

# Experimental Study on Advanced Food Dryer with Solar and Exhaust heat Radiation by Finned Copper Tubes as Heat Exchanger

V.Sudharshan<sup>1</sup>, E. Siva Reddy<sup>2</sup> and R.Meenakshi Reddy<sup>2</sup>

<sup>1</sup> Department of Mechanical Engineering, Santhiram Engineering College, Nandyal, Andhra Pradesh, India.  
[sudharshan.mechstar@gmail.com](mailto:sudharshan.mechstar@gmail.com)

<sup>2</sup> Department of Mechanical Engineering, G. Pulla Reddy College of Engineering, Kurnool, Andhra Pradesh, India.  
[enumalagprec@gmail.com](mailto:enumalagprec@gmail.com)

**Abstract** – Drying is a method used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several thousand years. Almost in all countries of the world, the application of solar thermal energy is required to use in agricultural sector and marine food in to conserve mainly perusable food items like raw vegetables, normal & dry fruits, coffee, sea foods and other crops has shown to be practical, economical for both farmers and country. Along with these spices, meat, fish, nuts and beverages such as tea leaves, coffee nuts are dried and consumed in very large quantities around the world. The main aim of our requirement irrespective of crop is to remove water content from fresh crop to extend its life before storage in all seasons. At finally a new product is obtain varying from actual crop, distinctly differs from original form like dried form of grapes. Global population is increasing rapidly beyond predictions and calculations. Therefore food production must be increased and preserved accordingly to meet the rising demand.

**Keywords** – Solar Drying, Wooden Cabin, Absorption Refraction, Exhaust Gas Heat, New Design, Copper Tubes.

## I. INTRODUCTION

Researchers claim right from 3000–5000 years ago agriculture was widespread in the Indian peninsula. The total production and economic value of horticultural produce, such as fruits, vegetables and nuts has doubled in India over the 10-year period. In 2012, the total horticulture produce reached 277.4 million metric tone and acquired a position as second largest producer of horticultural products. Even in species of winter cereals like barley, oats, and wheat continuous with good production .India in 2013 produced 81 million tonnes of fruits, 162 million tonnes of vegetables, 5.7 million tonnes of spices, 17 million tonnes of nuts and plantation products cashew, cacao, coconut etc. But we should keep in mind that India is country where 70% of farmers cultivate monsoon rains. So failed monsoon for one of the world’s biggest producers of horticulture and grains could add to pressure on global food prices. This results in high burden on the farmer mentally and economically. Activists and scholars have offered a number of conflicting reasons for farmer suicides, such as monsoon failure, high debt burdens, genetically modified crops and

not reaching of government policies. Every year we spend crore’s of rupees out of public exchequer for preventing decay and then spend a fortune again to dispose of the piled up waste .This results in inflation on particular crop. To overcome these problems preservation is need i.e. by removing the moisture content in food .So these high produced horticultural products are transformed to dry one to reach the demand for increasing population, balances the demand at monsoon failures.

### *Drying Fundamentals*

Drying mainly involves the removal of moisture in solar and thermal drying .So this process where we apply the heat to the product then heat increases vapour pressure of moisture in the product which is above to the surrounding air .By this pressure and thermal gradients results to move both liquid and vapour moisture moves to surface of product. Especially in crops there is a combination of free (unbound) and bound moisture particles.

## II. EXPERIMENTAL SETUP

Crops like cerals, grains, paddy, wheat, corn and dry nuts. All these crops have dry content in their weight when crop yields .So without proper removing of this moisture results in growth of moulds, fungi and damage the grain quality results in loss of crop. Harvest grain moisture content varies between 18-25% wet basis, if not dried quickly will reduce the quality of grain. Drying to reduce the moisture content to about 14% wet basis so that grain can be stored for longer, facilitate the milling process and to produce good quality grains. Similarly in horticulture crops like vegetables, fruits are facing a large scarcity in production and preservation for the balance of growing population .At less production and monsoon failure cases it results in Inflation. Under this circumstances farmer is unable to produce right crop at right time. Though production is more at good rains farmer is unable to get reasonable prize. Mostly these crops are perishable crops i.e. life time or durability is very less .So to get rid of this problem we have to store and protect the extra cultivation in various forms up to next good monsoon. By this we can control the scarcity of food as well as Inflation.

