PERFORMANCE OF DESICCANT WHEEL IN COMFORT CONDITIONING SYSTEM

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ABSTRACT

Desiccant wheel in air conditioning systems have been considered as one of the most effective process to control humidity of ambient air and reduce the energy consumption. Desiccant wheel air conditioning system do not use any ozone- depleting refrigerant and also intake lesser energy compared to vapour compression system.Removal of moisture from the air represents a considerable portion of the air conditioning load in hot and humid regions. Desiccant air conditioners offer a solution to meet the humidity and temperature requirements of buildings via decoupling latent and sensible loads**.**Desiccant Dehumidification systems remove moisture from the air by using a desiccant; a material which easily attracts and holds water vapor. Desiccant dehumidifiers are especially well-suited for removing moisture from air at a low temperature and low humidity level.

Key Words: Desiccant wheel, Heat recovery, Enthalpy wheel, Thermal Energy and Environment, Humidity.

INTRODUCTION

Recently, there is growing demand for energy saving technologies in buildings due to global warming and environmental impact issue. As a result to this, energy-efficient technologies are becoming more popular amongst researchers and designers. In this regards, to fulfil energy conservation demands, researchers have focused on the development of advance heat or energy recovery with energy-efficient ventilation system. The Aim of this paper/document is to review heat or energy recovery technologies for building applications [1]

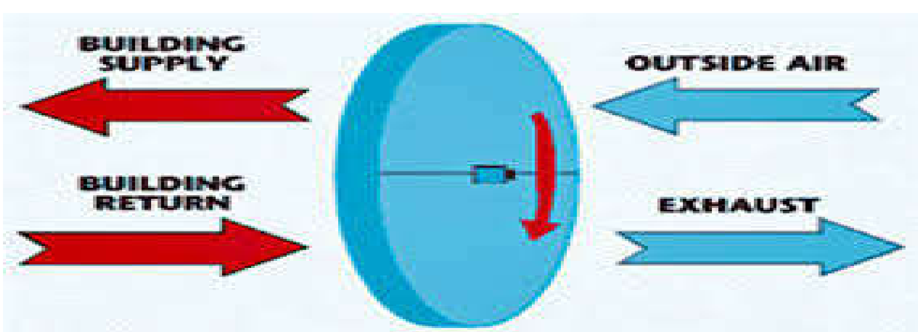

Figure 01- Desiccant wheel

The Developments of these technologies in integrated energy-efficient system such as mechanical and passive ventilation, air conditioning, dehumidification and photovoltaic panel have also been presented Many buildings require substantial amounts of outside air to bebrought in through their ventilation systems. In many cases schools and in other cases it constitutes make up air for contaminated exhaust air (laboratories). Regardless, exhausting expensive conditioned indoor air and replacing it with outdoor air is expensive. Energy recovery devises, like the Enthalpy Wheel, can be incorporated in the design to transfer outgoing temperature and humidity (energy) to the incoming outdoor air.

