Design and Working Principles of CIFT Solar Hybrid Dryers

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In India, out of the total fish production of 12 million metric tons, 20-30 % is dried or processed for export and local markets. Sun drying (open air drying) is the traditional method employed in most parts of the country to dry fishery products. It denotes the exposure of a commodity to direct solar radiation and the convective power of the natural wind. This form of energy is free, renewable and abundant in any part of the world especially in tropical countries. Although it offers a cheap method of drying, the final dried products remain inferior in quality due to dependence on weather conditions and vulnerability to the attack of dust, dirt, rains, insects, pests, and microorganisms. This leads to 10-40% post-harvest wet weight loss. The inferior quality of dry fish in India is seriously reflected in the decline in export of dry fish to developed countries. To overcome the limitations observed, ICAR-CIFT, Kochi has developed low cost, energy efficient and eco-friendly solar dryers for hygienic and quality drying of fish.

A solar hybrid dryer can generate higher air temperatures and consequential lower relative humidity, which are conducive to improved drying rates and lower final moisture content of the final products. To ensure reliability and better control of solar radiation during rainy period or cloudy days and its unavailability during night time an auxiliary heat source and forced convection system are recommended. A brief description of CIFT developed eco-friendly, cost effective hygienic solar dryers for fish are given below.

Solar dryer with electrical back up

The dryer assembly comprised of solar flat plate collectors with an area of 10 m^2 for harnessing solar energy to heat the air (Fig.1). This hot air flows in to the drying chamber for drying the product. When solar radiation is not sufficient during cloudy/rainy days to heat the air for circulation, alternative electrical back up is automatically actuated. Drying is carried out under controlled temperature and humidity conditions. The complete process parameters of fish drying can be controlled by a Programmable Logic Controller (PLC) system. The dryer can be used for drying 20 kg of fresh fish per batch and the specifications of the system are given in Table.1.

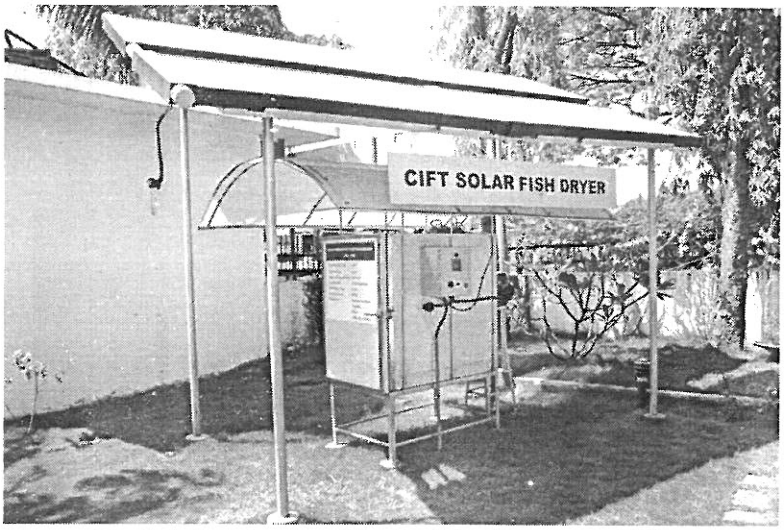

Fig.1 Solar dryer with electrical back up-20 kg

Table:1 Specifications of Solar dryer with electrical back up -20 kg

Dryer dimension (m)	1.85×0.85×1.3
Material of construction	PUF insulated panel (6cm) with stainless steel inside and Powder coated GI outside
Heat absorbing area	10 m^2 , FP solar air collectors – 4 Nos.
No. of trays	10
Tray dimension (m)	1.60 × 0.75 × 0.025 (900 mm X 600 mm X 20 mm)
Tray material	SS 304 Food Grade
Alternate energy back up	Electrial (Two coils of 1000W)
Blower	0.5 hp, Dia - 8" , 1425 rpm
Other accessories	PVC Pipe (4")- 18m, cable - 60m, Aluminum channel - 6m, MS Square tube, Angle Iron, GI tube, control panel with temperature control sensor

