Development and Evaluation of Low-cost Automatic Incubator that Applied Inverter Technology

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Abstract

An incubator is a device that is used to turn the fertile eggs hatching successfully at suitable environmental conditions by regulating the temperature and humidity of the enclosure. To meet the high demand of poultry production artificial egg hatching is needed. So temperature controls are an important factor for the incubation process. The source of power in an incubator is electrical energy. Energy is limited on earth. So proper use of energy is an important factor. By controlling the temperature and humidity efficiently we can reduce the electrical energy consumption. In this paper, we have discussed energy-saving techniques in hatching incubators which can save energy. The possibility of hatching egg is about 35-40° centigrade but the optimum temperature should be kept at 37.5° centigrade for 21 days and Below 35° centigrade and above 40.5° centigrade no embryo can be survived for hatching. Cooling eggs for short periods says 30-40 minutes out of 24 hours regularly with no harmful effect during incubation and probably profit. So to reduce energy consumption we introduced a power-saving mood that keeps the system shut off for 15-20 minutes within 24 hours during incubation. Using the inverter, we have simulated the backup system which has improved the temperature rise time and settling time compared to the conventional egg incubator. Calculation shows that this system is energy efficient.

Keywords: fertile, temperature, hatching, survived, embryo, simulate,

I. INTRODUCTION

An incubator is most important part of the poultry production process (hatching) and protects the environment conditions. Incubator an insulated enclosure in which temperature, humidity, and other environmental conditions can be regulated at levels optimal for growth, hatching, or reproduction. There are three principal kinds of incubators: poultry incubators, infant incubators, and bacteriological incubators. Incubators are core actors in entrepreneurial ecosystems. Incubator is a device used to grow and maintain microbiological, cell cultural practices. [Boleli, I.C. et al. (2016)]

Incubator based on the working principle that organisms require a particular set of parameters for their growth and development with the optimal condition (under artificial conditions) of temperature, humidity, oxygen, and CO2 levels. Avian incubation is a technique that keeps eggs warm in an artificial environment. An incubator is used for the artificial hatching of eggs; it lets the foetus grow inside without the presence of the mother to provide the conditions for growth and hatching. [J.A. Oluyemi and F.A. Robert,1982.]

The high cost of incubators is a major factor restraining the growth of this market. The higher cost of machines is due to the costly raw material required for egg incubators. Additionally, the energy cost is another hampering factor to this market in the forecast period. [E.A.O. Laseinde, Woye and Sons, 1994] Poultry farming has to face other challenges associated with high vaccination costs, and veterinary care services. [M.E. Ensminger, Poultry Science (Animal Agricultural Series)] The non-availability of credit is another issue affecting this industry. The growing population and increasing consumption of processed food along with government initiatives promoting the consumption of protein-rich diets are expected to increase the demand for eggs. Increasing the hen population would be required to meet the growing demand for eggs. [Hsieh, H. F., and Shannon, S. E., 2005.]

The ability of an incubator to improve the hatchability of eggs further assists the increase of hen population thereby grows up the demand for automatic incubators. [S. Sansomboonsuk, "An Automatic Incubator," J. Energy Research,] At a global level, the market growth for poultry

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consumption will be in-line with the global GDP in the long-term forecast. The increasing disposable incomes and lifestyle standards are further flourishing this industry. [Audretsch, D. B., 2007.] The equipment runs on solar energy and has an efficiency of around 90% for hatching chicken eggs. Such innovations for sustainable products will prevail in the egg incubator market. [Lamine, W., Mian, S., Fayolle, A., Wright, M.,Klofsten, M. and Etzkowitz, H., 2016] Most small-scale egg incubators are domestically fabricated with simple incubation technology and it leads to several complications and less hatching percentages. Egg incubators available in market have not the inverter technology. Hence development of low-cost small-scale incubator with improved technology has become very important Hence, this was an attempt to develop an automatic egg incubator with inverter technology. [Barbero, J. L., Casillas, J. C., Ramos, A., & Guitar, S., 2012.]

II. MATERIALS AND METHODOLOGY

Research was conducted in the School of Agriculture, Kundasale, Sri Lanka and the incubator obtained here was prepared using the following materials and equipments.

