DESIGN OF SOLAR POWERED ONION PRESERVATION CABINET

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Abstract— Onion known scientifically as Allium cepa is a perishable vegetable used in cooking. The preservation of onions has been a serious challenge for its domestic users, farmers, small scale and large scale business men despite the existence of traditional preservation systems. This calls for this paper that design Solar Powered Onion Preservation Cabinet at the capacity of preserving about 100kg . The design control temperature and humidity that preserves onion for a period of 6- 12 months. The materials to be used for fabrication of the cabinet include aluminum, wood, and solar power generating facilities. The design would be expanded after fabrication and test of the cabinet.

Keywords— Onion, Preservation, Cabinet, Solar energy, Humidity, Temperature, Material, Insulation.

I. INTRODUCTION

Design of Solar Powered Onion Preservation Cabinet is a preparation to store onion for a long period of time and which uses solar energy from the Sun as its electrical source. The reality is that ability to hold onions in long-term storage and deliver quality product months after harvest is directly related to advances in ventilation system design and management. The ventilation system is really the key to maximizing profits from storage. Once the onions are harvested and placed in storage, the ventilation system is the only tool one has to interact with the crop. Anything that we do to the onions will occur using the ventilation system. For example, the processes of curing, cooling to holding temperature and dehumidification are all driven by the ventilation system and its components. In short, the ventilation system is our life-line to the onions.

Some of the former methods of onion preservation adopted by our peasant farmers[I] were:

1. Bags: this method of preservation uses bags made up of lining material from plants and has a zip for opening and closing of a filled bag.
2. Bins: This is a basket with a special design, it has an opening from the top where the onion can be filled in and below is an opening where it can be removed.

FIGURE 1

3. Basket: This is a basket with handle which is hang in order to raised the base so that air can circulate underneath.

Large scale onion business men are always at the risk of high lost due to preservation problems, as such most of the onions would sprout or mold, and as the season of onions gone , a common man cannot afford to buy enough for his meal due to the inflation.

Aims and objectives

This paper is aim at improving the system of onions preservation. The former method of onion preservation such as baskets (eg wire hanging baskets or a perforated bowl), bags, bins etc are just mini method of onion preservation which did not provide the solution. Canning of onion, dehydration, concentration, fermentation and pickling may also not solve. Onions are not refrigerated with the exception of green onion, they are stored in a well ventilated space at room temperature.

Therefore, we are designing a mass onions preservation cabinet well ventilated space between 20^0C to 25^0C inside temperature, with correct humidity and powered by solar energy and we named it as " SOLAR POWERED ONION PRESERVATION CABINET". This can be expanded to solve the problem of farmers and large scale onion business people after fabrication and testing.

II BACKGROUND INFORMATION

The onion, known scientifically as *Allium cepa [II]*, is, on the surface (not deep in the ground), a humble brown, white or red, paper-thin skinned bulb; yet, despite its plain looks, it has an intense flavor and is a beloved part of the cuisine of almost every region of the world.

Onions are native to Asia, the Middle East and Africa and have been cultivated for over seven thousand years.[II] Onions were highly regarded by the Egyptians. Not only did they use them as currency to pay the workers who built the pyramids, but they also placed them in the tombs of kings.

Onion, being high in water content, is a delicate commodity to store and requires special procedure and parameters, giving rise to the concept of Onion cold storage. Onion is an important vegetable crop and forms a part of daily diet in almost all households throughout the year. But due to non-availability of appropriate post-harvest storage facilities, two third of the total produced onions are wasted, which in terms of value amounts to thousands of money.

Onions have been revered throughout time not only for their culinary use, but also for their therapeutic properties. As early as the 6th century, onions were used as a medicine in India, and it has beneficial effect on health such as cardiovascular benefits, support for tissues, anti-inflammatory benefits, cancer protection and it also act as potential for improvement of blood sugar balance for human who are seeking better sugar balance for their diet It contains vit. B and vit. C and minerals Ca and Fe. [III]

Onions serve as a source of income and also provide job opportunities for our local farmers.

The solar powered onion preservation cabinet is a rectangular box kept at its height. It is 200cm X 120cm. The thickness is 60cm. It consist of a frame of aluminium angle bar, perforated aluminium sheet, insulation of plywood, front door of a complete louvers, eight blower fans, four extractor fans, but the assembly and orthographic drawings in fig. x and fig.y use large fan size of 30cm diameter, the size depends upon the type available in your locality. The cabinet also consist of different settings of inside trays, and connection of solar facilities.

III. DESIGN CONSIDERATION

The design considered a lot of factors such as the humidity, ventilation, temperature, materials, insulations, solar energy etc.

Humidity and Ventilation

Humidity of different intensity gives numbers of effect to the onion. Onions easily absorb moisture and the wetness in the air will rot your onions, therefore, humidity level for onion preservation should be kept between 65- 70% [IV]. Onion should be stored in a well ventilated space, away from heat and bright light. All onions should be stored away from potatoes, as they will absorb their moisture and ethylene gas causing them to spoil more easily. , you should store them in a cool, dry, ventilated place – not in your refrigerator. Avoid storing onions in plastic bags during storage outside of the refrigerator [V]

Keeping air flowing around the onions will help prevent molding and rotting. Storing onions in this way allow them to breath properly. Any moisture they may have already come in contact with will soon evaporate, keeping your angiosperms a larger shelf life.

