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UTILIZATION OF SILICA GEL AS A DESICCANT MATERIAL OF MOIST AIR USING IN DRING PROCESS

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ABSTRACT

The dehumidifying process of moist air before using in drying process not only reduces the energy consumption in drying process but also improve the performance of the process. In this work, a new concept is developed by making the ambient air flows parallel on silica gel bed. A certain amount of the humidity of incoming air, which is removed by silica gel, depends on many parameters; the weight and thickness of silica gel, air flow rate and the bed diameter. The experimental work was carried out to investigate the performance and energy saving during drying process using the silica gel bed system. The obtained results indicated that the silica gel can be used as a desiccant material for removing the ambient air humidity and therefore increasing its efficiency during drying process of the agricultural products. The optimal conditions were; 12.5 cm bed diameter, 0.053 kg/s air flow rate and 1.2 kg silica gel weight. At these conditions the maximum values of water absorption rate, temperature increase and energy saving were; 6.4 g/kg air, 11 Cº, and 0.586 kW, respectively, and the minimum value of air moisture content (2.59 g/kg air) can be achieved.

INTRODUCTION

The use of fossil fuel in the mechanical dryers has become a common practice in Egyptian agriculture. With shortage and high price of fossil fuel, the reduction of energy consumption and the development and application of alternative energy source like solar energy become more and more important. The solar dryer uses the ambient air in the drying process; this ambient air usually has a high relative humidity and sequentially high moisture content. These characteristics of ambient air caused an increasing in energy consumption of solar dryer as a result of high moisture content of ambient air, which lead to increase the drying period. The dehumidifying process of moist air before using in drying process especially in solar dryer not only reduces the energy consumption but also improve the performance of drying process. Silica gel is hygroscopic, and responds to the relative humidity of the surrounding air. Because of its high internal surface area and its enormous number of angstrom-sized pores, this desiccant material has the ability to adsorb nearly 40 percent of its weight of water (Parsons, *et al*., 1987).

Silica gel desiccant is widely used in industrial drying processes: generally the beds are relatively thick and can be designed using quasi-steady breakthrough methods. In recent years silica gel has been considered for solar evaporative-desiccant air conditioning systems, at which pressure drop constraints require use of thin beds (less than 15 cm thick). The operation of thin beds is inherently transient and current design procedures are based on models of the transient heat and mass transfer occurring in the bed. Such models represent the overall heat and mass transfer from the air stream to the silica gel by psuedo gas-side transfer coefficients (Pesaran and Mills, 1986).

Moreover, David, *et al*., (2001) added that the most commonly used adsorbent is silica gel due to its high water capacity, chemical inertness, and ability to undergo an indefinite number of moisture cycles. Ng *et al*., (2001) and Tahat, (2001) mentioned that the silica gel has a great capacity to adsorb vapor water, of around 35 to 40% of its dry mass, along with low regeneration temperatures. In addition, Afonso and Silveira, (2005) stated that the choice of an adsorbent material will depend on the vapor to be adsorbed, in addition to the retention capacity of the adsorbent (kg adsorbate / kg adsorbent). They also added that the adsorption–desorption cycle can be repeated many times without significantly altering the physical-chemical properties of the adsorbent. They also concluded that, the amount of water adsorbed by silica gel ranged from 0.007 to 0.209 kg/kg. On the other hand, Saha *et al*., (2000) reported that the silica gel is a highly porous solid produced from sulfuric acid and sodium silicate. Each 1 m^3 of silica gel contains pores that if added would account for a surface area of about 2.8×10^7 m^2. However, Tahat, (2001) added that, silica gel is safe, non corrosive, cheep, abundant and it has been widely used to its great adsorption capacity and chemical stability.

National Energy Policy Office, (1998) stated that, due to the energy–economic crisis in the last few years, energy saving has become a crucial issue and various government agencies and organizations have implemented several campaigns and programs such as demand side management, different ratification rates, etc. Actually, there are many well-known ways to reduce the energy consumption of an air-conditioning system. One of them is the use of a desiccant such as silica gel to remove part of the moisture from either return or outdoor air in order to western sides of the drying cabinet, alternatively.

Even though most published research works concluded that desiccant air-conditioning is an interesting energy saving technique, to the best of our knowledge. In fact, most designers reject it systematically as they only focus on the high temperature of air leaving the bed which is expected to increase the sensible heat load (Chindaruksa, *et al*., 2001). Hirunlabh, *et.al*.,(2002) conducted an experimental analysis to investigate the performance and energy saving of a desiccant air-conditioning system in Thailand. The system was composed of a silica gel bed, (thickness of 3 and 5 cm), a split type air-conditioner (1.5 ton refrigeration) installed in a room of volume 76.8 m^3, air ducts and a blower. They recommended that the best bed thickness is 5 cm with a maximum adsorption rate of 473 g/h. The results also, showed that during the adsorption process of moisture by silica gel, a certain amount of heat is released which depends on the amount of adsorbed moisture; the higher the adsorbed amount, the higher the heat released. The corresponding electricity saving was about 24%.

