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Experimental Investigations on Solid Desiccant Cooling System

Chandrashekhar Kumar[1], Prof. Ranjeet Arya[2]

[1]M Tech Scholar, [2]Assistant Professor,
[1,2]Department of Mechanical Engineering,
[1,2]Corporate Institute of Science & Technology, Bhopal, Madhya Pradesh, India

ABSTRACT

Space cooling has become a necessity in present climatic conditions. A considerable fraction of today's energy consumption is due to air-conditioning of buildings, involving both heating and cooling. Maintaining comfortable indoor conditions in office building and industrial environments, it results higher energy bills due to heavy dependency on electrically operated air conditioning systems. Energy cost and environmental concerns force designers to find sustainable solutions. In order to explore ways and means to improve the energy efficiency and alternative energy resources, a feasibility study was conducted for combined cooling, heating and power system suitable for a tropical country This research has been conducted to evaluate the performance and applicability of desiccant cooling systems under Indian climatic conditions. The system has been analysed experimentally for the month of March and April. The performance of solid desiccant wheel at different rph (rotation per hour) was experimentally investigated in the month of March. The optimum speed for maximum value of average adsorption and regeneration rates was found to be 40 rph of both process and regeneration sectors. The variation of *COP* for the experiment has been analyzed with day time. It has been found that the *COP* ranges between 0.43 - .54 for the months of March.

OBJECTIVE

The aim of the experiments is to investigate the performance of a solid desiccant air conditioning system with a rotary desiccant wheel.

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INTRODUCTION

In the present scenario, there is a great need of better air conditioning systems as environment conditions are changing and living standard of society is improving day-by-day. As we know that, air conditioning systems have accounted a large part of energy consumption in the society worldwide.

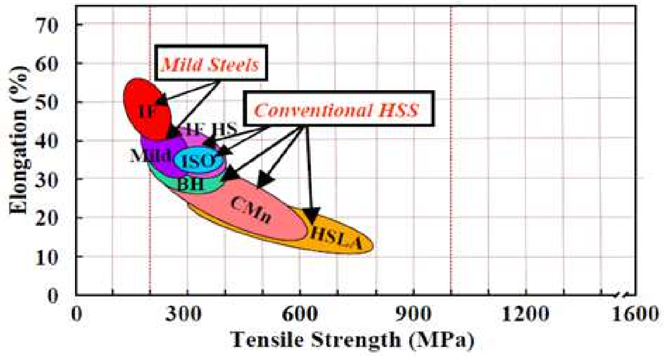
Desiccant cooling system is more attractive alternative than conventional vapour compression systems due to its advantages of utilizing low temperature energy and providing an environment conscious operation. Solid desiccant cooling method has following advantages.

LITERATURE REVIEW

In this chapter, detailed literature review related to the development of AHSS is given, with special emphasis on the third generation of AHSS. This review covers all the developmental stages of all three generations of AHSS particularly concentrating on the strength levels, industrial viability, limitations, compositions required and the mechanisms involved for achieving the desired properties.

High Strength Steel (HSS)

This category of automotive steel contains bake-hard enable steels (BH), carbon-manganese steels (CMn) and high strength low-alloy steels (HSLA). The main strengthening mechanisms in these steels are solid solution hardening. In the bake-hard enable steels (BH) the processing is done in such a way that carbon is taken out of the solution during paint baking cycle. In this way, these steels are made softer and more formable for the press working operations. However, it becomes more strengthen after being put in service due to work hardening during forming. Carbon-manganese (CMn) steels are mild steel solid solutions, which are strengthened by adding manganese as alloying element. High strength low alloy (HSLA) steels are actually CMn steel, which are strengthened by the addition of micro alloying elements such as vanadium, titanium or niobium. Among all these HSS steels, HSLA was the first commonly used HSS in automotive industries during 90s. These steels are still used in many vehicles, particulalrly in energy absorbing areas. Fig 2.1.1 shows elongations and strength banana curves of mild steel and conventional HSS, indicating a strength-elongation product of less than 15000 MPa%. At present, AHSS is replacing these HSS in energy absorbing applications areas, because they can absorb more energy than these HSS due to high strength [5]. Further, there is a continued efforts from the researchers all over the globe to enhance the strength-elongation product and aim a achieving this value to be around more than 50000 MPa%. There requires to be a good compromise between strength and ductility so that we can obtain high strength as well as high ductility together.



Shelpuk and Hooker (1979) started the development of desiccant technology under the scheme of US solar heating and cooling program. The basic operating principle of dehumidifier for open cycle adsorption system has been explained in the work.

Collier et al. (1981) described that solid desiccants could be regenerated using low grade energy at different levels of temperature. Temperature was found to be depended on the desiccant materials which were being used for the regeneration.