Temperature

If the temperature rises from 0°C to 20°C, a rapid increase in respiration intensity ensues. Temperatures of up to 30°C are admissible in the short term, but from 40°C the onions undergo physiological changes which are known in practice as "scalding" (physiological heat injury) and the symptoms of which include rot, spoilage, sprouting and self-heating. The onions acquire a glassy appearance, become mushy and exude a foul odor [IV].The required temperature for onion preservation is 20% to 25%. We should take note that if the inside temperature of the cabinet is too warm, your onions will begin to sprout, if inside the cabinet is too cold, the onions will start to rot.

To control the temperature in the cabinet for onion preservation we have introduced enough DC fans which include extractor fans and blower fans. The function of the extractor is to extract heat from the inner part of the cabinet while the blower fan is blowing cool air to the inside environment of the cabinet. As the extractor fan is extracting hot air from the cabinet simultaneously is drawing cool air from the vent window of the front face of the cabinet hence providing a very good ventilation.

Both extractor fans and blower fans were designed to be powered by solar energy collected by photovoltaic cells.

Control of micro-organism

If the scale leaves of the onions are dry and parchment-like, penetration of microorganisms is largely prevented. Moist scale leaves, on the other hand, lose their resistance and offer favorable living conditions to adherent microbes [IV].The general concept underlying the preservation of onions aims at preventing the development of micro-organism such as bacteria, yeast and mould to avoid onion spoilage during storage. At the same time, the chemical and biomedical changes mostly caused by micro-organisms must be controlled.

The material required in this fabrication depend upon the emission of material, thermal conductivity, absorption of moisture and the possible method of insulation.

We decided to use metallic material to have total control of the absorption of moisture. The metallic material is aluminum sheet, we determine the thermal conductivity and the emission properties The emittance (or emissivity) of the surface is defined as the ratio of radiation emitted by the surface to the radiation emitted by a black body at the same temperature. Emittance is a function of the material, its surface condition, and its temperature. [VI]

$$\text{The emissivity of Aluminium} = \frac{\text{Radiation emitted by Aluminium}}{\text{Radiation emitted by Black body}}$$

$= \varepsilon / \sigma$[at the same time]

When you take different value of radiations you will

continue to get a constant value of emissivity of Aluminum sheet equals to 0.1 for example at

$$= \varepsilon / \sigma$$

$$0.05/0.5 = 0.1$$

TABLE 1

Material	Emittance (~80 ^{0}F)
Aluminum Paint	0.5
Aluminum, commercial sheet	0.1
Aluminum, embossed	0.2
Galvanized steel, dipped or dull	0.3
Galvanized steel, new bright	0.1
Iron or steel	0.8
Painted metal	0.8

Insulation of the cabinet

A common design calculation associated with onion cabinet involves determining the thickness of insulation required to control the surface temperature to a certain value given the operating temperature of the cabinet (25^0c – 30^0c) and ambient temperature. It is designed to calculate the thickness of cabinet insulation required to keep the operating temperature at or below 25^0c – 30^0c (the air in the cabinet) and the ambient temperature is 37^0C. outside surface temperature at or below 37^0C by polishing the aluminum with zinc paint.

Newton's of cooling

It states that heat transferred from a hot body to a cold body is directly proportional to the surface area and difference of temperature between the two bodies. It is a general law, for the heat transfer which cannot be applied to all sets of conditions. But it served the way for other laws dealing in the heat loss.[VII]

Fourier's law of conduction

Fourier's law states that the rate of heat transferred, Q, from one side of wall at high temperature, T_1 , to the other side of wall at lower temperature T_2, is directly proportional to the surface area, A, normal to the direction of heat flow and to the temperature difference across the wall, ($T_1 - T_2$), and inversely proportional to the wall thickness [VIII]

$Q = -KA\frac{dT}{dX}$ where K = thermal conductivity of the material

Mathematically,

$Q\alpha = \frac{A(T1-T2)}{X}$ Or $Q = \frac{KA(T_2-T_2)}{X}$

The plan is to insulate the cabinet with 20mm (thickness) of plywood.