Khedari and Hirunlabh, (2001) developed a solar dryer using active adsorption-passive regeneration of silica gel beds. Three beds were installed at three sides of the drying cabinet: east, south, and west. The size of the silica gel bed is 0.6 m wide and 1.0 m high. The thickness of the bed is adjustable. The vertical bed is covered with a glass plate which attaches a wall of the drying chamber. The silica gel particles are 2-5 mm in diameter with a bulk density of 670 kg/m^3. The inlet air temperature, moisture ratio and air mass flow rate were controlled. They concluded that a silica gel bed thickness of 0.03 m and 0.02 kg/s air flow rate are recommended for the active adsorption process.

The main objective of this study was to conduct an experimental analysis to investigate the performance and energy saving of the silica gel bed system used for dehumidifying the moist air.

MATERIALS AND METHODS

This research work was carried out at Research and Test Station of Tractors and Agricultural Machinery, Sabahiya, Alexandria, Agricultural Engineering Research Institute, to investigate of some factors affecting silica gel bed performance during dehumidifying process of moist air. These factors include:

- Three different bed diameters of; 7.5, 10.0, and 12.5 cm.
- Seven different weights of silica gel (0.2, 0.4, 0.6, 0.8, 1.0, 1.2, and 1.4 kg).
- Three different air mass flow rates of 0.018, 0.038, and 0.053 kg/s

Silica Gel Bed Specifications:

Three different sizes of silica gel bed with constant volume of about 2430 cm^3 were used in this research work. The silica gel beds are cylindrical in shape and made from plastic material (PVC), which is not affected by the chemical materials. The bed cylinders with different diameters and lengths (D and L) were provided with an inlet air tube (d) diameter (as listed in Table: 1), the inside part of this tube was provided with many holes (each one has 5 mm diameter) around the tube. These holes were made to uniform distribute the ambient air throughout the silica gel drying bed as showed in Fig. (1). The maximum thickness of silica gel inside the drying bed is H cm while, the density of silica gel was 1.11 g/cm^3.

Table (1): The gross dimensions of silica gel beds :

Dryer	L (cm)	D (cm)	H (cm)	d (cm)
1	55	7.5	28.6	3.8
2	30.9	10	16.1	5
3	19.8	12.5	10.3	5

Air delivery unit:

Atmospheric air was supplied to the silica gel drying bed using an air blower. Control system was connected to the air blower (timer and flow regulator) to control the air flow rate. The specifications of air blower were: Electric motor power of 0.25 kW, at speed of 1400 rpm, the inlet air diameter is 8 cm and the outlet air diameter is 5 cm. The air velocity and the humidity ratio were measured using the Mini Thermo-Anemometer$^+$. While the air temperature was measured by 6 channels Data Logger, Omega Type RD1606 using thermocouple type T.

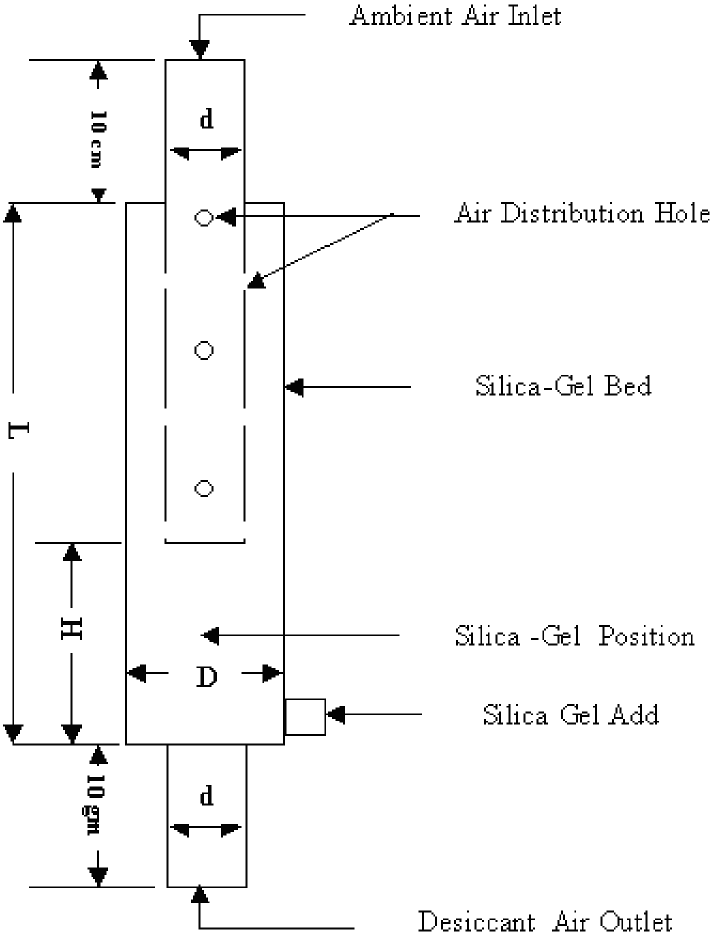

Fig. (1): Schematic diagram of silica-gel drying bed

Procedures:

