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Assessment of a firm Desiccant Dehydrator and Its appliance for aeration of Leafy Greens

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Abstract: Drying is an energy intensive operation in manufacturing process that account for 15% of industrial energy consumption (Atuonwu*et al*., 2011). The industries where production of tea, textiles, ceramics, milk powder, edible starch, baking powder, sugar, paper, raisins etc. rare carried out, and in pharmaceuticals industries large quantities of energy is used for drying. Desorption capacity (moisture removal capacity at reactivation side) is the capacity of the desiccant wheel to desorb moisture from the desiccant bed surface and it is the difference between reactivation out and reactivation in absolute humidity. A small size drying chamber with trays will be developed to study the drying characteristics of some leafy greens with dehumidified air. The rate of removal of moisture will be plotted against time to determine the drying rate. The condition of leafy greens after drying will be compared with conventional drying. The performance of dehumidifier to produce dehumidified air for about 15 days will give the information on the possible application of the dehumidifier for drying of various products.

Keywords: Energy, Pharmaceutical Industries, Moisture, Green Leaf, Dehydrate.

INTRODUCTION

Drying is an energy intensive operation in manufacturing process that account for 15% of industrial energy consumption (Atuonwu*et al.,* 2011). The industries where production of tea, textiles, ceramics, milk powder, edible starch, baking powder, sugar, paper, raisins etc. rare carried out, and in pharmaceuticals industries large quantities of energy is used for drying. Wide range of drying technologies available, which include convective air drying, sun and solar drying, vacuum drying, freeze drying, dielectric drying, infrared drying, low pressure superheated steam drying, osmotic dehydration and super critical carbon dioxide drying (Chua & Chou, 2001; Bourdoux*et al.,* 2016).

Most industrial driers operate by heating ambient air using solar energy and electric heaters. Solar drying relies heavily on weather conditions. Hot air increases the temperature and reduces the relative humidity of the drying air, thus allows the air to carry moisture from the product. Although this is adequate in relatively dry and less humid weather, it is not possible to reduce the actual moisture level from the air in humid climates. As a result, drying by heated air becomes costly, slow and less effective (Attkan*et al.,* 2016).

Recently, drying of products using low humidity low temperature air has become a research focus for its features of energy saving and eco-friendliness (Ge*et al.,* 2013). Low humidity air has better moisture adsorption capacity, and it enhances the drying rate and reduces drying time. Low temperature and low humidity air can be obtained by controlling reactivation temperature of the desiccant and air mass flow rate. Low temperature drying of agricultural produce leads to high retention of nutrients and better quality. Hence, drying using a solid desiccant dehumidifier is the best alternative method for food drying (Attkan*et al.*, 2016).

Desiccant Dehumidifier

In a solid desiccant dehumidifier, the moist air is allowed to pass through the desiccant materiallike silica gel, calcium chloride, titanium silicates, molecular sieve, activated alumina, zeolite (artificial and natural), lithium chloride, polymers, organic based desiccants and composite desiccants. The desiccant material adsorbs moisture in the air. The dry air comes out from the desiccant material (Fig. 1). As the process of adsorption is continued, the desiccant material will not be able to absorb moisture efficiently. In order to remove the adsorbed moisture from the desiccant material, regenerative heat source is used to supply heat to the desiccant material. Low grade heat sources like solar energy or waste heat can be used for regenerating or activating the desiccant material. In general, solid desiccant material is fitted on a rotary wheel called, desiccant wheel.

The desiccant wheel consists of a cylindrical matrix of channels that are coated with or constructed from a solid desiccant. To maximize moisture collection, the wheel rotates slowly, only 10 to 30 rotations per hour, through two air streams (Fig. 1).

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Process air passes through one section of the wheel. Desiccant on that section adsorbs water vapour, making the air drier than when it entered. Wheel rotation then exposes the moisture-laden desiccant to a regeneration air stream that strips the captured moisture away from the desiccant (desorption).