Solar cabinet dryer with electrical back up

The dryer consists of four drying chambers with nine trays in each chamber. The trays are stacked one over the other with spacing of 10 cm (Fig.2). The perforated trays accomplish a through flow drying pattern within the dryer which enhances drying rates. Solar flat plate collectors transmit solar energy to the air flowing through the collector which is then directed to the drying chamber. Electrical back up comes into role once the desired temperature is not attained for the drying process, particularly during rainy or cloudy days. Specifications of the Solar Cabinet Dryer of capacity 40 kg is given in Table.2

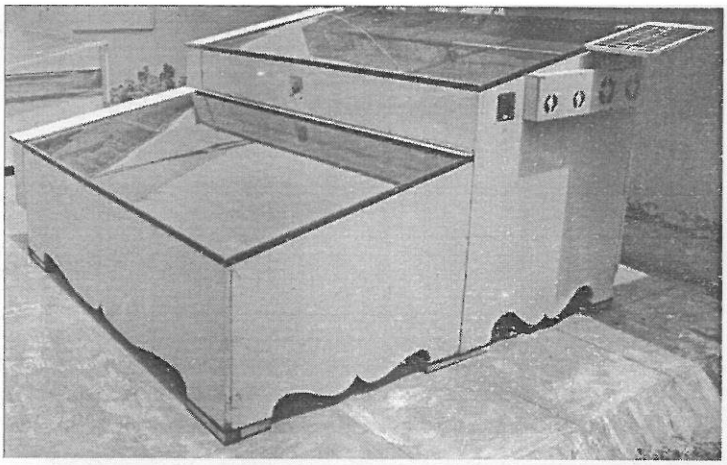

Fig.2 Solar cabinet dryer with electrical back up-40 kg

Table: 2 Specifications of Solar Cabinet Dryer with Electrical Dryer-40 kg

Dryer dimension (m)	3.1×2.45×1.3
Material of construction	PUF insulated panel (6cm) with stainless steel inside and Powder coated GI outside
Heat absorbing area	7 m^2 , FP solar air collectors – 2 Nos.
No. of trays	36
Tray dimension (m)	0.9 × 0.5 × 0.025
Tray material	SS 304 Wire mesh/perforated tray
Alternate energy back up	Electrical (Two coils of 1500 W)
Blower & two exhaust fan	0.5 hp& 2" Dia - 0.15hp
Other accessories	MS Square tube, Angle Iron, GI tube, Temperature control sensor, control panel, hinges, cable, padlock

Solar dryer with LPG back up

This is a hybrid solar drying system for hygienic production of dry fish by using environment friendly, abundantly and freely available renewable solar energy. Continuous drying of fish is possible in this system with the help of LPG back up, where the fish can be dried in unfavourable weather conditions without spoilage and maintaining its nutritional value. In this system, water is heated with the help of solar collectors installed on the roof and collected in a calorifier tank (Fig.3). The water from calorifier tank is collected through the solar collectors using a pump. Axial flow fans are provided in the drying chamber for hot air circulation across stainless steel trays loaded with fish for drying. The circulating air is heated by hot water passing through the heat exchangers. When solar radiation is not sufficient during cloudy/rainy days to heat the water for circulation, LPG back up heating system will be automatically actuated to supplement the heat requirement. The continuous drying is possible

in this system without spoilage of highly perishable commodity to obtain a good quality dried product. Drying is carried out under controlled temperature and humidity conditions. The complete process parameters of fish drying can be controlled by PLC system. The specifications of a Solar-LPG hybrid drying system are given in Table.3.

