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Regeneration of Soild Desiccant by Solar Parabolic Dish Collector in India: An Experimental Analysis

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Abstract: Recent years we have seen public interest in issue related to energy saving and concern for the environment. Due to the problem associated with the use of fossil fuel, alternative source of energy have became important and relevant in this cut throat competition. These sources, such as the sun, wind, ocean wave can never be exhausted and are so called them renewable energy source. They also have known as non convectional sources of energy because it cause very less emission and are available locally. They are viable sources of clean and limitless energy. The approach was to consider various aspects ranging from the analysis of the current energy consumption and the state of possible installation of a solar parabolic dish collector and their different uses. Also purely reduction in energy consumption and the optimization of current energy consuming equipment It is commonly assumed that dish type solar pressure cooker save energy and make a nutrient rich food. The energy concentration of dish solar collector has rarely been analyzed including their embodied energy. The energy provided by the dish collector has never integrated with regeneration of desiccant. The approach has been used to develop a parabolic dish collector integrated with the regeneration of desiccant material.

Keywords: Solar Parabolic Dish Collector (SPDC), Desiccant, Regeneration, Solar Energy.

I. INTRODUCTION

Energy is a central part of every human beings daily life either it is in the form of chemical energy (food), thermal energy (heat), or electricity. We all depend on a constant and reliable supply of energy - for our homes, businesses and for transport. But have you ever thought about the source of the energy you use? The world's primary energy sources consist of fossil fuels such as oil, natural gas and coal. The majority of the UK's electricity comes from burning fossil fuels (e.g. coal, oil and gas) which is a major contributor to climate change. The mix of fuel sources has changed significantly in the last 50 years. In 1950, about 90 per cent of our electricity came from coal; but today, coal accounts for only about 33 per cent. Gas now provides a large proportion, with oil and nuclear making up the rest and renewable energy accounting for only about 3.5 per cent. Unfortunately, combustion of fossil fuel release carbon dioxide (CO2) and other green house gases, as well as pollutants that have contributed to environmental problem such as global warming, air and water pollution and other damage to Earth eco system formatter will need to create these components, incorporating the applicable criteria that follow.

A. Parabolic Dish Collector

A parabolic dish collector is a point-focus collector that tracks the sun in two axes, concentrating solar energy onto a receiver located at the focal point of the dish. The dish structure must track fully the sun to reflect the beam into the thermal receiver as shown in figure 1. For this purpose tracking mechanisms are employed in double so as the collector is tracked in two axes. The receiver absorbs the radiant solar energy, converting it into thermal energy in a circulating fluid. The thermal energy can then either be converted into electricity using an engine-generator coupled directly to the receiver, or it can be transported through pipes to a central power-conversion system. Parabolic-dish systems can achieve temperatures in excess of 1500°C. Because the receivers are distributed throughout a collector field, like parabolic troughs, parabolic dishes are often called distributed-receiver systems.

- Because they are always pointing the sun, they are the most efficient of all collector systems.
- They typically have concentration ratio in the range of 600–2000, and thus are highly efficient a

thermal-energy absorption and power conversion systems.

- They have modular collector and receiver units that can either function independently or as part of a larger system of dishes.

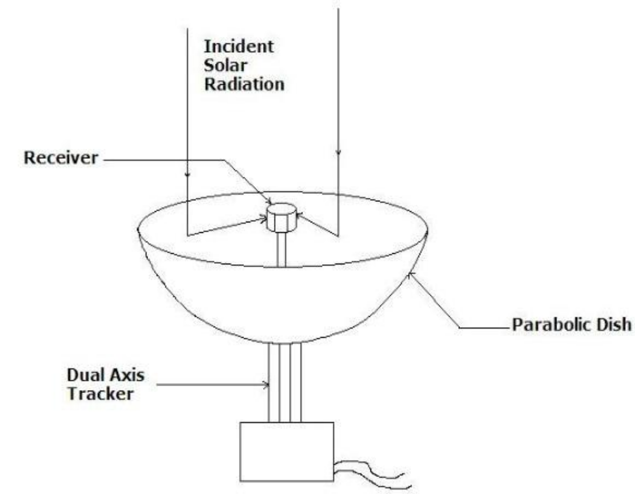

Figure 1: Parabolic dish collector.

Parabolic Dishes Have Several Important Advantages:

In this work we use a point concentrator type solar collector, which concentrates all the direct and diffuse radiation falls on the spherical dish of the reflector to the small absorber area of the collector. The concentration ratio of the parabolic dish collector is very high than the other type of solar collector. The temperature of the absorber is very high up to 500°C. This high temperature of the absorber is due its black surface and it is suitable to regenerate the desiccant material without the use of any high grade energy. The desiccant is regenerate only due to the high temperature without any hot air flow through them. The solid desiccant is further used to produce dry air.

