DEVELOPMENT OF AN EGG INCUBATOR USING LIGHTING CIRCUIT WITH SWITCHING POWER SUPPLY

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ABSTRACT

Chicken eggs are often incubated in complete darkness, obtaining light only fitfully with the incubator opening during the incubation process. There is very little knowledge available as to how light system effect on bird's production, and no data available as which light type is more energy-efficient in using. Therefore, this paper offers the modification of the design for egg incubator that will be used easily, affordable and simple to maintain and concentrates on aims to give a comprehensive concept of environmental stimuli during incubation can affect the chicken production. Thus, this paper aimed at designing and evaluating the performance of a LED lighting circuit that is applied in an egg incubator, for the ability to increase the hatching rate with the lowest power consumption using a switching power supply.The present study suggests using mosfet, capacitor, and inductor for AC applications, in this circuit that is rectified the output current through a bridge rectifier as well as reduces its ripple. This current is uniform with DC applications which suits to drive LED lighting system. This is a low cost and dynamic circuit and can be used for lamps up their power 40W effectively. To evaluate the effect supplying of the lighting system during the incubation period, it was incubated chicken eggs by an amplitude of 720 eggs under variable luminous flux and different lighting periods compared with incubation in the dark. It was demonstrated that providing LED light during incubation can reduce daily power consumption compared with the other lighting systems as well reduction of the death rate of embryos post-hatch. The results obtained of the test revealed the highest hatchability proportion value was 86.88% with daily power consumption of 154.32 W under luminous flux of 700 lm within 12 h of the lighting period as compared to 77.83% which was incubated in complete darkness, The equation of the trend line related to highest hatchability percentage is The Energy Consumption =78.852 luminous power + 8.58.

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1.INTRODUCTION

Now, research on egg incubation has become very popular however very few publications can be found available in the literature that discusses the issue of lighting system effect on bird's production. It is not known how different lighting environment during incubation impacts the hatchability percentage of a chicken egg. At the same time, Presently the commercial incubators used Light-emitting diode (LED) and compact fluorescent lamp (CFL) bulbs to replacement the incandescent lights. Light is one of incubation conditions that impact the embryonic growth which meaning reach to high economic hatchability efficiency. According to **(Archer et al., 2009)** providing eggs to 550 lx light during incubation have potential benefits in terms of decreasing the effects of stressors associated with production and growth on other words, exposing eggs to light during incubation may improve growth, hatchability and decrease incubation time thereby increasing productivity. But should also consider, it is not known how change in lighting setting during incubation may affect in poultry hatchability.

Another study **(Shafey and Al-mohsen, 2002)** found that if eggs expose to green light (1340-1730 lux) from 5 to 15 days of incubation, the growth and hatchability will increase by 4.8%. Gongruttananun N (2011) reported that today almost poultry production technologies focus on improving the environmental conditions for raise production at a reduced cost, whereas the environmental conditions are vital for embryogenesis stage. Applying light-emitting diode (LED) showed increase the production, decrease the mortality and lower energy requirement plus a longer life use compared to conventional incandescent or fluorescent lighting. With similar trend**, (Ghatpande et al., 1995)** found that the earliness of hatchability due to exposure egg to light may be indicate to accelerate embryonic development. Another significant factor indicated by **(Huth and Archer,2015**) that applying the LED light during incubation can improve chick quality as a result of, improvement the physiological and metabolic responses during embryonic development. **Shafey (2004) and Khalil (2009)** reported that the amount and type of light could help the metabolic rate and chicken embryos development hence could affect hatchability percentage. **Karim (2017)** reported that using LED lighting during incubation supply the daylight compared to the spectral gaps of other lightings. Therefore, he exposed the Fayoumi eggs to complete /complement LED lighting to study its impact, his results indicate the significant association between applying LED lighting during incubation and the high hatch chick’s performance. This paper offers design and evaluates the performance of a LED lighting circuit which utilized in an egg incubator, in order to increase hatchability rate and decrease the power consumption by applying a switching power supply.