The thermal conductivity (k) = 0.17

Inside temperature is 20^0c

Outside temperature is 37^0c

From fouriers law

$$Q = \frac{K(T_2-T_2)}{X}$$

where

Q = heat transfer

K = Thermal conductivity

T_2 = Outside temperature

T_1 = Inside temperature

X = Thickness of insulator (plywood)

$$Q = \frac{0.17(37-20)}{20}$$

$$Q = \frac{2.89}{20} = 0.1445$$

The heat transfer is now known

Q = 0.15

To know the thermal resistance of the insulator

The thermal resistance (R) can be obtained

$$R = \frac{X}{KA}$$

Where

R= Thermal Resistance

K= Thermal conductivity

A= Area

$$R = \frac{20}{0.17X2X1.2} = 0.042 \text{ k/w}$$

Load Profile

The load profile is summarized in tabular form below. All facilities in the solar system of the cabinet are enlisted with their specifications

TABLE 2

S/N	ITEM	Qty	Voltage	Current	Power
1	Photovoltaic cells	3	12	50	600
2	Battery	3	12	25	300
3	Controller charger	1	12	100	1200
4	Inverter	1	12	167	2000
5	Connecting wires	1 roll	-	-	-
6	Fans	12	12	25	300
7	switch	2	-	-	-

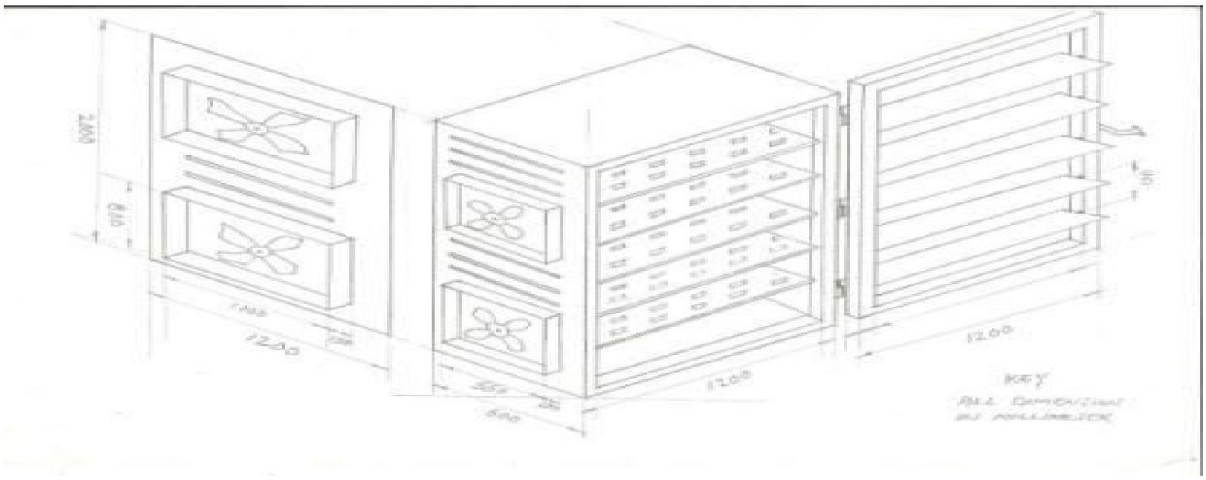

FIGURE 2 ASSEMBLY DRAWING

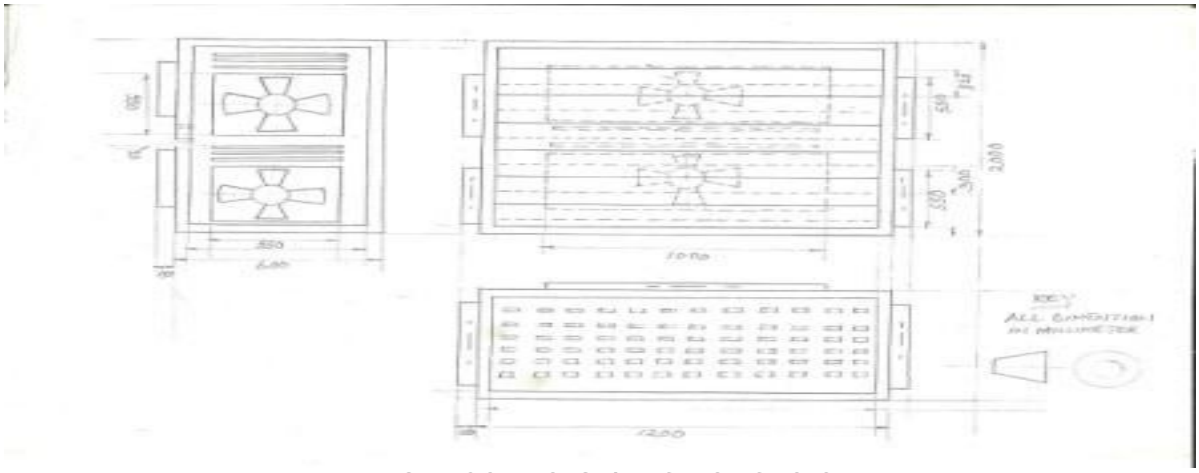

FIGURE 3 ORTHORGRAPHIC PROJECTIONS

CONCLUSION AND RECOMMENDATION

The design of Solar Powered Onion Preservation cabinet is very practical. The parameter of plywood for installation can be substituted from 20mm to 10mm thickness. Also it is advisable to use DC fans irrespective of the size, it will make the design more economical, because the inverter is not going to be installed the design will proceed to fabrication and testing. Lastly the enhancement of the tested fabrication of the cabinet for large scale of onion businessmen.

It is recommended that the attention of mechanical engineers in design and fabrication of onion preservation is very less, more of their attention is required for more contribution and enhancement

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