The principle of drying engineering essay

Engineering

Drying is a complex operation involving transient of heat and mass along with several rate processes, such as physical or chemical transformations, which, in turn may cause changes in product quality (colour, texture, odour, etc.) as well as the mechanisms of heat and mass transfer. Perhaps, it is the oldest, most common and most diverse of chemical engineering unit operations. Drying is a dual and simple process which easily accessible and widely used in present days. The dual process of drying includes (i) heat transfer to the drying object from the heating sources and (ii) removing moisture from the drying object being heated up, then, followed by removing moisture from drying object surface to the environments (Jinjai et al., 2009). (Fig. 2. 1)Fig. 2. 1: The drying principle of a product/sampleThe heat energy from heating sources transfer to drying object through conduction, convection, radiation, microwave and radio frequency fields, and/or combined mode. All modes except the dielectric (microwave and radio frequency) supply heat at the boundaries of the drying object so that the boundary of the material before it is transported away by the carrier gas (or by application of vacuum for non-convective dryers). Transport of moisture within the solid may occur by any one or more of the following mechanisms of mass transfer: Liquid diffusion, if the wet solid is at a temperature below the boiling point of the liquidVapour diffusion, if the liquid vaporizes within materialKnudsen diffusion, if drying takes place at very low temperatures and pressures, e. g. in freeze dryingSurface diffusion (possible although not proven)Hydrostatic pressure differences, when internal vaporization rates exceed the rate of vapour transport through the solid to the surroundingsCombinations of the above mechanismsEvaporation of moisture takes place in the form of evaporative losses and so the crop is dried.

Further a part of absorbed thermal energy is conducted into the interior of the product. This causes a rise in temperature and formation of water vapour inside the crop and then diffuses towards the surface of the crop and finally losses thermal energy in the crop and then diffuses towards the surface of the crop and finally losses the thermal energy in the form of evaporation. In the initial stages, the moisture removal is rapid since the excess moisture on the surface of the product presents a wet surface to the drying air. Subsequently, drying depends upon the rate at which the moisture within the product moves to the surface by a diffusion process depending upon the type of the product (Sharma, Chen and Vu lan, 2009).

Conventional Sun Drying or Open Air Drying

In agriculture, open air-drying in the sun was presumably one of the first conscious and purposeful technological activities undertaken by humanity (Imre, 1995). Traditionally, open-air solar drying methods are based on long-term experience and continue to be used all over the world to dry agricultural products in order to preserve them. The agricultural produce was placed on a plain surface and leaves it to dry under the sun. This process involves evaporation of moisture from the products by solar heat and to carry away the evaporated moisture from the products. During the drying, heat and air flow to remove the moisture from the products occurred at the same time (Sreekumar and Manikantan, 2008). When the solar energy hit on the products, the energy will be transformed into heat energy and warm the product to dry as the moisture was evaporated. Major content of fruit are constituent by water, therefore, remove the water can prevent the microorganism grow and slow down the reaction rates, results the shelf life of the fruits prolonged (Sharma, Chen and Vu lan, 2009). This method is simple, costless and the food original nutrients after drying process can preserve more complete compare with canning and freezing. This is good for our health and also can preserve to food for a longer period of time. Over the last two decades, open air drying has gradually become more and more limited because of the requirement for a large area, limitation of time, the possibilities of quality degradation, high level of des and atmospheric pollution from the air, cloudiness and rain, intrusion from animals and man, infestation caused by birds and insects and inherent difficulties in controlling the drying process (Imre, 1995). Furthermore over drying, insufficient drying, contamination by microorganism, discolouring by UV radiation could also affect products quality (Sharma, Chen and Vu lan, 2009). In general, open sun drying does not fulfil the international quality standards and therefore it cannot be sold in the international market. Fig. 2. 2. The principle of conventional sun drying or open air drying of products (Belessiotis and Delyanni, 2011).

Solar Dryer

Recently there is increasing interest to develop agricultural solar dryers which make use of known principles of heliotechnology to overcome some of the principal disadvantages of conventional sun drying (Irtwange and Adebayo, 2009). Although higher cost of fossil fuels and uncertainty regarding future cost and availability, use of solar energy in food processing is not simply a method for substituting fossil fuels. It is rather for producing dried materials of the required quality using heliotechnology. The quality dried materials could influence the marketing capacity and income generating potential, since a higher price can be obtained for products. It is the advent of higher charges for fossil fuels has stimulated the renewed interest using solar energy to dry agricultural products. Besides, solar dryer can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs. Thus, they can be useful in areas where fuel or electricity is expensive, limited land, plentiful of sunshine but high air humidity. Solar dryer can be considered as enhancement of the natural sun drying and it is a more efficient technique of utilizing solar energy. In order to solve the disadvantages of the sun drying process, solar dryer is the choice to replace the conventional method by enhances the productivity of the food. Solar dryer is an equipment to dehydrate the drying object, and this equipment is widely used by many individuals and countries. Solar dryer evaporate the water content in an object by using the solar energy, remove the water vapour through a ventilation system and air circulation. Solar dryer only require a sunny place to operate optimum and minimal maintenance. The principle lies behind in designing a solar dryer is as follows. Drying relative and absolute humidity are of great importance in a solar dryer. Air can take up moisture, but only up to a limit. This limit is the absolute (maximum) humidity, and it is temperature dependent. When air passes over a moist product it will take up moisture until it is virtually fully saturated, that is until absolute humidity has been reached. But, the capacity of the air for taking up this moisture is dependent on its temperature. The higher the temperature, the higher the absolute humidity is, and the larger the uptake of moisture. If air is warmed, the amount of moisture in it remains the same, but the relative humidity falls; and the air is therefore enabled to take up more moisture from it’s surrounding. Besides protecting the drying objects from outside and minimize the possible contamination, solar dryer also can increase the drying rate of the objects as temperature inside the solar dryer are higher than outside. The air flows inside the solar dryer are conducted by the natural characteristic of hot air, which is hot air rises and the air is heated by the solar collector. Gallali, Abujnah and Bannani, (2000) compared drying objects dried by solar dryers and natural sun drying and stated that solar dryers gave more advantages than natural sun drying, especially in terms of drying time.