2.MATERIAL AND METHOD

The primary objective in current research is provide the required lighting effect for the lowest installed load i.e. highest lighting at lowest power consumption. Therefore accurate-designed lighting circuit can be procuring substantial advantages as raise hatching ratio also it can help improve productivity and hence reduce operating costs. The involved methodology aimed implements the lighting circuit with compact power supply and the control circuit to govern the intensity and periods of lighting needed in the incubation system.

2.1. Design Methodology of Suggested Circuit

The initial step in the design is determination of the required illumination according to ASAE recommends a maintained illumination of 350 lux for hatcheries. The following step is to choose a suitable light source for the forced-draft incubator. To choose between various fixtures must knowledge the apparent power, luminous intensity, and the average life expectancy. luminous power is the measure of the total realized power of light source while luminous intensity is a measure of the realized power emitted by a source in an appointed direction per unit. It would be appropriate to use light emitting diode lamp, as to boards and chips can operate for over 100,000 hours before needing to be replaced. Which is why LEDs being more energy-efficient and longer lasting than their competitors. As well as light emitting diode bulbs have a power factor of 0.70 in the visible range.

2.2. Description and Design of lighting Circuit

A suggested approach can be driving the light circuit using a switching power supply for turn on LED based on providing a direct current input. Though for converting AC to DC power supply using transformer is quite popular and widely used, for applications like driving loads like LED, it proves to be quite costly and moreover, it is not possible to produce an adequate current signal using a transformer.

Keeping in mind all the factors, it has been designed a lighting circuit for driving an LED from 230VAC to 40VDC. This is accomplished using a switching power supply. This is a low cost and efficient circuit and can be used for lamps up their power 40W as shown in the following circuit in Figure 1.

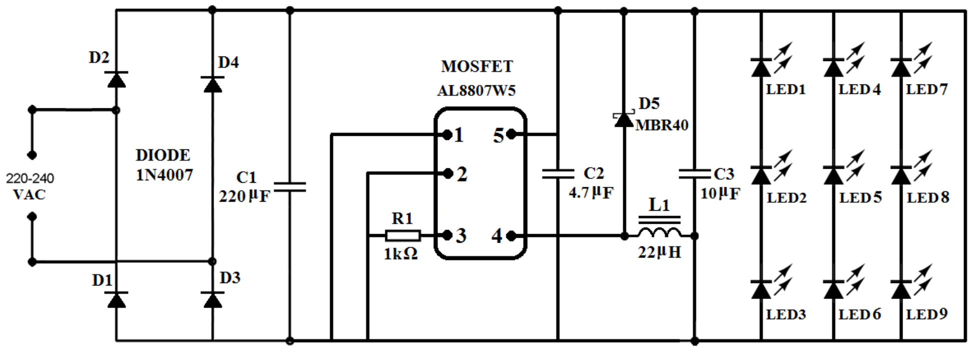

Fig 1. Lighting Circuit Diagram of 9W LED Lamp.

In this study, it was designed a 230V LED driver circuit, which can drive LED directly from the mains supply. The voltage ratings on pins 4 and 5 are 40 V, so driving LEDs is possible with sufficient voltage. The 3 pin determines the output DC current; 1 pin is for weak sign input and 4 pin is the output of MOSFET. This application is recommended for compact circuitry and high efficiency making it ideally suited for the replacement several of a various bulb.The application circuit is used in the case of AC applications, the input is rectified through a bridge rectifier. 2 pin and 3 pin are directly connected to the two terminals of the aluminum electrolytic capacitor C1 which reduces the current ripple. During the first switching phase, the internal MOSFET will charge the inductor with linearly rising current until the switching-off of MOSFET; during the second phase, the MOSFET is cut off, and the current stored in the inductor will discharge through the Schottky diode, D5 and the current decays till next period of switching. The output capacitor is used to reduce the current ripple in the LED. 3 pin is voltage regulated thus resistor connected to this pin determines it's current. This current is almost symmetric with the output constant current to drive lighting system.

2.3. Operation Theory of LED Driver Circuit:

Terminal 5 has a voltage rating of 6.0 to 40 VDC, therefore an input voltage up to 230 VAC at the bridge is safe. A capacitor C1 is necessary to keep a higher level of input voltage. Capacitor amplitude, 220 µF is adequate in this design. Voltage rating of C1 should be 230 VAC input. It must be used at least 4.7 µF for C2 as output capacitor to reduce output ripple. and therefore, raise the output current.

