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IMPROVING PERFORMANCE OF FORCED - AIR HEATING SYSTEM IN BROILER HOUSE

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Abstract

The main objectives of this study were to provide thermal comfort environment, reduce heating for energy requirements and specific heating for power and maximize meat production. The air heating system performance was evaluated under with and without duct during the life cycle of 1 to 5 weeks of age. The results showed that, at first brooding stage using forced- air heating system without perforated poly -ethylene tube the air temperature at height of 0.25m above floor the air temperature close to the floor was lower than the recommended by 4.11°C and 4.64°C at 2 and 8 day of age, respectively. While, using it with perforated poly ethylene tube the air temperature close to the floor was higher than the recommended temperature by 0.12°C and lower than the recommended by 3.36°C at 3 and 8day of age, respectively. Average indoor air relative humidity through the birds' life when using heater with perforated poly- ethylene tube reduced by 12.92% comparing with using heater without perforated poly-ethylene tube. Using perforated poly - ethylene tube reduce total energy requirements and specific heating power by 17.84 and 20.82% at the end of life and increased average body weight from 1.9 to 2.1 kg at fifth week of age. Hence, it is recommended to operate forced - air heating system using perforated poly - ethylene tube to obtain thermal comfort environment, reduce heating energy requirements, and specific heating power and maximize meat production

Key words: *broiler, forced air heating, energy requirements,temperature*

INTRODUCTION

Broiler is a good source of fairly cheap protein comparing with the other kinds of animal protein such as beef and buffalo. Broiler has relatively high feed efficiency and the short period of capital cycle. In 2012, Egyptian production of poultry meat reached 916,597 tonnes. The total national production of chicken's meat was 800,000 tonnes in 2012 (FAO, 2014) [4]. Increasing national broiler meat production depends not only on health protection, but also on environmental control. Indoor air temperature is one of the most important environmental factors because, maintaining the correct air temperature is crucial in chicks brooding, especially during the first 7 to 10 days of the chick's life. Early in life, the chick is poorly equipped to regulate its metabolic processes to adequately control its body temperature. As a result, the young chick is dependent on environmental temperature to maintain optimal body temperature. (Dozier and Donald, 2001) [3] reported that, forced -air furnace is more difficult to manage than pancake or radiant brooders for two primary reasons. First, furnaces produce warmth by producing heated air. This means that the floor must be warmed from hot air, which can require a long period since hot air rises, and temperature stratification can develop with hot air at the ceiling and cold air at the floor). Second, furnace heat does not allow chicks to select a comfort zone. (Lacy et al, 2003) [7] recommended that, litter moisture content should not exceed 30%. If litter moisture content exceeds this limit, ammonia is released. This means at higher moisture content leads to diffusion of ammonia. Litter moisture may affect the conversion rate of uric acid to ammonium- N. Conversion of urea to ammonia may be reduced at very dry conditions**.** (Czarick and Fairchild, 2005) [2, 5] conducted a trial in broiler house to measure stratification. In heating the house with forced air furnace, and it was found that, a 10 ˚C differences between floor and ceiling was a problematic from a heating cost and chick performance. It is reported that, at placement floor temperatures should be at least 32°C with forced- air heating. (Cobb Broiler Management Guide, 2008) [1]. If radiant heaters/brooder stoves are used, floor temperatures should be 40.5°C under the heat source. (Fairchild, 2012) [5] recommended that, brooding should be at 34 ºC floor temperature during the first week and to decreased about

3 ºC every week until the cycle end reaching 24 ºC . House preheating before chick's arrival is very important (Ross Broiler Management Guide, 2009) [1]. Temperature and relative humidity should be stabilized for at least 24 hours prior to chick arrival. If the air relative humidity is below 50%, litter would be too much dry, and if air relative humidity is above 70%. litter cackling can occur.

The main objectives of theses study were to a) Improve the performance of forced - air heating system heating b) obtain thermal comfort zone c) reduce specific heating power and heating energy requirements d) and increase broilers average life weight.

