of the supply side. Purge section and labyrinth sealing system combine to limit cross contamination to 0.04% of the exhaust air by volume.

6. APPLICATION

Enthalpy wheels integrated commonly to recover energy and cut down size of air-conditioning systems in hotels, auditoriums, super markets etc., are generally avoided while designing systems for hospitals of both problems i.e. due to fear of cross contamination and bacterial carryover.

Eco-freshener reduces the energy required to heat, cool, humidify or dehumidify the air by as much as 90%. Its design reduces the operating cost of the UVAC system to the extent that initial investment is typically returned in energy cost savings in about 6 months existing system.

Specification of ecofreshener

1. Blower motor- power 75w, speed=1350 rpm-02 Nos.

2. Heat recovery wheel-U-150D-01 No.

3. Filters-16x6x2 - 02 Nos.

4. HRW motor-power 5KW , speed=1400rpm-01 No.

5. Blowers-150mm dia-02 Nos.

7. OBSERVATIONS

1. Supply Room Conditions

DBT: 27 ^{o} C

WBT: 21.67 ^{o} C

AH: 207.23 gm /Kg

2. Exhaust Room Condition

DBT: 29^{o} C

WBT: 23.33^{o} C

AH: 268.95 gm/ Kg

Supply Air Cut-out = 10.16 X 15.24 Cm

= 154.83 Sq. Cm

Velocity from Blower = 5.28 m/s

CMM = Area x Velocity

= 154.83 x 10 $^{-4}$ x 5.28 = 0.08175 m^{3} /s

= 4.905 m^{3} / min

Exhaust air cut –out = 30.48 x 5.08 cm

= 154.83 Sq. Cm

Velocity from Blower = 5.28 m/s

CMM = Area x Velocity

= 154.83 x 10 $^{-4}$ x 5.28

= 0.08175 m^{3} /s

= 4.905 m^{3} /min

8. EFFICIENCY CALCULATIONS FOR HEAT RECOVERY WHEEL (HRW)

A) Supply Air Efficiency

SAE = [Supply air CMM (enthalpy difference) x 100] / [Exhaust air CMM (enthalpy difference)]

= [4.905 (95.249 – 74.432) x 100] / [4.905 x (95.249 -70.175)]

= <u>83.02 %</u>

B) Exhaust Air Efficiency,

EAE= [supply air CMM (enthalpy difference) x100] / [Exhaust air CMM (enthalpy difference)]

= [4.905(91.318 – 70.175) X100] / [4.905(95.249 – 70.175)]

= 84.32 %

9. TONNAGE REQUIRED FOR COOLING THE 4.90 CMM (Ambient Air) THROUGH SPLIT CONDITIONER

Temperature of outside air = 35 ^{o} C at 253.5 gm / Kg

Enthalpy = 95.249 KJ /Kg (From psychometric chart)

If we cool air through split A/C dew point, is 12. 22˚C.At this temperature

Enthalpy of cold air is 52.290 KJ / Kg.

Tonnage required for 4.905 CMM {i.e. 4.905x1.2 (standard value of density of air in kg/m^3)}

= [(95.249 -52.290) x4.905x1.2] / 210 = 1.204 TR

NOTE: To cool the 4.905 CMM fresh air tonnage required is

= 1.204 TR

Therefore, the operating cost of the compressor is as follow:

Total tonnage required = 1.204 x 3.5

= 4.214 KJ/sec

So, Cost = 4.214 x 4.5 (where Rs.4.5 is the unit rate of electricity bill)

= 18.96 Rs.KW /hr. say Rs.19 KW/hr.

For 08 working hours = 19x8

= 152 Rs. /Day

For 01 month = 4560 Rs.

10. OPERATING COST TO COOL 4.905 CMM THROUGH ECOFRESH HEAT RECOVERY WHEEL (HRW)

Supply motor-1/4 H.P = 0.1865 KW

Exhaust motor-1/4 H.P = 0.1865 KW

Bed motor -120 W = 0.12 KW

TOTAL KW=0.373+0.12

= 0.493

To operate through the system for 01 hour

=0.493x4.5

=2.2185 Rs.