Throughout the experimental work, some measurements were executed on the inlet and outlet ambient air such as temperature, relative and absolute humidities and air velocity. The values of temperature, relative and absolute humidities of the ambient air were; 18 C^o, 70% and 8.99 g $_{water}$/kg $_{air}$, respectively. While for outlet air these values were recorded at different factors affecting drying process. On the other hand, some determinations such as the amount of water absorbed from air and the air relative humidity were calculated using the Psychometric Chart. The mass flow rate of air could be calculated from the velocity of the ambient air and the cross section area of inletwhile, the energy saving due to the drying process of desiccant air temperatures was calculated according the following equation:

$$Q_{save} = m \times specific\,heat \times \Delta T \qquad kW$$

Where, Q_{save} = energy saving kW

m = air mass flow rate kg/s

Specific heat of air = 1.0057 kJ/kg. K°

ΔT= the differences between outlet and inlet air temperature, K°

RESULTS AND DISCUSSION

The silica gel desiccant was used to dry the ambient air. The different factors affecting the drying process such as; silica-gel weight, bed diameter and air flow rate and its effect on water absorption rate, desiccant air temperature, and the energy saving were studded and the obtained results are listed in Table (2).

1- Water absorption rate from ambient air

The effect of silica-gel weight, bed diameter and air flow rate on water absorption rate from ambient air are illustrated in Table (2) and Fig.(2). The obtained data showed that the absorption water rate (g_{water}/kg_{air}) increases gradually with the increase of the bed diameter until reached the maximum value of 6.4 g/kg (about 71.2% air relative humidity). At this value the output air humidity reached the minimum value of 2.59 g/kg (about 28.8% air relative humidity). This may be due to increase the surface area of the silica gel with increase the bed diameter and therefore, increasing the absorption efficiency. Moreover, with increasing the silica gel weight from 0.2 to 1.4 kg, the water absorption rate increases at different bed diameters and air flow rates. At 7.5 cm bed diameter, it was increased with increasing silica gel weight at all air flow rates till reached the maximum values of 6.4; 5.6 and 5.4 g water/kg air at 1.4 kg silica gel weight and 0.018; 0.038 and 0.053 kg/s air flow rates, respectively. While it was decreased with increasing the air flow rates. However, with 10.0 cm bed diameter, the maximum value of water absorption rate (6.4 g/kg) occurred at 1 kg silica gel weight and then it was constant at higher weights and 0.018 kg/s air flow rate. While this maximum value occurred at 1.2 and 1.4 kg silica gel weight and 0.038 kg/s air flow rate and 1.4 kg silica gel weight and 0.053 kg/s air flow rate. It was also, clear that using 1.4 kg silica gel resulted in constant values of water absorption rate at all air flow rates. Whereas with bed diameter of 12.5 cm, the water absorption rate reached the maximum and constant value of 6.4 g/kg at 0.8, 1.0, and 1.2 kg of silica gel weights and air flow rates of 0.018, 0.038, and 0.053 kg/s respectively. Fig. (2) also revealed that, the water absorption rate was decreased with increasing the air flow rate at different silica gel weights and all bed diameters, except at silica gel weight of 1.4 kg and 10.0 cm bed diameter and 1.2 and 1.4 kg silica gel weight and 12.5 cm bed diameter it was constant at all flow rates .

The maximum water absorption rate was 6.4 g/kg, this value is less than that obtained by Afonso and Silveira, (2005), who concluded that the amount of water adsorbed by silica gel ranged from 7.0 to 209.0 g/kg. At the maximum value of water absorption rate, the ambient air humidity ratio

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reached the minimum value of 2.59 g/kg (about 28.8% air relative humidity). These values of maximum water absorption rate and minimum ambient air humidity ratio occurred at 1.4 kg silica gel weight with 7.5 cm bed diameter and 0.018 kg/s air flow rate. While with bed diameter of 10.0 cm this value occurred at 1.0, 1.2 and 1.4 kg silica gel weight and 0.018, 0.038, and 0.053 kg/s air flow rates respectively. At bed diameter of 12.5 cm, this value occurred at 0.8, 1.0, and 1.2 kg silica gel weight and the same air flow rates, respectively.

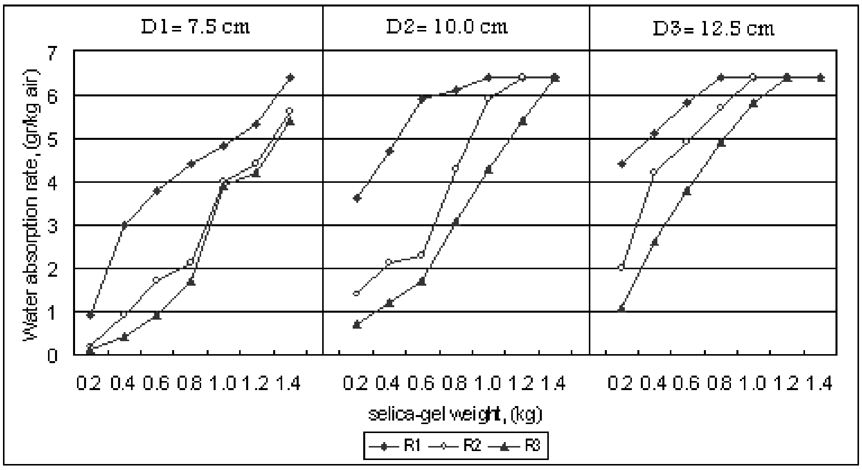

Fig. (2): Effect of silica-gel weight, bed diameter (D) and air flow rate (R) on water absorption rate.

