

SOLAR DRYING – PSYCHROMETRY

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I. INTRODUCTION

As a very important issue of national strategy , energy security requires to be placed as prime issue of the planning process as there is frequent rise in crude oil prices. Achievement of national economic development goals and improvement in the quality of life of people are greatly influenced by energy security. Global warming by emissions of green house gases from fossil fuels is also a matter of major concern . So it is essential to use alternative and renewable energy sources in addition to conventional sources for meeting energy demands. In low temperature applications , use of renewable energy is essential to reduce combustion of fossil fuels and reducing CO₂ emission. As it is abundant, inexhaustible, renewable , cheap, non-polluting and environment friendly, SOLAR ENERGY is an important source of energy. Approximately 4000 trillion kWh energy (electromagnetic radiations) per day is received by earth from sun .Use of this energy in tropical areas is very feasible. These areas receive at least 6 hours per day sun shine of 500- 800 W/m² per hour.

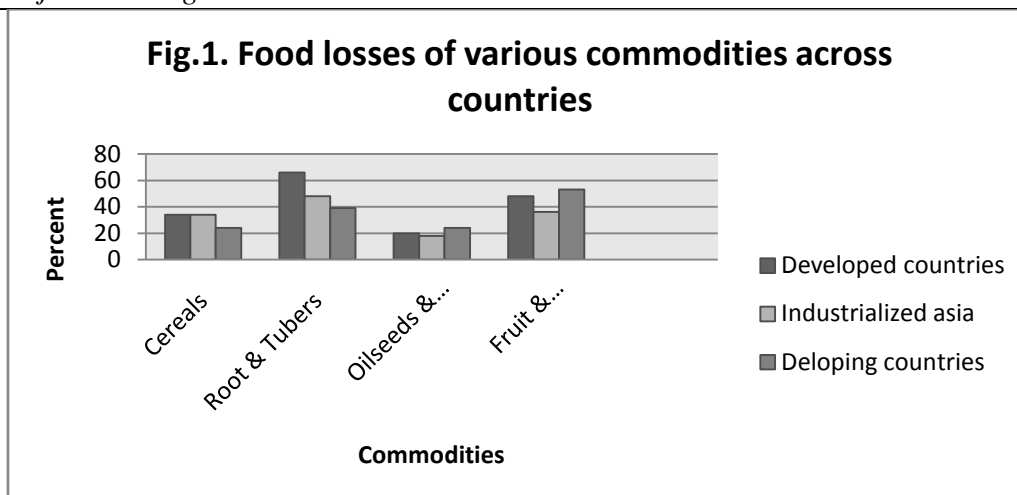
India , a tropical country situated between 7°N and 37°N latitude, receives plenty of sunshine. Clear sunny days are 250-300 per year. About 5000 trillion kWh of solar energy is received annually. This energy can be used for thermal applications, particularly for drying of agricultural produce before their storage. Solar dryers are alternatives to replace sun drying, especially during hostile weather conditions during which sun drying is difficult/impossible or resulting into loss of quality and quantity. There is great potential for various applications(residential and industrial) by applying solar energy . Use of solar energy for drying of agricultural produce is applicable world over. Annually 657-1530 PJ energy can be obtained and utilized by solar applications. Low temperature requirement , simple solar equipment design and sufficient availability of solar radiations makes solar drying of crops , most suitable alternative to fossil fuels.

II. IMPORTANCE OF DRYING

Food is one of the essential basic requirement of human being. According to estimates of Food and Agriculture Organization , world over , more than 870 million people were undernourished during 2010-2012 . This figure includes data of developing countries ,countries in transition and industrialized countries. The expected population of world up to year 2020 will be around 7.6 billions. Agricultural production requires to be increased to meet the future food demands. About 50% more food grains will be required , more particularly in developing countries. Cutting the food losses during production, harvest, post- harvest and distribution is an answer to future food problems.