Justifications

To remove moisture, solid desiccant wheel technology presents an energy efficient alternative to traditional systems especially when solar energy and waste heat come into play(Goodarzia*et al.*, 2017). Solid desiccant wheels could be coupled with other systems to provide desired air quality. Desiccant cooling is an environmentally attractive alternative to conventional mechanical air-conditioning (Goldsworthy& White, 2012).The main component in these systems is desiccant wheel which should operate efficiently.

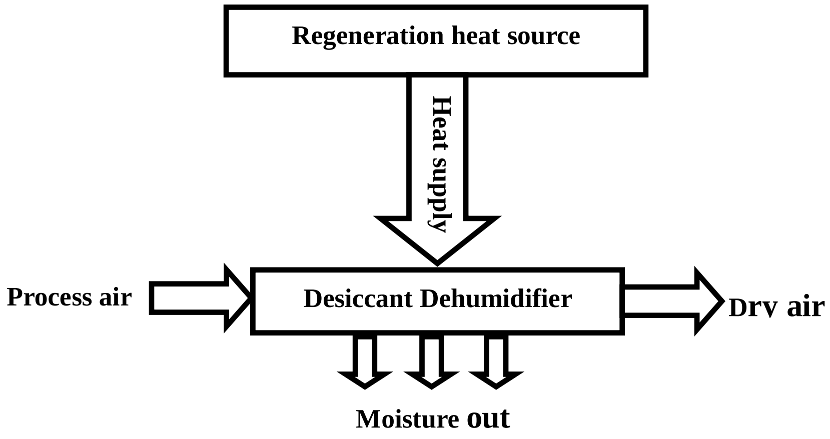

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Figure 1. Working principle of solid desiccant dehumidifier

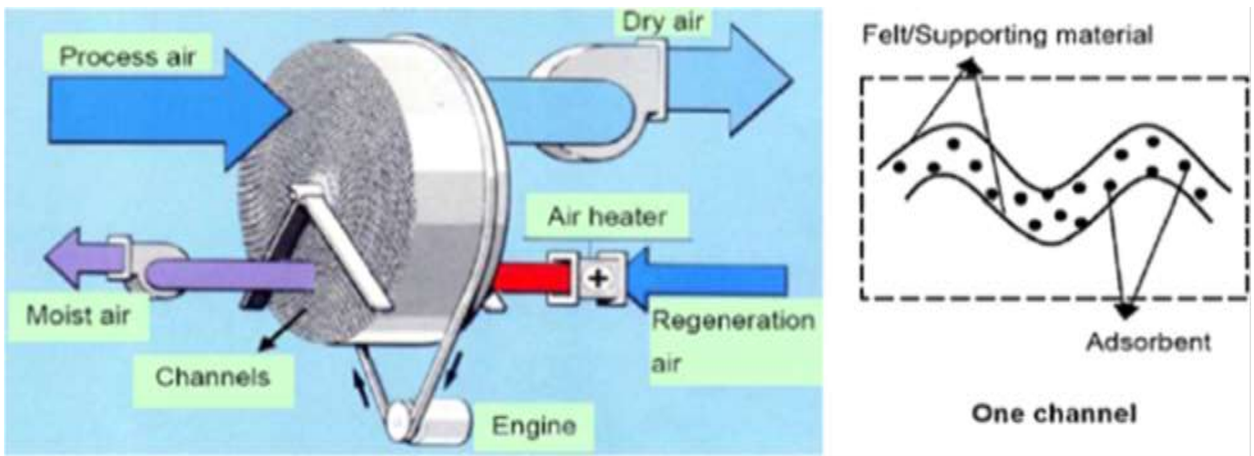

Figure 2. Rotary desiccant dehumidifier (La *et al.*, 2010)

Silchar in the southern Assam has tropical warm humid climate (temperature 15-35ºC, relative humidity >75%) with heavy rainfall (>2500 mm). Solid desiccant dehumidifier seems to have a great potential for drying and storage of various food products in Silchar, particularly leafy greens and green leafy vegetables. The potential and performance of desiccant wheel under ambient conditions of Silchar is not available in literature. In the present study, an attempt is made to evaluate the performance of a solid desiccant dehumidifier to reduce moisture from ambient air, and use the low temperature dehumidified air to dry the leafy greens.Objectives of our study were

- To evaluate the performance of a solid desiccant dehumidifier to reduce the moisture from ambient air.
- To assess the use of dehumidified air for the low temperature drying of leafy greens.