A. Materials

Temperature controller, Timer, 220v current indicator, DC fan, holder, bulb, TT wire, 3 core wire, 13A plug top, 12v power supply, 12v to 220v ac inverter, reform box small, tape, turning motor, Switch, Aluminums bar. Measurement tape, Paper cutter, wrench, Screw driver, lighter, Glue gun, Glue stick, revert gun, Bouth Machine, soldering iron.

C. Methodology

The measurement was taken of a regiform box by first (18.5 inches long, 15.7 inches, width, and 14.1 inches Height) was prevented, giving beauty fully covered by yellow color cello tape. The temperature controller, timer, switch, humidity meter, current indicator, and inverter were Arranged and fixed by a plastic tray and lid of the regiform box. Then put some holes on the side of the plastic tray to make air ventilation.

The wires of all devices were connected by the tray. Then fixed the 12-volt DC fan under the lid in the central position (DC fan 4-inch-long and wide,1-inch thickness), (fixing bolt and nut 8mm thickness and 8 inches long). The heat bulb was a fixed lid on the Regiform box between the fan and the lid (We used a motorbike head bulb for a heating source). The PVC pipe bulb holder was fixed by the center of the regiform lid and a small hole in the lid inserted the wire fixed bulb. Power was supplied and the incubator (All controlling devices are connecting the control panel) finally fixed the controlling unit on a regiform box (Take the measurement and fix the middle of the lid) using a 6mm wall plug and glue to fix the control panel.

Figure 01: Regiform box with tools

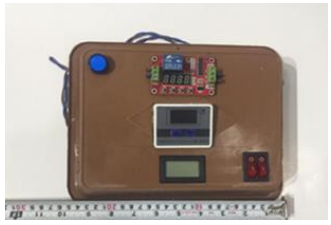

Figure 02: Control panel

Table 01: Cut the entire Aluminum bar for the automatic system with the measurement

Aluminium Bar Type	**Length of the bar**	**Need Quantity**
0.75:0.75 inch L bar	17.7 inches	2 pieces
0.75:0.75 inch L bar	15.7 inches	2 pieces
0.75:0.75 inch L bar	3.5 inches	4 pieces
0.75:0.5 inch L bar	12.9 inches	4 pieces
0.75:0.5inch L bar	13.7 inches	2 Pieces
0.75:0.5 inch L bar	5.9 inches	1 pieces
0.5:0.5 inch u bar	12.5 inches	5 pieces
0.5:0.5 inch u bar	4.7 inches	1 pieces

To develop the automatic system for an incubator, bind 11.7 inches 2 pieces of L bar along with 15.7 inch 2-piece L bar like rectangular shape by rivet gun. It acts as the outer tray of an incubator. Then bind the 12.92 inch 2 pieces of L bars with 13.7

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inch 2 pieces of L bars by rivet gun. It acts as an incubator tray and, after that binds 12.9inch 2 pieces of L bar with 3.5 inch 2 pieces of L bar like before. It's a water-content tray. Connect for H runner with inner tray and joint 12.5-inch U bar 5 pieces with inner tray at 5cm spacing. Fixed the bold and nut in the middle of the motor shaft (1.5-inch-long, 2 inch 3mm thickness bold and nut were used).

III. RESULT AND DISCUSSION

Table 02: Hatching detail

Trail		HATCHING 1 Trail-1		HATCHING 2 Trail-2		HATCHING 3 Trail-3	
Eggs	BOVEN BROWN	15	14	30	27	-	-
	DEKALB WHITE	15	12	-	-	30	27
Total		30	26	30	27	30	27
Percentage (100%)		86.6%		90%		90%	
Average Percentage		88.8%					

This Table 02 was illustrated of three trail hatching percentage of egg, were used to two type varieties of eggs first trail half of percentage brown and white eggs used to measure the percentage of hatching then trail 2 only used to brown eggs, trail 3 only used to white egg and make the calculation.