For 08 hours =2.2185x8

=17.748 Rs. /Day

F0r 01 month =17.748x30

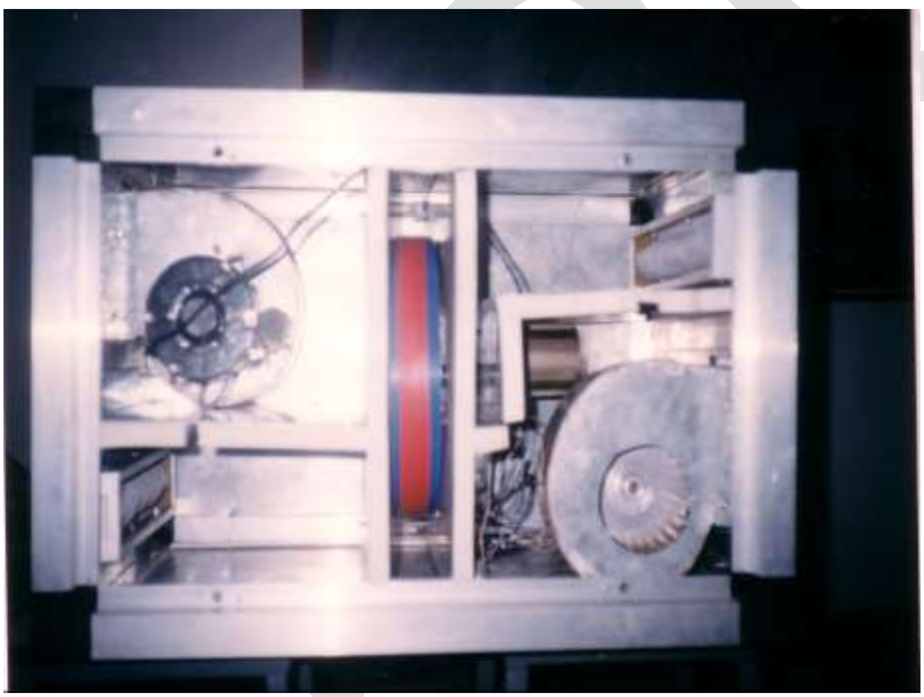
= 532.44 Rs.

Total electricity bill required to cool 4.905 cmm for 0 1 month is Rs. 532.44

11. CONCLUSION

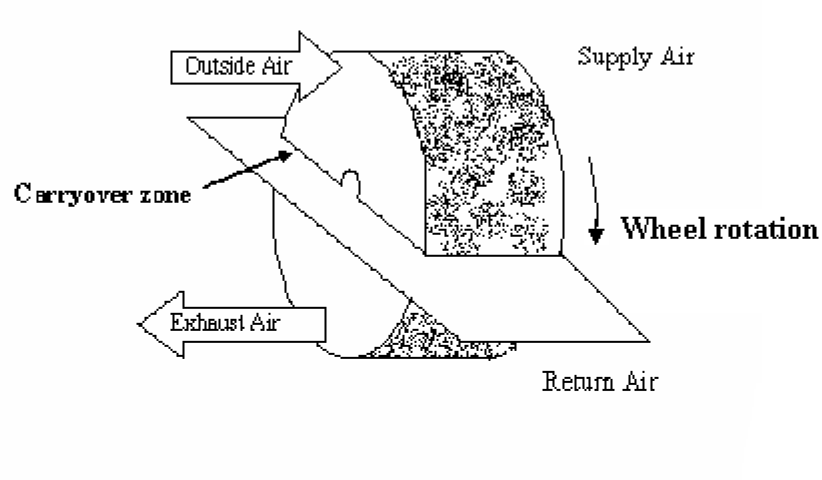
With increased concern for IAQ and the consequent need to take more fresh air in, energy recovery from exhaust has become an important area of attention in HVAC. Among recovery devices, the enthalpy wheel is the most effective and energy saving, particularly in tropical climates, can be substantial. Recent development in the wheel technology has minimized the risks of cross contamination and has made them safe for use in critical application. A wheel has to be evaluated for many considerations other than just its effectiveness and pressure drop. The wheel seal is structurally rigid with minimum deflection under the air pressures of the system. The sealing and purging arrangements must be effective. The type of desiccant used may also be critical in many applications. Exhaust air energy recovery technology provides a valuable opportunity for engineers to reduce the first costs and operating costs of buildings. Owners benefit not only in these initial and annual savings, but may also receive incentives for operating a “green” building in some areas. Use of energy recovery reduces the use of non-renewable resources and promotes a cleaner environment. Therefore, whether mandated by state or local building codes, or not, proper application of energy recovery wheels and heat recovery in general is a win-win proposition. And finally, the cost of installing a wheel must be justified by savings.

