Sizing of Solar Photovoltaic for Mechanical and Thermal Energy of Automatic Egg Incubator

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Abstract— *Artificial egg incubator is the example of scientific solutions used to solve a biological problem on natural egg incubator process. In this work, modeling and sizing of solar PV for automated egg incubator were conducted and contains sensors for monitoring temperature, and humidity of inside of the incubator. Mechanical and thermal analysis has been done for 200 eggs. It is incorporated with a controlled mechanical egg tilting mechanism for tilting the eggs at an angle of 45^0 alternately which is once every 3 hours for adequate ventilation. The heat loss through the walls by conduction, and convectional ventilation hole were 136.5 W and 1.206 W respectively. The total heat required for the incubator was 200.32 W. The energy consumption needed by all the loads in the incubator for the period of 24 hours was* $21.1752 MJ$. *The sizes of the solar panels, charge controller, batteries and inverter power designed and used were 1000 W, 60 A,1200 AH and 1 kW respectively. The recommended temperature was maintained within 36 to 39^{o}C which was achieved with the aid of the temperature control system.*

Index Terms— Egg incubator, Heat loss, Humidity, Solar PV, Temperature, Tilting, Ventilation.

1. Introduction

The Ethiopian population is increasing at an alarming rate. The need for getting protein content food is also becoming too high. Egg and chicken is one of the most protein content food that are available everywhere in the country. In Ethiopia chickens are the most widespread and almost every rural family owns chickens, which provide a valuable source of family protein and income [1]. The total chicken population in the country is estimated to be 56.5 million with native chicken representing 96.9%, hybrid chicken 0.54% and exotic breeds 2.56% [2]. The most dominant chicken types reared in Ethiopia are local ecotypes, which show a large variation in body position, plumage color, comb type and productivity [3]. However, the economic contribution of the sector is not still proportional to the huge chicken numbers, attributed to the presence of many productions, reproduction and infrastructural constraints [3,4]

To maximize the amount of egg and chicken production man started using an artificial incubation system. The foundation of the modern poultry industry is artificial incubation in which the mechanical equipment is used to replace the broody hen for egg incubation. The art of incubation has been known for several thousand years, but it has been employed on a commercial scale only within the last 60-70 years. This is the large scale method of poultry farming for adequate supply of chicks, since one cannot rely on broody hens [5].

Several sources of energy have been used in the past for the process of artificial incubation – electric and Kerosene as sources of heat in incubation process but, it can be not affordable to the rural dwellers because of the cost and irregular nature. There is need to provide very cheap and highly abundant source of energy to this group for their poultry incubation.

Since incubator needs approximately constant supply of heat and humidity for the development of embryo. One of the best and uninterrupted power supply available for rural peoples is solar system. PV solar panels are also the best and the cheapest source of power that is available everywhere for the purpose of poultry production. During the sunshine hours the PV gets energy. The energy will then be converted in to electrical energy. The electrical energy is then converted to heat energy by using an incandescent lamp [3]. The objectives of this research is sizing appropriate solar PV for mechanical and thermal energy needed for automated egg incubator.

2. Literature Review

As reported by various researcher's incubation conditions such as temperature, humidity, ventilation and turning are the most important factors significantly affecting the hatchability of poultry eggs and chick quality [6, 7, 8, 9, 10, 11, 12, 13]. The effect of temperature on the hatchability of fertile eggs had been examined by many researches. Oluyemi and Roberts [11] recommended that the minimum and maximum temperature for the first 18 days should be 37.7^{o}C and 39.3^{o}C respectively. After 18 days of incubation, the temperature should be reduced from 37.8^{o}C to 36.0oC until the chicks were hatched. Hence for the whole period of incubation, the temperature should be maintained within the range of 36^{o}C and 39^{o}C which is in accordance to the report by other researchers [8, 9, 10, 11, 12, 13, 14]. Aremu, A. and E.I. Shaiwoye, [15] suggested that the optimum temperature is between 37°C and 38°C in forced draft incubator and about 1°C higher in still air incubator. Wilson [16] reported that the increase in temperature during incubation was very critical for chick embryos. Moreover, it was revealed that growth was retarded or ceased and the incidence of poor second quality chicks increased as the temperature was raised. Temperature is a very important factor affecting embryo development hatchability [17, 18], and post hatch performance [16]. Temperature is extremely important during incubation (especially during the first week). Tazawa et al. [18] stated that chicken embryos are poikilothermic, relying on an external source (hen or incubator) to provide heat to develop and maintain normal metabolic functions.