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Fig. 1. Experimental Setup

### III. DRYER DESIGN CONSIDERATIONS

For the purpose of preservation we designed a chamber to remove moisture from food. Wooden cardboard is a material having low thermal conductivity and acts as insulation wall, acts as closed system. According to the preliminary investigation with the cabin designed we take 2.6kg per m<sup>2</sup> (tray loading). And the vegetables used for this setup is cut in to 3mm thick. Design of this cabin is in a way that cool air at bottom of surface circulates and enters in to chamber with an angle of the slope of the dryer cover is 15° for the latitude of location by natural circulation. In cabin air gets heated by reflected solar rays through the glass. Here glass acts as good refractor i.e. rays won't reflect back in to the atmosphere once they entered in to chamber .So a trap is arranged for maximum heat with solar rays.

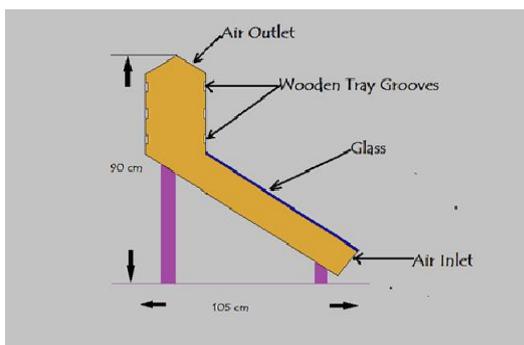


Fig. 2. Side View of the Constructed Solar Dryer

Next to the glass chamber we have the chimney shaped chamber here we have drying trays on which we place food items to dry .Hot air from glass chamber passes through this mesh collects the moisture content in the food. So by this technique we can remove moisture content in horticulture crops and can transform in to cooking powders and soups. In this we calculate the removal of moisture in dry basis and wet basis. To reduce the loses for the dryer an insulation material was made using 8 mm wooden plywood.

The insulating wooden flanks are with different shapes and different sizes. The wooden flanks are cut from the following 130×130 cm wooden sheet. By using the scribe mark the required wooden flanks dimensions on the wooden sheet.

### IV. HEAT EXCHANGER

Heat exchangers are devices allows transferring heat from high temperature fluid to low temperature fluid. Heat exchangers used in our daily lives are condensers, evaporators arranged in air conditioning units and refrigerators. Similarly we have boilers and condensers in heavy plants and Industries. And we also have heat exchangers in automobiles as radiators and oil coolers. Copper has many suitable properties for good thermal efficiency and suitable for heat exchangers. And copper is the best heat conductor as well as exchanger of degree of temperature. Desirable properties of copper next to conductivity is corrosion resistance, specific heat, tensile strength yield strength and easy of fabrication .Conductivity of copper is to be found as 399 W/(m k).The exhaust gases of diesel engine containing pollutants and contaminants but with high temperatures..Heat exchangers of compact kind have many benefits, among others massive heat transfer surface per unit volume of the core

#### *Copper Heat Exchangers*

The copper tubes are organized at rock bottom of the trays. The copper tubes get heated because of the flow of exhaust gases from the engine. The natural air coming into through the duct passes through the copper tubes and therefore the temperature of the air will increase. Then the new air passes through the trays and removes the wet from the merchandise that is unbroken on the trays and {also the} cabin temperature also will increase considerably. Fin is analyzed by design of fin with various extensions such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions. The heat transfer performance of fin with same geometry having various extensions and without extensions is compared. Near about ranging 5% to 13% more heat transfer can be achieved with these various extensions on fin as compare to same geometry of fin without these extensions. A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it.



Fig. 3. Copper Tubes as Heat exchangers

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*Finned Copper Tubes as Heat Exchanger*

The thermocouples are accustomed indicate the temperature of the air. The 3 thermocouples are organized at wherever temperatures are required. The primary thermometer is placed at the recess of the air, other placed at the entry of the recent air in to the chamber; third one is placed at the exit of the recent air at the vents. The thermometer ire’s are connected to the digital measuring system for taking the temperatures as above.