Fig. (3) illustrates the effect of silica-gel weight, bed diameter and air flow rate on the desiccant air humidity. The obtained results showed that the desiccant air humidity was decreased with increasing the silica gel weight and bed diameter, while it was increased with increasing the air flow rate except at silica gel weight of 1.2 and 1.4 kg and bed diameter of 10.0 and 12.5 cm, it was constant. The minimum value of desiccant air humidity was 2.59 g/kg air (about 28.8% air relative humidity). At the bed diameter of 7.5 cm, it occurred only with the air flow rate of 0.018 kg/s and 1.4 kg silica gel weight, while at the other two air flow rates this value was higher (3.39, and 3.59 g/kg air respectively). With bed diameter of 10 cm, the minimum value of desiccant air humidity was occurred at 1.0, 1.2, and 1.4 kg silica gel weight and 0.018, 0.038, and 0.053 kg/s air flow rates, respectively. While at bed diameter of 12.5 cm it was achieved at 0.8, 1.0, and 1.2 kg silica gel weight and 0.018, 0.038, and 0.053 kg/s air flow rates, respectively. The air flow rate of 0.018 kg/s gave the best values of desiccant air humidity followed by 0.038 and 0.53 kg/s air flow rates, respectively. The minimum value of desiccant air humidity (2.59 g/kg air) was achieved at 1.4, 1.0, and 0.8 kg silica gel weights with bed diameters of 7.5, 10.0, and 12.5 cm, respectively. This value was constant at silica gel weights ranged from 1.0 to 1.4 kg and bed diameter of 10.0 cm and from 0.8 to 1.4 kg and 12.5 cm bed diameter. At 0.038 kg/s air flow rate and bed diameter of 10.0 cm, the desiccant air humidity reached the minimum value at 1.2 and 1.4 kg silica gel weight, while with 0.053 kg/s air flow rate and bed diameter of 12.5 cm, this value occurred at silica gel weight of 1.0 kg. The results also indicated that the bed diameter of 12.5 cm gave the best values of water absorption rates and desiccant air humidity (6.4 and 2.59 g/kg). These values were obtained at 1.2 kg of silica gel and greater than 1.2 kg with different air flow rates. This may be attributed to increase the surface area and the decrease of the thickness of silica gel layer (recommended value was 5 cm, as reported by Hirunlabh, et.al., (2002) and less than 15 cm as reported by Pesaran and Mills, (1986).

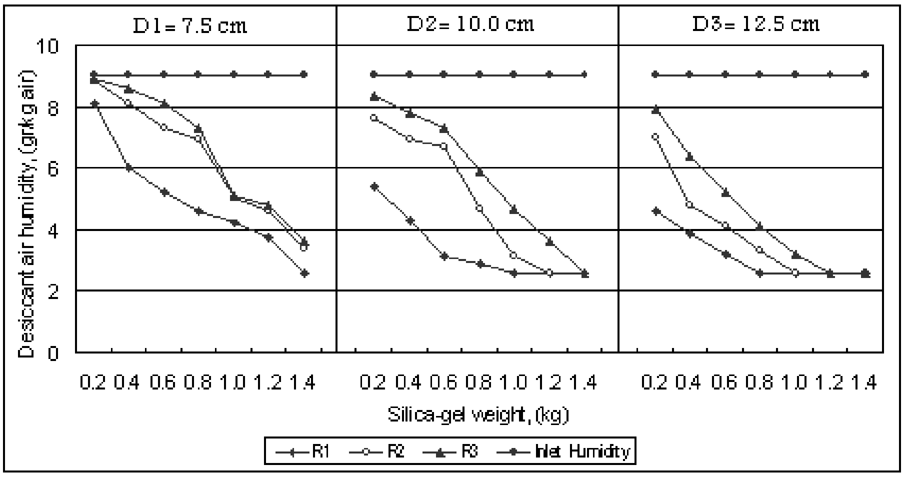

Fig. (3): Effect of silica-gel weight, bed diameter (D) and air flow rate (R) on desiccant air humidity.

2-The desiccant air temperature.