(a)

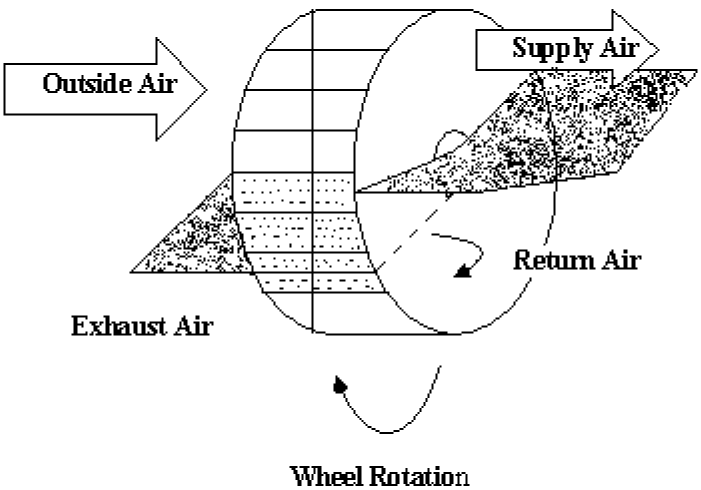


(b)

Fig. 1 (a),(b) - Experimental set- up of ecofreshner



(a)



(b)

Fig. 2 (a) , (b) - Structural diagram of recovery wheel with purge section

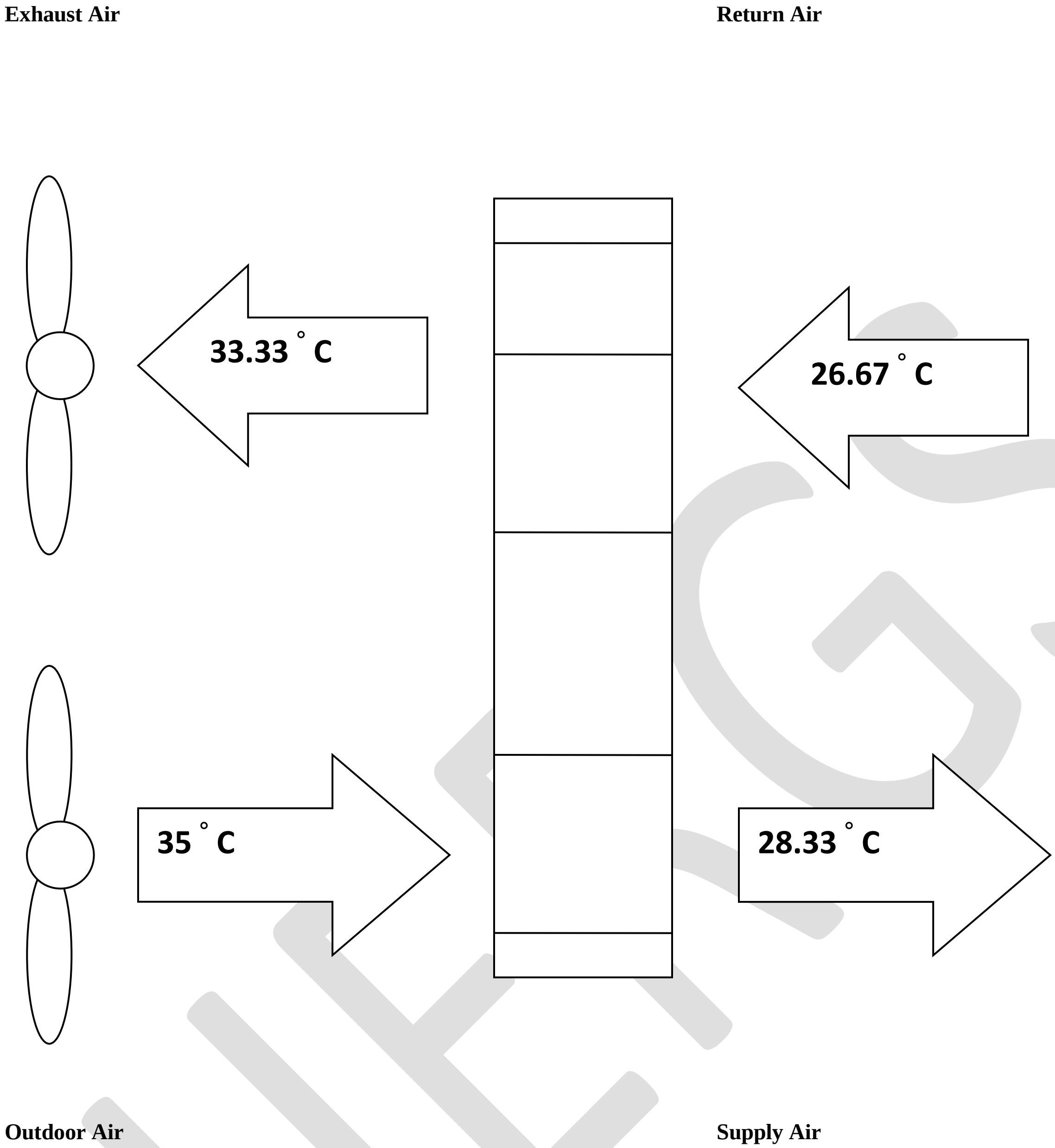


Fig. 3: Principle of operation of recovery wheel

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