The present study is expected to provide an insight into the potential of solid desiccant dehumidifier for low temperature drying of leafy greens. The literature has revealed low temperature drying has resulted in the removal of moisture and retention of original color and texture.

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REVIEW OF LITERATURE

The objectives of the present work are to evaluate the performance of a solid desiccant dehumidifier to remove the moisture from ambient air, and to investigate the use of dehumidified air for the low temperature drying of leafy greens. Several researchers have developed and evaluated the desiccant dehumidifiers, and assessed the use of dehumidified air for low temperature drying of various food products. A concise report from the relevant published recent literature is presented in this Chapter. This Chapter is presented under the following heads:

- Performance of solid desiccant wheel for air dehumidification
- Use of dehumidified air for drying various food products

Performance of Solid Desiccant Wheel for Air Dehumidification

Dai *et al.* (2001) presented waves analysis using psychrometric chart to evaluate the rotary desiccant dehumidification. The continuity and energy conservation equations for the transient coupled heat and mass transfer were established and solved using a finite differential model. The locus of points of outlet air states along the rotational direction might be plotted as two wave fronts and one breakthrough point for both dehumidification and regeneration processes. Thermal wave, concentration wave, and middle zone point were explained in terms of the different characteristics of their own. The rules to improve the performance of dehumidification according to the wave shape were proposed and some important parameters, such as heat capacity, adsorption heat, rotation speed, regeneration temperature, thickness of the desiccant matrix and the desiccant isothermal shape were discussed in detail using psychrometric chart. It was demonstrated that the chart method was feasible and rapid in evaluating the performance of the rotary dehumidifier.

Zhang &Niu (2002) reported that the desiccant wheels have two major applications. They are, air dehumidification and enthalpy recovery. Since the operating conditions were different, heat and mass transfer behaviors in the wheels were quite different. They compared the performances of desiccant wheels used in air dehumidification and enthalpy recovery with each other. To accomplish this task, a two-dimensional, dual-diffusion transient heat and mass transfer model which took into account the heat conduction, the surface and gaseous diffusion in both the axial and the thickness directions were presented. Effects of the rotary speed, the number of transfer units, and the specific area on the performance of the wheel were investigated and compared in the two situations. The cycles that the desiccant and air undergo in the wheel were plotted in psychrometric charts to demonstrate the different heat and moisture transfer mechanisms during the dehumidification and enthalpy recovery processes.

Beccali*et al.* (2003) presented simple models to evaluate the performance of rotary desiccant wheels based on different kind of solid desiccants e.g. silica gel and LiCl. ‘Model 54’ was developed for silica gel desiccant rotor. The model was derived from the interpolation of experimental data obtained from the industry and the correlations were developed for predicting outlet temperature and absolute humidity. The ‘Model 54’ consisted of 54 coefficients corresponding to each correlation for outlet absolute humidity and temperature and it was found that the model predicted very well the performance of silica gel desiccant rotor (Type-I). A psychrometric model was presented to obtain relatively simple correlations for outlet temperature and absolute humidity. The developed psychometric model was based on the correlations between the relative humidity and enthalpy of supply and regeneration air streams. The model was used to predict the performance of three type of desiccant rotors manufactured by using different kind of solid desiccants (Type I, II and III). The model was tested corresponding to a wide range of measurement data. The developed psychometric model was simple in nature and able to predict very well the performance of different kind of desiccant rotors.