Use silica gel to reduce the relative humidity of the ambient air resulted in a heat release, which occurred due to transform of water molecules from the vapor phase to the adsorbed phase (adsorption process). The effect of silica-gel weight, bed diameter and air flow rate on the desiccant air temperature are illustrated in Fig. (4). The results evidently showed that, desiccant air temperature increased with increasing the bed diameter and silica gel weigh while it was decreased with increasing the air flow rate . The minimum temperature of desiccant air was 18.5 C^{o} at bed diameter of 7.5 cm, silica gel weight of 0.2 kg and air flow rate of 0.053 kg/s. Whereas, the maximum temperature was 29 C^{o} which occurred at bed diameter of 12.5 cm, silica gel weight of 1.0 kg and air flow rate of 0.018 kg/s, and it was constant at silica gel weigh of 1.2 and 1.4 kg and all flow rates with the same bed diameter. At bed diameter of 7.5 cm, the desiccant air temperature increased from 19 to 27 Cº with increasing the silica gel weight from 0.2 to 1.4 kg at air flow rates of 0.018 and 0.038 kg/s, while it was increased from 18.5 to 26.5 Cº at air flow rate of 0.053 kg/s. The increasing ratio in desiccant air Increasing the bed diameter from 7.5 to 10.0 cm resulted in increase the desiccant air temperature at all air flow rates. The desiccant air temperatures at 10.0 cm bed diameter and 0.2 kg silica gel weight were increased from 22, 21, and 20 Cº at to 28 Cº at 1.4 kg silica gel weight and air flow rates of 0.018, 0.038, and 0.053 kg/s, respectively. The increasing ratios in desiccant air temperature ranged from 11.1% at silica gel weight of 0.2 kg and air flow rate of 0.053 kg/s to 55.6% at 1.0 and 1.2 kg silica gel weights and air flow rate of 0.018 kg/s, and at 1.4 kg with all air flow rates as compared with ambient air. On the other hand at 10.0 cm bed diameter the increasing ratios reached to15.8, 10.5, and 8.1% at 0.2 kg silica gel weight and air flow rates of 0.018, 0.038 and 0.053 kg/s, respectively as compared with 7.5 cm bed diameter. These increasing ratios decreased with increasing the silica gel weight from 0.2 to 1.4 kg, till reached the minimum values of 3.7% at air flow rates of 0.018 and 0.038 kg/s and 5.7% at air flow rate of 0.053 kg/s. However, at the bed diameter of 12.5 cm, the desiccant air temperature increased from 23 Cº at silica gel weight of 0.2 kg and air flow rates of 0.018 and 0.038 kg/s and from 21 Cº at air flow rate of 0.053 kg/s to reach the maximum value of 29 Cº at 1.2 and 1.4 kg silica gel weight and all air flow rates. The increasing ratios of desiccant air temperature as compared with the ambient air temperature (18 Cº) ranged from 16.7% at 0.2 kg silica gel weight and air flow rate of 0.053 kg/s to 61.1% at 1.0 kg silica gel weight and air flow rate of 0.018 kg/s and at 1.2 and 1.4 kg silica gel weights with all air flow rates. The increasing ratios in desiccant air temperature at the bed diameter of 12.5 cm as compared with the bed diameter of 10.0 cm were; 4.5, 9.5, and 5% at the silica gel weight of 0.2 kg and air flow rates of, 0.018, 0.038, and 0.053 kg/s, respectively. These ratios were decreased with increasing the silica gel weight till reached the minimum value of 3.6% at 1.4 kg silica gel weight for all flow rates. On the other hand, the increasing ratios in desiccant air temperature at the bed diameter of 12.5 cm as compared with the bed diameter of 7.5 cm were; 21.1% at silica gel weight of 0.2 kg and air flow rates of 0.018 and 0.038 kg/s and 13.5% with air flow rate of 0.053 kg/s. At silica gel weight of 1.4 kg, these ratios were decreased until reached the minimum values of 7.4% at 0.018 and 0.038 kg/s air flow rates and 9.4% at air flow rate of 0.053 kg/s.

Figure (4) also, illustrated that, the bed diameter of 12.5 cm gave the higher difference in desiccant air temperature (11 Cº) at 1.2 and 1.4 kg silica gel weights and all air flow rates followed by bed diameters of 10.0 and 7.5 cm, respectively. Also, it indicated that the silica gel weights of 1.0, 1.2 and 1.4 kg gave the higher desiccant air temperature values and about the same desiccant air temperature values at all bed diameters and air flow rates. However, air flow rate of 0.018 kg/s gave the higher values of desiccant air temperature followed by 0.038 and 0.053 kg/s, respectively, at all bed diameters.

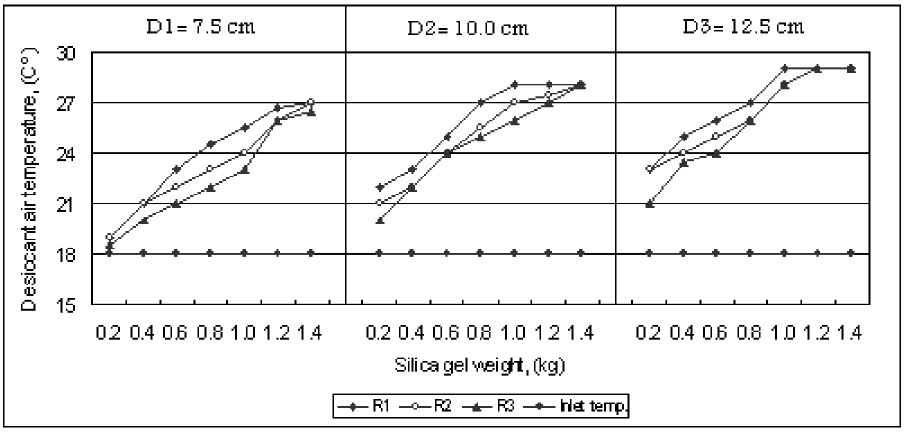

Fig. (4): Effect of silica-gel weight, bed diameter (D) and air flow rate (R) on the desiccant air temperature.