MATERIALS AND METHODS

The experimental work was executed in private broiler house, Egypt (latitude and longitude, 30.7°N and 30.99°E, respectively) during the winter season of 2011

Broiler house and brooding stages

It is orientated with East-West direction. The experiment was conducted in two successive living cycles. The bird's density was 10 bird /m^2 at one day of age (Cobb hybrid). During the two living cycle, the chicks were brooded in three successive stages.

Stage 1

In the first chick brooding, all birds were brooded on small floor surface area (187.5 m^2) of the house (15 m long and 12.5 m wide) for ten days of the chick's life to regulate their metabolic processes to adequately control their body temperatures.

Stage 2

The small floor surface area of brooding operation during the second stage was increased to 352.5 m^2 (15 m wide and 23.5 m long) for 10 days of age.

Stage 3

After 20 days of age the floor surface area of brooding was increased to be 525 m^2 (15 m wide and 35 m long) by removing curtains and the chick spread on all the floor surface area of the boiler house until the end of living cycle.

- In the first living cycle the house heating was executed using forced - air heating system.
- Whereas in the second living cycle the house heating was performed using forced - air heating system connected with perforated polyethylene tube.

Polyethylene tube was punched off-center (in “4 o’clock” and “8 o'clock" positions) and holes numbers was 246 circles holes with 5 cm in diameter and was distributed on both sides of polyethylene tube uniformly to give an aperture coefficient of 1.7.

The tube length was varying according to the length of brooding area.

The distances between holes vary depending on brooding space length in order to distribute the hot air inside the broiler house.

The tube situated 2.0 m above the floor surface.

The heating system was adjusted to provide a 34ºC in at the first day of chicks live and was reduced gradually 3ºC every week until reached 24 ºC at age of five weeks.

Heating system sensor was at height of 25 cm of floor surface and was in the middle of brooding area and far 2.5 m near the house south wall.

Heating system

Forced air heater E 120 BABYSER consists of (furnace made of stainless steel, counter flow heat exchanger, axial fan 75 cm taken motion directly from electric motor 3 phase with 1.5 kW in power).

The fan air displacement is 11000 m^3. /h. and electric control box. The heating system was connected with gas burner model CIB UNIGAS (ITALY) S10 model, LPG fuel, Gas flow rate min. - max Stm^3 /h 6.9-12.7.

The position of heating system sensor was at the middle of every brooding area according to the brooding stage.

Measurements

Temperature measurements

One data logger were 16 channels which connected by the sensors constructed from therimstors to measure inside air temperature at 15 points at height 0.25 m of floor.

One sensor was placed outside the broiler housing to measure outdoor dry bulb temperature.

Relative humidity measurements

Thermo-Hygrometer with range of 10-95% was used to measure the air relative humidity inside and outside the broiler house with ± 5% accuracy.

The air relative humidity during the experimental work was measured every six hours daily through the living cycle.

Broiler body mass

Broilers body mass was estimated weekly. A sample of 200 birds were taken and weighted and the total weight was used to calculate the increasing in broilers weight.

Calculation

The aperture coefficient and number of circle holes were calculated using the following equation (George, 1997) [6]:

$$\text{Aperature coefficient} = \left(\frac{\text{Holes total area}}{\text{Duct cross-section area}}\right)$$

$$\text{Number of holes} = \left(\frac{\text{Holes total area}}{\text{Holes cross area}}\right)$$

Specific heating power

Specific heating power was determined using the following formula:-

$$Sp = \frac{Q_{add}}{V_h}$$

Q_{add}= Supplementary heating ,W

Sp = specific heating power, W/m^3

V_h = house volume, m^3.

Energy requirements

An energy requirement was estimated using the following equation:

$$\text{Energy requirements} = \frac{Q_{add}}{\text{Total body mass}}$$

Where:

Energy requirements = kJ/hr.kg

Q_{add} = Heat energy addition, kJ/hr.

