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PERFORMANCE EVALUATION OF INDIRECT TYPE SOLAR DRYER FOR DRYING HERBALS

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ABSTRACT
Drying is one of the methods to preserve food item other than freezing, canning etc. During drying process the moisture content present in the food particle will be removed and it can be stored for long time. Drying has many types like open sun drying, shadow drying, oven drying and solar drying. From the above methods solar drying is the most efficient and less expensive of drying and this way of drying can protect the food particle from rain, wind, dust, insects. In this present a simple and less expensive solar dryer can be designed and the product chosen for drying is herbals.
The conventional method of drying herbals is open drying and sometimes shadow drying for siddha and yunani treatments. The important phenomenon is the process of reduction moisture up to the safe limit of medical use. Based on the theoretical calculations, the length of the air collector is 1.5 m and width of the air collector is 0.5 m was chosen. To find the effective length and width of the solar dryer the various parameters like solar intensity, height of the collector and intensity of the day will be varied and calculated. The efficiency of the solar dryer for the effective area of 0.75 m² is 25.46%. By drying herbals in solar drying will provide the 3.5% more moisture.

INTRODUCTION
Drying is one of the most efficient methods used to preserve food products for longer periods. A solar dryer is an enclosed unit, to keep the food safe from damage, birds, insects, and unexpected rainfall too. The food is dried using solar thermal energy in a clean and healthier way [2]. Solar dryers are usually classified according to the mode of air flow as, natural convection and forced convection dryers. Natural convection dryers do not require a blower(external aid) to pump the air through the dryer. Therefore research efforts will be focused on designing and constructing a simple natural convection dryer [4]. The use of solar technology has often been suggested for the dried fruit industry both to reduce energy costs and economically speed up drying which would be beneficial to final quality.

This type of solar dryer has a solar collector for heating air and a drying chamber to accommodate trays over which products are spread. The drying chamber is covered by a transparent glass which protects the products from dust. The solar collector collects the solar rays from the sun and heats the air entering through an inlet. Heated air enters the drying chamber from beneath to tray and flows upwards through the products carrying moisture with it. This moist air goes out of the opening provided at the top. Ventilation is provided by natural convection inside the drying chamber. It is used for improving food stability, since it decreases considerably the water activity of the material, reduces microbiological activity and minimizes physical, chemical changes during its storage period, lighter weight, less storage space, lower packing and transportation costs and encapsulates original flavor. Dried products have almost unlimited shelf life in proper packages and substantially lower transportation, handling and storage costs compared to products of other preservation methods. When herbs are dried they are safe from bacteria, mold and yeast, and will remain potent for at least one year. Use the sun heat to dry herbs but don’t expose herbs too much direct sunlight as this could cause them to bleach. Solar drying can be as low-tech as placing drying screens outside until your herbs are brittle. Herbs are dry under the windshield or rear window of your car on a hot day [1]. A solar food dryer with stackable drying screens, a glass top to trap radiation, an absorber plate to transmit heat and a vent for air circulation is useful too.To remove moisture all you need is air circulations.Washing herbals usually is not necessary if they are grown organically.

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THEORITICAL ANALYSIS

DRYING RATE (DR)

The Drying Rate (DR), kg/s is normally defined as the ratio between the mass of the moisture lost and the time taken during drying to achieve the said moisture loss [1].

The drying rate is given as,

$$DR = \frac{m_i - m_f}{t_d}$$

where,

m_i Mass of sample before drying, kg
m_f Mass of sample after drying, kg
t_d Drying time duration, s

MOISTURE LOSS (ML)

The Moisture Loss (ML), kg is defined as the difference between the mass of sample before and after drying [1].

The moisture loss is given by

$$ML = m_i - m_f$$

where,

m_i Mass of sample before drying, kg
m_f Mass of sample after drying, kg

EFFICIENCY OF SOLAR DRYING

The efficiency (%) of solar drying can be studied under two contexts: Collector efficiency (η_c) and the System efficiency (η_s). The Collector efficiency (η_c) measures how effectively the incident solar energy (on the collector) is transferred to the air flowing through the collector and is given by the ratio of the useful energy output (over a specified time period) to the total radiation energy (I) available during the same period: The thermal performance of the solar collector is determined by obtaining the values of instantaneous efficiency using the measured values of incident radiation, ambient temperature, and inlet air temperature. This requires continuous measurement of incident solar radiation on the solar collector as well as the rate of energy addition to the air as it passes through the collector, all under steady state or quasi-steady state conditions.