The LED current range is 0~350 mA, so the current rating of inductor around 1000 mA is suitable. Voltage across the freewheeling D5 diode shows that voltage spikes over 20 V can be found even with 230 VAC input. A higher input voltage further stresses the diode, so the voltage rating on D5 should be 30 V or 40 V. ON Semiconductor's Schottky rectifier was selected for D5.

3 pin configures the value of the output current and voltage of 5 pin is regulated with adding a resistor between 3 and 2 determines the 3 pin current, which has relationship with output voltage:

$I_{LED} = 2500 \times I_{pin3}$ $\qquad$ $Vs = I_{pin3} \times R_1$

It can be calculated that for 900 mA outputs, I_{Pin3} = 0.360 mA. The resistor, R_1value should be 638.89 Ω.

Table 1: Shows specifications of lighting circuit.

No	Part Name	Category	Rated Value
1	MOSFET	AL8807W5	50 V/1000mA
2	From D1to D4	1N4007	50V/950mA
3	D5	MBR40	1000mA/50V
4	C1	C2063/ High Frequency	220uF/450V
5	C2	C59418	4.7uF/50V
٦	C3	XRL Series	10uF/50V
٧	L1	LQH2MCN	22µH ±10%/500mA
8	LED	CREE Xlamp	5V/200 mA

A smaller resistance will possibly increase the output current, but it is recommended to use at least 1kΩ for stable operation.

2.4. Appointment of the required Heat Energy:

The thermal calculation was done to determine the amount of heat energy appropriate to incubate the demanded number of chicken eggs. This is the total of the expecting heat loss out of the walls of the incubator, insulator and the effective heat required for incubation process. It was based on calculated by the difference between the room temperature and optimum temperature inside the incubator.

The following equation attaches the heat sucked to elevate the total absorbed temperature (Q_E),

$$\mathbf{Q_E = Q_a + Q_e + Q_w + Q_t + Q_s + Q_g}$$

Calculate heat absorption using the formula:

$$\mathbf{Q = m\ C\ \Delta T}$$

Where: Q = heat absorbed, m = substance mass, C= specific heat of the substance and ΔT = change in temperature.

Table 2: Shows the meaning of heat absorbed symbols, substance mass and its specific heat of the substance.

Symbol of heat absorbed	Substance/ Media	Substance mass (m)	Specific heat (C)	Heat absorbed kJ
Q_a	air	0.86	1.005	10.80
Q_e	eggs	39.60	3.18	1574.10
Q_w	water	10	4.182	522.75
Q_t	egg tray	2.4	1.67	50.10
Q_s	sandwich panel	20	1.3	325
Q_g	glass	0.30	0.50	1.88
Total absorbed temperature (QE)				2484.63

With regard to calculating the predicted heat loss out of the system walls, the following equation can be used $\mathbf{Q_L = Q_{tb} + Q_s + Q_b + Q_g + Q_f}$

Where: Q_L; sum heat loss, Q_{tb}; the lost heat of the top and bottom, Q_s; side plates, Q_b; back surfaces Q_g; glass window, Q_f; front surfaces can be calculated as follow;

The heat loss is given as; $q_{tb} = k\, A_{tb} \frac{(T_2 - T1)}{t_h}$

Where: k is thermal conductivity; for wall material=0.045 and 1.05 for glass and t_h is thickness.

The heat loss at the top and bottom surfaces of the incubator is given as;

A= 0.96×0.72 = 0.69 m^2, whereas there are two equal surfaces

Hence, A_{tb}= 0.69 ×2 = 1.38 m^2 $q_{tb} = k\, A_{tb} \frac{(T_2 - T_1)}{t_h} = 17.25\, w$

The heat loss at opposite sides of the incubator;

A_s= 1.10×0.96 = 1.06 m^2 Hence, A_s= 1.06×2 = 2.12 m^{2,}

$$q_s = k\, A_s \frac{(T_2 - T_1)}{t_h} = 26.50\, w$$

The heat loss from sandwich panel wall at the back;