Ahmed *et al.* (2005) evaluated and optimized a solar desiccant wheel performance. A numerical model was developed to study the effect of the design parameters such as wheel thickness, wheel speed, regeneration to adsorption area ratio, wheel porosity, and the operating parameters such as air flow rate, inlet humidity ratio of the air and regeneration air temperature on the wheel performance. It was also used to draw the performance curves of the desiccant wheel to quantify the optimum design parameters for certain operating conditions. An open test loop for the desiccant wheel was constructed with appropriate control devices and measuring instruments. A perforated plate solar air heater of 2 m^2 area, together with an electric heater, was used as a source of energy to regenerate the desiccant material. The experimental tests were used to validate the numerical model and to evaluate the performance of the solar system and the desiccant wheel under actual conditions of Cairo climate (30° Latitude). Comparison between numerical and experimental results showed good agreement between them, especially at low flow rates of air. Numerical results showed that there was a maximum value of each design parameter at each operating condition, and above that no remarkable changes in the wheel performance were noticed. The results also showed that there was an effective range of the air flow rate, due to which wheel performance became inefficient. This range was found to be between 1 and 5 kg/min. The performance curves of the wheel, which helped to determine the humidity reduction ratio, were drawn for wheel speeds between 15 and 120 rev/h, dimensionless wheel thickness between 0.15 and 0.5, air flow rate equal to 1.9 and 4.9 kg/min, and

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regeneration temperature equal to 60 and 90°C. These curves showed that there was an optimum value of the wheel speed for each wheel thickness to obtain the best wheel performance for certain operating conditions. Experimental results showed that the perforated plate solar air heater of 2 m^2 area could share about 72.8% of the total regeneration energy required at 1.9 kg/min air flow rate and 60°C the regeneration air temperature. This value decreased to about 13.7% at a flow rate equal to 9.4 kg/min and regeneration temperature equal to 90°C. The perforated plate solar air heater area required to completely fulfil the regeneration energy during the day time was also calculated.

Jeong&Mumma (2005) investigated the performance of the aluminium desiccant wheel with silica gel and molecular sieve matrix. It was found that when the fresh and exhaust air flow speeds were both 1.5 m/s, the total energy effectiveness could reach 93.4% and 84.9%, respectively for silica gel and molecular sieve coated wheel. The face velocity and air flow ratio showed a very high contribution to both sensible and latent effectiveness. The humidity of the entering fresh air and conditions of the exhaust air showed relatively small contributions to sensible effectiveness, but they showed higher contribution to latent effectiveness.

Jia*et al.* (2006) investigated a novel desiccant wheel to improve the dehumidification and regeneration effectiveness. This desiccant wheel consisted of a two layered silica gel offering a host matrix of open pores and a hygroscopic substance, such as lithium chloride, penetrating into the micropores. Results indicated that the novel desiccant wheel removed 20-30% more moisture from the humid air compared to the normal silica gel wheel, and the COP reached 1.28, which was about 35% higher than the latter.

Cho *et al.* (2007) evaluated the dehumidification performance of the Functional Adsorbent Material- Zeolite (FAM-Z) rotor, which is expected to offer superior dehumidification at lower regeneration temperatures. Hot and humid air was passed through a FAM-Z rotor (desiccant rotor), dry bulb temperature and the relative humidity both before and after passage through the FAM-Z rotor was measured, and the difference in absolute humidity was calculated. Dehumidification performance of a FAM-Z rotor and a silica gel rotor was determined. Some parameters, such as the regeneration temperature and airflow, which might affect the performance of the desiccant rotor, were analyzed. At the regeneration temperature of 50°C, the dehumidification performance of the FAM-Z rotor was superior to that of the silica gel rotor. At the regeneration temperature of 60°C and above, the silica gel rotor performed better.

Jeong*et al.* (2010) opined that a desiccant dehumidification system with air could decrease energy consumption because it could be driven by low grade waste heat below 80°C. If this system could be driven by low temperature heat sources whose temperature is below 50°C, exhausted heat from fuel cells or air conditioners that exist everywhere could be used as heat sources. This could lead to considerable energy saving. It was possible to make a four partition desiccant wheel a low temperature driving heat source, and achieve considerable energy saving by the simulation and experiment. Further, the study investigated the in depth performance of a hybrid air conditioning system with a four partition desiccant wheel by simulation. As a result, it was clear that there existed an optimum rotational speed to maximize the dehumidification performance and that the hybrid air conditioning system improved COP by approximately 94% as compared to the conventional vapour compression type refrigerator.