The Thermal efficiency of the PV/T collector (η_{th})

$$\eta_{th} = \frac{q_u}{I \times A_p}$$

where,

q_u Useful heat gain, W
I Solar intensity, W/m²
A_p Area of the absorber plate, m²

The Electrical efficiency of the PV/T collector (η_{el})

$$\eta_{el} = \frac{P_{\max}}{I \times A_p}$$

where,

P_{max} Maximum power produced from PV panel, W

The Total efficiency of PV/T collector (η_T)

$$\eta_T = \eta_{th} + \eta_{el}$$

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Top Loss Coefficient (U_t)

$$U_t = \left(\frac{M}{\left(\frac{c}{T_{pm}}\right)\left(\frac{T_{pm}-T_a}{M+f}\right)^{0.33}} + \frac{1}{h_w} \right)^{-1} + \left(\frac{\sigma\left(T_{pm}^{\ 2} - T_a^{\ 2}\right)\left(T_{pm}+T_a\right)}{\frac{1}{\varepsilon_p + 0.05M\left(1-\varepsilon_p\right)} + \frac{(2M+f-1)}{\varepsilon_c} - M} \right)$$

where,

M Number of glass cover

T_a Ambient temperature, K

T_{pm} Plate mean temperature, K

V wind velocity (m/s)

$c = 365.91\,(1-0.00883\beta+0.0001298\beta^2)$

$f = (1-0.04h_w+0.0005h_w^2)(1+0.091M)$

$h_w = 5.7 + 3.8\,V$

Bottom Loss Coefficient (U_b)

$$U_b = \frac{k_i}{\delta_i}$$

where,

k_i Thermal conductivity of the insulator, W/mK

δ_i Insulation thickness m

USEFUL HEAT GAIN (q_u)