B. Desiccants

Many materials are desiccants; that is they attract and hold water vapor. Wood, natural fibers, clays, and many synthetics attract and release moisture like commercial desiccants do, but they lack the holding capacity of some special desiccant materials. For example, woolen carpet fibers attract up to 23 % of their dry weight in water vapor, and nylon can take up almost 6 % of its weight in water. In contrast, a commercial desiccant takes up between 10 and 1100% of its dry weight in water vapor, depending on its type. and the moisture available in the environment . Furthermore, commercial desiccants continue to attract moisture even when the surrounding air is relatively dry, a characteristic that other materials do not share. All desiccants behave in a similar way in that they attract moisture until they reach equilibrium with the surrounding air. Moisture is usually removed from the desiccant by heating it to temperatures between 48.8◦C and 260 ◦C and exposing it to a scavenger airstream. After the desiccant dries, it must be cooled so it can attract moisture once again. Sorption refers to the binding of one substance to another. It always generates sensible heat equal to the latent heat of water vapor taken up by the desiccant, plus an additional heat of sorption that varies between 5 and 25 % of the latent heat of the water vapor. This heat is transferred to the desiccant and the surrounding air.

C. Types of Desiccants

Desiccants can be basically divided in two categories

Liquid Desiccant: Liquid desiccants are solution that has a high affinity for water vapour. Liquid desiccant are very strong solutions of the ionic salts lithium chloride and calcium chloride. It has been used in industrial dehumidifier and is used to produce the dry air without any over cooling it. In standard practice, the behavior of a liquid desiccant can be controlled by adjusting its concentration, its temperature, or both. Desiccant temperature is controlled by simple heaters and coolers. Concentration is controlled by heating the desiccant to drive moisture out into a waste airstream or directly to the ambient. As a practical matter, however, the absorption process is limited by the surface area of a desiccant exposed to the air being dehumidified and the contact time allowed for the reaction. More surface area and more contact time allow the desiccant to approach its theoretical capacity. Commercial desiccant systems reflect these realities either by spraying the desiccant onto an extended surface much like in a cooling tower, or holding a solution in a rotating extended surface with a large solution capacity.

Solid desiccant: Adsorbents are solid materials with a tremendous internal surface area per unit of mass; a single gram can have more than 50,000 ft2 of surface area. Structurally, they resemble a rigid sponge, and the surface of the sponge in turn resembles the ocean coastline of a fjord. This analogy indicates the scale of the different surfaces in an adsorbent. The fjords can be compared to the capillaries in the adsorbent. The spaces between the grains of sand on the fjord beaches can be compared to the spaces between the individual molecules of the adsorbent, all of which have the capacity to hold water molecules. The bulk of the adsorbed water is contained by condensation into the capillaries, and the majority of the surface area that attracts individual water molecules is in the crystalline structure of the material itself. Adsorbents attract moisture because of the electrical field at the desiccant surface. The field is not uniform in either force or charge, so it attracts polarized water molecules that have an opposite charge from specific sites on the desiccant surface. When the complete surface is covered, the adsorbent can hold still more moisture, as vapor condenses into the first water layer and fills the capillaries throughout the material. As with liquid absorbents, the ability of an adsorbent to attract moisture depends on how much water is on its surface compared to how much water is in the air.

That difference is reflected in the vapor pressure at the surface and in the air. The adsorption behavior of solid adsorbents depends on (1) their total surface area, (2) the total volume of their capillaries, and (3) the range of their capillary diameters. A large surface area gives the adsorbent a larger capacity at low relative humidity. Large capillaries provide a high capacity for condensed water, which gives the adsorbent a higher capacity at high relative humidities. A narrow range of capillary diameters makes an adsorbent more selective in the vapor molecules it can attract and hold; thus, some will fit and others will be too large to pass through the passages in the material. There are many solid desiccant materials like silica gel, activated alumina, activated charcoal, (figure 2) zeolite etc which perform very well in hot and humid climatic conditions of India.

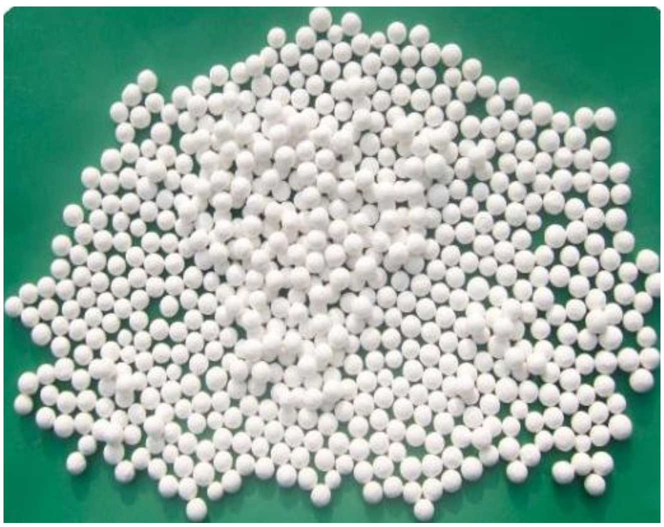

Figure 2: Activated alumina balls (Solid desiccant).