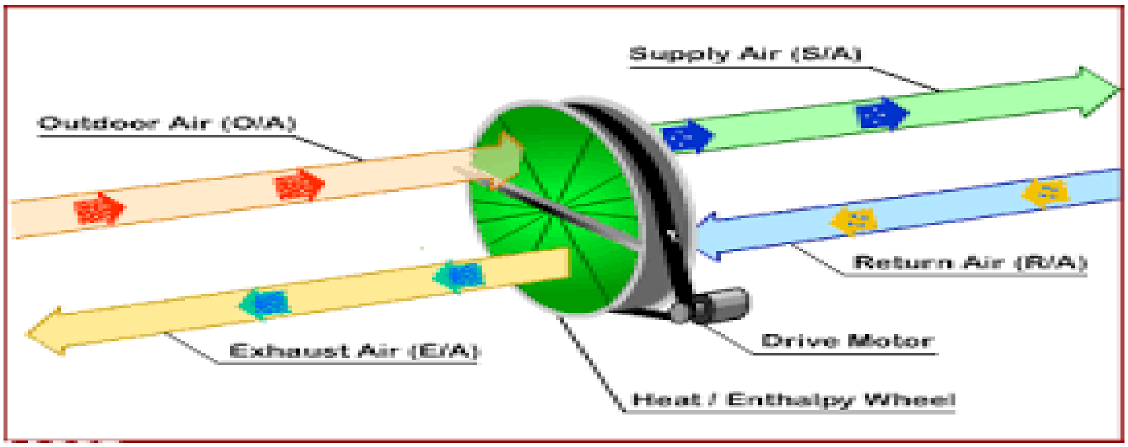

Figure -02 – Supply – Exhaust air flow

A thermal wheel, also known as a rotary heat exchanger, or rotary air-to-air enthalpy wheel, or heat recovery wheel, is a type of energy recovery heat exchanger positioned within the supply and exhaust air streams of an air-handling system or in the exhaust gases of an industrial process, in order to recover the heat energy. Other variants include enthalpy wheels and desiccant wheels. A cooling-specific thermal wheel is sometimes referred to as a Kyoto wheel.However, the system COP of enthalpy wheel-based system is nearly double that of the reheat system. [2] .A thermal wheel consists of a circular honeycomb matrix of heat-absorbing material, which is slowly rotated within the supply and exhaust air streams of an air-handling system. As the thermal wheel rotates, heat is picked up from the exhaust air stream in one half of the rotation and given up to the fresh air stream in the other half of the rotation.

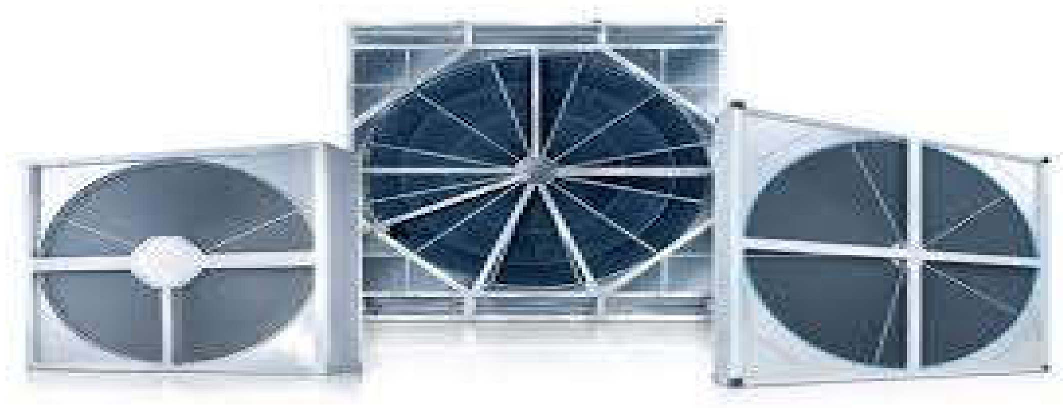

Figure -03- Honeycomb Desiccant Wheel

Thus waste heat energy from the exhaust air stream is transferred to the matrix material and then from the matrix material to the fresh air stream, raising the temperature of the supply air stream by an amount proportional to the temperature differential between air streams, or "thermal gradient", and depending upon the efficiency of the device. Heat exchange is most efficient when the streams flow in opposite directions, since this causes a favorable temperature gradient across the thickness of the wheel. The principle of course works in reverse, and "cooling" energy can be recovered to the supply air stream if so desired and the temperature differential allows[3].

The heat exchange matrix may be aluminum, plastic, or synthetic fiber. The heat exchanger is rotated by a small electric motor and belt drive system. The motors are often inverter speed-controlled for improved control of the leaving air temperature. If no heat exchange is required, then the motor can be stopped altogether. Because of nature of thermal wheels in the way that heat is transferred from the exhaust air stream to the supply air stream without having to pass directly through an exchange medium, the gross efficiencies are usually much higher than that of any other air-side heat recovery system. The shallower depth of the heat exchange matrix, as compared to that, say, for a plate heat exchanger, means that the pressure drop through the device is normally lower in comparison. Generally, a thermal wheel will be selected for face velocities between 1.5 and 3.0 meters per second (4.9 and 9.8 ft/s), and with equal air volume flow rates, gross "sensible" efficiencies of 85% can be expected. Although there is a small extra energy requirement to rotate the wheel, the motor energy consumption is usually very low and has little effect upon the seasonal efficiency of the device. In addition, the ability to recover "latent" heat, depending upon the materials and coatings used, can improve gross efficiencies by 10–15% [4]

A desiccant wheel is very similar to a thermal wheel, but with a coating applied for the sole purpose of dehumidifying, or "drying", the air stream. The desiccant is normally silica gel. As the wheel turns, the desiccant passes alternately through the incoming air, where the moisture is adsorbed, and through a “regenerating” zone, where the desiccant is dried and the moisture expelled. The wheel continues to rotate, and the adsorbent process is repeated. Regeneration is normally carried out by the use of a heating coil, such as a water or steam coil, or a direct-fired gas burner. Thermal wheels and desiccant wheels are often used in series configuration to provide the required dehumidification as well as recovering the heat from the regeneration cycle. [5]The enthalpy wheels are available in several sizes and configurations and are being integrated in small, compact standardized units for installation in hotels, restaurants, discotheques, bars, pubs, offices, nursing homes, as unitary systems and are being sold as energy saving fresh air preconditioners to handle smaller loads [6]