The energy saving from drying the ambient air using silica gel:

Using the silica gel to dry the ambient air resulted in increase the desiccant air temperature and consequently saving the energy consumed to increase the air temperature. Table (2) and Fig. (5) illustrate the effect of silica-gel weight, bed diameter and air flow rate on energy saving through dry of the ambient air using silica gel bed. The obtained results showed that the maximum value of energy saving was 0.586 kW which occurred at air flow rate of 0.053 kg/s ,bed diameter of 12.5 cm and silica gel weight of 1.2 and 1.4 kg. While the minimum value was 0.027 kW which occurred at the same flow rate and bed diameter of 7.5 cm and silica gel weight of 0.2 kg. The results also revealed that, the energy saving increased with increasing the bed diameter, air flow rate and silica gel weight. At bed diameter of 7.5 cm, the maximum energy saving were; 0.163, 0.344, and 0.453 kW at silica gel weight of 1.4 kg and the air flow rates of 0.018, 0.038, and 0.053 kg/s, respectively with increasing ratios of 111 and 178% at flow rates of 0.038 and 0.053 kg/s, respectively, as compared with air flow rate of 0.018 kg/s. While the increasing ratio reached to 31.7% as the flow rate increase from 0.038 to 0.053 kg/s. However, at bed diameter of 10.0 cm these values were; 0.181, 0.382, and 0.533 kW at the same air flow rates and silica gel weight, with increasing ratios of 111 and 194.4% at air flow rates of 0.038 and 0.053 kg/s, respectively, as compared with 0.018 kg/s air flow rate. While it reached only 39.5% as the air flow rate increased from 0.038 to 0.053 kg/s.

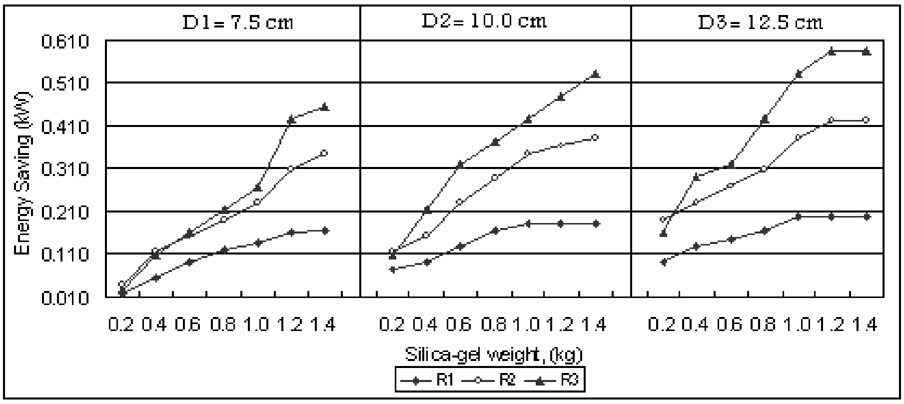

Fig. (5): Effect of silica gel weight, bed diameter and air flow rate on energy saving.

In addition, using the bed diameter of 12.5 cm resulted in increase the maximum energy saving values. These values were; 0.199, 0.420, and 586 kW at the same air flow rates and silica gel weight, respectively. The increasing ratios were the same of that recorded at bed diameter of 10.0 cm. Furthermore, the silica gel weights of 1.2 and 1.4 kg gave the same energy saving values at all air flow rates.

On the other hand, Fig.(5) illustrated also that, at the first flow rate (0.018 kg/s), increasing the bed diameter from 7.5 to 12.5 cm led to increase the energy saving but with low ratio. The maximum values were 0.163, 0.181, and 0.199 kW at 1.4 kg silica gel weight and bed diameters of 7.5, 10.0, and 12.5 cm, respectively. The increasing ratios were 11% and 22% at bed diameters of 10.0 and 12.5 cm, respectively as compared with 7.5 cm bed diameter. It also noted that, the energy saving values are the same at silica gel weight of 1.0, 1.2, and 1.4 kg and bed diameters of 10.0 and 12.5 cm. At the second flow rate (0.038 kg/s), the maximum values of energy saving were; 0.344, 0.382, and 0.420 kW at the same bed diameters, respectively. The increasing ratios were the same as the first flow rate (0.018 kg/s). While with air flow rate of 0.053 kg/s, the maximum values of energy saving were 0.453, 0.533, and 0.586 kW at the same bed diameters, respectively, with the increasing ratios of 17.6 and 29.4% at 10.0 and 12.5 cm as compared with 7.5 bed diameter, respectively.