II. LITERATURE REVIEW

The study of literature review is divided into the two parts:

A. Analysis of Parabolic dish collector
B. Analysis of Regeneration of solid desiccant

A. Analysis Of Parabolic Dish Collector

Kaushika, N.D., [1993] developed a geometric optics equation for multifaceted parboiled dish collector and discuss the various operating parameter like its reliability, life time properties, survival and cost. The dish diameter of 5 meter and short focal length of 1.8meter are good for better result [1]. Imadojemu.H.E., [1994] designed noval concentrating collectors which are focusing on high concentration ratio and high tower range and easily patent in various countries. The temperature range is very high in these collectors due to good reflecting material, movable tracking mechanism and having good optical efficiency [2]. Daniel feuermann and jeffrey M. Gordon [2000] presented a new concept for efficient solar energy concentration and power delivery is proposed that offered substantial advantages in efficiency, compactness, reduced mechanical loads, and ease of fabrication and installation relative to conventional solar designs. The design exploited the availability of low-attenuation optical fibres, as well as the practical advantages of mass producing highly accurate very solar dish which concentrates sunlight into a single optical fibre. The fibre transport power to a remote receiver. A second-stage concentrator could boost flux levels to those approaching the thermodynamic limit and can be performed either in each individual dish or collectively in one or more larger devices at the entrance to the remote receiver. Systems were modular and can be employed in central power generation ranging from a few kilowatts to tens of megawatts. Designs for maximum efficiency attaining collection efficiencies as high as 80% were achievable [3].

Kaushika.N.D and Reddy.K.S [2000] developed a low cost steam generating system which is incorporated with solar parabolic dish collectors system. The result indicated that the steam conversion efficiency lie between the 70-80% at 450^0 C and cost of collector lie between 8000-9000 m^2 also it has very low weight and reflectivity are close to glass mirror [4]. Soteris A. Kalogirou [2004] gave a paper on solar thermal collectors and applications and he presented an introduction into the uses of solar energy is attempted followed by a description of the various types of collectors including flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish and heliostat field collectors. This was followed by an optical, thermal and thermodynamic analysis of the collectors and a description of the methods used to evaluate their performance. Typical applications of the various types of collectors were presented in order to show the extent of their applicability. The application described in this paper show that solar energy collectors can be used in a wide variety of systems, could provide significant environmental and financial benefits, and should be used whenever possible [5].

Palavras, G.C. Bakos [2006] presented a paper on development of a low-cost dish solar concentrator and its application in zeolite desorption. The presented paper deals with the development and performance characteristics of a low-cost dish solar concentrator and its application in zeolite desorption. The dish solar concentrator consisted of an old damaged satellite dish, purchased from a scrap yard, and a polymer mirror film used as reflecting surface. The proposed concentrator was connected to a sun-tracking system which was based on an electronic circuit that processes the input signals from a set of sensors and drives the dish actuator. The solar thermal energy application to adsorption technology (with the sorption pair water/zeolite) was simulated using the ‘Ice-Quick’ device manufactured by Zeo-Tech GmbH. Samples from two types of zeolites were initially brought to saturation condition and then mounted on the focal point of the solar concentrator in order to be regenerated. The dish concentrator system reached temperatures of more than 3001C in the focal point region, which was sufficient for the regeneration of zeolites [6].

N. Sendhil Kumar and K.S. Reddy [2007] reported that the numerical investigation was performed to study the natural convective heat loss from three types of receivers for a fuzzy focal solar dish concentrator, namely cavity receiver, semi-cavity receiver and modified cavity receiver. The natural convection heat loss from the receivers was estimated by varying the inclination from 0° (cavity aperture facing sideways) to 90° (cavity aperture facing down). The orientation and geometry of the receiver strongly affected the natural convection heat loss. A comparative study was performed to predict the natural convection heat loss from the cavity, semi-cavity and modified cavity receivers. The convection heat loss was high at 0° and decreases monotonically with increase in angle up to 90° in all three cases. The convection heat losses at 0° and 90° inclination of the modified cavity receiver were 26.03% and 25.42% of the convection heat loss of the cavity receiver, respectively. The influence of area ratio (Aw/A1) on the convective heat loss is investigated for the modified cavity receiver, and an optimum Aw/A1of 8 was found for minimum natural convection heat loss. Among the three receivers, the modified cavity receiver was the preferred receiver for a fuzzy focal solar dish collector system [7].

Shuang-Ying Wu et al. [2009] gave a paper on a parabolic dish/AMTEC solar thermal power system and its performance evaluation. This paper proposed a parabolic dish/AMTEC solar thermal power system and evaluated its overall thermal–electric conversion performance. The system was a combined system in which a parabolic dish solar collector was cascaded with an alkali metal thermal to electric converter (AMTEC) through a coupling heat exchanger. A separate type heat-pipe receiver was selected to isothermally transfer the solar energy from the collector to the AMTEC. To assess the system's overall thermal–electric conversion performance, a theoretical analysis had been undertaken in conjunction with a parametric investigation by varying relevant parameters, i.e., the average operating temperature and performance parameters associated with the dish collector and the AMTEC. Results showed that the overall conversion efficiency of parabolic dish/AMTEC system could reach up to 20.6% with a power output of 18.54 kW corresponding to an operating temperature of 1280 K[8].