RESULTS AND DISCUSSIONS

Indoor air temperature

The relationship between air temperature at chick's zone and broiler age at different brooding stages when using forced air heating system with and without perforated tube inside broiler housing as revealed in (figure 1) It evidently revealed that, the average floor air temperatures at a height of 25 cm above the floor surface along the broiler house when employed the forced air heater with and without perforated polyethylene tube were varied from day to another according to the age of birds. The Fig. 1 showed the daily average air temperature at height of 0.25m with and without tube. It also showed that, during the first stage of brooding, the recommended floor temperature was 34°C at the first day of chick's life and reduced gradually until reached 30°C at the end of brooding stage. The indoor air temperatures decreased as the broiler age increased throughout the living cycle. Due to the brooding temperatures dependent on broiler age especially in the two first and second brooding stages or on their body temperature, metabolic rate, ratio of average life weight to surface area, insulation from feathering and thermoregulatory ability are all relativity low. The highest value of floor air temperature was 29.89°C at 2 day of age and the lowest value was 26.36°C at 8 day of age when using forced air heating without perforated polyethylene tube. That's mean; the air temperature close to the floor was lower than the recommended by 4.11°C and 4.64°C at 2 and 8day of age, respectively. While, using the perforated polyethylene tube the highest, value of floor air temperature was 34.12°C at 3 day of age and the lowest value was 28.64°C at 8 day of age. So, the air temperature close to the floor was higher than the recommended temperature by 0.12°C and lower than the recommended by 3.36°C at 3 and 8day of age, respectively. At the second brooding stage the recommended floor temperature was 30°C at the 11 day of chick's life and reduced gradually until reached 27°C at the end of second brooding stage. The highest value of floor air temperature was 26.15°C at 13 day of age and the lowest value was 21.77°C at 20 day of age when using forced air heating without perforated polyethylene tube. That's mean the air temperature close to the floor was lower than the recommended by 2.85°C and 5.23°C at 13 and 20day of age , respectively. While, employing the perforated polyethylene tube the highest, value of floor air temperature was 28.8°C at 12 day of age and the lowest value was 25.92°C at 20 day of age. So, the difference between recommended temperature and air temperature close to the floor was 0.2°C and 1.08°C at 12 and 20day of age, respectively. After 20 day of age the birds were translocated from partial to all house brooding. The recommended floor temperature ranged between 26 and 24°C at this stage. When, using forced air heating without perforated polyethylene tube the highest value of floor air temperature was 23.91°C at 33 day of age and the lowest value was 20.78°C at 34 day of age. That's mean the air temperature close to the floor was lower than the recommended by 0.1°C and 3.24°C at 33 and 34day of age , respectively. While, employing the perforated polyethylene tube the highest, value of floor air temperature was 28.25°C at 23 day of age overridden the recommended temperature by 2.25°C and the lowest value was 21.06°C at 35 day of age lower than the recommended temperature by 2.94°.

The floor temperature was lower than the recommended temperature during all brooding stages when heating the house without duct. As result of that, chicks are chilled, huddle together and will not seek feed or water and nutrients that might have been used for body development are used to maintain body heat and they loose weight and not grow properly. In contrast, using duct for heat distribution the indoor temperature was close to the recommended.