Komolafe et al. [19]; Oluyemi and Roberts [11] recommended that the minimum and maximum humidity values within 18 days should be 52% and 62% respectively. After the 18th days, the relative humidity should be increased from 55% to 71% until the end of the period of incubation which is in line with related research works. Hence for the whole period of incubation, the relative humidity should be varied between 52% and 71%.

In the incubator egg must be turned at least three times a day. If the turning is more than three, the result will be better but it has to be an odd number of times per day. The turning mechanism is also one of the main factor in poultry production. Most of the time egg is turned at an angle of 45 degrees from horizontal but total of 90 degrees per turning [20].

More so, candling is very helpful during incubation, as it helps to determine whether the embryo is developing. The usual times for testing are 7th and 14th days of incubation, sometimes testing is done only once on the 10th day. The eggs must not be candled after the 18th day to avoid disturbing the unhatched chicks because they need to rest and should not be handled during the last few days [21].

For sustainability in poultry chick production, the need for sustainable and environmentally friendly energy supply resource can never be overestimated. Such energy resource measure should be attractive and easy to come by or renewed by nature for example the use of solar energy. A special feature of solar powered incubator is that it could harnesses solar energy by using Photovoltaic materials. and is adaptable to both rural and urban poultry productions. Major advantages of solar powered poultry egg incubator are that it could lead to a pollution-free environment, systems that are free from fire hazards and the development of small, medium to large-scale commercial incubators.

3. Methods and Materials

3.1 Case Study

Bure is one of the Woredas in the Amhara Region of Ethiopia. Its name comes from its largest town, Bure. It was part of former Bure Wemberma woreda. Bure (also transliterated Burye) is a town in western Ethiopia. Located in the Mirab Gojjam Zone of the Amhara Region, this town has a longitude and latitude of 10°42′N 37°4′E with an elevation of 2091 meters above sea level.

3.2 Configuration of solar PV

In many stand-alone photovoltaic systems, batteries are used for energy storage. Below fig shows a diagram of a typical stand-alone PV system powering DC and AC loads. Figure 5.7 shows how a typical photovoltaic hybrid system might be configured.

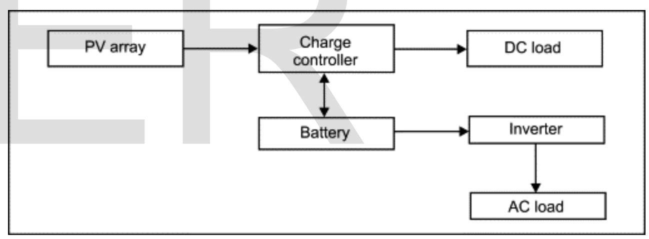


Figure 1 Configuration of Solar PV [22].

3.3 Mechanical and Thermal Analysis of the System

Capacity of the Incubator Egg Tray

Measured Dimensions of the Egg

Major Diameter of Egg (N) = 60mm

Minor Diameter (D) = 46mm

Border End = 24mm

The volume of the Egg try can be estimated

$$V = \frac{\pi D^2 HN}{4}$$

v = volume of the egg tray (m^3) and h = height of the egg tray or minor diameter = 0.06m

$$\boldsymbol{V = 0.005m^3}$$

The egg tray was rectangular in shape with a height of 60mm. The volume of the tray can be calculated as;

$$V = L * B * H$$

B = breadth and h = height=0.06m

L = length of the egg tray (m) (Let L=2b)