Barlow (1983) also worked on the same methodology to find out the efficient air conditioning method.

Sheridan et al. (1985) described theoretically solid desiccant cooling system as an effective system than conventional vapor compression systems.

Shrivastava and Eames (1988) presented a review study of adsorbents and absorbents used in various investigations on solid – vapor adsorption heat pumps.

Belding and Delmas (1997) explained and investigated the indirect evaporative cooler incorporated in novel type desiccant cooling system.
Parametric Studies

Jurinak et al. (1980) investigated the applicability of desiccant cooling system in meeting residential cooling loads by dynamic simulation using the computer program TRANSYS. Further in 1984 evaluated the performance of open cycle desiccant air conditioners for residential application and compared it with vapour compression air conditioning system on the basis of cost and energy. They also suggested that when these systems were coupled with solar energy to regenerate the desiccant wheel, they performed better than the conventional air conditioners

Schen and Worek (1996) suggested that a solid desiccant absorber can be optimally designed on the basis of first and second law of thermodynamics.

Panaras et al. (2007) proposed a methodology for the definition of the system's achievable working range under specific set of space requirement.

Kanoglu et al. (2013) developed a procedure for the energy and exergy analysis of open cycle desiccant cooling system and that procedure has been applied to an experimental unit operating in ventilation mode with natural zeolite as the desiccant.

Experimental procedure
The aim of the experiments is to investigate the performance of a solid desiccant air conditioning system with a rotary desiccant wheel. An experimental system has been designed and fabricated. The regeneration and the adsorption rates of desiccant wheel for producing the dry air have been experimentally investigated. In this chapter, an experimental study on the feasibility of solid desiccant air conditioning system with evaporative cooler has been carried out. The regeneration and the adsorption rates at fixed air flow rate & at different direction of rotation for desiccant wheel are analyzed for the climatic conditions of IIT (PATNA).Wheel effectiveness for regeneration sector and for adsorption sector has also been studied in this chapter.

The schematic and actual experimental set-up side and front view of solid desiccant dehumidification cooling system has been shown in the Figure 3.1, 3.2 and 3.3 respectively.

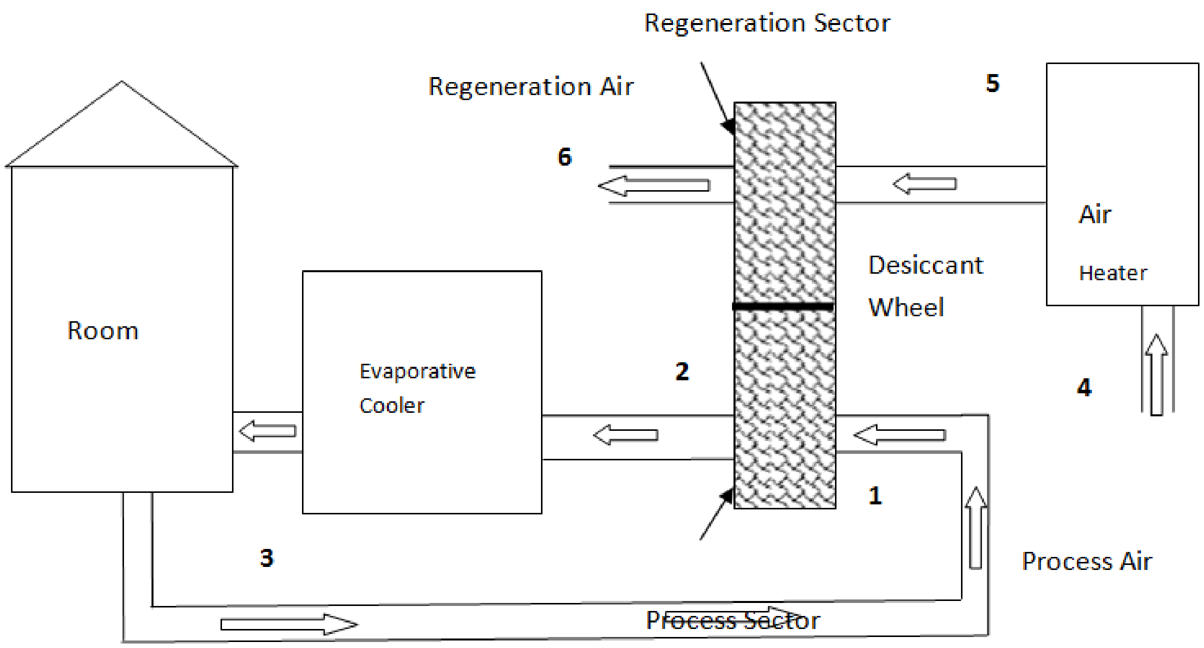


Figure 3.1: Schematic of the experimental set-up

The main parts of the proposed system are shown in the schematic (Figure 3.1) which are,

