

# HYBRID DRYER

Nijith P<sup>1</sup>, Jeffin Augustin<sup>1</sup>, Sarathkrishna S<sup>1</sup>, Manikandan<sup>2</sup>

B. Tech Student, Department of Mechanical Engineering, MBC College of Engineering & Technology, Kuttikanam, Kerala, India<sup>1</sup>

Assistant professor, Department of Mechanical Engineering, MBC College of Engineering & Technology, Kuttikanam, Kerala, India<sup>2</sup>

**ABSTRACT:** LPG and biomass are the two main renewable energy sources extremely suited for drying application. Since the availability of solar is limited only during the sunny days. The drying process is interrupted during the cloudy or rainy days and also at night. The uses of biomass burner as a backup heater is preferable. Many agriculture producers now a days are applying a dryer associated by electricity or biomass fuel to extend the period of drying after sunset and during the cloudy days, as well as drying large capacity of products. As comparing to other dryers in the modern world, the heat transfer rate as well as the heat transfer area is increased. This leads to a vital role in increasing quality, texture, shape of the product also. Normally, our design “hybrid dryer”, satisfies less time consuming, energy saving, pollution free, etc.

## I. INTRODUCTION

Drying of agricultural products is the oldest and widely used preservation method. It involves reduction as much water as possible from foods to arrest enzyme and microbial activities hence stopping deterioration. Moisture left in the dried foods varies between 2- 30% depending on the type of food. Drying lowers weights and volume of the product hence lowers costs in transportation and storage. However, drying allows some lowering in nutritional value of the product e.g., loss of vitamin C, and changes of colour and appearance that might not be desirable. Various drying techniques are employed to dry different food products. Each technique has its own advantages and limitations. Choosing the right drying techniques is thus important in the process of drying of these perishable products. Drying lowers weights and volume of the product hence lowers costs in transportation and storage. However, drying allows some lowering in nutritional value of the product e.g., loss of vitamin C, and changes of colour and appearance that might not be desirable. Various drying techniques are employed to dry different food products. Each technique has its own advantages and limitations. Choosing the right drying techniques is thus important in the process of drying of these perishable products. The combination of biomass and liquified petroleum gas can be used for drying effectively. It has extended the period of drying perhaps during night as well, while drying high-value products.

## II. RELATED WORK

- **Serafica E. and del Mundo R**, “Design and Qualitative Performance of a Hybrid Solar-Biomass Powered Dryer for Fish”.2005.
- Serafica E. and del Mundo R, “Design and Qualitative Performance of a Hybrid Solar Biomass Powered Dryer”
- **Madhlopa and G. Ngwalo**, “Solar dryer with thermal storage and biomass backup heater,” *Solar Energy*, vol. 81, no. 4, pp. 449-462, Apr.2007.
- **S.C. Bhattacharya, Tanit Ruangrunchaikul, and H.L. Pham**, “Design and Performance of a Hybrid Solar/Biomass Energy Powered Dryer for Fruits and Vegetables,”2000.
- **J. Prasad, V. Vijay, G. Tiwari, and V. Sorayan**, “Study on performance evaluation of hybrid drier for turmeric (*Curcuma longa* L.) drying at village scale,” *Renewable Energy*, vol. 30, no. 14, pp. 2097-2109, Nov.2005.
- **T. Thanaraj, D. Dharmasena, and U. Samarajeewa**, “Development of a Rotary Solar Hybrid Dryer for Small Scale Copra Processing,” *Tropical Agriculture Research*, vol. 16, pp. 305-315,2004.
- **J. Prasad, V. Vijay, G. Tiwari, and V. Sorayan**, “Study on performance evaluation of hybrid drier for turmeric (*Curcuma longa* L.) drying at village scale,” *Journal of Food Engineering*, vol. 75, no. 4, pp. 497-502, Aug.2006.
- **E. Tarigan and P. Tekasakul**, “A Mixed-Mode Natural Convection Solar Dryer with Biomass Burner and



HeatStorage Back-up Heater,” 2005.

- **G. Mastekbayeva, B. Chandika P., M. L. Augustus, and S. Kumar**, “Experimental studies on a hybriddryer,” 1999.
- **R. Driscoll**, “Food Dehydration,” in *Food Processing Principles and Applications*, First Edition., Blackwell Publishing, 2004, pp.31-44.