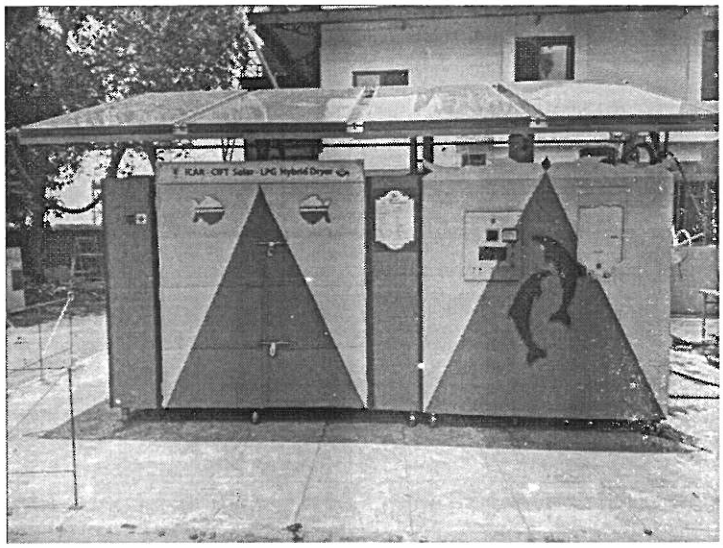

Fig.3 Solar dryer with LPG back up-60 kg

Table: 3 Specifications of Solar-LPG Dryer-60 kg

Dryer capacity	60 kg
Material of construction	Multi-wood with MS angle frame for support &Heat resistant aluminum foil (0.5 mm) insulation ; PUF insulated panel (6cm) with stainless steel inside and Powder coated GI outside
Overall dimension (m)	4.23 × 1.00 × 1.80 (L × W × H)
Drying chamber dimension (m)	2.46 × 1.00 × 1.80 (L × W ×H)
No. of solar radiation collector	4 Nos. Vacuum tube collectors (VTC)
Total heat absorbing area	12 m^2
Solar tracking system	Manual
Alternate energy back up	LPG
No. of trays	60
Tray dimension (L × W × H), m	0.80 × 0.45 × 0.25
Tray material	SS 304 Perforated tray, 18 Gauge Tray holder – 6 Nos.
Blower	4 Nos. (0.5 HP) Dia – 12.5", 2800rpm Standard: Crompton & greaves, EBM,

Heat exchanger	2 Nos. 500 mm × 500 mm × 110 mm, Copper tubes with GI fins
Pre-heating element*	2 Nos. (1000 W)
Exhaust fan	1 Nos. 0.15hp, Dia - 8"
Pump	3 Nos., 0.5 hp
Gas geyser	1 Nos., 15 L
Water tank	1 Nos., 100 L (Insulated)
Other accessories	Temperature controller – 3Nos Temperature & RH Sensor – 4 Nos. Toggle switch - 4 Nos. Indicator, Cable, Control panel box

**Optional accessory*

Technology benefits of CIFT Solar hybrid dryers

- Green drying technology
- Hygienic drying conditions even during cold/rainy days
- All contact parts are made of food grade stainless steel
- Protection against dust, insects, birds, rodents and adverse climatic conditions
- Reduction of drying time
- Safe and uniform drying to storable conditions
- Drying under controlled conditions of temperature and humidity
- Improved product quality
- Preservation and nutritional properties

Market potential/Target group

- Ideal for drying fish, fruits, vegetables, spices and agro products
- Target group ranges from SHG to Processing industry

Solar tunnel dryer

An energy efficient and low cost solar tunnel dryer was developed for bulk drying of fish and fishery products. This dryer can be used by fishermen or small-scale fish processing units for bulk drying during seasonal higher catch/excess landing of fish. The capacity of the solar tunnel dryer is 50 kg with the floor area of 12 m^2 (Fig. 4). The materials of construction are UV stabilized transparent polythene sheet for roof cover, black absorber sheet for floor, supporting frames of CPVC and GI rod. Three ventilator fans of 0.5 hp were provided for air inlet and moisture removal. The trays with tray holder were placed inside the dryer for spreading and hooking the fishes for drying. The tunnel dryer was designed as a stand-alone system as it does not require any external power source/electricity. The fans were operated by means of a solar PV panel fitted on roof top of the dryer and associated battery setup. It is also

of affordable cost (Rs 65,000 plus GST) and suitable to the Indian fisherfolks. Specifications of the dryer are given in Table 4.

Table: 4 Specifications of solar tunnel dryer – 40 kg

Dryer dimension (m)	4 × 3 × 2
Floor Area (m^2)	12
No. of trays	12
Tray material	Wood and iron mesh
Dryer fabrication material	UV stabilized transparent polythene sheet (200μ), black absorber sheet, CPVC and GI rod.
Inlet and exhaust fans	0.5 hp – 3 Nos.
Loading capacity (Kg)	50
Approximate cost (Rs)	67,000.00
Purpose	Bulk drying of fish and fishery by-products