Dascomb J., [2009]give a dissertation on low cost solar parabolic collector which is used for producing the generation of steam and compare with the other renewable technology and found that solar parabolic concentrator give 80% better performance than any other technology and overall cost is minimum [9]. Mo Wang and Kamran Siddiqui [2010] presented a paper on the impact of geometrical parameter on the thermal performance of a solar receiver of dish-type concentrated solar energy system. In the presented paper three-dimensional model of parabolic dish-receiver system with argon gas as the working fluid was designed to simulate the thermal performance of a dish-type concentrated solar energy system. The temperature distributions of the receiver wall and the working gas are presented. The impact of the aperture size, inlet/outlet configuration of the solar receiver and the rim angle of the parabolic dish were investigated. The results show that the aperture size and different inlet/outlet configuration had a considerable impact on the receiver wall and gas temperatures, but the rim angle of the parabolic dish had negligible influence. [10].

Lovergrove.K.et al [2011] developed a new design of large 500m^2solar parabolic concentrator with 13.4m focal length and altitude-azimuth tracking. It uses 380 identical spherical mirrors of 1.17m × 1.17m, which incorporate the glass- metal laminate mirror. Optical analysis shows that operation of receivers with geometric concentration ratio of at least 200 times should be possible. [11]. Li lifang and dubowsky.S [2011] presented a new developed approach of solar parabolic dish collector with reflecting parabolic mirrors. These parabolic petals are experimentally studied and studied on the basis of finite element analysis and advantages like easily transportation less cost also increases the energy efficiency by 40% and concentration ratio increases 200 times. [12]. Mohammed Ibrhaim [2012] design and developed a solar parabolic dish solar system for hot water generation and observe that solar dish are very useful even in a winter conditions and can generated the hot water around 150^0 C. Thermal efficiency are usually around 55-57% without any movable tracking. [13].

Y. Rafeeua and M.Z.A. Kadir., [2012] presented a paper on the Thermal performance of parabolic concentrators under Malaysian environment. In this paper the three experimental models with various geometrical sizes and diameter of about 0.5 m of solar dish concentrators were used to analyze the effect of geometry on a solar irradiation and temperature and in maximizing the solar fraction under Malaysian environment. These models were used to analyze the performance of parabolic concentrating collector's parameters such as reflector materials, aperture diameter, depth of concentrator, size of focal point and temperature at the focal point with different solar irradiations to increase the thermal efficiency. The efficiencies were calculated and results were conclusive. The 3 M Silverlux aluminum films were much efficient than stainless steel and increasing the area of the concentrator gave much more considerable variation in the results. [14].

B. Study of Regeneration of Solid Desiccant

Sukhmeet Singh and Parm Pal Singh., [1997] gave a paper on Regeneration of solid desiccant in multi-shelf regenerator. In the given research work an investigation on the regeneration of solid desiccant (silica gel, activated alumina) in a modified design of dehumidifier called "Multi-shelf Dehumidifier", had been reported. The range of regeneration air temperature was 42°-72°C, while bed air velocity varied from 0.175~).55 m/s and number of shelves from 2 to 4.A "Packed Bed Dehumidifier" was used as control. Both the dehumidifiers were fabricated and tested simultaneously. The effect of regeneration air temperature, bed-air velocity and number of shelves on regeneration of silica gel was investigated. The regeneration time decreased with the increase in regeneration air temperature, bed air velocity as well as with time. [15]. S. Techajunta et al., [1998] doing an experimental investigated on the regeneration of solid desiccant bed with simulated solar energy in which incandescent electric bulbs were used to simulate solar irradiations. The regeneration rate was slightly affected by air flow rate but found to be strongly dependent on irradiation. In air dehumidification process, the dehumidification rate decreased with decrease in irradiation but slightly increased with air flow rate. They suggested that this system worked better in tropical humid climate using regeneration process during the day and dehumidification during the night. [16].

H. Lounici, et al., [2000] gave a research paper on Novel technique to regenerate activated alumina bed saturated by fluoride ions. A novel technique to regenerate adsorbent column is presented. The process used was based on the utilization of an electrochemical cell which regenerates several saturated adsorbent bed. This paper presented the regeneration of the activated alumina (AA) bed saturated by fluoride ions. The results obtained in this study demonstrated that desorption of fluoride from activated alumina was a rapid process. Most of the fluoride content desorbed within 6–15 min. The utilization of the electrochemical cell allows a complete desorption of the fluoride under optimum conditions. The reduction of about 90% of the sodium hydroxide amount was attained by the electrochemical process. A study of adsorption–regeneration cycles showed that the electrochemical technique was more efficient than current techniques. A 95%, recovery of the adsorption capacity was realized with the electro regeneration system. In addition, the volume of water used to regenerate the saturated bed was lower than for current regeneration techniques. The washing did not exceed 6% of the treated water volume. The electro desorption operation was successfully applied for fluoride desorption from saturated activated alumina column by natural water with strong mineralization. [17].

