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Solar Air-Conditioning using Desiccants

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Abstract –*India receives adequate solar radiation for 300 days, making it to 3,000 hours of sunshine equivalent to over 5,000 trillion kwh. The National Institute of Solar Energy in India determined the country's solar power potential at about 750 GW, but less than 0.5% has been used till date. Air-conditioning is one of the major consumers of electrical energy. The demand can be expected to increase because of changing working times, increased comfort expectations and global warming. Solar cooling/refrigeration is therefore, the most relevant application for our country, especially in view of the rapidly increasing demand for energy.*

Key Words: **Air-Conditioning, Desiccant, Adsorption, Absorption, Compression, Dehumidification**

1. INTRODUCTION

Solar air-conditioning is basically process of converting solar thermal energy(heat) into conditioned air. It can be operated with green resources of heat as backup resources when solar radiation is unavailable. It is eco-friendly as well as energy-efficient. A desiccant dehumidifier is a tool for controlling humidity levels for conditioned air spaces. Desiccant systems work in conjunction with conventional air conditioning systems to dehumidify the air. Desiccant material attract moisture due to difference in vapor pressure. Desiccants can be in the form of a solid or liquid and have been identified to be appropriate as a component of commercial heating, ventilation and air conditioning (HVAC) systems.

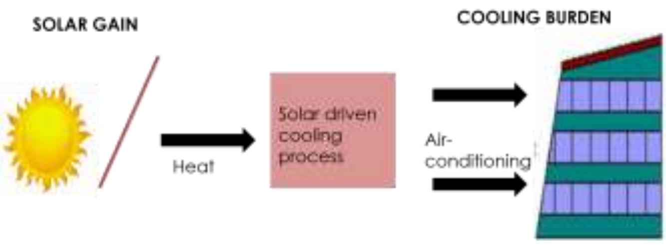

Fig -1: Basic concept of solar air-conditioning

1.1 Comparison between Conventional and Solar Air-Conditioning

Conventional air conditioning consumes electricity required to run the compressor for cooling. When a liquid/gas changes its state, it takes or extract heat. At lower pressure, state changes at lower temperature. It makes use of compressor to increase the gas pressure, forcing the gas to become liquid again by the use of a condenser coil.

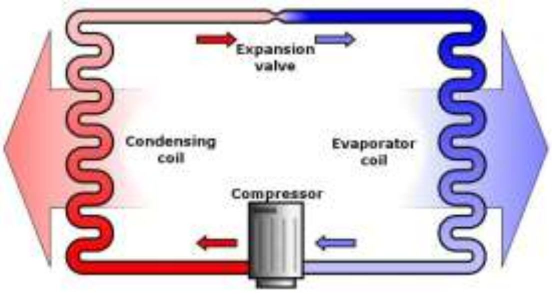

Fig -2: Conventional Air-Conditioning system

On other hand, Solar air-conditioning uses the sun energy as the heat source to produce the energy to run the cooling process. Gas gets compressed when heated. After compression, gaseous refrigerant is heated up in the solar panel up to 90°C. The solar heat from the sun is used to superheat the refrigerant for it to begin changing the state. It allows more of the refrigerant to change its state back to liquid faster and at the same allows the transformation of more liquid into the metering device.