Antonellis*et al.* (2010) investigated the performance and optimization of desiccant wheels. The analysis was carried out through a one dimensional gas side resistance model which considered developing temperature and velocity profiles along the channels. Simulation results showed a good agreement with experimental data available in literature in a wide range of operating conditions. The model was used to analyze the influence of working conditions on desiccant wheel performance and on the optimal revolution speed. Several performance criteria were introduced and each one of them was used to investigate and find out the optimal desiccant wheel configuration. For each criterion the best process air angular sector and revolution speed were identified, and the obtained results were compared. Through a practical example it was finally shown how each criterion leads to different optimal configurations.

White *et al.* (2011) proposed a number of new desiccant materials which have the potential to improve the performance of desiccant wheels being regenerated at low temperature. They compared the desiccant wheels containing two such desiccant materials (zeolite and super absorbent polymer) with a conventional silica gel desiccant wheel. The super absorbent polymer desiccant wheel achieved greater dehumidification than the silica gel wheel when dehumidifying high relative humidity air with low temperature (50°C) regeneration air. The temperature of dehumidified air exiting the polymer wheel was also lower. The zeolite desiccant wheel was generally less effective at dehumidifying air and had a higher pressure drop.

Yadav&Bajpai (2011) used the software to study the performance of an adiabatic rotary dehumidifier parametrically and determined the optimal rotational speed by examining the moisture removed by process area in the desiccant wheel. Effect of air flow rate on the reactivation air and process air was also studied. The basic parameters for a particular wheel of thickness 200 mm and diameter 550 mm were: ambient air at

30°C DBT and 17 g/kg humidity ratio, process air flow rate varied between 1.5 to 5.5 m/s, reactivation air flow rate between 1.5 to 5.5 m/s and rotational speed of wheel varied from 10 to 40 rph. It was observed that for low velocity of process air (1.5 to 2.5 m/s), 10 rph and 20 rph were found to be optimum for operation. In case of high velocity (>2.5 m/s), little effect of rph was observed. The most optimum rph was found to be 20. For both high and low reactivation inlet velocity, 20 rph was the most optimum rotation speed. However, the best results were observed at 3.5 to 4.5 m/s reactivation inlet velocity.

Yadav&Bajpai (2012) analysed the regeneration and adsorption performance of different desiccants, such as silica gel, activated alumina, and activated charcoal, for producing dry air. The air needed for regeneration was heated in an evacuated-tube solar collector. The desiccants were regenerated at temperatures in the range of 54.3 to 68.3°C. The regeneration performance was greatly affected by the regeneration temperature, but also depended on the initial moisture content, temperature of the desiccants, and flow rate of regeneration air. Comparison of the performances showed that at high hot air flow rates the regeneration times and adsorption times were shorter for these desiccants than at low flow rates. Silica gel was observed to perform better than activated alumina and activated charcoal for regeneration and adsorption at high and low flow rates.

Goldsworthy & White (2012) used a numerical model of a desiccant wheel to investigate the specific influence of the desiccant equilibrium adsorption isotherm on the overall wheel performance. The heat of adsorption, moisture diffusion rate, desiccant specific heat capacity and density were varied to provide further insight into the limiting heat and mass transfer mechanisms for low temperature regeneration. In addition, an optimization analysis of the desiccant adsorption isotherm shape was performed for a range of process conditions. The results showed that the extent of dehumidification was limited primarily by a combination of thermal affects caused by both the exothermic adsorption process and the carryover of heat from the regeneration stream.

Rabah (2012) investigated the influence of change in operation conditions on the performance of a Lithium Chloride (LiCl) wheel. A rigorous experimental rig that facilitated the measurement of temperature, pressure, pressure drop, relative humidity, airflow rate and rotational speed was used. The measurements covered balanced flow at a wide range of rotational speeds (0-9.8 rpm), regeneration temperatures (50-70°C), airflow rates (280-540 kg/h) and relative humidities (30-65%) at ambient condition. The influence of those operation conditions on the wheel sensible effectiveness and coefficient of performance (COP) were analyzed. The result revealed that a maximum COP occurs at a rotational speed of 0.2 rpm (12 rph).