Tony Sarvinder Singh and K. K. Pant., [2003] presented a research work on Equilibrium, kinetics and thermodynamic studies for adsorption of As (III) on activated alumina. This paper surmised Contamination of drinking water due to arsenic is a severe health hazard problem. Most of the techniques developed for pentavalent arsenic [As (V)] species were not very effective for trivalent arsenic ions [As (III)] which are more toxic and mobile than arsenate ions. Present investigation aims to remove arsenite ions [As (III)] by activated alumina. Effect of adsorbent dose, solution pH, and contact time has been investigated. Kinetics revealed that uptake of As (III) ion is very rapid in the first 6 h and equilibrium time was independent of initial As (III) concentration. The arsenite removal was strongly dependent on pH and temperature. Equilibrium studies show that As (III) ions have high affinity towards activated alumina at pH 7.6. Both Freundlich and Langmuir adsorption isotherms were well fit to the experimental data. Thermodynamic parameters depict the exothermic nature of adsorption and the process was spontaneous and favourable. The results suggest that activated alumina can be used effectively for the removal of As (III) ions. Activated alumina was found to be a suitable adsorbent for the removal of As (III) from drinking water. The adsorption was found to be strongly dependent on pH, adsorbent dose and contact time. A maximum of 96.2% As (III) removal could be achieved at pH 7.6. [18].

M. Dupont, et al., [2003] presented a paper on Desiccant solar air conditioning in tropical climates: I—Dynamic experimental and numerical studies of silica gel and activated alumina. This paper presented a dynamic study of moist air dehumidification in view of its use in an air conditioning process by evaporative cooling in tropical climates. A special device had been built to study dehumidification of tropical-like inlet air, through a fixed compact bed of silica gel and activated alumina. The compact desiccant storage was composed of two parallel beds to reduce the pressure drop. A good agreement is obtained for our experiment, and the computed amount of cycled water from the numerical model in the adiabatic process. This analytical model was used to simulate a complete air conditioning open cycle operating with hot and humid air. [19] SubhashiniGhorai and K. K. Pant., [2003] gave a paper on Investigations on the column performance of fluoride adsorption by activated alumina in a fixed-bed. In the presented study, removal of fluoride ions using activated alumina (AA) was investigated in batch and continuous operations. The fluoride removal performance was investigated as a function of the fluoride concentration, flow rate, amount of adsorbent dose and PH. Sorption data have been correlated with Langmuir and Freundlich isotherms. PH was shown to be a decisive parameter on fluoride removal. Percentage fluoride removal as a function of time and uptake capacity related to flow volume were determined by evaluating the breakthrough curves. [20]

SubhashiniGhorai and K.K. Pant., [2004] presented a research work on Equilibrium, kinetics and breakthrough studies for adsorption of fluoride on activated alumina. Contamination of drinking water due to fluoride was a severe health hazard problem. Excess of fluoride (>1.5 mg/l) in drinking water was harmful to the human health. Various treatment technologies for removing fluoride from groundwater have been investigated in the past. Present investigation aims to remove fluoride by activated alumina. Adsorption isotherm has been modeled by Langmuir equation and isotherm constants. The dependence of the adsorption of fluoride on the pH of the solution has been studied to achieve the optimum pH value and a better understanding of the adsorption mechanism. It was found that maximum adsorption takes place at pH value of 7. Breakthrough analysis revealed that early saturation and lower fluoride removal takes place at higher flow rate and at higher concentrations. Activated alumina was a suitable adsorbent for the removal of fluoride from drinking water. The removal of fluoride from aqueous solutions strongly depends on the contact time, pH of the solution and adsorbent concentration. [21]

SurajitrPramuang and R.H.B. Exell., [2006] used a compound parabolic concentrator collector to regenerate the solid desiccant for an air conditioning system. The regeneration rate and regeneration efficiency was greatly dependant on solar radiation but slightly dependant on different initial moisture content of silica gel and number of silica gel beds. It was also found that the silica gel could be regenerated at 40˚c by high air flow rate (0.03 kg/s) and at 50˚c by low flow rate (0.003 kg/s). [22] Jia et al., [2007] developed a novel compound desiccant wheel made up of more hygroscopic composite material which worked under low regeneration temperature and had higher dehumidification capacity. The performance of this system was analyzed by a mathematical model and it was pointed out that this system could work under very low regeneration temperature having high COP. Hence, low grade thermal energy resources like solar energy, waste heat etc could be used to operate the system efficiently. [23]

Junling WANG, et al., [2009] gave a research paper on adsorption capacity for phosphorus comparison among activated alumina, silica sand and anthracite coal. Experimental researches on adsorptive capacity of activated alumina, silica sand and anthracite coal for phosphorus were conducted. Results showed that performances of three filter media were all in line with Langmuir isotherm, and activated alumina adsorptive performance was much better than silica sand and anthracite coal for phosphorus removal. The adsorptive capacity of activated alumina, silica sand and anthracite coal for phosphorus was 3333μg/g, 49μg/g and 100μg/g respectively. Activated alumina displayed adsorptive function well for phosphorus, because its inner porosity, specific surface area and surface iso-electric pH value were all higher than those of other two filter media. While activated alumina was used as filter material in water treatment process, phosphorus would be removed strongly because of adsorptive characteristic of activated alumina. [24]