Table 03: Comparison between My incubator and Company product

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No	Data	Company Product	New Research Product
1	Incubator Body Material	Out Site Stainless Steel inside Aluminium sheet	Out Site insulation tape inside Regiform
2	Temperature Controller Model	XM -18 E Computerized controlling system 220V AC	W-300 temperature controller 12V-DC
3	Heating Material	electrical heater (500w)	motor bike head bulb
4	Air Ventilation System	AC-220 v 12inch fan	DC - 12 v 4 inch fan
5	Automatic Turning System	45 angle rotation method	rolling type rotation method
6	Automatic Turning System Material	Iron steel	Aluminium bar
7	Electricity consumption	90 unit (21days) 150 watts hour per day	4.2 unit (21days) 0.2 watts hour per day
8	Hatching rate	90-92%	85-90%
9	Hatching time	21days	21days
10	Chicks Quality	Good	Good
11	Cost of Product	75000/=	12500/=
12	Used Technology	Recommendation method	Reducing electricity consumption inverter technology
13	Egg Candler Method	manual egg Candler	manual egg Candler
14	Humidity control	automatic motor	manual hand sprayer
15	Power Source	220V direct current AC/single phase	AC DC 220V-12V inverter 220V AC single phase
16	Egg Capacity	60	30

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17	Total Weight of the Machine	35 Kg	1.8 Kg
18	Incubator Model	AP incubator (India)	My own product
19	Used Parameters		
20	1 – Temperature	37.5C	37.5C
21	2 – Humidity	1-18days 60-65% 18- 21 days 80%	1-18days 60-65% 18- 21 days 80%
22	3 - Turning Time	1 hour interval per 1 turning	1 hour interval per 1 turning
23	4 - Candling time	10-18 days	10-18 days
24	Suitability	large scale farmers	Small Scale Farmers
25	Total Watts	0.2 Kw / hr	0.0083 Kw/hr

This Table 03 was illustrated compared to the marketing products and our research products. The research products low cost and highly efficiency of small scale farmers,

A. Sensory Analysis

Above the quality & quantity parameters are used to develop incubators collection among small-scale farmers. According to their response, 20 customers were selected and given the incubators for trial and data collection. Then collected data were compared with standard incubators using parametric and nonparametric procedures. A 5 point Likert scale was used to evaluate the compatibility of the incubator.

B. Data Analysis

Data analysed by SPSS Software, VERSION – 25, mean separation method is turkey. The Kruskal-Wallis Test analysed all the non-paramedic data.

C. Questionnaire Survey on Developed Tool

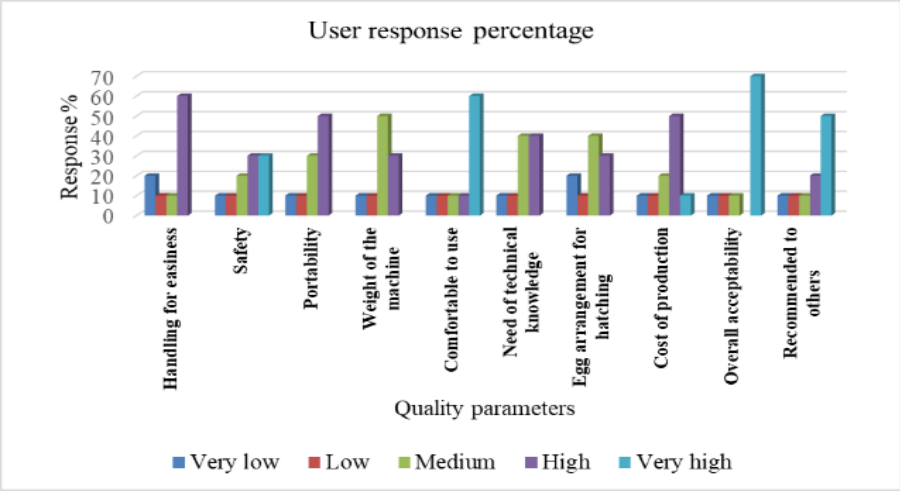

Figure 04: User responses collected through a survey

It was observed that the highest percentage (60%) of respondents highly accepted the handling for easiness, the lowest percentage (10%) of respondents low & medium level accepted and 20% of respondents very lowly accepted the handling for easiness.