Relative humidity

The ability of indoor air to hold moisture depends upon its temperature. The level of indoor air relative humidity influences the ability of the birds to cool them through panting and influences ammonia production. In addition to, increasing the moisture adding to the house from broiler fecal. An air relative humidity level of 50 to 70% is recommended to minimize ammonia production and dust. (Figure 2) clarifies the relation between indoor air relative humidity when using forced air furnace with and without perforated poly ethylene tube during different brooding stages. At first stage of brooding the indoor relative humidity increased with increased birds in age when, using forced air furnace from 28.36 to 57.78 % at the end of the first brooding stage. While, using forced air furnace with perforated poly ethylene tube the indoor relative humidity increased from 28to 48.39 % at the end of the first brooding stage. After ten days of brooding (second brooding stage) the brooding surface area was increased to 352.5 m^2. Using forced air furnace, the lowest percentage of indoor air relative humidity was 53 % at the beginning of second brooding stage and increased until reach the highest percentage at age of 15 days which is 69% and reduced to be 57% at the end of this stage. Whereas, using perforated tube for heat distribution the indoor relative humidity was 51.6 % at the first of second brooding stage and reaches the maximum percentage to be 56.36% at age of 13 days of chicks' life and was 54.67% at the end of this stage. After 20 days of age the curtain was removed and the birds spreads on the entire house until the end of living cycle. The indoor air relative humidity was 57.09% at the age of 21 days and increased gradually to overridden the maximum percentage of indoor relative humidity to be 72.65% at age of 31days and reach the 78% at 32days of age when, heating house without duct .The indoor air relative humidity increased at the end of the heating period due to the heat energy supplied during that time was insufficient to absorb more moisture from the indoor air. While performed heater with tube for heat distribution the indoor relative humidity was ranged between 52.34 % at 22 days of age to be 64.85 % the last two days of life. The indoor relative humidity decreased compared with first treatment because of, perforated tube downward heat to house floor which was sufficient to absorb more moisture from the indoor air as shown in (Figure 2)

Specific heating power

(Figure 3) clarifies the relationship between the specific heating power for one cubic meter of house volume and the broiler age when using forced air furnace with and without perforated poly ethylene tube. Specific heating power depends mainly upon the heat energy addition to the broiler house during heating operation and the volume of that house. As, the bird's age increased, the specific heating power was decreased. Specific heating power during the first living cycle when the forced air heating system was used without perforated polyethylene tube was 94.6 W/m^3 at the first week of age and reduced gradually until reached 26.25 W/ m^3 at the fourth week of age, after that, it increased again until reached 29.15 W/ m^3 at the fifth week of age. This increasing can be almost completely attributed to the increase of house volume and the heat energy addition to the broiler house accordingly at this period (the brooded birds were translocated from a small partial area to the whole house brooding).

Thereafter, when the forced air heating system was connected to perforated polyethylene tube for uniformly distributing the hot air inside the broiler house, the specific heating power for one cubic meter of the house volume gradually decreased from 66.38 W/m^3 at the first week of age until reached to 19.9 W/m^3 at the end of living cycle. The previous obtained data revealed that, using perforated polyethylene tube resulted in reduced the specific heating power for one cubic meter of the house volume. Because, it was delivered the heat energy to the end of the house, increased the floor surface temperature, and decreased the total heat energy addition to the broiler house, in spite of the house volume increased particularly after three weeks of age.

Heating energy requirements

The heating energy requirements depending mainly upon the heat energy addition to the broiler house during the heating operation and broiler body life weight.