In India approximately 70% population earns livelihood from agriculture and the contribution of agriculture to national GDP is roughly 27%.Hence agriculture serves as backbone to Indian economy. In pre-independence time, agriculture was insufficient to feed the nation due to low productivity, drought, flood etc. Due to adoption of high yield varieties and improved technology, use of fertilizers and proper irrigation system, agriculture has improved significantly.

On the basis of present food requirement patterns, there will be need of additional approximately 6 million tones of food grains annually. Appropriate post – harvest technology and storage facility is also an essential part to match with increased production. Estimates suggest that a considerable amount of post harvest losses can be avoided and those food items will be available for feeding the people.



Important post-harvest operation to save grains and other agricultural produce for safe storage is drying. ‘Drying’ means removal of organic solvents and water in the form of vapors by air. It is most widely used method of preservation.

When water content of any edible commodity is below 10%, the microbes responsible for decay and spoilage, are deactivated. In such conditions, they can not multiply and grow. Also enzymes and other bio-molecules are disabled in absence of water. In order to preserve nutrition and flavor of edible item, moisture should be below 5%. Drying results in extended shelf life.

Drying operation of agricultural produce is very energy intensive. Huge amount of energy is consumed in drying of raisins, tea, milk powder and other agri-products. Approximately 8-12% of total energy demand is for drying operations. This leads to rise in market price of dried products.

III. HISTORICAL BACKGROUND

For off – season availability, preservation of food has been in practice since ancient times, and drying is one of the oldest methods in practice from ancient to present times.

Probably sea expeditions were not possible without dried food items like dried grains, fruits, vegetables etc. The adventurous voyages of Vasco da Gama and Christopher Columbus would have failed without use of dried foods by them and their crew.

During World War I, there was demand for more quantity of food to feed the troops, this led to realize the importance of dried foods and drying process. After World War II, drying was studied in the light of science, engineering and technology. This development resulted in considerable reduction in losses of crops at pre- and post-harvest stages and making more food available. Dried foods and food grains are easy to transport and store as they become light in weight, smaller in volume also. They require less space to store.

Due to oil crisis in 1970s, non-conventional sources of energy were given due consideration for energy requirements for drying of agricultural produce. Solar energy, being a non-conventional energy is collected using a collector and converted to a suitable form for direct use or stored for future applications.

IV. PSYCHROMETRY

Psychrometry is study of thermodynamic properties of moist air. Moist air is a mixture of dry air and water vapor. Dry air is a mixture of 78% nitrogen, 21% oxygen and remaining CO₂ and other gases

The life of perishable commodities is greatly affected by their environment. Atmospheric air plays an important role in drying process.

During drying process, heat and mass transfer takes place from wet solid through moist air. There are changes in thermodynamic properties of air. These changes should be evaluated before and after drying process to measure the effectiveness of drying process.

V. PSYCHROMETRIC VARIABLES

There are several psychrometric variables of moist air. These are as follows – Dry Bulb Temperature: This is the temperature of air measured by a common thermometer. Wet Bulb Temperature: It is the air temperature measured by a thermometer putting its bulb covered with a muslin cloth sleeve. Sleeve is kept moist with clean water. There are two types of ‘wet bulb temperature’ Sling Wet Bulb Temperature: It is the temperature of air recorded in moving air above 2m/s. It can also be recorded by whirling a sling hygrometer.

Screen Wet Bulb Temperature : It is temperature of still air measured with a wet bulb thermometer.

Thermodynamic Wet Bulb Temperature : When there is an adiabatic saturation of air with water, a thermal equilibrium is attained between water, air and water vapor. The temperature of air at this equilibrium state is 'thermodynamic wet bulb temperature or adiabatic saturation temperature.

Dew Point Temperature : Due to cooling of air without changing its water content, a temperature reaches when it becomes saturated. If it is cooled further, water starts condensing. This temperature is called 'Dew Point Temperature'.

Humidity Ratio or Specific Humidity : It is the ratio of weight of moisture content in a moist air sample to the weight of dry air in the same sample. From the point of view of comparison of two conditions, it is very useful ratio..