LigyPhilipa, et al., [2009] gave a paper on As (III) removal from drinking water using manganese oxide-coated-alumina Performance evaluation and mechanistic details of surface binding. This paper describes the arsenite [as(iii)] removal performance of manganese oxide-coated-alumina (moca) and its interaction with as(iii) in drinking water. moca was characterized by xrd, sem, edax, gas adsorption porosimetry, and point of zero charge (phpzc) measurements. raman spectroscopy coupled with sorption experiments were carried out to understand the as(iii) interaction with moca. as(iii) sorption onto moca was ph dependent and the optimum removal was observed between a pH of 4 and 7.5. The sips isotherm model described the experimental equilibrium data well and the predicted maximum adsorption as(iii) sorption capacity was 42.48 mg g^{-1} , which is considerably higher than that of activated alumina (20.78 mg g^{-1}). The sorption kinetics followed a pseudo-second-order equation. based on sorption and spectroscopic measurements, the mechanism of as(iii) removal by moca was found to be a two-step process, i.e. oxidation of as(iii) to arsenate (as(v)) and retention of as(v) on moca surface, with as(v) forming an inner surface complex with moca. The results of this study indicated that moca is a promising alternative sorbent for as (iii) removal from drinking water. [25]

Dong La, et al., [2010] presented a experimental investigation and theoretical analysis on solar heating and humidification system with desiccant rotor. In this paper, a solar heating system, which combines the technologies of evacuated tube solar air collector and rotary desiccant humidification together, had been configured, tested and modelled. The system mainly includes 15m^2 solar air collectors and a desiccant air-conditioning unit. Two operation modes were designed, namely, direct solar heating mode and solar heating with desiccant humidification mode. Performance model of the system had been created in TRNSYS. The objective of this paper is to check the applicability of solar heating and evaluate the feasibility and potential of desiccant humidification for improving in door thermal comfort. Experimental results showed that the solar heating system can convert about 50% of the received solar radiation or space heating on a sunny day in winter and increases indoor temperature by about 10°C. Compared with direct solar heating mode, solar heating with desiccant humidification can increase the fraction of the time within comfort region from about 10% to 20% for standalone solar heating and from about 30% to 60% for solar heating with auxiliary heater according to seasonal analysis. It was confirmed that solar heating with desiccant humidification was promising and worthwhile being applied to improving in door thermal comfort in heating season. [26]

Isabelle Polaert, et al., [2010] presented a research work on Adsorbents regeneration under microwave irradiation for dehydration and volatile organic compounds gas treatment. In adsorption processes, adsorbent regeneration was by far the most time and energy consuming step for which microwave technology offers many advantages. Nevertheless, desorption under microwave was a complex process: electromagnetic energy conversion into heat strongly linked to several other phenomena such as thermodynamic equilibrium, heat and mass transfers as well as transport. This study points out the key parameters controlling desorption under microwave irradiation. In this paper, an experimental study was presented using several types of adsorbents (silica, activated alumina, NaX and NaY zeolites) and various adsorbents (water, toluene, n-heptane and methyl cyclohexane). Theses solids and liquids have been selected for their contrasted dielectric and structural properties. Water desorption from several adsorbents exhibits very different behaviours linked, not only to the evolution of their dielectric properties with temperature and water content, but also to the structure of the adsorbents and more especially to the quantity and position of the exchange cations. Simulated temperature profiles in the solid bed show that, in some cases, desorption can be effective and rapid without reaching very high temperatures in the solid. Results obtained with a zeolite NaX show that desorption rates and effectiveness strongly differ from an adsorbate to another, and seem to be mainly controlled by the microwave absorbed power profile. [27].

W.R.Abd-Elrahman, et al., [2011] presented a research work on experimental investigation on the performance of radial flow desiccant bed using activated alumina. In the present work, an experimental investigation on the performance of radial flow desiccant bed using activated alumina has been carried out. 39.860 kg of spherical particles of activated alumina with an average diameter of 4 mm was used to form a hollow cylindrical bed with length of 90 cm and outer and inner diameters of 27.8 and 10.8 cm, respectively. During the experiments, the weight of the bed was measured instantaneously using load cell to determine the adsorbed and desorbed water during the adsorption and desorption processes, respectively. The experimental tests were carried out at different conditions of inlet air and initial bed parameters. Temperature and humidity of air at inlet and exit of the bed were measured. The transient variation of air conditions and the bed performance is presented. The effect of bed pre-cooling on the system performance was highlighted. The obtained results show that air with inlet humidity ranging from 18.7 to 12.5 g/kg could be dehumidified, using activated alumina, to a lower level of humidity (1.2 g/kg).[28]

C. Objectives of Work

Here the objective of my dissertation work is as follows:

- To experimentally investigate the regeneration performance of activated alumina by parabolic dish collector in Indian climatic condition.
- To experimentally investigate the adsorption performance of activated alumina at normal room condition.