$$q_u = A_p F_R \left[I(\tau \times \alpha)_e - U_o (T_i - T_a) \right]$$

where,

Fr Heat removal factor

$(\tau \times \alpha)_e$ Transmittance of cover

MODELLING

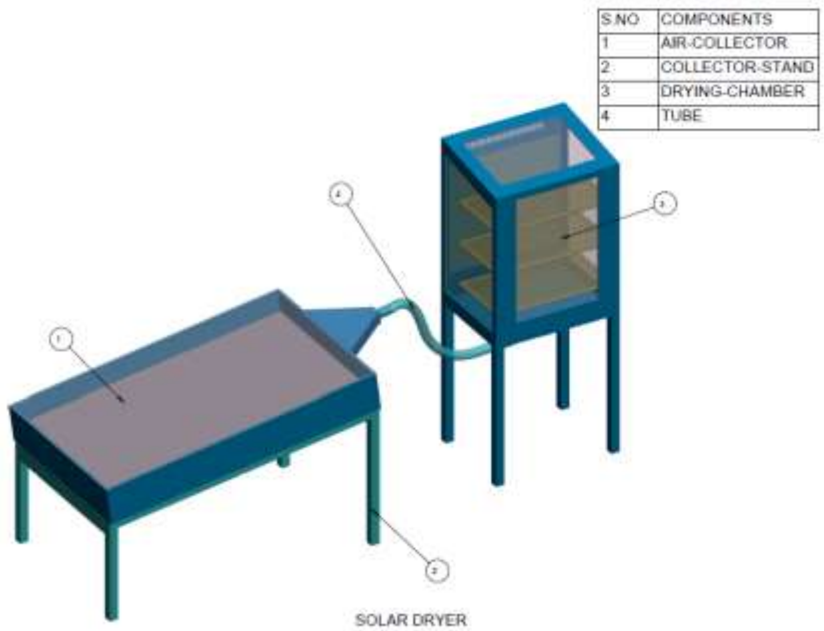

Figure 1.1 PRO-E modeling of solar dryer setup

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RESULTS AND DISCUSSION

MAXIMUM THERMAL EFFICIENCY, USEFUL WITH RESECT TO MASS FLOW RATE

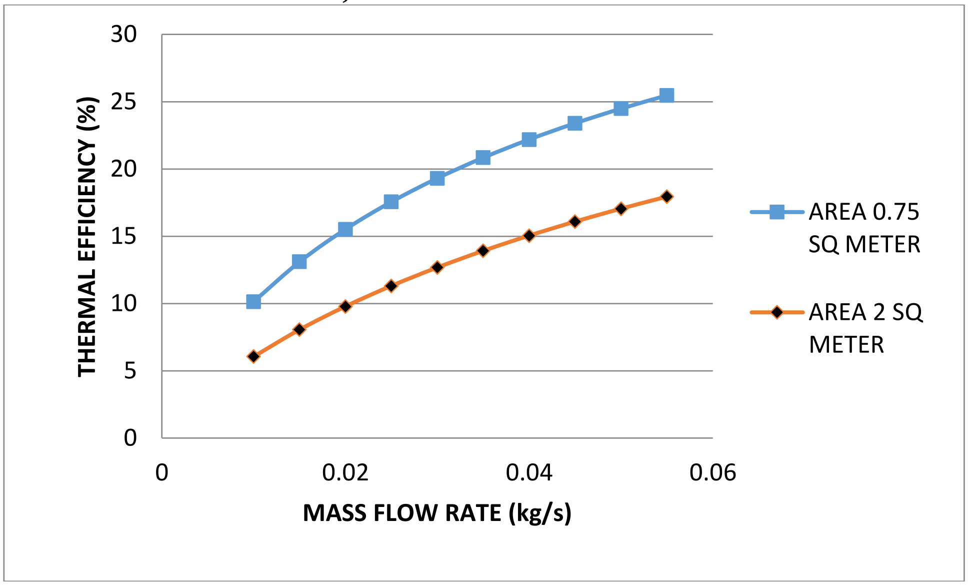

Figure 1.2 Thermal Efficiency with respect to mass flow rate

The thermal efficiency will be increase with increases in mass flow rate . But when the area of the collector decreases the thermal efficiency will increases because when the area rate decreases the cumulative heat gain be will higher compared to large area of collector. The Figure 1.2 show the variation of thermal efficiency with mass flow rate.

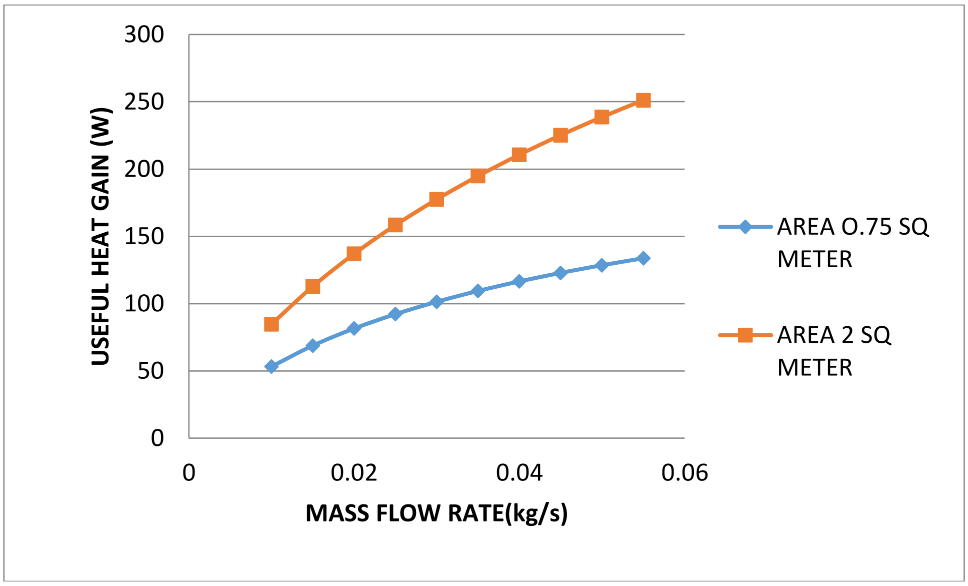

Figure 1.3 mass flow rate with respect to useful heat gain

The useful heat gain will be increase with increases in mass flow rate . But when the area of the collector decreases the will useful heat gain increases because when the area rate decreases the cumulative heat gain be will higher compared to large area of collector. The Figure 1.3 show the variation of useful heat gain with mass flow rate.