Fig. 4. Advanced designed finned Copper tube

**V. DIESEL ENGINE**

In internal-combustion engine combustion cycle, there's the energy balance of fuel combustion, thirty fifth of energy used because the work, two hundredth of the energy is lost because the engine agent, 100 percent is lost by radiation and thirty fifth is lost with the exhaust gas . Quality waste heat from the flue gas area unit warm temperature, and therefore the bigger potential price for warmth recovery. Heat lost with the exhaust gas of thirty fifth could be a potential that may be used for varies functions like for steam power plants, foodstuffs and agricultural product dryers, heating, or for alternative functions. There area unit 2 main criteria to utilize exhaust gas as a heating area unit exhaust gas temperature and exhaust gas mass rate. Internal-combustion engine exhaust gas temperature will reach two hundred °C looking on the ability and cargo variations. Exhaust gas mass rate related with the number of engine power, the degree of a cylinder, engine rpm, still because the fuel air quantitative relation.

*Arrangement of Crop On Trays*

In the cabin we have arranged the wire mesh trays at a distance of 10cm each vertically. Three trays were used with average of 10 cm spacing arranged vertically one on top of the other, the tray size was 21 × 50cm<sup>2</sup>. Movement of air around produce is further facilitated by drying on mesh trays rather than on solid platforms so aluminium net is stretched on wooden frames and supported by Kitchen wire. On these trays we arranged the crop items in a quantity of 200 grams as a test in this equipment. Slices of

crop with the thickness of 3mm placed on trays for the process of drying. And firstly we tried with the natural solar convention drying through cabin drying during the summer months i.e May April. Next we conducted this natural drying with arrangement of copper tubes with diesel engine waste exhaust heat .Copper tubes are good conductors and exchangers of heat. For this reason we used copper tubes with nor999mal and fins arrangement on tubes. And arrangement and drying pictures can be seen in below figure.



Fig. 4. Arrangement of the trays in cabin before drying

*Moisture Removed Calculations*

Amount of moisture removed from a given quantity of cucumber slices to bring the moisture content to a safe storage level in a specified time. The amount of moisture to be removed from the product, m<sub>w</sub>, in kg was calculated using the following equation

$$m_w = m_p(M_i - M_f) / (100 - M_f)$$

Where: m<sub>p</sub> is the initial mass of product to dried, M<sub>i</sub> is the initial moisture content, % wet basis and M<sub>f</sub> is the final m98oisture content, % wet basis.



Fig. 4. Arrangement of the crop before drying

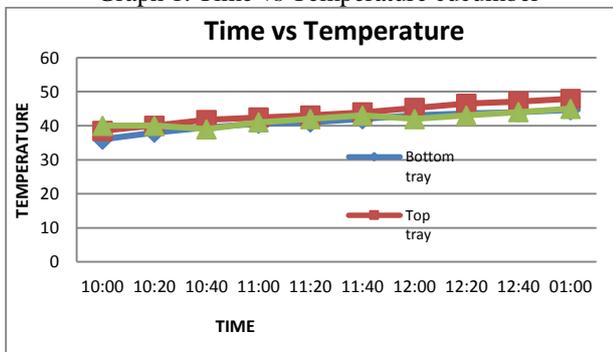
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**Advantages**

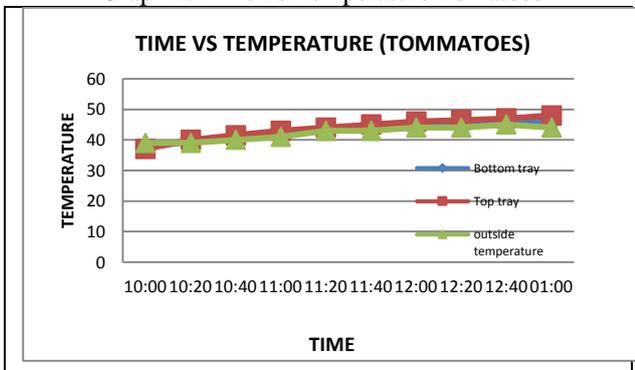
- Dryer efficiency continuous at non sunny days.
- Reducing moisture content in crops will be easy by both solar and exhaust heat.
- Easy to install at Godowns and warehouses for preservation for long time.
- Safe from contamination and insects irrespective of time and climate.
- We can control temperature range depending on position of trays.
- Requires less space and more efficient.
- This protects food from natural calamities, UV rays so that preserves along with nutrition & colour.
- No much manpower is required.
- Quick drying time reduces chances to spoilage.
- Complete drying allows food for longer storage. Waste exhaust gas makes useful work for extracting moisture