An equal percentage of (30%) respondents were highly accepted and very highly accepted (30%) of the safety of the incubator and an equal percentage of respondents were lowly (10%) and very lowly (10%) of the safety and 20 % of respondents were medium level accepted the safety.

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The highest percentage of (50%) respondents highly accepted the portability comparatively lower percentages (10%) of respondents were very slowly and lowly accepted the portability and the remaining 30% of respondents accepted the portability medium level.

The highest percentage of (50%) respondents accepted the weight of the machine as medium level comparatively lower percentage (10%) of respondents accepted the weight of the machine as very low &low level

The highest percentage of (60%) respondents were very highly accepted the comfortable to use. From the remaining 40% of respondents, 10% of respondents accepted the very low level, 10% of respondents accepted the low level, 10% of respondents accepted the medium level & final 10% of respondents accepted the high level comfortable to use.

The highest percentage of (40%) respondents highly and medium level accepted the need for technical knowledge and the lower percentage (10%) of respondents very low & low level accepted the need for technical knowledge

The highest percentage of (40%) respondents were medium level accepted the egg arrangement for hatching and the lowest percentage (10%) of respondents lowly accepted 30% of respondents were high level accepted the egg arrangement remaining 20% of respondents were very low-level accepted.

The highest percentage of (50%) respondents highly accepted the cost of production, a lower percentage (10%) of respondents were very low, low, and very high levels of acceptance and the remaining 20% of respondents were medium level accepted the cost of production.

The highest percentage of (70%) respondents very highly accepted the overall acceptability 10% of respondents accepted very low level, 10% of respondents accepted low level and 10% of respondents accepted medium level

The highest percentage of (50%) respondents very highly accepted the recommendation 20% of respondents highly accepted and from the remaining 30% of respondents; 10% of respondents very low level accepted, 10% respondents accepted low level and 10% of respondents accepted medium level of recommended to others.

D. *Performance of the Machine*

Table 04: Mean value for treatments

Data	Ranks Treatments	No	Mean rank	P-value
Easiness	My incubator	20	15.05	0.000
	Market product	20	5.95	
Safety	My incubator	20	13.30	0.019
	Market product	20	7.70	
Portability	My incubator	20	15.50	0.000
	Market product	20	5.50	
Weight	My incubator	20	5.50	0.000
	Market product	20	15.50	
comfortable	My incubator	20	14.20	0.002
	Market product	20	6.80	
Need of technical knowledge	My incubator	20	5.95	0.000

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	Market product	20	15.05	
Egg arrangement	My incubator	20	10.50	1.000
	Market product	20	10.50	
Cost of production	My incubator	20	5.50	0.000
	Market product	20	15.50	
Overall acceptability	My incubator	20	10.50	1.000
	Market product	20	10.50	
Recommendation	My incubator	20	15.50	0.000
	Market product	20	5.50	

The value represents 5 point Likert scale. The $p<0.05$ is significant for easiness, portability, safety, comfort, weight need of technical knowledge, cost of production & recommendation of the machine, according to fried man test. The $p<0.05$ is not significant for egg arrangement, overall acceptability.

IV. CONCLUSION AND RECOMMENDATION

Performance evaluation of the incubator reveals the above average results; from 30 fertile eggs the average hatchability rate is 88.6%. Cost evaluation of incubator with minimal electricity consumption 4.2 units per 21 days Cost of production also very low compared with market product. So this incubator is highly accepted by farmers. Data collection from farmers also highly satisfied and accepted all the features therefore can highly recommend this incubator applies on inverter technology according to hatchability percentage, electricity consumption, cost of production, and easiness of handling.

In the future, there is a chance to modify the incubator to hold large numbers of egg capacity. Can use batteries instead of current. Can minimize the amount of electricity consumption than now. Can change the heating source and temperature controller instead of the XM -18 computerized controller. Energy storage solutions such as battery or renewable energy sources. Examine the possibility of establishing networks of incubators connected by the Internet of Things to exchange information and insights. Based on the power source renewable energy options are likely to gain attention in forecast years owing to manufacturers' focus on eco-friendly production and cost-effectiveness. With the renewable option, companies can decrease their carbon emission and aid in sustainability development

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