Then,

$$B = \sqrt{\frac{0.005m^3}{2 * 0.06m}} \cong 0.204m$$

Therefore, $\mathbf{L = 0.408m}$

Let's give 3mm clearance between each eggs for length (L) and width (B) and 10 eggs in length and 5 eggs in width row (5*10=10).

$$L = 0.444m \; and, B = 0.225m$$

Thus, the dimension of each egg trays

$\boldsymbol{L * B * H}$ **=444mm* 225mm*8om**

Egg Tray Holder

Give a clearance (c) for each four sides of the egg holder and the thickness of the egg holder (10mm) **c=5mm + 10mm= 15mm** for each sides of the egg holder therefore, its total dimension.

Therefore, its total dimension **459mm* 240mm*95mm**

3.4 Volume of air in the incubator

The volume of the air in the incubator equal to the volume of incubator chamber. Let thickness of the cover of all surface area **= 77mm.**

$$\boldsymbol{v = l * b * h}$$

Where: - $\boldsymbol{v}$ = Volume of the incubator (m^3), l=Length of the incubator=0.72m, b = Breadth of the incubator = 0.61m and, h = Height of the incubator = 2m.

$$v = 0.8784m^3 \cong \mathbf{0.878}\boldsymbol{m^3}$$

Mass of air inside the incubator

The amount of mass of the air inside the incubator chamber can be calculated;

$$m = \mathbf{1.07994}\boldsymbol{kg} \cong \mathbf{1.08}\boldsymbol{kg}$$

Design of Air Supply (Ventilation holes)

This is critical on home-made incubators. It is possible to **suffocate** the eggs and chicks in an air-tight container. However, excessive ventilation removes humidity and makes it difficult to heat incubators properly.

Angular speed of the fan in rev/sec, ω_{fan}=0.05rev/sec Taking the diameter of the fan as 250 mm and its radius is r=125mm = 0.125m

Derive the total cross sectional area of the ventilation holes from below equation

$$\dot{\boldsymbol{v}} = A_t * V_{fan} = \frac{\boldsymbol{v}}{\boldsymbol{t}}$$

Where: $\dot{v}$ = volume flow rate of air

A_t = Total cross sectional area of the ventilation holes

V_{fan} = Speed of the fan $= 2\pi * \omega_{fan} * r \left(\frac{\mathrm{m}}{\mathrm{s}}\right)$

$\boldsymbol{t}$ = is save time required to empty all the air in the chamber in seconds **(3hrs)**

$\boldsymbol{v}$**=** volume of the air in the incubator equal to the volume of incubator chamber.

$$A_t = \frac{v}{V_{fan} * t} = \mathbf{0.00207}\boldsymbol{m^2}$$

Volume flow rate of the air,

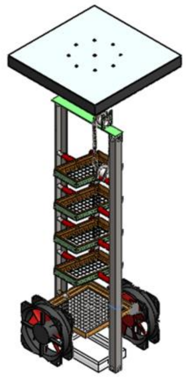
$$\dot{v} = \frac{0.878m^3}{3 * 3600\text{sec}} = \mathbf{8.13x10^{-5}m^3/sec}$$

Radius of the hole,

$$r = \sqrt{\frac{A_t}{\pi}} = \; = \mathbf{0.0257m}$$

Let's make nine holes at the top of the incubator chamber, calculate radius of each hole r_e,

$$r_e = \frac{0.0257\text{m}}{9} = \mathbf{2.86mm}$$



3.5 Total Energy Required

Heat required q, is determine as mcΔt. therefore, heat required to raise the temperature of the incubator is the heat required to raise the temperature of the air and eggs.

Assume negligible heat required for glass, egg tray, water and coverage wall.