Relative Humidity : It is the ratio of water vapor pressure in the air to the saturation vapor pressure at the same temperature. It is expressed as percentage.

Degree of Saturation : This parameter is defined as the ratio of actual specific humidity of saturated air at same temperature.

Specific Enthalpy : Heat energy content of a sample of air- water vapor mixture is called 'Specific Enthalpy'. It is the sum of enthalpy of dry air and associated water vapor per kg. of dry air.

Specific Volume : It is the volume of air- water vapor mixture per kg. of dry air.

VI. PSYCHROMETRIC CHART

A psychrometric chart is a graphical representation representing the thermodynamic properties of moist air. It is bounded by 'dry bulb temperature line' (abscissa) and the 'vapor pressure or humidity ratio'(ordinate). The left hand side of the chart is bounded by 'saturation line'.

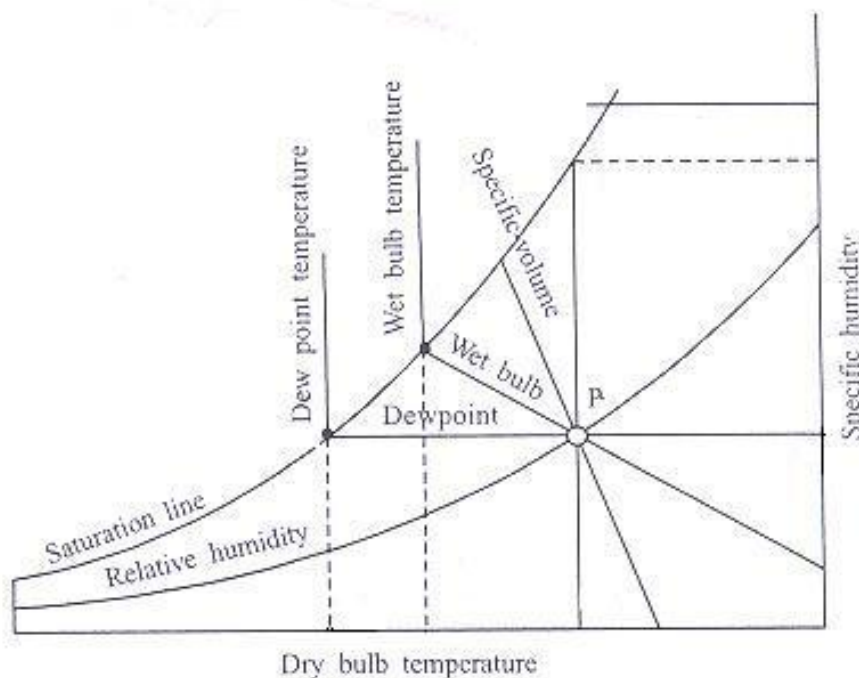


Fig.2. General Psychrometric Chart

After locating any state point 'P' on the chart, the other psychrometric variables can be obtained from the chart. Study of psychrometric variables is helpful to improve the post-harvest drying, cooling and cooling conditions of perishable agri-products. It gives the idea about the changes in properties of air during the course of drying and in turn the efficiency of dryer.

National and International Recognition

Food quality highly affects human health, hence a worldwide matter of concern. The term 'quality' refers to the degree of fitness for the purpose. 'Quality' also includes external and internal factors. Due to drying, there are some changes in the quality of food products.

External Factors : Shrinkage, cracking of surface, change in colour, flavor, texture etc.

Internal Factors : Nutritional loss (vitamins etc.), chemical change like discoloration, browning etc.

The quality of dried food items must be maintained to the level of customer satisfaction. There are several national and international standards to monitor the quality of food products, labeling issues regarding ingredients and nutritional information like Agricultural Produce Grading and Marketing (Agmark) Act, 1937, Bureau of Indian Standards(BIS), 1986, Hazard Analysis and Critical Control Point (HACCP).

Using correct technique for drying, the quality (physical, nutritional) of rehydrated food products are only slightly lesser than fresh ones.

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