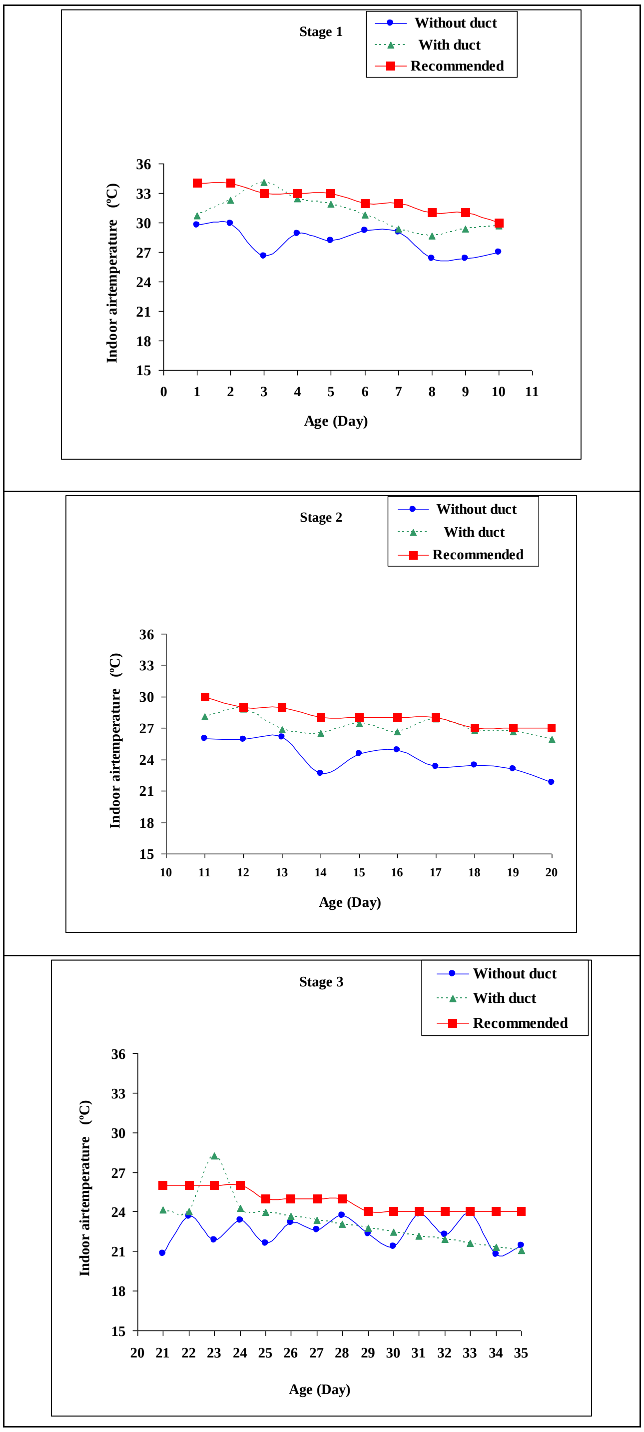

Fig. 1. Daily average indoor air temperature during different brooding stages with and without tube

As, the birds increased in age their body life weight increased and the total heat energy addition by the heating system is decreased. (Figure 4) shows the relationships between the energy requirements and the broiler age when using forced air furnace with and without perforated poly ethylene tube.