DESICCANT's WHEEL MATERIAL& METHOD

The enthalpy wheel results depend highly on the type of a desiccant that is chosen. One of the most commonly used desiccants is silica gel. It has excellent water absorbance characteristics and can perform well in acidic environments. Stainless steel, aluminium, ceramic, and synthetic materials can be used too. Aluminium, for example, expands when it is heated, and carries that energy around with it as the wheel rotates. When it hits a cooler airstream, the aluminium contracts and the heat energy is released into the air. Enthalpy wheels with the familiar honeycomb matrix were introduced in US in the mid-1960s and now days widely used in Dubai, UAE and India.The medium was asbestos paper impregnated with lithium chloride (LiCl). However, because of inherent absorption properties ofasbestos and LiCl, these rotors had short lives. Because of environmental concerns. In the mid-1970s, two new enthalpy wheel designs were introduced; one an oxidized aluminum wheel and the other is a silica gel wheel on an aluminium matrix. Oxidized aluminum wheels are made of corrugated aluminum foil wound on a mandrel. By dipping this assembly into a bromide solution, a layer of oxidized aluminum, a known enthalpy, is formed. However, they are weak structurally and suffer from enthalpy migration problems. The other enthalpy wheel design introduced in the 1970s uses silica gel bonded to an aluminum matrix substrate. This enthalpy wheel is still widely used. From the 1980s, considerable advances have been being made in the fabrication of silica and other compounds for the semiconductor industry. A derivative of these innovations was the development of molecular sieves—synthetic zeolite desiccant that could be designed at the molecular level.

At the same time, manufacturing processes developed permitting the bonding of a breathable layer of enthalpy to metal or plastic surfaces. These technologies made molecular sieve enthalpy wheels, currently a very common type, possible. Silica Gelis a highly porous solid adsorbent material that structurally resembles a rigid sponge. It has a very large internal surface composed of myriad microscopic cavities and a vast system of capillary channels that provide pathways connecting the internal microscopic cavities to the outside surface of the sponge. Silica gel enthalpy wheels transfer water by rotating between two air streams of different vapour pressures. The vapour pressure differential drives water molecules into or from these cavities to transfer moisture from the more humid air stream to the drier air stream.

The most basic configuration or method of a desiccant wheel consists of simply an adsorbent-coated wheel rotating between two air streams, with a sensible cooling coil (or evaporator) to remove the sensible load. The rotation speed of the wheel is generally low enough (~1 rotation per minute) that the sensible energy transferred from the regeneration airstream to the process airstream is small. I recently used these kind of recovery wheel while working in a project with CPWD , New Delhi. However, the water vapor adsorbed onto the desiccant surface in the process stream undergoes a phase change from vapor to an adsorbed quasi-liquid (an absorbed substance generally has internal energy somewhere between its solid and liquid forms at the given temperature). The release of that latent heat raises the process air temperature, and in practice this sensible heat gain is roughly equal to the latent energy removed from the process stream. In this sense the desiccant wheel is a constant enthalpy device that exchanges latent energy for sensible energy, simultaneously dehumidifying and heating the process airstream.Even in this most basic configuration, a desiccant wheel can be very helpful. Since the process stream is dehumidified already, the evaporator/cooling coil need only provide sensible cooling. Thus it only has to cool the process air to the desired dry bulb temperature, rather than all the way to the (much cooler) desired dew point temperature, improving the cooling system COP and capacity.

RESULT & DISCUSSION:

The most widespread application of enthalpy (heat) wheels is for preconditioning fresh outside air before it is introduced to a building. The system can easily be tapped into an existing ventilation system. A portion of the air that would normally be recirculated through the system is exhausted through the wheel and fresh air is introduced into the building in its place. Operating in virtually any climate zone, a single desiccant wheel operated with just a small motor to rotate the wheel can deliver fresh air on a year round basis that is generally within 3-7 degrees and 10% RH of inside conditions, regardless of what outside conditions are (without any type of mechanical cooling or heating). The cost to provide high levels of fresh air ventilation becomes minimal compared to the normal heating cooling requirements of the building. The potential benefits are numerous. Current standards for outside air ventilation can be met or exceeded with minimal energy cost impact on the building.