For heat consumption in the egg; $\boldsymbol{Q_E = NM_E C_E \Delta T}$

For heat consumption in the air; $\boldsymbol{Q_A = M_A C_A \Delta T}$

Where :- C_A and C_E=specific heat capacity of air and eggs respectively, $\Delta\mathbf{T}$ = change in temperature and, M_E *and* M_A = mass of eggs and air respectively , and $N = numbers\ of\ eggs\ inside\ the\ incubator$

a. heat consumption in the egg;

Heat required to raise the temperature of eggs from 25℃ (room temp.) to 38℃ (optimum temperature of hatching eggs). The largest mass of eggs lays by hens is 0.068kg and 3.18 KJ/Kg℃ is specific heat capacity of the eggs. Therefore, by using equation (5.6) for 200 Eggs.

$$\boldsymbol{Q_E == 593.25kJ}$$

However, this heat provides gradually to avoid cooking of the eggs. Thus, quantity of heat required to raise temperature of the 200 eggs from 25℃ to 38℃ in watts is calculated as follow:

According to bell and weaver [23] the air in the incubator needs to be changed about eight times a day or once every 3 hours for adequate ventilation. This same quantity of air within every 3 hours contains the heat energy required to raise the temperature of egg from 25℃ to 38℃. Amount of power required for 200 eggs;

$$Q_w = \frac{Q_E}{t}$$

where: - t is save time required to empty all the air in the chamber in seconds

$$Q_w = \frac{\mathbf{593.25kJ}}{\mathbf{3*3600s}} = \mathbf{54.93w}$$

B. **heat required** to raise the temperature of air from 25℃ (room temp.) to 38℃ (optimum temperature of hatching eggs)

$$\boldsymbol{Q_A} = 1.08\text{kg} * 1.005\ {}^{\text{KJ}}/_{\text{Kg℃}} * (13)\text{℃} = \mathbf{14.1102kJ}$$

Amount of power required heating air;

$$Q_w = \frac{\mathbf{14.1102kJ}}{3 * 3600\text{s}} = \mathbf{1.3065w}$$

therefore, total heat required

$$Q_T = \boldsymbol{Q_E} + \boldsymbol{Q_A} \quad (W)$$

$$Q_{E,A} = \mathbf{56.2365w}$$

Determination of the amounts of heat energy in the incubator

Amount of energy required to balance a heat loss

$$Q_{Req} = Q_{THL} - Q_{egg}$$

Where:- $Q_{Req} = Energy\ required\ (w)$, $Q_{THL} = Total\ heat\ loss\ (w)$ $Q_{egg} = total\ heat\ generated\ by\ egg\ (w)$

3.6 Heat loss

Even if the incubator has a thermal insulation material which is surrounded by plywood and poly foam, we cannot be certain a perfected insulation to say negligible of heat loss to surrounding. Therefore, the heat loss will be calculated for all six surface of the incubator and through the glass.

i. Conduction heat loss

$$Q = KA_s\left(\frac{T_S - T}{x}\right)$$

where: - k = is thermal conductivity of surface; $A_s =$ surface area; $x = thickness\ of\ the\ the\ wall$; $T - T_S =$ inner and outer surface of the wall respectively.

Thermal conductivity and thickness of the chamber fall all sides of the incubator use identical materials and properties. thus,

Take average thermal conductivity of the cell polystyrene insulation materials is

$$K_{T,B} = 0.02 - 0.05 = 0.035w/mk$$

$Thicness\ of\ the\ incubator\ chamber$

$$= \text{sheet metal} + 2 * \text{plywood} + \text{insulation} + \text{Tar paulin (water prrof)}$$

$$x_{T,B} = 1mm + 2 * 3mm + 70mm + 0.25mm = 77.25mm = 0.07725m$$

$$x_{T,B} = 0.07725m$$

A. **the heat loss through the top and bottom** wall will give as

$$A_{s,TB} = L * B = (0.702 * 0.76)m^2 = 0.5335\text{m}^2$$

$$Q = 0.035w/mk * 0.5335\text{m}^2\left(\frac{38 - 25}{0.07725m}\right)k = 3.142w$$