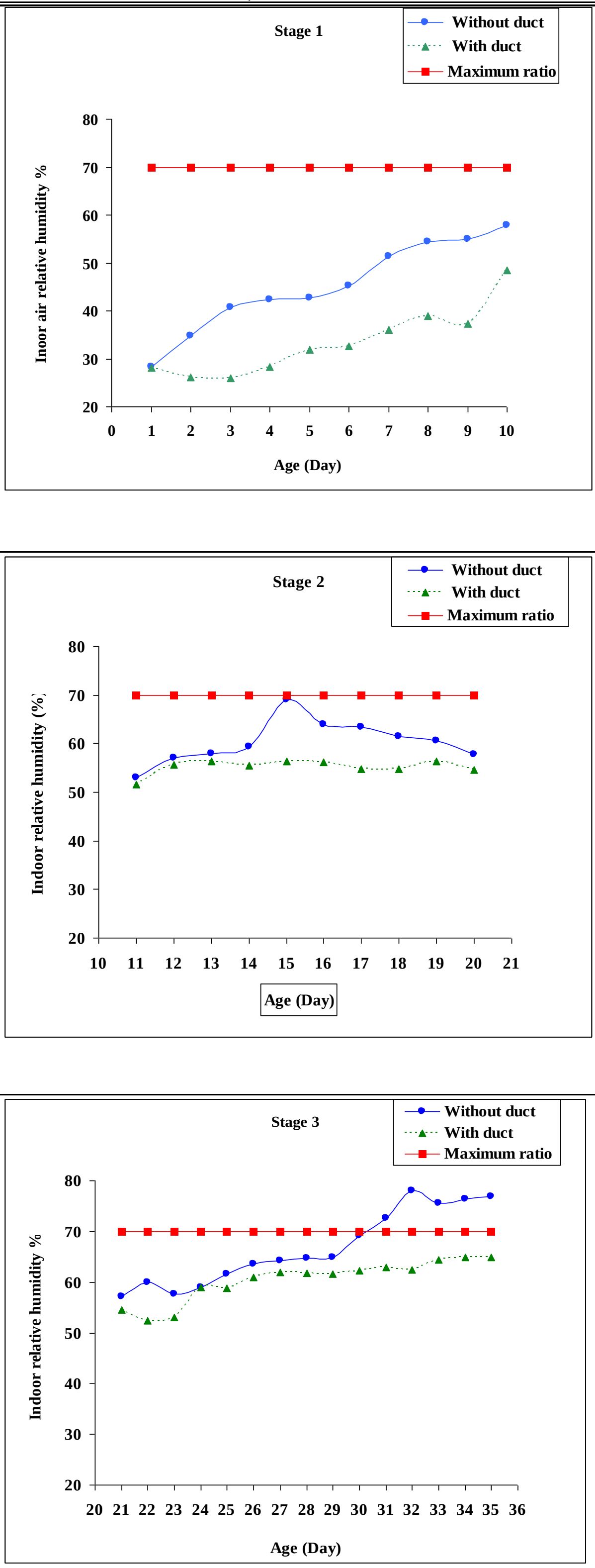

Fig. 2. Daily average indoor relative humidity during different brooding stages with and without tube