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MAXIMUM THERMAL EFFICIENCY, USEFUL HEAT GAIN WITH RESPECT TO SOLAR INTENSITY

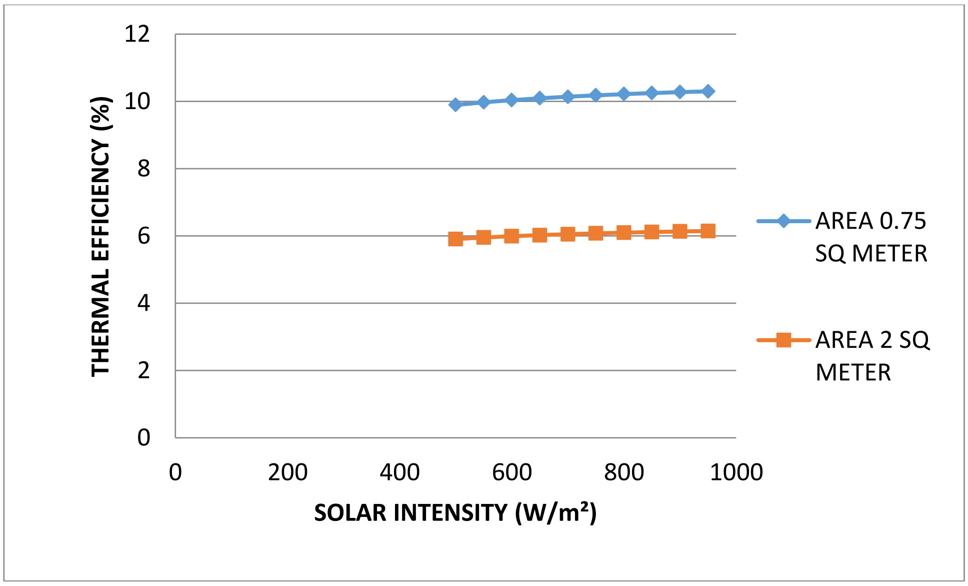

Figure 1.4 Thermal Efficiency with respect to solar intensity

The Thermal efficiency will be increase with increases of intensity . But when the area of the collector decreases the will thermal efficiency increases because when the area rate decreases the cumulative heat gain be will higher compared to large area of collector. The Figure 1.4 show the variation of thermal efficiency with solar intensity .

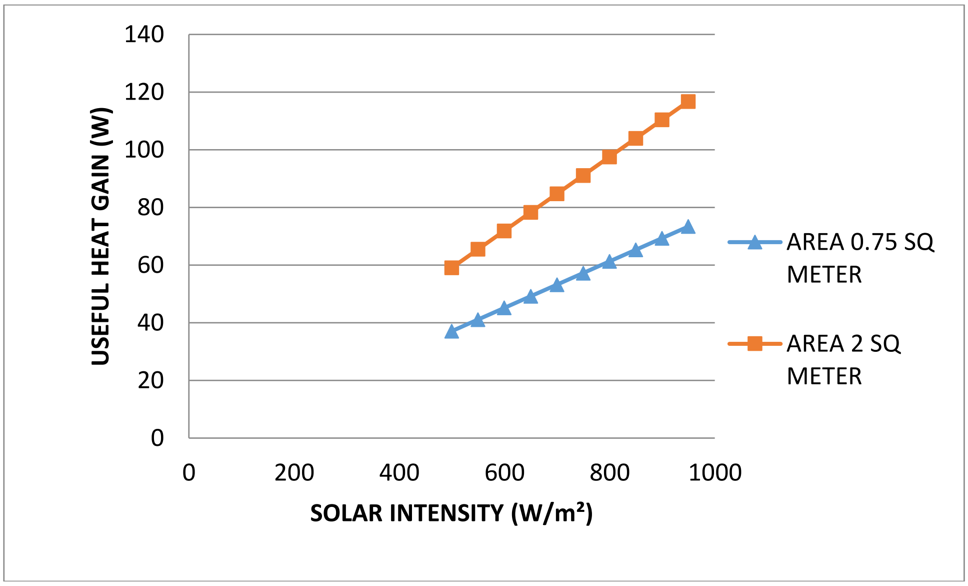

Figure 1.5 useful heat gain with respect to solar intensity

The useful heat gain will be increase with increases in solar intensity . But when the area of the collector decreases the will useful heat gain increases because when the area rate increasese the cumulative heat gain be will higher compared to large area of collector. The Figure 1.5 show the variation of useful heat gain with mass flow rate.

EXPERIMANTAL ANALYSIS

The moisture removal rate of the Nillavembu can be compared with both open and shadow drying.