A_b=1.10×0.72 = 0.79 m^2

$$q_b = k\, A_b \frac{(T_2 - T_1)}{t_h} = 9.88\, w$$

The heat loss through the glass window is given by;

A_g= 0.30×0.14 = 0.04 m^2

$$q_g = k\, A_g \frac{(T_2 - T_1)}{t_h} = 11.67\, w$$

The heat loss from sandwich panel wall at the front;

A_f= 0.79 – 0.04 = 0.75 m^2

$$q_f = k\, A_f \frac{(T_2 - T_1)}{t_h} = 9.38\, w$$

Therefore, can be calculated the total heat loss by last values;

$$Q_L = 74.68 \text{ w}$$

The next formula was used to calculate the total power suitable for running the system and able to incubate the required number of chicken eggs;

$Q_T = Q_E + Q_L$ Q_T = 2484.63 + 74.68 = 2559.31 kJ

$$P_T = \frac{Q_T}{t} = \frac{2559.31 \times 10^3}{3600} = 710.92\, w$$

Where: t = time required per hour therefore the air heater will be selected 1000W inside incubation system.

2.5. <u>Hatchability and Death Rate:</u>

The percentage of hatchability and fertility of incubated eggs must be calculated for evaluating the incubator and hatch efficiency. Fertility is the most important factor in determining hatchability as follows.

$$\text{HP} = \frac{\text{Number of chicks hatched out}}{\text{Number of fertile eggs}}$$

Death rate was determined on the basis of total eggs set and was calculated using following formula:

$$\text{DR} = \frac{\text{Number of dead chicks}}{\text{Number of fertile eggs}}$$

2.6. <u>Apparent power:</u>

Apparent power, Pa is the total power drawn by lamps, inductors and capacitors in an electric lighting circuit during each cycle it can be calculated as follows;

$$P_a = \frac{P_r}{PF}$$

Where: P_r and PF are the real power (power consumed by the lamp circuit) and the power factor of light source, respectively.

3.RESULTS AND DISCUSSION

The paper offers the modification of the design for egg incubator that will be used easily, affordable and simple to maintain. The modification implements the lighting circuit with switching power supply. Furthermore, apply control circuit to control the intensity and change periods of lighting depend on incubation system requirement. The modification has substantial advantages improve productivity so reduce operating costs, the obtained results will be debated under the following items:

3.1. Effect of luminous flux on Energy Consumption:

Luminous flux has a great effect on energy requirements at different lighting periods and this relation can be noticed in Fig 2. The obtained results show that increasing luminous flux increased energy consumption.

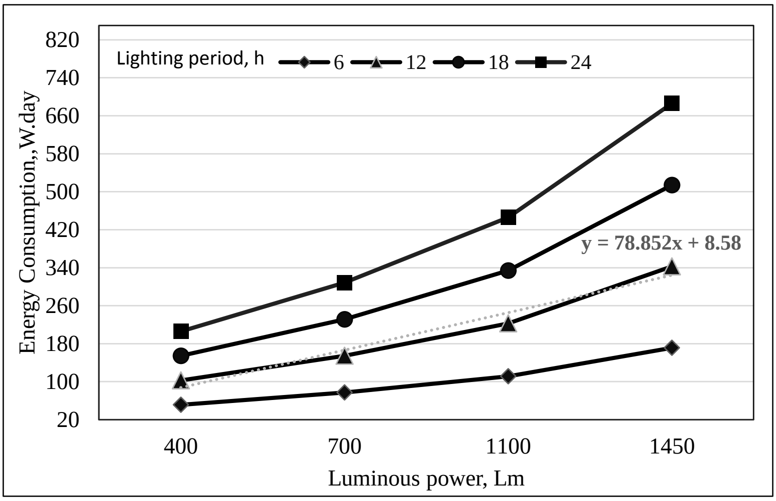

Figure 2: The effect of luminous flux on energy consumption. l at different lighting periods of 6, 12, 18 and 24 h, increased energy consumption from 51.42 to 171.67, from 102.84 to 342.84, from 154.26 to 514.26 and from 205.68 to 685.68 W.day, respectively.The daily power requirements increased by increasing luminous flux by reason of the increase of apparent power at the same time unit. By looking at the equation of the trend line to 12 hour as preferred lighting period for high hatchability rate % , the relation follow this equation

The Energy Consumption = 78.852 luminous power + 8.58.