- Rotary desiccant wheel,
- Evaporative Cooler,
- Air Heater
- Pannel Fan
- Pump

Result and Discussion

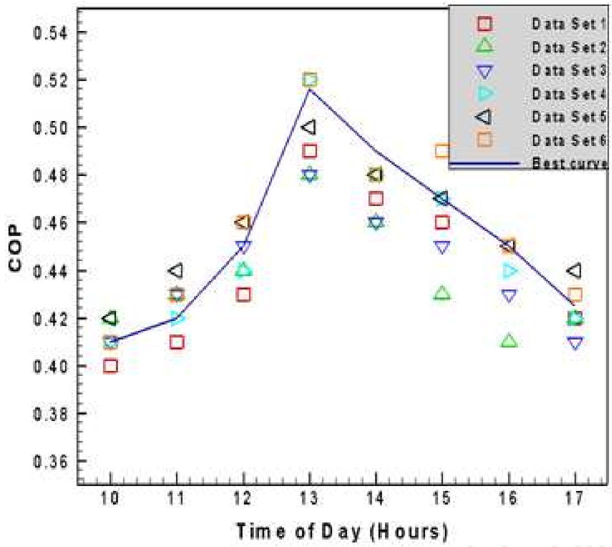


Figure 4.1: Variation of *COP* with Time of Day for the different sets of reading

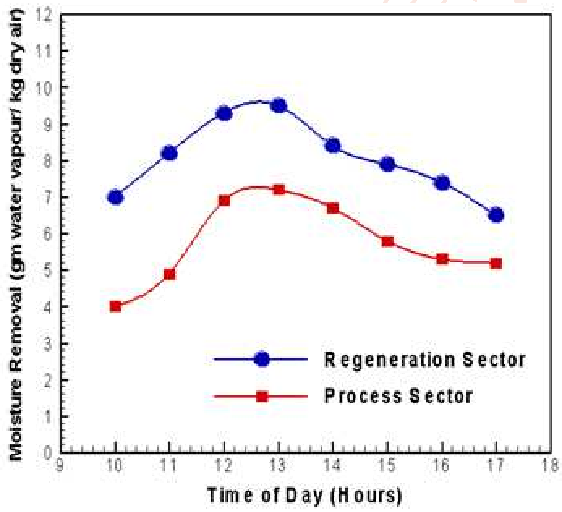


Figure .4.2: Variation of Moisture removal with Time of day for 10th March

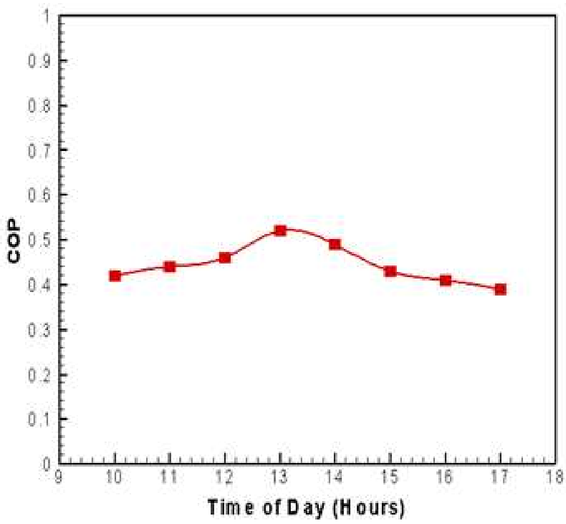


Figure 4.3: Variation of *COP* of the system with Time of day for 10th March

CONCLUSIONS

The main objective of the present research work was to explore the feasibility of solid desiccant dehumidification system for typical hot and humid climatic conditions of IIT PATNA. Major thrust in this work has been given to the solid desiccant dehumidifier due to its advantages of having lower regeneration temperatures and its capability to be driven by renewable energy. The main conclusions emerging from the present work are:

The performance of solid desiccants was experimentally investigated for both adsorption as well as regeneration processes in the Indian climatic conditions. It has been found that effectiveness of wheel in regeneration process was higher.

The performance of solid desiccant wheel at different rph was experimentally investigated in the month of March. The optimum speed for maximum value of average adsorption and regeneration rates was found to be 40 rph of both sectors.

The performance of the system for wheel effectiveness for process sector and regeneration sector was analysed. Wheel effectiveness was higher during solar noon for all data sets for March and April.

The moisture removal capacity of the experimental system has been analysed for process Sector and regeneration sector for the time of day during March and April.

The variation of *COP* for the experiment has been analysed with day time. It has been found that the *COP* ranges between 0.43 - .54 for the months of March.

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