### III. METHODOLOGY

- There Are Two Heating Sources That Can Be Used Independently Or Complimentarily, Biomass And GasBurners (Liquified Petroleum Gas )
- This Removes The Moisture Given Out In The Drying Process. On The Other Hand, When There Is Drop In Temperature Set Or There Is Need To Continue Drying In The Night To Dry The Products To Its Safe LevelFor Storage Or When Weather Condition IsBad.
- The Counter Flow Heat Arrangement Provide Maximum Heat Transfer Than A Parallel Flow. The Hot Air IsThen Opened To The Drying Chamber For Heating Purpose. The Burnt Gases Is Passed Through The Chimney.
- Biomass Product Such As Palm Shell And Fiber, Rise Husk, Coconut Shell And Wood Chips Are Very Useful In The Utilization Of Domestic Fuel, Agriculture And Industries Application And Also For Power Generation
- These Biomass Wastes Needs To Be Dried Before Proceeding Into Further Processes

### EQUIPMENT'S USED



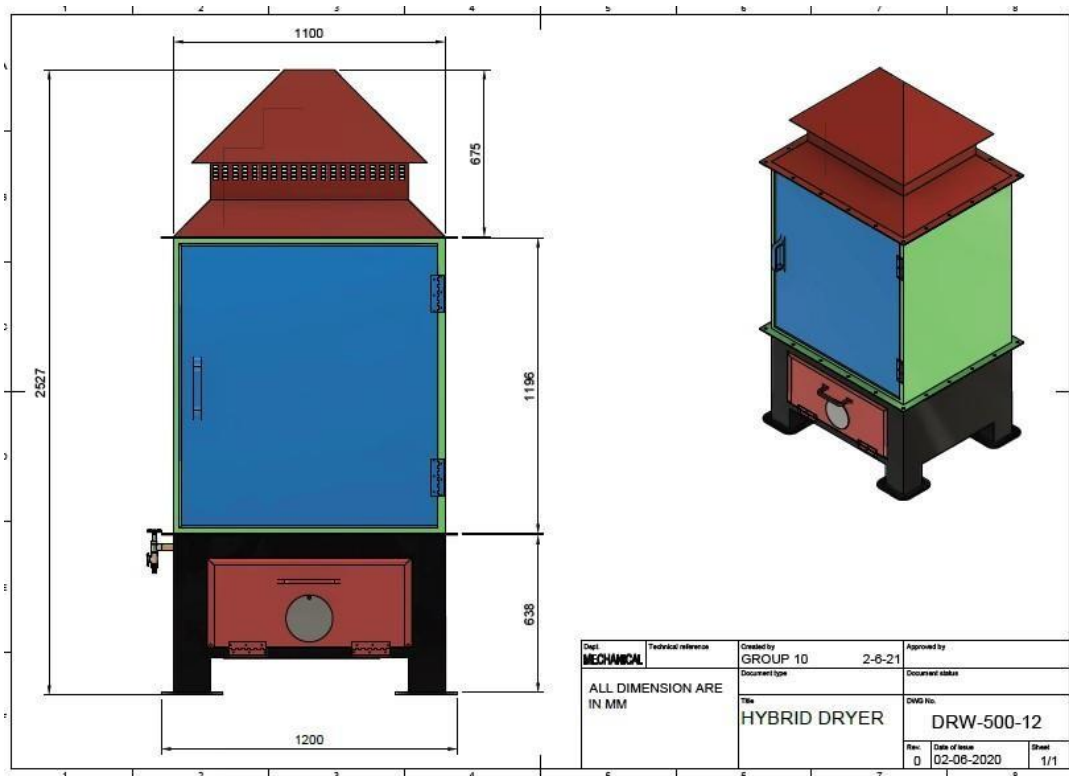
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1.Gas control valve 2.Thermometer 3.Moisture meter