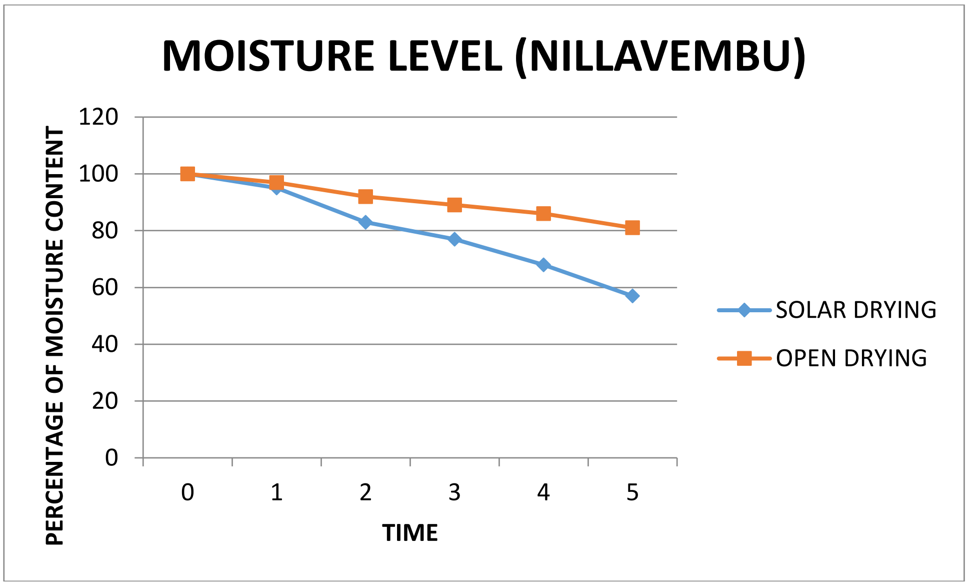

Figure 1.6 moisture level variation of solar drying and open drying

Solar drying can have the higher range of moisture removal rate when compared to open drying for drying herbals because of hirher heat gain accumulated in the system.

The moisture content of the Thuthuvalai can be compared with open and solar drying. The moisture removal rate of the solar drying can be higher than the open drying. The variation of moisture level are ploted in the graphs with respect to day.

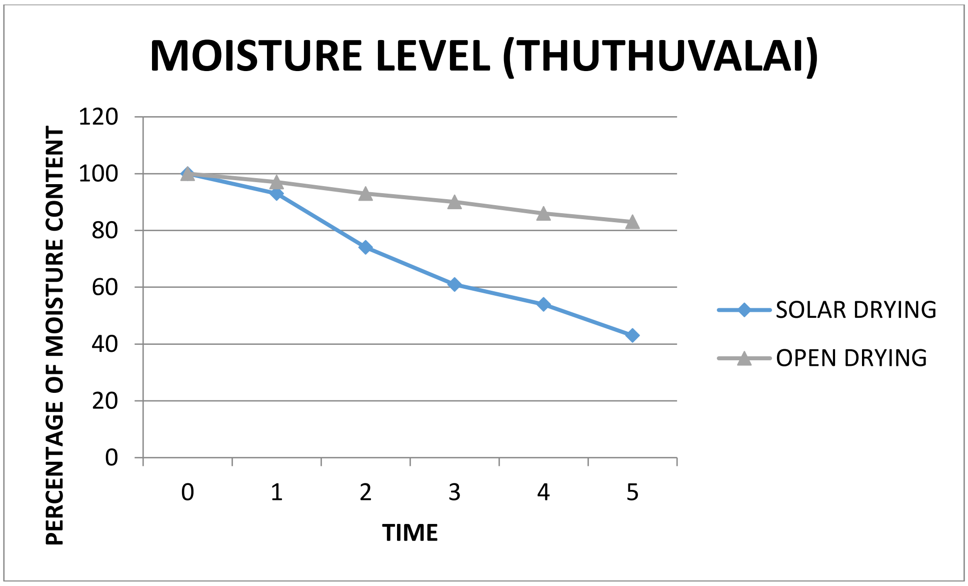

Figure 1.7 Moisture level variation of solar and open drying

CONCLUSIONS

Based on the theoretical calculation following conclusion were arrived,

- Maximum thermal efficiency of solar dryer was achieved 10.14% and 8.65% for $0.75m^2$ and $2m^2$ respectively for the mass flow rate of 0.01 kg/sec.
- Two sizes of design each having size of 0.75 m^2 & $2m^2$. the maximum overall efficiency of dryer obtained from the area of $0.75m^2$.
- The MRR level for drying herbals will be 3.5 higher than the open drying.

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- Conventional method of open type of solar drying can be purely changed into solar drying.
- The safe limits can be obtained in hours in solar drying and it will take some days in solar drying.

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