The results also indicated that, increasing air flow rat from 0.018 to 0.053 kg/s led to increase the energy saving with higher ratios as compared with the increase in bed diameter.

Conclusions and Recommendations

1-The ambient air humidity reached the minimum value (2.59 g/kg air) at the maximum water absorption rate (6.4 g/kg air). The air flow rate of 0.018 kg/s gave the best values of water absorption rate at all bed diameters followed by 0.038 and 0.053 kg/s respectively. The best silica gel weight was 0.8, 1.0, and 1.2 kg at 12.5 cm bed diameter and 0.018, 0.038 and 0.053 kg/s air flow rates, respectively.

2-The maximum increase in the desiccant air temperature (11 Cº) occurred at 12.5 cm bed diameter, 1.0 kg silica gel weight and 0.018 kg/s air flow rate, and 1.2 and 1.4 kg silica gel weight at all air flow rates. The air flow rate of 0.018 kg/s gave the highest values of desiccant air temperature at all bed diameters followed by 0.038 and 0.053 kg/s, respectively.

3- The maximum energy saving (0.586 kW) was obtained at 12.5 cm bed diameter and 1.2 and 1.4 kg silica gel weight and 0.053 kg/s air flow rate. The air flow rate of 0.053 kg/s gave the highest values of energy saving at all bed diameters followed by 0.038 and 0.018 kg/s, respectively.

4- Using of silica gel to dry the ambient air lead to increase the desiccant air temperature by 61% as compared with inlet air, provided an energy of 0.586 kW and decrease the air humidity by 71.2%.

5- The bed diameter of 12.5 cm gave the best values of the water absorption rate, the desiccant air temperature and the energy saving followed by 10.0 and 7.5 cm, respectively

6- It can be recommended that the silica gel bed may be used for drying the ambient air at the optimal conditions of 12.5 bed diameter, 0.053 kg/s air flow rate and 1.2 kg silica gel weight. At these conditions the maximum values of water absorption rate (6.4 g/kg air, about 71.2% from the ambient air humidity), heat added (11 Cº), and energy saving (0.586 kW) and minimum value of ambient air humidity (2.59 g/kg air, about 28.8% from the ambient air humidity) can be obtained.

7- It can also be recommended that further experimental testing could be conducted to study the factors affecting the drying process and the time required to dry the saturated silica gel to increase its efficiency of humidity absorption.

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استغلال السيليكا جيل كمادة مجففة للهواء الرطب المستخدم فى عملية التجفيف

ناصر مصطفى العشماوى ، سلوى شفيق حنا و مصطفى كامل البخشوان
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تستخدم المجففات الشمسية الهواء الجوى فى تجفيف المنتجات الزراعية, ونظرا لارتفاع الرطوبة النسبية للهواء فى بعض المناطق وبالتالى زيادة المحتوى الرطوبى مما يتطلب ضرورة إزالة هذه الرطوبة من الهواء قبل دخوله فى عملية التجفيف وذلك لزيادة قدرة الهواء على حمل كميات اكبر من رطوبة المنتج المراد تجفيفه مما يقلل من الطاقة المستهلكة و الوقت اللازم لعملية التجفيف و يحسن من أداء هذه العملية 0 وحيث أن عملية تجفيف الهواء تستهلك الكثير من الطاقة سواء كانت طاقة تقليدية أو غير تقليدية فقد تم اتباع نمط جديد لتجفيف الهواء فى هذا البحث يعتمد على مروره على مادة مجففة لإزالة الرطوبة منه, هذه المادة هى السيليكا جيل0 حيث تعتمد كمية الرطوبة المزالة من الهواء على وزن و سمك طبقة السيليكا جيل, معدل سريان الهواء و قطر المجفف0

و قد أجرى هذا البحث فى محطة أبحاث و اختبار الجرارات و الآلات الزراعية بالإسكندرية , معهد بحوث الهندسة الزراعية لدراسة أداء مجفف يعمل بمادة السيليكا جيل وكذلك الطاقة التى يمكن الحصول عليها من هذا النظام أثناء استخدامه فى تجفيف الهواء الجوى 0حيث تم تصنيع عدد 3 مجففات من مادة ال PVC بحجم 2430 سم^3 و ذات أقطار 7.5, 10 و 12.5 سم , تم وضع مادة السيليكا جيل داخل المجففات بأوزان مختلفة (0.2, 0.4 , 0.6 , 0.8 , 1 , 1.2 و 1.4 كجم) مع استخدام ثلاث معدلات لسريان الهواء (0.018 , 0.038 و 0.053 كجم/ث) 0 و كانت خصائص الهواء الجوى الداخل فى التجارب هى: درجة الحرارة 18 م^o, الرطوبة النسبية 70%, كمية الرطوبة فى الهواء 8.99 جرام / كجم هواء0