$$\mathbf{q_{t,b} = 2 * q = 2 * 3.142w = 6.428w}$$

B. the heat loss through the left and right side wall of incubator chamber

$$A_{s,L,R} = H * B = (2 * 0.631)m^2 = 1.262m^2$$

$$Q = 0.035w/mk * 1.262m^2\left(\frac{38 - 25}{0.07725m}\right)k = 7.433w$$

$$\mathbf{q_{l,r} = 2 * q = 2 * 7.433w = 14.866w}$$

C. the heat loss at the front and back sides of the incubator chamber surface area of the back side is

$$\boldsymbol{A_{sB} = A_{s,L,R} = 1.262m^2}$$

surface area of the front side

= surface area of the back side − surface area of the glass

$$A_{sF} = A_{sB} - A_{s,G}$$

$$A_{s,G} = H * B = (0.5 * 0.2)m^2 = 0.1m^2$$

$$A_{sF} = 1.262m^2 - 0.1m^2 = 1.162m^2$$

$$q_{f,b} = 0.035w/mk * (1.262 + 1.162)m^2\left(\frac{38 - 25}{0.07725m}\right)k = \mathbf{14.277w}$$

a. Heat loss through the glass window.

Thermal conductivity of the mirror glass is $\mathbf{1.05w/mk}$ and 0.01m is its thickness

$$\mathbf{Q_G = 1.05w/mk * 0.1m^2\left(\frac{38 - 25}{0.01}\right)k = 136.5w}$$

ii. Convection heat loss

Negligible heat loss through due convection mode of all surface of the incubator to the environment since there is no temperature difference between them except through ventilation holes

a. Heat loss through ventilation loss

Quantity of heat loss by ventilation holes can be calculated

$$\mathbf{Q_V = mC_P\Delta T = C_P\rho\dot{v}\Delta T}$$

Where: -

C_P *is a specific heat capacity of the air at room temperature* $= 1.005\ {}^{KJ}/_{Kg°C}$, *ρ is denssity of the air* $= 1.135\ Kg/m^3$

$\dot{v}$ *is ventilation rate of the air* $= 8.13x10^{-5} m^3/sec$

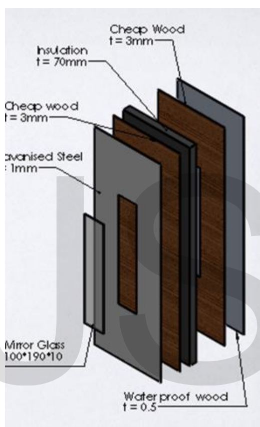
$$Q_V = 1.005\ {}^{KJ}/_{Kg°C} * 1.135\ Kg/m^3 * 8.13x10^{-5} m^3/sec * (38 - 25)°C = 1.206w$$

The total amount of heat loss,

$$Q_{THL} = Q_V + Q_G + Q_{L,R} + Q_{L,R} + Q_{T,B}$$

$$Q_{THL} = 1.206 + 136.5 + 14.277 + 14.866w + 6.428 = 173.277w$$

Heat Production of eggs



Heat production due to the metabolic activities of the eggs was estimated using the average of Lourens et al [8] heat production rate of 137mW for small egg and 155mW for big egg. A heat production rate of 146mW was used for the design.

$$\boldsymbol{Q_{G,Egg} = 200 * 146mW = 29.2w}$$

Amount of energy required to balance a heat loss

$$\boldsymbol{Q_{Req} = Q_{THL} - Q_{egg}}$$

$$\boldsymbol{Q_{Req} = 173.277w - 29.2w = 144.077w}$$

The total amount energy required for an incubator, is the addition of heat required to raise the temperature inside the incubator and heat required to balance the heat loss

$$\boldsymbol{Q_T = Q_{Req} + Q_{E,A} = 144.077w + 56.2365w = 200.32w}$$

Thus, the solar incubator chamber needs four incandescent bulbs with 50 wats and one with 25 watt

4. Result and Discussion

4.1 System sizing

System sizing is the process of evaluating the adequate voltage and current ratings for each component of the photovoltaic system to meet the electric demand at the facility. Determine the total power and energy consumption of all loads that need to be supplied by the solar PV system which is as follows:

The **electric loads** in the incubator system are **electric fan** ($\boldsymbol{P_F}$), **electric reversed motor** ($\boldsymbol{P_M}$), and **incandescent electric bulbs** ($\boldsymbol{P_B}$), which are to be powered by the solar system.