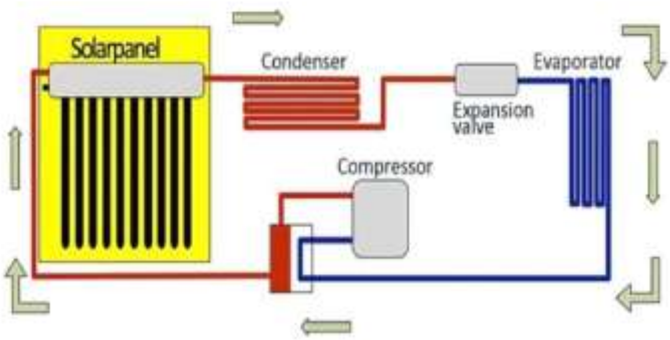

Fig -3: Solar Air-Conditioning process

1.2 Working

Desiccants are chemicals with great affinity to moisture. Desiccants are substances that attract water-vapor molecules from the air via an adsorptive or absorptive process. Adsorption refers to a desiccant that does not change phase as it collects airborne moisture. Most adsorbents are solids; familiar examples include activated alumina, silica gel, and zeolites (molecular sieves). In absorption, collecting moisture changes the desiccant physically or chemically. Most absorbents, such as solutions of lithium chloride or tri ethylene glycol in water, are liquids. Dehumidification is said to occur when the vapour pressure of the surface of the desiccant is less than that of the surrounding air and it continues until desiccant material reaches equilibrium with surrounding air. Regeneration of this desiccant is said to occur when the vapour pressure of the desiccant is larger than that of the surrounding air.

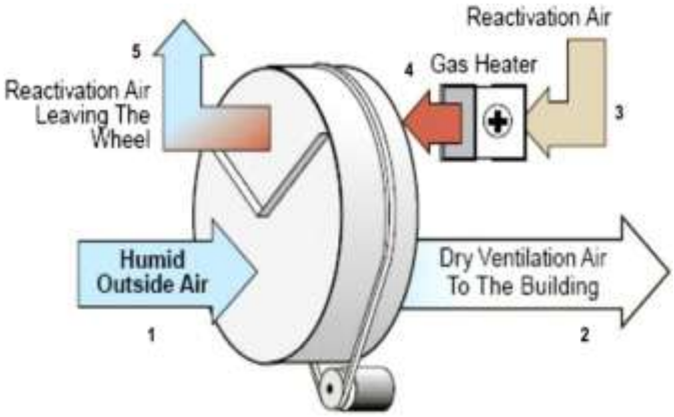

Fig -4: Working of Desiccant wheel

The cooling process occurs in two cycles:

Cooling air cycle- Hot and humid air passes over desiccant wheel where vapor pressure is lower than the ambient air, so it adsorbs the humidity from the air. This hot and dry air is now made to pass through cooling unit. The cool dry air is through evaporate cooler to increase the humidity of totally dry air up to a required level which is used to condition the space.

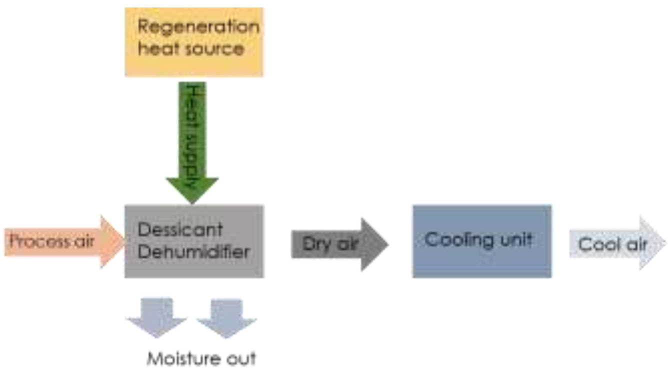

Fig -5: Cooling air cycle

Desiccant recovery cycle-

Ambient air is introduced at stage 1. The air is dried up as it passes over desiccant resulting in hot and dry air as it exits the dehumidifier at stage 2.