و قد أظهرت النتائج المتحصل عليها إمكانية استخدام السيليكا جيل كمادة مجففة لإزالة الرطوبة من الهواء الجوى وبالتالى زيادة كفاءة عمليات تجفيف المنتجات الزراعية0 و كانت الظروف المثلى للتشغيل هى: قطر المجفف 12.5 سم, معدل سريان الهواء 0.053 كجم/ث, وزن و سمك طبقة السيليكا جيل 1.2 كجم و 8.8 سم على الترتيب0 عند هذه الظروف تم الحصول على أعلى قيمة لمعدل امتصاص الرطوبة (6.4 جرام /كجم هواء, حوالى 71.2% من رطوبة الهواء الداخل فى التجارب), الحرارة المكتسبة (11م^o) , الطاقة المكتسبة (0.586 ك واط) , و كذلك أقل قيمة لرطوبة الهواء المجفف (2.59 جرام/ كجم هواء, حوالى 28.8% من رطوبة الهواء الداخل فى التجارب)0

Table (2): Effect of silica-gel weight, bed diameter and air flow rate on water absorption rate, desiccant air temperature, and the energy saving through drying of ambient air using silica-gel.

Bed diameter	Silica gel		Water absorption rate, (g/kg air)			Desiccant air humidity (g/kg air)			Desiccant air temperature (C°)			Energy Saving (kW)					
	Weight	Thickness	Air flow rat, kg/s			Air flow rat, kg/s			Air flow rat, kg/s			**0.018 kg/s**		**0.038 kg/s**		**0.053 kg/s**	
(cm)	(kg)	(cm)	**0.018**	**0.038**	**0.053**	**0.018**	**0.038**	**0.053**	**0.018**	**0.038**	**0.053**	ΔT(K°)	Q (kW)	ΔT (K°)	Q (kW)	ΔT(K°)	Q (kW)
7.5	0.2	4.1	0.9	0.2	0.1	8.09	8.79	8.89	19	19	18.5	1.0	0.018	1.0	0.038	0.5	0.027
	0.4	8.2	3	0.9	0.44	5.99	8.09	8.55	21	21	20	3.0	0.054	3.0	0.115	2.0	0.107
	0.6	12.2	3.8	1.7	0.9	5.19	7.29	8.09	23	22	21	5.0	0.091	4.0	0.153	3.0	0.160
	0.8	16.3	4.4	2.1	1.7	4.59	6.89	7.29	24.5	23	22	6.5	0.118	5.0	0.191	4.0	0.213
	1.0	20.4	4.8	4	3.9	4.19	4.99	5.09	25.5	24	23	7.5	0.136	6.0	0.229	5.0	0.267
	1.2	24.5	5.3	4.4	4.2	3.69	4.59	4.79	26.7	26	26	8.7	0.157	8.0	0.306	8.0	0.426
	1.4	28.6	6.4	5.6	5.4	2.59	3.39	3.59	27	27	26.5	9.0	0.163	9.0	0.344	8.5	0.453
10	0.2	2.3	3.6	1.4	0.7	5.39	7.59	8.29	22	21	20	4.0	0.072	3.0	0.115	2.0	0.107
	0.4	4.6	4.7	2.1	1.2	4.29	6.89	7.79	23	22	22	5.0	0.091	4.0	0.153	4.0	0.213
	0.6	6.9	5.9	2.3	1.7	3.09	6.69	7.29	25	24	24	7.0	0.127	6.0	0.229	6.0	0.320
	0.8	9.2	6.1	4.3	3.1	2.89	4.69	5.89	27	25.5	25	9.0	0.163	7.5	0.287	7.0	0.373
	1.0	11.5	6.4	5.9	4.3	2.59	3.09	4.69	28	27	26	10.0	0.181	9.0	0.344	8.0	0.426
	1.2	13.8	6.4	6.4	5.4	2.59	2.59	3.59	28	27.5	27	10.0	0.181	9.5	0.363	9.0	0.480
	1.4	16.1	6.4	6.4	6.4	2.59	2.59	2.59	28	28	28	10.0	0.181	10.0	0.382	10.0	0.533
12.5	0.2	1.5	4.4	2	1.1	4.59	6.99	7.89	23	23	21	5.0	0.091	5.0	0.191	3.0	0.160
	0.4	2.9	5.1	4.2	2.6	3.89	4.79	6.39	25	24	23.5	7.0	0.127	6.0	0.229	5.5	0.293
	0.6	4.4	5.8	4.9	3.8	3.19	4.09	5.19	26	25	24	8.0	0.145	7.0	0.268	6.0	0.320
	0.8	5.9	6.4	5.7	4.9	2.59	3.29	4.09	27	26	26	9.0	0.163	8.0	0.306	8.0	0.426
	1.0	7.3	6.4	6.4	5.8	2.59	2.59	3.19	29	28	28	11.0	0.199	10.0	0.382	10.0	0.533
	1.2	8.8	6.4	6.4	6.4	2.59	2.59	2.59	29	29	29	11.0	0.199	11.0	0.420	11.0	0.586
	1.4	10.3	6.4	6.4	6.4	2.59	2.59	2.59	29	29	29	11.0	0.199	11.0	0.420	11.0	0.586