Incoming outside air is dehumidified by the desiccant wheel, allowing the rest of the ventilation system to run dry. As a result, indoor humidifies are maintainable well below the conditions that would favour the growth of mould, mildew and other microbial contamination. The need for cooling capacity that normally would be required to dehumidify and cool outside air is eliminated. This is typically 30 to 50% of total system capacity depends on space where air conditioning system is being used. In most cases, the cost of the energy wheels is almost less than the cooling capacity it is replacing. The first cost of a building's cooling system can actually be reduced with a wheel system.Many utilities charge extra for the electrical energy used during peak cooling periods. A wheel system can significantly reduce peak demand charges. In the winter, wheel systems can preheat and humidify incoming cold dry air. Because the system is capable of recovering 80% of the heating or cooling energy that is exhausted from a building, the cost of fresh air ventilation is reduced. Annual savings can range from US$1 to $2 annually for each cfm of fresh air ventilation.

It is cleared that the cost of the system is similar to the cost of conventional heating and cooling capacity, the system has an immediate payback. In retrofit applications, where cooling capacity is already in place, payback would typically take place in1 to 3 years.

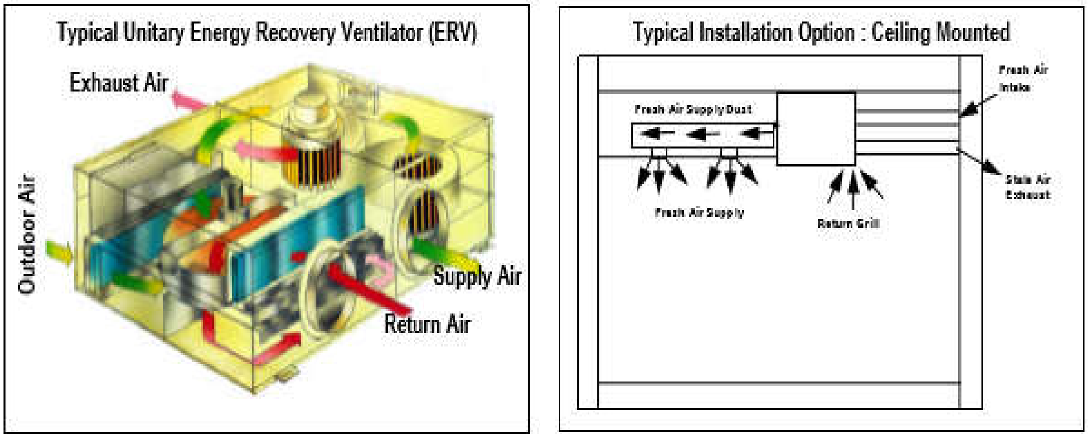

Figure -04 – Typical Unitary Energy Wheel

The TFA incorporating Energy Recovery Devices is also known as Energy Recovery Ventilators or Fresh Air Pre-conditioners. These Treated Fresh Air Units incorporating Energy devices or TFAs as they are commonly known as, provide many answers to the challenges faced by the designers today. They meet need of the millennium. TFAs are typically used for treating/ preconditioning ventilation air i.e. fresh air as well as far achieving acceptable IAQ, Humidity control, Energy conservation/efficiency, and in the process reducing the building envelope. TFAs incorporating Energy Recovery differ in many ways from the conventional system. Some major areas of difference are listed below : Two tier system handling exhaust and supply air stream i.e. Exhaust air section , Supply air section , Inlet damper section , Filter section both for exhaust and supply , Rotary Heat Exchanger section , Cooling section (optional) and Supply air blower / motor section etc.