III. EXPERIMENTAL SETUP AND WORKING

A. Introduction

In this research paper, the regeneration and adsorption rates of two different solid desiccants (activated alumina) for dehumidification of air have been proposed. The main objective in this research paper is to study the feasibility of regeneration of solid desiccants using solar parabolic dish collector. This solar parabolic dish collector is used to regenerate the solid desiccants (activated alumina) at atmospheric air flow rates and experimental comparison of regeneration rate of two different solid desiccants as shown in figure 3. After that its air dehumidification performance are analyzed and compare the adsorption rate of activated alumina at room condition. The regeneration rate of two solid desiccants (activated alumina) is experimentally investigated for two different days in the month of May for the same interval of time. The results of this experiment are presented in next chapter. [30]

B. Experimental setup

Figure 3: Experimental diagram of the parabolic dish collector.

1. Components of Parabolic Dish Collector

The parabolic dish collector consists of the following component:

- Outer ring frame
- Aluminium foil reflector
- Supporting frame
- Tracking screw and wheel
- Absorber frame

Outer Ring Frame: The outer ring frame of the parabolic dish collector is made of the mild steel circular channel. The diameter of the outer ring frame is 1.4m. At the top of the outer ring frame two steel plates are screwed for positioning the tracking screw. Inside the circular channel of the frame the aluminum foils are placed to form the reflector as shown in figure 4.

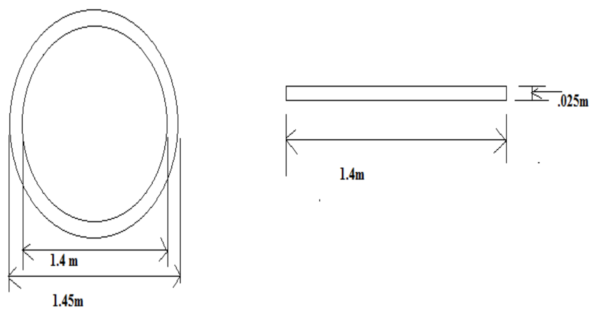

Figure 4: (a) Top view of the outer ring frame, (b) side view of the outer ring frame.

Aluminum Foil Reflector: Aluminum foil reflector is made by joining the 40 segments of the aluminum. These segments are joined with the help of screw from outer side and placed inside the outer ring frame by sliding with hand. Then these aluminum segments are screwed together at the inner side to form the parabolic shape of the reflector. The anodized aluminum material of the reflector has reflectivity greater than 80% and the optical efficiency of the collector is 40%. The diagram of the aluminum foil reflector is shown in figure. 5.

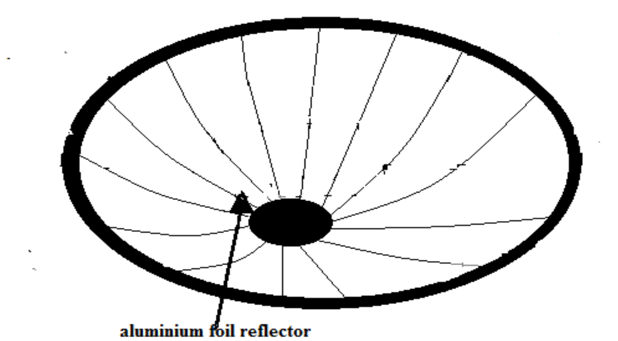

Figure 5: Schematic diagram of aluminum foil reflector.

Supporting frame: The supporting frame is made of mild steel bar of square cross section in a way to support the outer ring frame. It is also connected to the absorber frame to support the frame. The supporting frame is also connected with the tracking system and wheel for proper tracking of collector. It is also connected with the holding screw to lock the collector at specified position.

Tracking screw and wheel: Tracking screw is situated on a steel plate which is connected to the supporting frame. Tracking of collector is done in a normal direction to sun by reducing the shadow of the tracking screw to zero. Wheel is also used for tracking of collector in a direction relative to the axial movement of sun. Wheel is connected at the bottom of the supporting frame by the screw.

Absorber frame: The absorber frame is connected at the focus point of the collector with the help of steel rod which connected to the supporting frame. The absorber frame has fixed at their position at focus of the collector, it still remains at the same position during tracking. The absorber frame is move with the vertical angular movement of collector. All the radiation falls on the collector is concentrate at the absorber frame. Container used for the regeneration of the silica gel is placed on the absorber frame.

IV. RESULTS AND DISCUSSION

In this research paper, the main focus is on the regeneration rate of two different solid desiccants (activated alumina) by the parabolic dish collector and then the adsorption process of these materials at room air flow rate. The experimental data has been collected in the month of May 2012 during which the ambient temperature varied from 30 to 46 in most of the clear sky days (10:00 hr-20:00 hr). The tests were performed in the noon for regeneration and in room conditions for adsorption. The regeneration rate & adsorption rate of activated alumina has been analyzed and their comparative performance is evaluated. Four cases are considered and various results have been obtained. The regeneration rate (G_r) was monitored continuously throughout the experimental run by measuring the bulk weight of the dry solid desiccant(activated alumina,) layers and the rate of change of moisture content of solid desiccant (dry basis) dw/dt [Pramuang et al., 2006].

$$G_R = \dot{m}_{ds}\frac{dw}{dt} \quad (1)$$

The adsorption rate (G_a) was monitored continuously throughout the experimental run by measuring the bulk weight of the humidified (wet) solid desiccant (activated alumina) layers and the rate of change of moisture content of soild desiccant (wet basis), [Pramuang et al 2006].