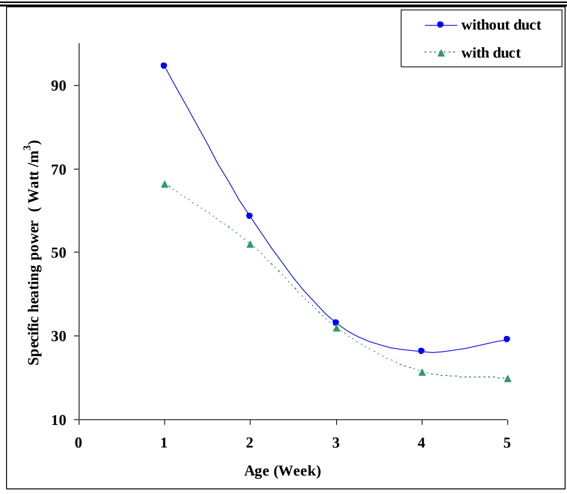

Fig.3. Specific heating power with and without Perforated polyethylene tube

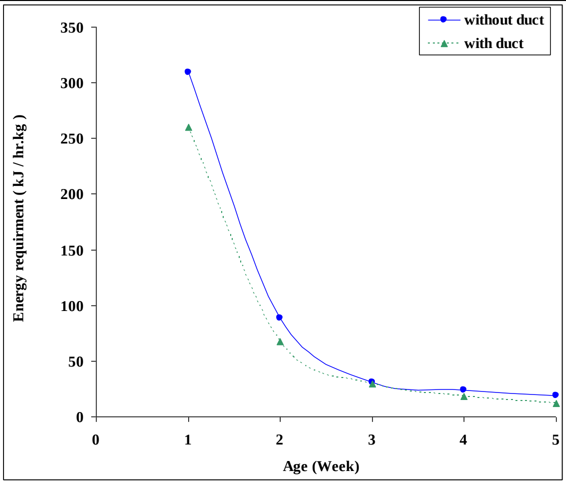

Fig.4. Energy requirements with and without Perforated polyethylene tube

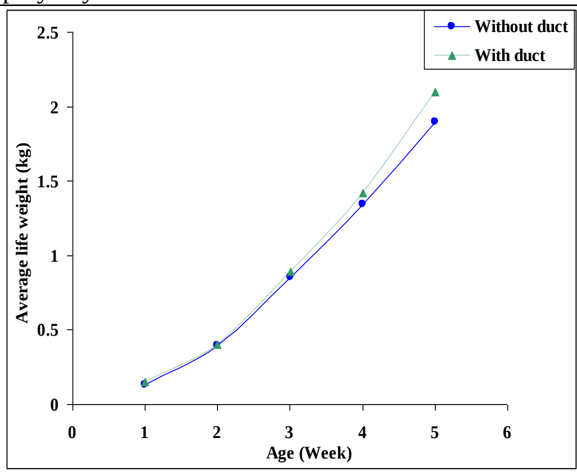

Fig.5. Average life weight with and without perforated tube

The obtained data evidently showed that, the energy requirements were namely decreased with increased the birds in age with and without perforated poly ethylene tube. When the forced air heating system was used without perforated polyethylene tube the energy requirements reduced gradually from 308.9 to19.25 kJ/hr. kg of broiler life weight.

While, when the forced air heating system was connected to the perforated polyethylene tube (during the second living cycle) for uniformly distributing the hot air inside the broiler house, the total energy requirements reduced gradually from 260.2 to11.95 kJ/hr. kg of broiler life weight. It is obviously clarified that, the forced air heating system with the perforated polyethylene tube led to reduce the total energy requirements by an average of 17.84%. This retubeion in heat energy requirements can be attributed to the heating system with perforated tube expelled the hot air continuously downward into the chick's zone which enhanced the chick's life weight. In addition, this heating system decreased the total heat energy addition to the broiler house. Due to the previous reasons, the total heat energy requirements were decreased when using perforated polyethylene tube for uniformly distributing the hot air inside the broiler house.

Average life weight

Due to the prevalent environmental factors which positively impact on growth and development of broiler chicken within the two successive living cycles were at or around the desired level particularly with using the developed heating system, the birds were grown well during the experimental period. When adequate broiler house temperature is obtained and chicks are well managed, they should be distributed throughout the whole house surface area and not huddling together or sitting mostly in the feed pans. The relationships between the average life weight in kilogram and the broiler's age in week during the two successive living cycles (forced air heating system was used with and without perforated polyethylene tube) are plotted in (Figure 5) for the duration of the experimental work, the average life weight was found to be directly proportional to broiler's age.

When the forced air heating system for heating the broiler house was functioned without perforated polyethylene tube, the average life weight was gradually increased with the increase of bird's age from 0.130 kg at the end of the first week until realized market average life weight of 1.90 kg at the end of living cycle (after 35 days). It observed that, the average life weight was increased by different rates throughout the experimental period. The weekly average increasing rate of life weight was found to be 0.4425 kg. The greatest rate of increasing in the life weight (0.5544 kg). When the forced air heating system for heating the broiler house was connected to perforated polyethylene tube for uniformly distributing the hot air inside the broiler house, same trend was observed in the average life weight of broiler chickens. They were gradually increased with the increase of bird's age from 0.1505 kg at the end of the first week till achieved the market average life weight of 2.10 kg at the end of living cycle (also after 35 days). It also observed that, the average life weight was increased by different rates throughout the experimental period. The weekly average increasing rate of life weight was found to be 0.4874 kg. The greatest rate of increasing in the life weight (0.6794 kg) was achieved on the last week of living cycle as revealed in (Figure 5) Consequently, the modified heating system which was used during the second living cycle was on average 10.53% more protubeive.

CONCLUSIONS

The main results of the present research can be summarized as follows:

-Using perforated polyethylene tube increased average floor air temperature through the birds' life by 7.99%.

-Using perforated poly ethylene tube reduced the average indoor air relative humidity through the birds' life by 12.92% .

- Perforated polyethylene tube reduced the total energy requirements by an average of 17.84%.

- Perforated polyethylene tube reduced the specific heating power by an average of 20.82%. .

- Using perforated tube helped in increasing broilers body mass by a 10.52%.

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