Type of Solar Dryer

Since there is no standardization for solar dryers, and less commercialization, in many cases they are constructed base on experience rather than in scientific design and technical calculation (Belessiotis and Delyannis, 2011). Solar dryers are being classified according to their heating modes and the manner in which the solar heat is utilized. Generally it can be classified into two main groups, which is active solar energy drying systems (using forced circulation solar dryers) and passive solar energy drying systems (using natural ventilation solar drying system). Both active and passive solar dryers depend solely on the solar energy as the heat source. A systematic classification of available solar dryers, based on the design of system components and the mode of utilisation of solar energy, is presented in Fig. 2. 3Figure 2. 3 : Classification of solar dryers and drying modes

Active Solar Dryers

Active solar dryers, also known as forced convection solar dryers, are suitable for larger amounts of materials to be dried. They use either a direct absorption system through transparent covers or indirect solar dryers with solar collectors. Most of the time, they are hybrid systems by using auxiliary sources of energy as conventional fuels, biomass, gas, etc., when possible, some disadvantages of passive solar dryers were avoided. Therefore, active solar drying systems are more complicated and high cost compare to passive system as they need motorized fan, ventilators for air circulation and piping loops. And the direction of the air can be either pushes the air out or sucks air from the ambient (Belessiotis and Delyanni, 2011).

Passive Solar Dryers

Passive solar dryer or natural ventilation solar dryer, is still common in many region such as in Mediterranean, tropical and Asia or in small agricultures communities. The heating take places by natural convection, through the dryer transparent cover in a solar collector. The passive type solar dryers are simple, low construction cost, easy to install and operate in non-electricity region. " Chimney effect" may be used at this passive solar dryer to increase the vertical flow of air without use of a ventilator (Belessiotis and Delyanni, 2011).

Concept of Solar Dryers

There are three main concepts of solar dryers which is direct (Fig. 2. 4), indirect (Fig. 2. 5) and mixed mode (Fig. 2. 6). In direct solar dryers, the drying objects are placed in an enclosure, with transparent covers of side panels. Heat is generated by absorption of solar radiation on the objects itself as well as the internal surfaces of the drying chamber. For indirect solar dryers, air was first heated on a solar collector and then induced to the drying chamber (El-Sebaii and Shalaby, 2012). While the mixed-mode solar dryers, the heated air from a separate solar collector is passed through the drying rack, simultaneously the drying chamber absorbs solar energy directly through the transparent walls or roof (Olalusi and Bolaji, 2008). Figure 2. 4: Sectional view of direct mode solar dryer, cabinet solar dryer (Parm, Sukhmeet and Dhaliwal, 2006)Drying chamber(Non-transparent materials)Solar CollectorFigure 2. 5: Sectional view of Indirect Solar Dryer, multi-later solar dryer (Yogesh, 2011)Figure 2. 6: Sectional view of the mixed-mode solar dryer (Olalusi and Bolaji, 2008)

The equilibrium moisture content

The equilibrium moisture content refers to the moisture content when the water vapours pressure exerted by the moisture of the crops equals vapour pressure of the nearby environment air. This means that moisture desorption from the product is in dynamic equilibrium with the absorption of the environmental air moisture contain. Relative humidity (%RH) at this point is known as the " equilibrium relative humidity", and is characterized by the curves of moisture content plots against equilibrium humidity known as moisture equilibrium isotherms. These describe sorption phenomena but only few found universal acceptance (Belessiotis and Delyanni, 2011).

Effect of Black Colour on Temperature

According to Smith and Throop (2006) who compared few colour of hardhats, conclude that the lighter colour absorb less solar radiation, as it generating less heat inside the hardhat than darker colour. Black is the colour absorbs heat most due to its specific properties of the colour and the light. When light transmitted on surface of objects, the colour of the objects either absorbs or reflects the incoming light. For example, a red object absorbs all kind of colour except red colour, which reflects and perceive by our eyes as red. If the same red objects, test with a light without red wavelength, it would appear almost black, because that is no red wavelength of light reflected to the eyes. When white light hits on a black object, it absorbs the entire wavelength and none of the wavelength was reflected, which cause the object appears as black. Since light is a form of energy, which mean the more light being absorbed the more energy being gained. The object then radiates the energy by emitting it at a longer wavelength that is invisible to the eye, but is still a kind of energy. It is emitted at the infrared level, which is heat. No heat is lost during the transformation, it just transformed into a new form, a new wavelength (Kelsey, 2010).

Solar Collector

Solar collector is the core in getting the heat resources from the sun, as the sun light heat up the air inside the solar collector, and flow into the drying chamber. Different pattern of solar collectors will have different efficiency. According to Koyuncu (2006), the most efficient solar collector was Model-2 as showed in Fig. XXXX. Koyuncu (2006) also suggested when fabricating an solar collector using local available materials, the collector must be single covered and front-pass type to get the highest efficiency. This indicated a black painted solar absorber should be placed at the bottom of a solar collector. Fig. 2. 7: Model-2 of solar collector as proposed by Koyunchu (2006)