Energy consumption of all loads in the egg incubator ($\boldsymbol{E_C}$) are,

$$\boldsymbol{E_C = P_F T_F * P_M T_M * P_B T_B}$$

$\boldsymbol{P_F}$, $\boldsymbol{P_M}$, and $\boldsymbol{P_B}$ are consumes 20W, 50W, and 225W electric power rating respectively.

Considering the starting torque of the electric motor where the electric motor draws a high inrush current during starting which is two times the operating electric current [9], the electric power of the electric motor was calculated as:

$$\boldsymbol{P_M = 2 * 50W = 100W}$$

Total power consumption,

$$\boldsymbol{P_T = 20 + 100 + 225 = 345W}$$

Since the loads (electric bulb and electric fan) are required to be working for the whole day while the electric motor is to be rocking 3 seconds after every one hour throughout the whole day (or 72 seconds per a day), then

$$\boldsymbol{E = (24 * 20) + (24 * 225) + (0.02 * 100) = 5882Wh/day}$$

4.2. Sizing of the Solar Array

Recent Advances in Renewable Energy Sources Before sizing the array, the total daily energy in Watt-hours (E), the average sun hour per day Tmin, and the DC-voltage of the system (VDC) must be determined. Once these factors are made available we move to the sizing process. To avoid under sizing, losses must be considered by dividing the total power demand in Wh.day-1 by the product of efficiencies of all components in the system to get the required energy $\boldsymbol{E_r}$.

To avoid under sizing we begin by dividing the total average energy demand per day by the efficiencies of the system components to obtain the daily energy requirement from the solar array:

$$E_r = \frac{E}{\eta}$$

Where:- E is daily average energy consumption and, η is $product\ of\ componens'\ efficiencies$.

The select panel is (Lion Bird Monocrystalline Solar Module, 250W)

The Specification of PV panel

- Manufacturer: LION BIRD.
- Model name: PV-MF1250UD4.
- Cell type: Mono-crystalline Silicon.
- Number of cells: 60 cells.
- Maximum power rating STC (Pmax): 250watts
- Open circuit voltage (Voc): 37.44V.
- Short circuit current (Isc): 8.81A.
- Maximum power voltage (Vmp): 31.2V.
- Maximum power current (Imp): 8.01A.

$$E_r = \frac{5882wh/day}{0.8} = 7352.5\ wh/day$$

To obtain the peak power, the previous result is divided by the average sun hours per day for the geographical location Tm

$$P_p = \frac{E_r}{T_m}$$

$$P_p = \frac{7352.5\ wh/day}{7.5h/day} = 980.33w_P$$

The total current (I_{DC}) needed can be calculated by dividing the peak power by the DC- voltage of the system.

$$I_{DC} = \frac{P_P}{V_{DC}} \quad \text{Where:- } V_{DC} \text{ is System Voltage.}$$

$$I_{DC} = \frac{980.33w_P}{31.2\ V} = 31.42\ Amps$$

Modules must be connected in series and parallel according to the need to meet the desired voltage and current in accordance with:

First, the number of parallel modules:

$$N_P = \frac{I_{DC}}{I_R}\ where.I_R\ Maximum\ power\ current.$$

$$N_P = \frac{31.42\ Amps}{8.01\ A} = 3.92 = 4 \text{ Panel}$$

Second, the number of series modules which equals to:

$$N_S = \frac{V_{DC}}{V_R};\ where.V_R\ Maximum\ power\ volatge.$$

$$N_P = \frac{24}{24} = 1\ panel$$

Finally, the total number of modules;

$$N_T = N_S * N_P = 4 * 1 = 4$$

The PV array of the system consists of 4 panels in parallel.