Eicker*et al.* (2012) conducted experimental investigations on several commercially available and newly fabricated rotors in two different laboratories to evaluate performance trends. Experimental uncertainties were analyzed and the parameters determining the rotor performance were investigated. It was found that the optimal rotation speed was lower for lithium chloride or compound rotors than for silica gel rotors. Higher regeneration air temperatures lead to higher dehumidification potentials at almost equal dehumidification efficiencies, but with increasing regeneration specific heat input and enthalpy changes of the process air. The influence of the regeneration air humidity was also notable and low relative humidities increased the dehumidification potential. Finally, the measurements showed that rising water content in the ambient air caused the dehumidification capacity to rise, while the dehumidification efficiency was not much affected and both specific regeneration heat input and latent heat change of the process air decreased.

Yadav&Yadav (2014) used a mathematical model to predict the performance of a desiccant wheel with effective regeneration sector. The model was used to conduct a comparative performance of desiccant wheel with effective and ordinary regeneration sector. It was found that for all the cases considered in the study like rotation of wheel, regeneration temperature, velocity and ambient moisture, the desiccant wheel with effective regeneration sector gave better result as compared to ordinary regeneration sector.

Goodarzia*et al.* (2017) evaluated the performance of solid desiccant wheel and investigated the factors consisting of air humidity ratio, regeneration process and air process temperatures, mass flow rates and wheel revolution. Software provided by Novel Aire Company was used to calculate outlet air conditions. Using the software, the performance of a rotary dehumidifier was studied based on effectiveness parameters including moisture removal capacity (MRC), sensible coefficient of performance (COPSen), latent coefficient of performance (COPLat) and total coefficient of performance (COP Total). In addition, affecting factors were changed as described: inlet air temperature between 15°C to 40°C, regeneration temperature between 65°C to 110°C, humidity ratio between 10 to 20 g/kg, air flow rates between 0.72 m/s to 1.28 m/s, and rotational speed of wheel between 10 to 40 rph.

Use of Dehumidified Air for Drying Various Food Products

Seyhan&Evranuz (2000) dried the cultivated mushrooms (*Agaricusbisporus*) slices of 2.5 and 5 mm thick with dehumidified air at 20, 30 and 40°C. Rehydration ability of dried mushrooms was used as criteria for the evaluation and determination of optimum conditions. Drying mechanism of the mushroom slices was expressed by unsteady state diffusion and the results were interpreted by Fickian model. Drying temperatures lower than 40°C promoted the production of light coloured mushrooms with high rehydration ratios. Diffusivity constants were in the range of $2.6-12\times10^{-11}$ m^2/s and the activation energies varied in the range of 23·5−30·3 kJ/g mol depending on the temperature and sample thickness.

Thoruwa*et al.* (2000) developed three low cost, solar regenerative clay–$CaCl_2$ based solid desiccant materials, established their moisture sorption and regeneration characteristics, assessed their performance in comparison with commercial desiccants, and integrated these within a low cost solar drying system for small scale village based crop drying. The moisture sorption and desorption performance of the desiccants were characterized in a Fison Environmental Cabinet at conditions of 85% relative humidity and 25°C for 120 h for moisture sorption and 50°C and 20% relative humidity for 8 h for regeneration. These conditions were representative of the environmental conditions monitored in the solar drying system. The bentonite–$CaCl_2$ (type 1) desiccant gave a maximum moisture sorption of 45% dry weight basis while bentonite–$CaCl_2$ (type 2) and kaolinite–$CaCl_2$ (type 3) solid desiccants each gave moisture sorption values of 30% dry weight basis. It was concluded from the moisture sorption and regeneration characteristics that their application in solar crop drying and air dehumidification was highly useful due to their low regeneration temperatures (below 100°C).\

Nagaya *et al.* (2006) reported a new low temperature food drying system with controlled airflow and temperature. Low temperature drying allowed foods such as vegetables to be dried without losing the original color and texture. Existing low temperature systems were slow, and it was difficult to obtain uniform product quality. The system proposed consisted of an airflow control system to improve drying speed, and temperature control to ensure minimal damage to the food during the drying process in comparison with sun drying. Through experimental evaluation of the system, it was demonstrated that dried vegetables produced by this method retained their fresh color and high vitamin content.