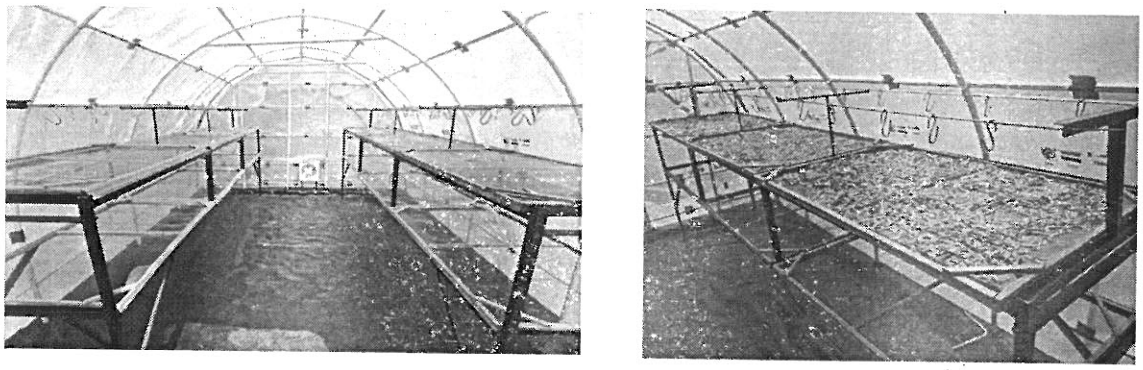

Fig. 4 Solar tunnel dryer

Energy Conservation

It was found that all solar based drying systems are energy efficient and promote conserving electricity or fossil fuels. The Solar dryers work on minimal operating expenses and provide better quality hygienic products. The energy consumption chart of CIFT developed solar hybrid dryers is depicted in Table.5, while that of electrical and LPG dryers in Table.6. The comparison chart among Solar hybrid and electrical/LPG dryers are given in Table.7. It is evident from the table that the Solar hybrid dryers are energy efficient with a reduction in energy expenses in the tune of 40-60 %.

Table 5: Energy consumption chart for CIFT developed Solar hybrid dryers

Type of the Dryer	Component	Power consumed in watts per hour	Total energy consumption (KWh) for 1 year (240 days)*	Approximate electricity charge for 1 year**(in INR)
Solar-Electrical Dryer-20 kg	Blower	335	1795.20	14,361
	Heating coil	600***		
Solar-Electrical Dryer-40 kg	Blower	335	2586.048	20,688.38
	Exhaust fan	111.9		
	Heating coil	900***		
Solar-LPG Dryer-60 Kg	Blower	1492	5227.96	41,823.74
	Pump	1119		
	Exhaust fan	111.9		

** Considering 8 months of operation @ 1 batch per day (1 batch approximately equivalent to 8 hours)*

*** Unit cost of electricity @ Rs. 8/- per unit*

**** 30% of energy supply through heating coils and 70% by solar collectors during day time*

Table: 6 Energy consumption chart for Electrical and LPG Dryers

Type of dryer	Capacity (in kg)	Power consumed in watts per hour		Total energy consumption (KWh) for 1 year (240 days)*	Approximate electricity charge for 1 year** (in INR)
Electrical dryer	20	Blower	335	4483.2	35,865.6
		Heating coil	2000		
Electrical dryer	40	Blower	335	6618.64	52,944.38
		Exhaust fan	111.9		
		Heating coil	3000		
LPG dryer	60	Blower	1492	9054.336	72,434.68
		Exhaust fan	111.9		
		Pump	1111.9		
		Heating coil	2000		

** Considering 8 months of operation @ 1 batch per day (1 batch approximately equivalent to 8 hours)*

***Unit cost of electricity @ Rs. 8/- per unit*

Table: 7 Comparison between Solar Hybrid, Electrical and LPG Dryers

Type of the dryer and capacity	Total energy consumption (KWh) for 1 year (240 days)*	Approximate electricity charge for one year** (in INR)	Percentage reduction in energy	Percentage reduction in cost
Solar Electrical Hybrid - 20 kg	1795.20	14,361	59.95	59.96
Electrical - 20 kg	4483.2	35,865.60		
Solar Electrical Hybrid - 40 kg	2586.04	20,688.38	60.92	60.36
Electrical - 40 kg	6618.64	52,949.12		
Solar LPG Hybrid - 60 kg	5227.96	41,823.74	42.26	42.26
LPG - 60 kg	9054.336	72,434.68		

Being a clean, green and affordable technology, many fishers, fisherwomen and entrepreneurs have taken up dry fish production using solar hybrid dryers as a commercial venture. All the financial viability criteria including B-C ration, NPV and IRR are found to be positive for the solar drying technology.

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