3.2. Effect of Luminous Flux on Hatchability Rate:

The percentage of hatching is more sensitive to different factors such as luminous flux and lighting periods as indicated in Fig 3.

It was noticed that increasing luminous flux increased hatchability proportion up to 700 lm, any further increase in luminous up to 1450 lm hatchability rate will decrease.

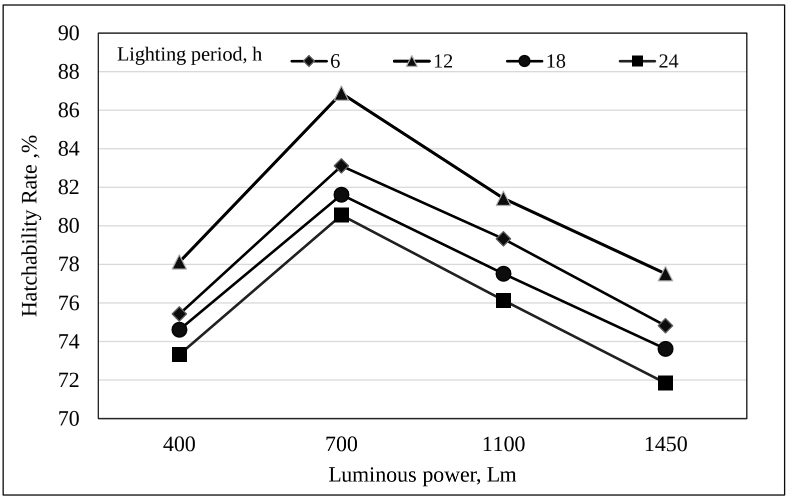

Fig 3: The effect of luminous power on hatchability rate.

Representative values clarify that increasing luminous flux from 400 to 700 lm measured at the same previous lighting periods increased hatchability proportion from 75.42 to 83.11, from 78.12 to 86.88, from 74.61 to 81.61 and from 73.33 to 80.55 %, respectively. any further increase in luminous flux more than 700 up to 1450 lm decreased hatchability from 83.11 to 74.82, from 86.88 to 77.52, from 81.61 to 73.62 and from 80.55 to 71.84 %, respectively. Both higher and lower values of luminous flux more or less than the optimum value tend to decrease hatchability proportion and increase death rate because of do not provide intensity of lighting required.

3.3. Effect of luminous flux on death rate:

Luminous flux is considered on important factor, which effects on death rate at different lighting periods in Fig 4. It is clear that death rate was significantly decreased by increasing luminous flux up to 700 lm, any further increase in luminous up to 1450 lm death rate will increase.

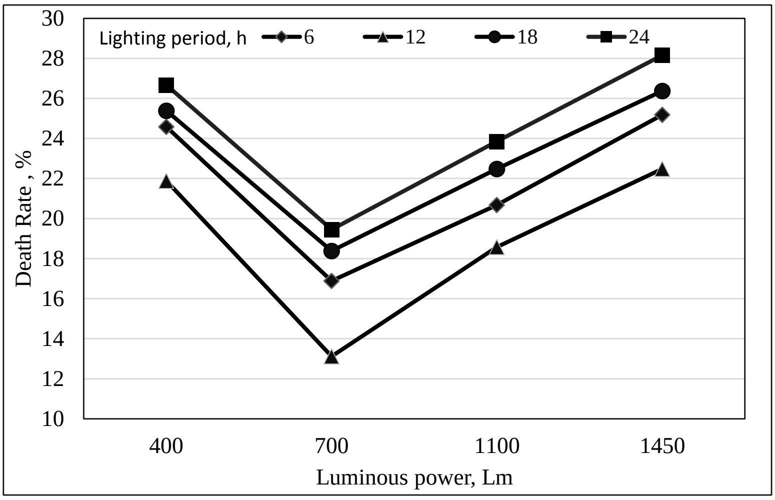

Fig 4: The effect of luminous power on death rate.