Atuonwu*et al.* (2011) reported an energy efficient method for drying heat sensitive products based on drying air dehumidification by zeolites and process integration. Two optimization approaches were considered: sequential and simultaneous. In the sequential approach, a zeolite adsorption dryer was optimized for energy efficiency, subject to product temperature and final moisture constraints using the zeolite, drying and regeneration air flow rates as well as the regeneration air inlet temperature as decision variables. Heat was then optimally recovered from the process exhaust streams using pinch analysis. In the simultaneous method, heat recovery was considered an integral part of the drying process and the entire system simultaneously optimized. Since the heat recovery stream properties were unknown a priori, the pinch point was not unique but determined by optimization. The sequential and simultaneous methods reduced energy consumption by about 45% and 55%, respectively, compared to a conventional convective dryer at the same drying temperature of 50°C.

Djaeni*et al.* (2011) studied the energy efficiency of a dryer using dehumidified air (dehumidified by zeolite). Experimental results were fitted to a dynamic model to find important variables for the drying operation. The results showed that ambient air temperature as well as the ratio between air flow for drying and air flow for regeneration, affected the energy efficiency significantly. Relative humidity of used air and shift time had a minor effect on the dryer performance. From the total work, it could be noted that the dryer efficiency operated at 50-60°C achieved 75%, which was attractive for drying of food products.

Attkan*et al.* (2014) reported that low temperature drying allowed foods such as green leafy vegetables to be dried without losing the original color and texture. They proposed a system that consisted of desiccant dehumidifier which removed the moisture from the air and increased its adsorption capacity. Airflow rate and regeneration temperature of the dehumidifier was controlled to ensure minimal damage to the food during the drying process in comparison with tray drying. Fenugreek green leaves were dried from an initial moisture content of 88.6 % to 5% (wet basis). The fenugreek dried with rotary desiccant bed dehumidifier had superior green color, flavour and maximum retention of various nutrients.

Attkan*et al.* (2016) evaluated the performance of the rotary bed desiccant dehumidifier for air mass flow rates of 0.32, 0.63, 0.95 and 1.30 kg/s and different reactivation temperatures of 60, 70, 80, 90, 100, 110 and 120°C, respectively. Obtained experimental data including temperature and absolute humidity at both process and reactivation side via random factorial scheme were analyzed. Comparison of data average was carried out with the help of the multi amplitude test of Tukey. Statistical analysis of experimental data showed that reactivation temperature and air mass flow rate have a reasonable impact on the process and reactivation out temperature and absolute humidity. However, a combined effect of reactivation temperature and air mass flow rate on process and reactivation out temperature and absolute humidity was not meaningful ($p>0.05$). Process air inlet moisture content affects outlet moisture, if air was more humid entering the dehumidifier, it would be more humid leaving the unit. More moisture was removed from the process air as inlet humidity ratio increased. Process air mass flow rate through the desiccant bed strongly affected leaving moisture. Outlet humidity ratio was less if process air flow rate was less. Thus, more moisture was removed when the air mass flow rate was less. Results showed that by controlling air mass flow rate and reactivation temperature, a good range of temperature could be attained which is suitable for drying of agricultural crops at low humidity. Low temperature food drying enhanced the product quality, drying rate and retention of nutrients.

CONCLUDING REMARKS

Due to the latent heat of evaporation required, conventionaldrying is energy intensive operation. Drying should also ensure retention of desired quality levels in the product after drying. In any given conventional dryer, high efficiency of moisture removal is obtained by drying at high temperatures. But, it is done at the expense of product quality. The review of the published literature presented above reveals that by dehumidifying the drying air, the moisture removal capacity and hence, energy efficiency can be increased while drying at low temperatures. This necessitates the evaluation of the solid desiccant dehumidifier under actual ambient conditions for moisture removal, and assessment of the dehumidified air for drying of the selected food product.