4.3 Sizing of the Battery Bank:

According to the selected battery (AGM LEOCH Flat plate 300AH, 12V-DC).

Days of autonomy or the no-sun days = 3 days.

The amount of rough energy storage (E_{rough}) required is

$$E_{rough} = E * D$$

Where; E is total power demand and D is number of autonomy (three days) in

$$E_{rough} = 5882 \frac{wh}{day} * 3days = 17646\, w$$

For safety, the result obtained is divided by the maximum allowable level of discharge (MDOD):

$$E_{Safe} = \frac{E_{rough}}{MDOD} = \frac{17646\, w}{0.75} = 23528\, W$$

The capacity of the battery bank needed can be evaluated: C

$C = \frac{E_{Safe}}{V_b}$ where; V_b *is battery system voltage*

$$C = \frac{23528\, W}{24\, V} = 980.33\, Amps$$

The total number of batteries is obtained by:

$$N_T = \frac{C}{C_b} = \frac{980.33\, Amps}{300\, Amps} = 3.27 \cong 4\, Batteries$$

The connection of the battery bank can be then easily figured out. The number of batteries in series equals the DC voltage of the system (V_{DC}) divided by the voltage rating of one of the batteries (V_r) selected:

$$N_S = \frac{V_{DC}}{V_r} = \frac{24}{12} = 2$$

Then number of parallel paths N_P is obtained by dividing the total number of batteries (N_T) by the number of batteries connected in series (N_S):

$$N_P = \frac{N_T}{N_S} = \frac{4}{2} = 2$$

The number of batteries needed is, N_P = 4 batteries. Two parallel branches and 2 series batteries.

4.4 Sizing of the Voltage Controller:

According to its function it controls the flow of current. A good voltage regulator must be able to withstand the maximum current produced by the array as well as the maximum load current. Sizing of the voltage regulator can be obtained by multiplying the short circuit current of the modules connected in parallel by a safety factor F_{Safe}. The result gives the rated current of the voltage regulator I:

According to selected controller (XANTREX C60, Voltage: 24 V, Capacity: 60A, Voltage: 55 V)

the rated current of the voltage Controller I:

$$I = I_{SC} * N_P * F_{Safe}$$

I =8.81 A*4*1.25=44.05 Amps

The factor of safety is employed to make sure that the regulator handles maximum current produced by the array that could exceed the tabulated value. And to handle a load current more than that planned due to addition of equipment, for instance. In other words, this safety factor allows the system to expand slightly.

The number of controller equals the Array short current Amps divided by the Amps for each controller:

The number of controller equals to, $\boldsymbol{N_{Controller}}$

$$N_{Controller} = \frac{I}{Amps\ each\ controller} = \frac{44.05\, A}{60\, A} = 0.73 \cong 1$$

Therefore, It needs only one regulator.

4.5 Sizing of the Inverter:

The power of devices that may run at the same time is: P_{Total}= 1000 $Watt$.

The inverter needed must be able to handle about 1000-W at 220-Vac.

Model Huber One 1024 Inverter-charger

Rated Power =1000 watt, 24-Vdc, 220-Vac

Efficiency: 93%

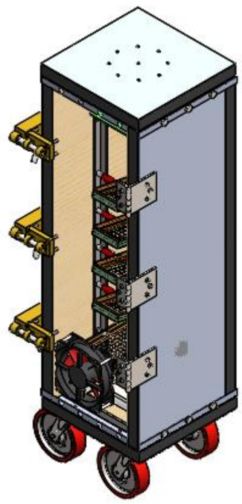


Fig 2 Model of Automated Solar Egg incubator.

5. Conclusion

A solar powered egg incubator was design, modeling and sizing of appropriate solar PV with its accessories. The developed solar incubator. the developed solar egg incubator was 720mm * 610mm * 2000mm in size with the capacity of 200 eggs. Reversed gear motor, and incandescent bulb (thermocouple) were connected to the controlling device in order to control or sense the tilting of egg tray, and temperature range of inside the incubator respectively.

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