*Temperature variations and weight loss in the dryer (Natural Convection):*

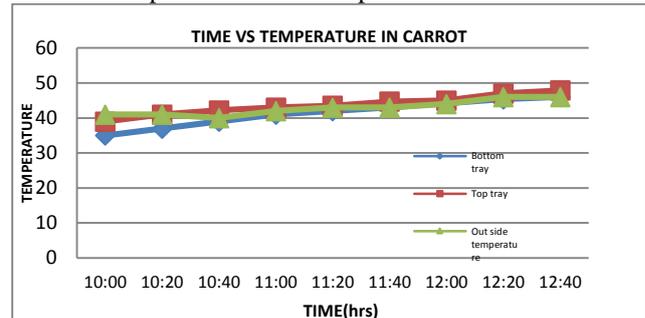
Graph 1. Time vs Temperature cucumber



Graph 2. Time vs Temperature Tomatoes



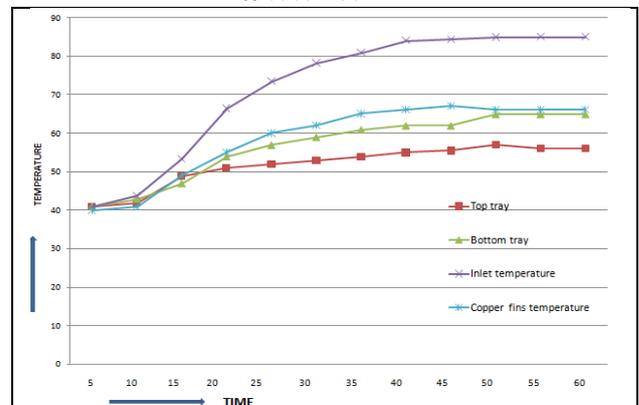
Graph 3. Time Vs Temperature in Carrot



Here we observed that tomatoes crop have more moisture content than other crops .And here we can see that tomatoes can be preserved by removing its 50% of moisture but it took almost 3 hrs in sunny summer days of May. So this crop has lot of usage in every cooking items .And if we dry this crop we have chance to control fluctuations of prices as well as usage of this in various forms in dried powders as well as soups according to the requirement of household as well as in food courts. This will defiantly gain lot of confidents to farmers to grow this crop twice or thrice in a year. We also tried on potatoes and beetroot and we got less moisture removal in these crops. Here we came to know that this crops has less moisture content so initially the good amount of moisture was removed. After half of time its moisture percentage is reduced and only powder dried state is remained. From this result we came to know that we can also make dried chips from crops with more fats and powder contents.

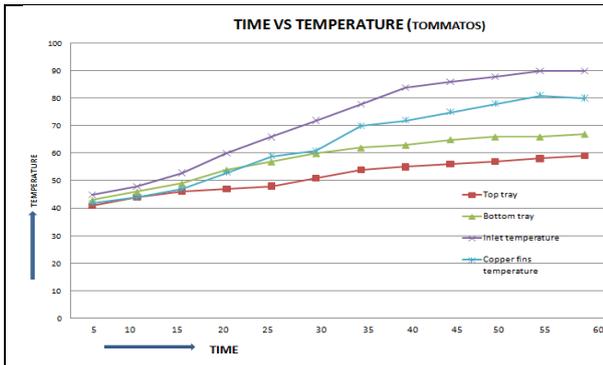
*Temperature variations and weight loss in the dryer (Exhaust gas copper heat exchanger tubes plane and with fins)*