$$G_A = \dot{m}_{ws}\frac{dw}{dt} \quad (2)$$

A. Regeneration rate of activated alumina balls

Figure 6 show the relation between the reduction of weight of activated alumina balls and solar intensity over a period of time. The DBT and WBT of the ambient are 38°C and 26°C respectively at the starting of the experiment. The

1 kg activated alumina balls is placed in the container and put at the absorber area of collector. The solar intensity are in the range of 690- 800 $W/_{mm^2}$ during regeneration. The weight of the activated alumina balls is reduce rapidly at initial stage due to sudden increase in the temperature and then it decrease with the constant rate as it attain steady regeneration temperature and at the end the slope of curve becomes zero due to evaporation of all the water present in the pores of activated alumina balls. The result shows that reduction of weight in later is not much depended on the solar intensity.

Table 1 Variation of weight of activated alumina balls and solar intensity with time during regeneration process

Time (hour)	Weight (gram)	Solar intensity (W/m^2)
10:34	1000	728
10:38	984	730
10:42	974	732
10:46	970	746
10:50	963	797
10:54	954	768
10:58	950	770
11:02	948	780
11:06	946	803
11:10	944	798
11:14	944	801

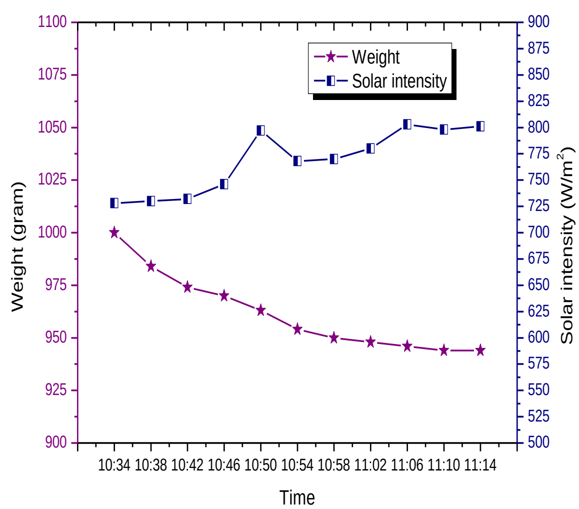

Figure 6: Variation of weight of activated alumina balls and solar intensity with time during regeneration process.

Table 2 Variation of regeneration rate with time for activated alumina

Time (hour)	Regeneration rate (kg/hr)
10:34	0
10:38	0.24
10:42	0.15
10:46	0.06
10:50	0.1
10:54	0.135
10:58	0.059
11:02	0.03
11:06	0.03
11:10	0.03
11:14	0.03
11:18	0

Figure7 shows the variation of regeneration rate of activated alumina during a passage of time. The regeneration rate is very high (0.24 kg/hr) in initial state due to the sudden increase in the temperature of activated alumina which evaporate most of moisture from the pores of activated alumina. After that it decreases with the time as the temperature attain steady state. After that there is continuous up and down variation in the regeneration rate with time due to presence of less amount of moisture content in the pores of activated alumina and after some period of time regeneration rate is zero because all the moisture is evaporated and desiccant becomes completely dry.

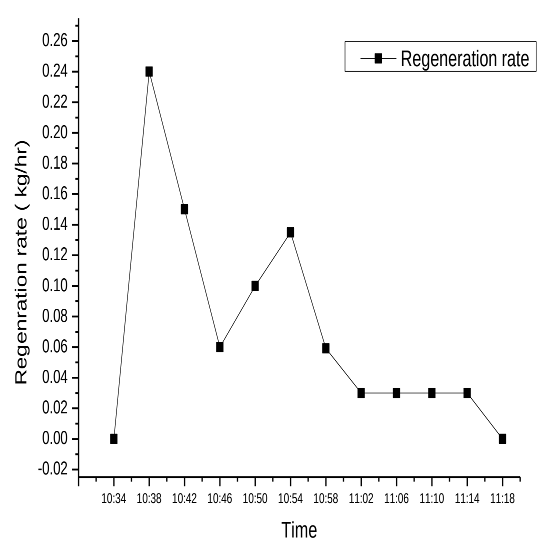

Figure 7: Variation of regeneration rate with time for activated alumina.

V. CONCLUSIONS

The main objective of this research paper is to calculate the regeneration rate and adsorption rate of activated alumina for the same period of time in two day by parabolic dish collector. The result shows that solid desiccant are easily regenerate by solar energy without consuming any convectional source of energy There are following conclusion has drawn from the experiment:

- The regeneration rate is increasing sharply in the initial stage of experiment for the material activated alumina.
- The maximum regeneration rate is 0.24 kg/hr for activated alumina. So it is concluded that regeneration rate of activated alumina is better than other material. The results shows that maximum regeneration rate obtain for material activated alumina is at 10:38 A.M for two days of experiment.
- During regeneration process, the moisture removal is maximum for activated alumina (54 g) for 1 kg of solid desiccants. During the adsorption process, maximum adsorption rate for activated alumina is (0.0192 kg/hr).
- In adsorption process, activated alumina is adsorbed more moisture during the process.

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