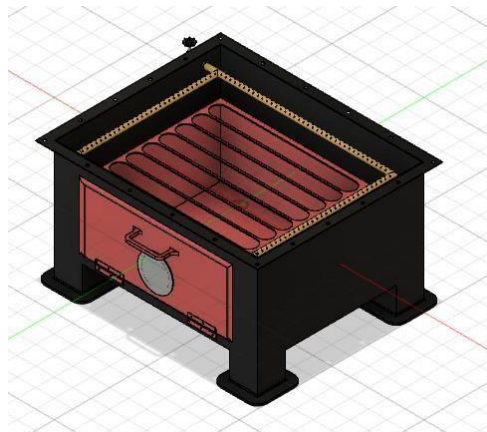
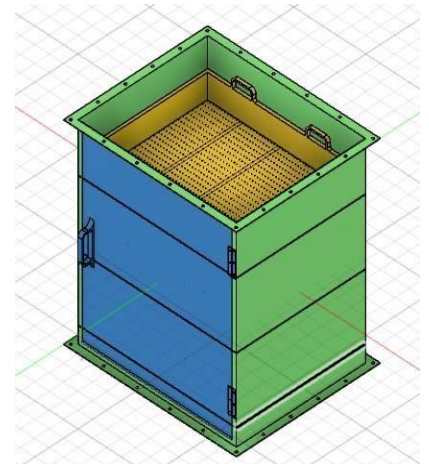
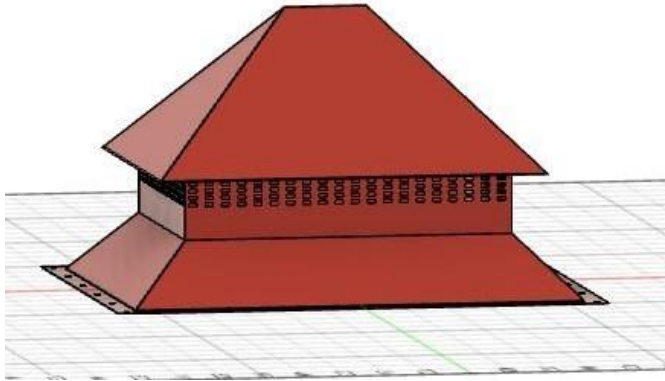


**DESIGN OF HYBRID DRYER**



**MAJOR PARTS OF HYBRID DRYER**

1. Chimney
2. Chamber
3. Furnace



**ANALYTICAL WORK**

1. Moisture Loss In AirDryer
2. Efficiency Of Air Dryer
3. Heating Effect Produced By AirDryer

**1. Moisture loss in air dryer**

- Drying Rate Of The Dryer Can Be Calculated By Obtaining Moisture Loss

Moisture Loss (ML) =  $\frac{M_i - M_f}{M_i}$

Where  $M_i$  Is Mass Of Sample Before Drying And  $M_f$  Is Mass Of The Sample After Drying

- For Tomato  $M_i = 2000g$   $M_f = 850g$

Moisture Loss (ML) =  $\frac{M_i - M_f}{M_i}$



For Apple  $M_i = 1000g$   $M_f = 750g$

$$\frac{2000 - 850}{2000} *$$

$$= 57.5\%$$

Moisture Loss (ML) =  $\frac{M_i - M_f}{M_i} * 100$

$$\frac{1000 - 750}{1000} * 100$$

$$= 25\%$$

• For Cardamom  $M_i = 4000g$   
 $M_f = 2000g$

Moisture Loss (ML) =  $\frac{M_i - M_f}{M_i} * 100$

$$\frac{4000 - 2000}{4000} * 100$$

$$= 50\%$$

Efficiency of Air dryer

• Adiabatic Air Drying Efficiency Is Given By:  $H = \frac{(T_1 - T_2) * (T_1 - T_a)}{T_1}$

Here  $T_1$  Is Temperature At Heat Chamber  $T_2$  Be Temperature Of Air At Exit  
 $T_a$  Be The Ambient Temperature

Here It Is Observed That Ambient Temperature Is 293k And  $T_1$  And  $T_2$  Be 353k And 348k  $H =$

$$\frac{(353 - 348) * (353 - 293)}{353} * 100$$

$$= 84\%$$

#### HEATING EFFECT PRODUCED BY AIRDRYER

• Amount Of Firewood Placed In Combustion Chamber = 5kg

Air Dried Fire Wood Typically Consist Of 10% Of Moisture In It Or 0.93 Pound Of Water 1 Pound = .453 Kg