It was evident that increasing luminous flux from 400 to 700 lm measured at different lighting periods of 6, 12, 18 and 24 h, decreased death rate from 24.58 to 16.89, from 21.88 to 13.12, from 25.39 to 18.39 and from 26.67 to 19.45%, respectively. any further increase in luminous flux more than 700 up to 1450 lm increased death rate from 16.89 to 25.18, from 13.12 to 22.48, from 18.39 to 26.38 and from 19.45 to 28.16 %, respectively. Have been concluded from the above results that provision the lighting system was feasible because it gave an exemplary climatic environmental condition. Furthermore, improving hatchability proportion and shorten the daily power requirements during the incubation process. Decidedly, lighting system evidenced an actual possibility to carry out feature of this technique and apply them to the commercial scope Which is achieved the more profitable product.

4.CONCLUSION

The information presented in this design includes the various factors desired around designing lighting circuit. The Device allows smaller footprint, fewer components for a compatible adapter. Selecting high-quality LEDs with smaller forward voltage is very important in this design to achieve a stable output current. Where it was implemented the lighting circuit with switching power supply and the control circuit in the intensity and periods of lighting needed in the incubation process for driving a light circuit from 230VAC to 40VDC based on provide a direct current input.

It is recommended incubate the egg under luminous flux of 700 lm for 12 h as lighting period to reach to highest hatchability percentage, 86.88%and lowest Energy consumption 154.32W.day whereas apply conventional hatching process recorded a lower value ٧٧,٨٣%.

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الملخص العربي

تطوير مفرخ البيض باستخدام دائرة إضاءة ذات مصدر قدرة تحويلية

د. أماني عبد المحسن متولى*

غالباً ما تتم عملية التفريخ الصناعي لبيض الدجاج في الظلام، على العكس من سلوك الدجاجة في الطبيعة أثناء هذه العملية فإنها تعرض البيض للضوء على فترات متباينة. ومن هذا المنطلق تولدت فكرة هذا البحث بتصميم وتطبيق نظام إضاءة ليد ذات مصدر قدرة تحويلية. تم اختيار المصباح الليد كمصدر للضوء لتحقيق شدة إضاءة قدرها $350\ lm.m^{-2}$ تلائم عملية التفريخ بمعامل قدرة يبلغ ٠,٧٠ في المدى المرئي، لذا سيكون من المناسب استخدام هذا النوع لما له من كفاءة في توفير الطاقة وعمر افتراضي أكبر مقارنة بالنظم الأخرى.

ومن ثم تم تقييم تأثير الإضاءة على أداء المفرخ الصناعي بصورة دورية خلال فترة التجربة. وتضمنت عملية التصميم دائرة إضاءة مكونة من مصابيح ليد وتشغيلها عن طريق مصدر قدرة تحولية مكون من عدة عناصر إلكترونية (موسفت – مكثف – دايود – محث – مقاومات) لتحويل مصدر الجهد المتردد 230VAC إلى جهد مستمر 40VDC مع شدة تيار تناسب تشغيل المصابيح حتى قدرة 40W وهي دائرة ذات استجابة عالية ومنخفضة التكلفة وبمكونات متوافره في السوق المحلى.

أجريت هذه التجربة لتقييم أداء المفرخ الصناعي بعد تركيب دائرة الإضاءة تحت أربع مستويات من تدفق الإضاءة هي (1450 lm – 1100 -700 -400) لتحضين بيض الدجاج البلدي بسعة ٧٢٠ بيضة وعلى فترات إضاءة مختلفة (6-12-18-24 h) وقد تم تقدير كل من استهلاك القدرة، نسبة الفقس ومعدل الوفيات في الكتاكيت.

أشارت النتائج إلى أن توفير ضوء الليد بشكل دوري أثناء عملية التفريخ يمكن أن يحسن من نسبة الفقس ويقلل من معدل الوفيات فقد لوحظ أن أعلى قيمة لنسبة الفقس كانت ٨٦,٨٨٪ مع استهلاك قدرة ١٥٤,٣٢ واط فى اليوم الواحد تحت تدفق ضوى قدره ٧٠٠ لومن أثناء عملية التفريخ خلال ١٢ ساعة من فترة الإضاءة بالمقارنة مع نسبة فقس ٧٧,٨٣٪ تم احتضانها في الظلام.

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