Graph 4 Time vs Temperature in finned copper tube in 89cucumber

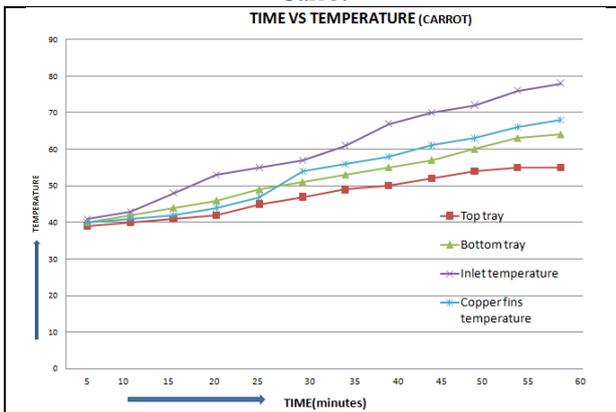


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Graph 5. Time vs Temperature in finned copper tube in Tomatoes

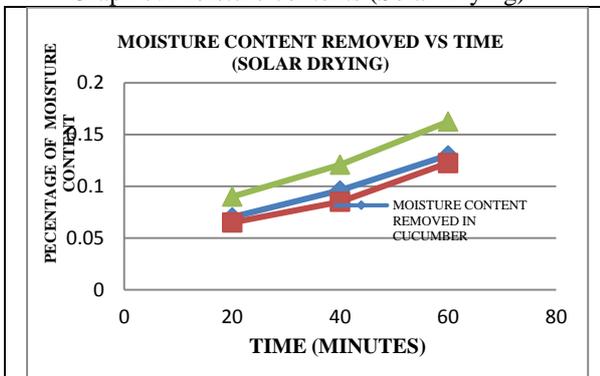


Graph 6. Time vs Temperature in finned copper tube in Carrot

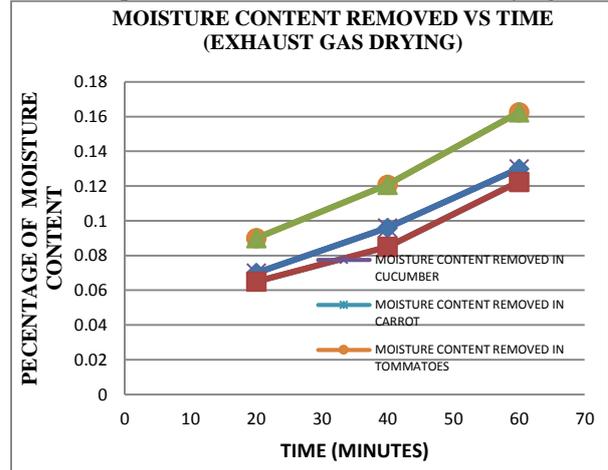


Comparison Between Weights Lost And Moisture Content Removed natural Solar Convection And Exhaust Gas Copper Finned Tubes:

Graph 7. Moisture contents (Solar Drying)



Graph 8. Moisture contents (Exhaust Drying)



## VI. CONCLUSION

Here project is concentrated on decreasing loses in horticultural. Associate experimental study of however this dryer fare compared to alternative dryers.. So by using these type dryers we can install at storages houses, warehouses and godowns can use generator exhaust to remove moisture for preservation until next crop.

- [1] Internal-combustion engine or generator that emits the exhaust gases that has the temperature to dry the vegetables is employed.
- [2] Accordance with the characteristics of the exhaust gas of diesel engines may be a compact device menstruation length and diameter of every 0.56m, 0.13 m, exploitation consecrate formed surfaces manufactured from copper material with a thickness of 0.6 mm. and also the copper tube with fin is with 1inch inner diameter and fin length is 3mm.
- [3] Exploitation the exhaust gas during this drier for drying besides additional economical, it's additionally environmental and farmer friendly.

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### AUTHORS' PROFILES



**V.Sudharshan** completed his M. Tech., presently working as Assistant Professor in Santhiram Engineering College, Nandyal. His Research Interest includes Renewable Energy Research Interest includes Thermal science and Heat Transfer



**E. Siva Reddy** completed his M. Tech., presently working as Assistant Professor in G.Pulla Reddy Engineering College, Kurnool. His Research Interest includes Renewable Energy



**R.Meenakshi Reddy** completed his M.Tech and PhD., presently working as Assistant Professor in G.Pulla Reddy Engineering College, Kurnool. His Research Interest includes Solar Energy