• Calorific Value Of Dry Wood = 18-21MJ/Kg,

• Theoretical Heat Value  $Q_{actual} = 7100 \text{btu/Lb}$

• The Heat Present In Exhaust Gas;  $Q_{fg} = M * V_{fg} - C_{fg}(t_{fg} - t_{fgc})$

Where

$M$  = quantity Of Wood



$V_{fg}$ =specific Volume Of Flue Gas Produced In The Combustion Of 1kg Of Firewood  $C_{fg}$ =specific Heat Capacity Of Flue Gas When Pressure Is Constant

$T_{fg}$  = Temperature Of Flue Gas

$T_{fge}$  = Temperature Of Flue Gas Air Cooled To The Temperature Of Combustion Air , Taking 10% Moisture Content

Assume  $T_{fg}=130^\circ\text{C}$  And  $T_{fge}=50^\circ\text{C}$  Take M From The Table Given Below

Consider Moisture Content Is 10%

Table 2. The effect of firewood moisture content on the energy efficiency of a boiler, fuel consumption, and the production of flue gases when 1 GJ of heat is produced.

Fuel	Moisture Content	Heating Value	Specific Volume of Flue Gases from 1 kg of Wood	Thermal Efficiency of a Boiler	Consumption of Firewood to Produce 1 GJ of Heat	Production of Emitted Flue Gases when 1 GJ of Heat is Produced	Atmospheric Thermal Load by Flue Gases
	$W^r$	$Q_n$	$V_{fg}$	$\eta_k$	$m_{p-1GJ}$	$V_{fg-1GJ}$	$Q_{fg}$
	[%]	[kJ·kg <sup>-1</sup> ]	[m <sup>3</sup> ]	[-]	[kg]	[m <sup>3</sup> ]	[MJ·GJ <sup>-1</sup> ]
Fuel wood	10	16,159	9.34	0.883	73.38	704.02	96.2
	20	14,075	8.44	0.878	87.49	738.47	101.3
	30	11,992	7.54	0.871	107.05	807.12	110.1
	40	9908	6.64	0.861	129.06	856.98	122.9
	50	7825	5.74	0.845	169.27	971.58	143.2
	60	5742	4.8	0.819	245.03	1188.87	179.8

$M= 73.38 \text{ Kg}$

So

$Q_{fg} = 73.38 \times 9.34 \times 1700 \times (130 + 213) - (50 + 273)$

$= 93.2 \text{ MJ}$

- The Firewood Burned In Combustion Chamber To Produce Heat Of 10J Is Calculated By

$M_p = q_{n10} \times \eta_k$   $Q_n$  and  $\eta_k$  are from the table

Hence On Substituting We

Get As;  $M_p = \frac{106}{1659 \times 0.883}$

$= 70.08$

$\text{Kg/Gj}^{-1}$



- Heating Value Of Fire

Wood Q=18840-2135

x w

- W=10  
%

Hence Q (Theoretical) = 18818.64kJ/Kg

Now For Comparing The Heating Effect We Need To Use Thermometer And Moisture Meter Respectively.

Q (Theoretical) = 18818.64 kJ/Kg Q<sub>actual</sub>=7100btu/Lb=7100\*2.326=16514.6 kJ/kg

#### IV. CONCLUSION

It can be concluded that both objectives of this project were achieved. From the results it shown that three-dimensional computational fluid dynamics simulation tools was able to analyse the temperature and air flow distribution inside hybrid dryer. The new design of the dryer was found to be more efficient compared to the current design. From the result, the air temperature inside the proposed dryer was increased by up to 28.4% and the air velocity was increased up to 64.7% especially at the chimney area compared to the current design. This study was aimed to investigate the performance of a portable hybrid dryer with thermal backup. The evaluation process composed of mathematical calculation and numerical simulation. The fluid flow and temperature contours inside the dryer were studied from simulation. The comparisons between the experimental and simulation results are plotted. The prediction of the airflow inside the dryer can be helpful on the design of most suitable geometric configurations of the device, improving the drying process.

#### V. FUTURE WORK

For the current study, the simulation was done only for steady state condition for selected time in a day. In the future, further study should be carried out to simulate the internal climate of the hybrid dryer continuously for certain period of time especially at day time where the drying process takes place. This can be done by analyzing using the transient type of analysis. Continuous simulation for certain period of time can be used to study the effect of weather to the internal climate of the dryer more accurately.

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