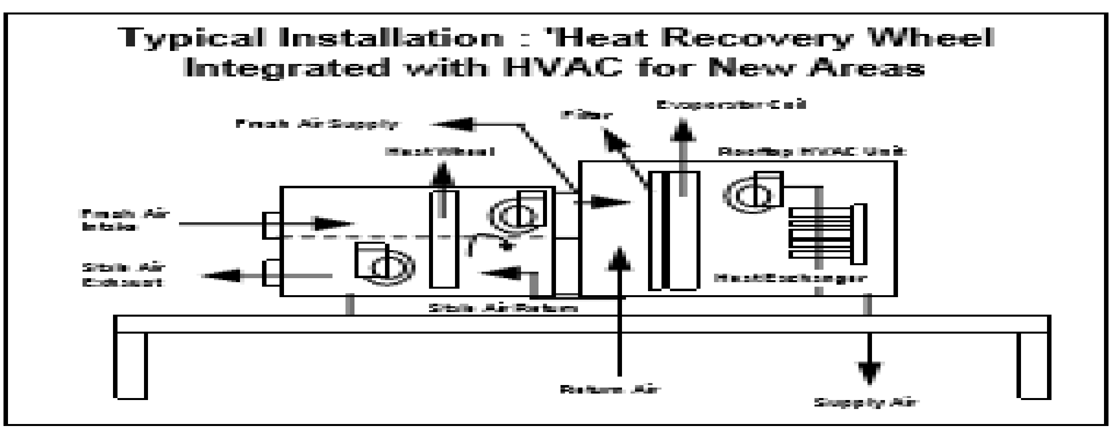

Figure -05 Installation of heat recovery wheel

The TFA incorporating Energy Recovery device exchanges the energy from the exhaust air to incoming fresh air. The exhaust air drawn through the exhaust section is passed through half section of the rotary heat exchanger, where it gives up its energy to the exchanger. The filtered supply air passes over the other half of the rotating heat exchanger, in the supply section and exchanges the energy. This, pre-treated air passes over a cooling (optional) coil, for further, before it is supplied into the area. These TFAs incorporates the 'Eco-fresh' Rotary heat recovery wheels which gives it an overwhelming advantage over conventional systems. Some benefits of using the Eco fresh wheels are as in sequence that istypical recovery: 80% ,No cross contamination between exhaust and fresh air , Selective adsorption: special grade molecular sieve desiccant allows only water molecules to pass through it rejecting all other pollutants. Two tier system handling exhaust and supply air stream, Inlet damper section , Filter section both for exhaust and supply, bag filters for dusty application

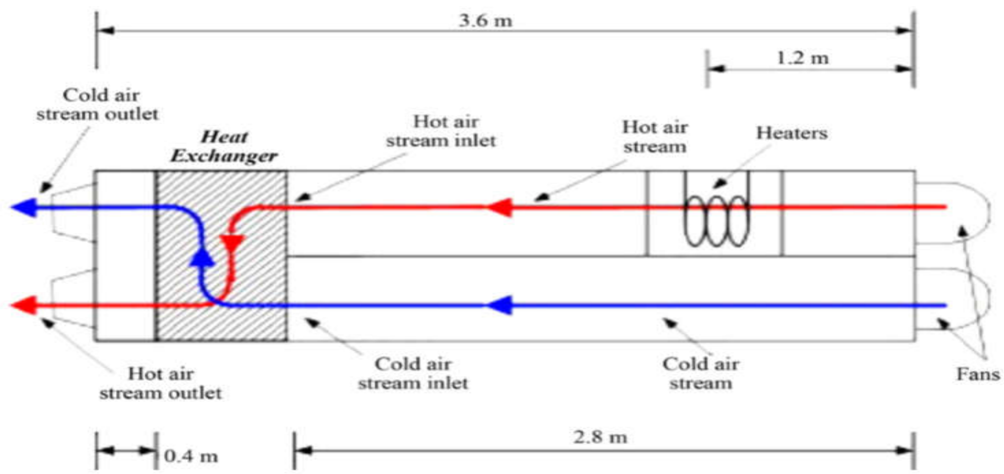

Figure -06 Flow diagram of air travel

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

Table 01: below mentioned and Comparison of Ton of Refrigeration with and without Heat Recovery / Desiccant 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**

TABLE -01- Tabular format

From the above comparison it is clear that using heat recovery wheel 46.02% of energy is recovered. As above table heat load calculation is done through HAP software and found that heat load requirement is 251.7 TR as normal and heat requirement is 135.86 TR , when heat recovery wheel is being installed in air conditioning system.

CONCLUSION

An enthalpy wheel or desiccant wheel integrated air-conditioning system is studied in this article. The desiccant wheel enhances the dehumidification of supply air thereby increasing scope for low humidity air-conditioning. The dew-point temperature of the supply air is lowered by about 2 degree Celsius and the COP is marginally lowered by about 5% compared to the conventional system.

The testing and performance optimisation of a new internally cooled desiccant wheel that has around 64% of its face area used for coating desiccant and uses 24°C chilled water as cooling source. For inlet air conditions of 30°C, 60% RH at 2m/s, a regeneration air temperature of 60°C at 2m/s, and cooling water at 24°C and 4.0L/min, the outlet temperature of the supply air was only 4°C lower than that from an adiabatic wheel and 8°C higher than the inlet temperature. Our modelling results confirm that the lower-than-expected performance is mainly caused by the high average heat-transfer resistance between the air in the desiccant layers inside the tubes and the cooling water. By decreasing the number of desiccant layers inside the tubes to no more than two, an optimised design is estimated to achieve close to isothermal dehumidification performance with outlet air conditions of 30°C for temperature (same as the inlet temperature) and 11.7g/kg for absolute humidity (1.5g/kg lower than that of the conventional desiccant wheel [7]

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