The solid desiccant materials are used in the solid desiccant dehumidifiers to remove air moisture content. Adsorbents remain in solid form, and retain water vapor and other gases proportional to their surface areas. Several solid desiccant materials such as silica gel, calcium chloride, titanium silicates, molecular sieve, activated alumina, zeolite (artificial and natural), lithium chloride, polymers, organic based desiccants and composite desiccants are used.The use of desiccant materials depends on the source of thermal energy, cost and the operating conditions (Attkan*et al.*, 2016).

Keeping these facts in view, an attempt is made in the present work, to evaluate the performance of the solid desiccant dehumidifier to remove moisture from the ambient air and assess the use of dehumidified air for low temperature drying of leafy greens.

MATERIALS AND METHODS

The present work was undertaken to evaluate the performance of a solid desiccant dehumidifier to reduce the moisture from ambient air, and to assess the use of dehumidified air for the low temperature drying of leafy greens. The materials used and the methodology followed to fulfil the set objectives are presented in this Chapter. This Chapter is presented under the following heads:

- Details of solid desiccant dehumidifier
- Evaluation of the performance of solid desiccant dehumidifier to reduce moisture from ambient air
- Assessment of the use of dehumidified air for the low temperature drying of leafy green

Details of Solid Desiccant Dehumidifier

Figure 3. Solid Desiccant Dehumidifier

A solid desiccant dehumidifier is procured which is having the following technical specifications (Table 1):

Table 1. Specifications of solid desiccant dehumidifier

Sl. No.	Particulars	
1.	Temperature of air entering the dehumidifier	Ambient, to be measured
2.	Relative humidity of air entering the dehumidifier	Ambient, to be measured
3.	Nominal air flow rate of process air, ft^3/min	150
4.	Fan motor power of process air, hp	0.5
5.	Diameter of dehumidifier wheel, mm	500
6.	Desiccant material	Silica gel, honey comb design
7.	Rotary speed of dehumidifier wheel, rph	100
8.	Drive motor to dehumidifier wheel, hp	1
9.	Temperature of air leaving the dehumidifier	To be measured
10.	Relative humidity of air leaving the dehumidifier	To be measured
11.	Type of regeneration	Electric heater
12.	Regeneration temperature, °C	30 - 90
13.	Heater power, kW	3.5
14.	Nominal air flow rate of reactivation air, ft^3/min	40
15.	Fan motor power of reactivation air, hp	0.5

Evaluation of the Performance of Solid Desiccant Dehumidifier to Reduce Moisture from Ambient Air

Adsorption study of desiccant dehumidifier will be carried out throughout the day for 15 days under ambient conditions. Process air flow rate will be maintained at150 ft^3/min. The variation in temperature and relative humidity of process air will be measured at every hourly interval from 10.00 a.m. to 5.00 p.m. The regeneration temperature will be set tone value between 30-90°C. The rotary speed of desiccant wheel is fixed at 100 rph.

The temperature and relative humidity of air leaving the dehumidifier will be measured at every hourly interval. The variation in temperature and relative humidity of air entering the dehumidifier and air leaving the dehumidifier will be plotted against the time in each day. Adsorption capacity is the capacity of the desiccant wheel to adsorb moisture on the surface, and it is the difference between process inlet and process out absolute humidity.

Desorption capacity (moisture removal capacity at reactivation side) is the capacity of the desiccant wheel to desorb moisture from the desiccant bed surface and it is the difference between reactivation out and reactivation in absolute humidity.

The performance of dehumidifier to produce dehumidified air for about 15 days will give the information on the possible application of the dehumidifier for drying of various products.

Assessment of the Use of Dehumidified Air for the Low Temperature Drying of Leafy Greens

A small size drying chamber with trays will be developed to study the drying characteristics of some leafy greens with dehumidified air. The rate of removal of moisture will be plotted against time to determine the drying rate. The condition of leafy greens after drying will be compared with conventional drying.

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