- The increase in temperature is due to heat of condensation of water vapor where moisture is removed by the desiccant material.
- Thus hot and dry air is cooled sensibly as it passes through the rotary regenerator and is allowed to transfer much of the heat to the return air stream.
- Now cool and dry process air at stage 3 is further evaporate cooled and humidified by the process side evaporative cooler at stage 4 and it is then introduced to the conditioned space through the supply duct.
- Then cool air provides the comfort condition necessary to meet the building cooling demands.
- After removing the building sensible and latent cooling loads, air returns to the desiccant air conditioner through the return ducts and in again evaporatively cooled at stage 6.
- Here it passes through the rotary regenerator and picks up the heat from the process air to attain the warm and damp state 7.
- The air then passes over the hot water coil, which circulate hot water obtained from the solar auxiliary heater combination.
- The warm damp air is then heated up to the required regeneration temperature of the desiccant material and hence very hot and humid air exits at stage 8.
- The hot air passes over the desiccant wheel to regenerate the desiccant and is sufficient enough to do this process of regenerator in dehumidifier matrix of silica gels.
- Finally, Very warm and humid air exits at state 9 where it is exhausted to the surroundings.

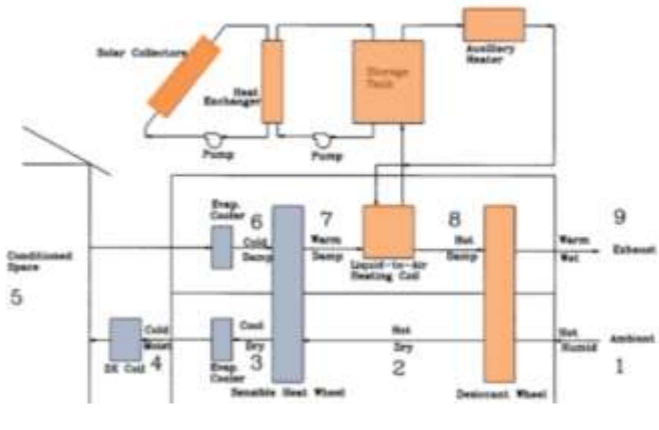

Fig -6: Desiccant recovery cycle

1.3 Analysis

Assumptions: 1 ton AC with a daily 8 hour use with 1.5KW/h and 1 kwh being sold at 5 rupee.

Electric AC

If a normal ac of 1 ton is used for average 8 hrs per day, Its input power would be 1500W and the electricity consumption would be

=8 *1500 =12000w=12kwh per day.

Therefore, it would cost 12*5=60/- per day, which makes it **60*30=1800/- per month.**

Initial Cost - Rs 20,000 (Including Taxes & Installation);

Running Costs if used for 8 hours for 30 days - Rs 1,800/ month or Rs 21,600/ year or Rs 4,32,000 for 20 years.

Total: 20,000 + 4,32,000 = Rs 4,42,000 = **Rs 4.5 Lakhs approx.** (maintenance cost not included).

Solar AC

The solar air conditioner would use only 900 W or about 40% of electricity, which means 900W x 8 = 7.2 KWH / day, Therefore, it would cost 7.2*5=36 Rs / day which makes it **36*30=Rs 1080/ month.**

The total saving 12-7.2= 4.8 KWH / day

=4.8x30 KWH/month = 144 KWH /month

Therefore, total amount saved = 144*5 = Rs 720/month.

Initial cost - Rs 75,000 (Including Taxes & Installation);

Running Cost if used for 8 hours for 30 days - Rs 1080 / month, Rs 14,400 / year or Rs 2,88,000 for 20 years.

Total: 75,000 + 2,88,000 = Rs 3,63,000 == **Rs 3.5 Lakhs approx.**(maintenance cost not included).

3. CONCLUSION

Conventional air-conditioners running at highest temperatures of the day contribute to power grid demands leading to outages. Solar air-conditioners offer environmental benefits including load shifting during peak usage, reduced electricity costs and reduced greenhouse gas emissions. If the system provides both comfort cooling and dehumidification for the space, investigate the benefits of using a desiccant when the required supply air dew point is below 50 °F. Reduction in energy requirement for HVAC system for various desiccant application are 30-60% for large office buildings (1,80,000 sq.ft.), 20-35% for Medium sized office buildings, 50% for Small commercial buildings (2000 sq.ft.) and 25-30% for Supermarkets (30,000 sq.ft.).

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