STUDY THE EFFECT OF EGGS INCUBATION PARAMETER THROUGH DEVELOPMENT OF NEW EXPERIMENTAL RIG FOR IKTA QUAILS SPECIES

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A thesis submitted in

fulfillment of the requirements for the award of the

Degree of Master Mechanical Engineering

Faculty of Mechanical and Manufacturing Engineering

Universiti Tun Hussein Onn Malaysia

AUGUST 2017

For my beloved father, mother, wife and family.

ACKNOWLEDGEMENT

All praise to the Almighty Allah, the Most Gracious, Most Merciful and Most Benevolent for giving me an opportunity to study in higher education and giving me strength and patience in completing this master thesis.

I am very fortunate to have a kindhearted person to guide me throughout my research work and here I would like to show my heartfelt sincere gratitude to my respectful mentor which is my supervisor Associate Professor Ir.Dr.MD SAIDIN WAHAB for his invaluable guidance and support. I am very indebted for his inspiration and continuous motivation which really help me in completing my project.

I also extend heartfelt thanks to my colleague Mr. Azli, Khairu, Aqeel, Abdul ladim, Rahman and Mokhtar. I owe him a great deal for his valuable guidance and informative suggestion which been really a great help for me to complete my project.

Finally, I would also like to thank my beloved late father mother, wife and family for giving me the support and confidence during the entire this research work. It is a true blessing for me having them in my life as they are my inspiration and motivation.

ABSTRACT

Nowadays, machine is utilized as an alternative way to hatch eggs, however various temperature settings are used that result in different percentages of hatching between hatcheries. This study aims to investigate the effect of increasing incubation temperature, eggs movement type, and incubation time through a set of experimental rigs developed specifically to suit the experimental needs to determine the best eggs incubation parameter. Air flow and heat movements were simulated using Computational Fluid Dynamic Simulation and Modelling (CFX) to study the heat flow effect on hatchability before incubation construction. For case study, Institut Kemahiran Ternakan Ayam (IKTA) species used as test subjects. Incubation period took 17 days to completed. Setting temperature in each test run was different in the first day to the 14th and 15th to 17th day. First test run, the setting was 37 °C for 14 days then 38 °C for 3 days. In second incubation, 38 °C on the 14th day and 39 °C for 3 days, then third setting at 39°C on the 14th day and 40 °C for 3 days. Each setting was repeated three times, thus nine test runs were performed. With the same setting incubation temperature and humidity, two types of eggs movement were conducted in the same incubation chamber, 40 eggs were placed in 45 ° swing and 360 ° rolling. Unhatched eggs were opened and examined to see any abnormalities that may cause death of the embryo. From the data collected, temperature 37 $°C_{14day}$ 38 $°C_{3day}$ produced 89.17% eggs hatch, first eggs hatch in day 14 with average 5.42%, ends in day 16. By increasing 1-degree temperature, it decreased hatching to 84.17% with 6.67% hatch in day 14. By increasing 1 degrees, resulted just 76.67% eggs hatch, average 12.91% hatch in day 14. Thus, proved that by increasing temperature to 39°C was not as successful as 37 °C. Excessive temperature did not increase hatchability but speed up hatching time, it may cause embryonic mortality to egg development. Overall, experimental rig produces 83.16% hatching with 360 ° rolling produced slightly higher hatching average at 83.33% compared to 83% with 45° swing.

ABSTRAK

Pada masa ini, mesin penetasan digunakan sebagai alternatif untuk menetaskan telur, namun tiada panduan tetapan suhu piawaian digunakan, lalu mengakibatkan kadar penetasan yang berbeza. Kajian ini melihat kesan peningkatan suhu penetasan, jenis pergerakan telur, dan masa pengeraman melalui satu set rig eksperimen dibangunkan khusus. Aliran udara dan pergerakan haba disimulasikan menggunakan analisis CFX. Bagi kajian kes, telur puyuh dari spesies Institut Kemahiran Ternakan Ayam (IKTA) dipilih. Pengeraman mengambil masa 17 hari, suhu pengeraman pada setiap ujian berbeza pada hari pertama hingga ke hari ke-14 dan hari ke-15 hingga ke-17. Set pertama, suhu ditetapkan 37 °C selama 14 hari kemudian ditingkatkan kepada 38 °C selama 3 hari. Set kedua suhu ditingkatkankan 38 °C hingga hari ke-14 dan 39 °C selama 3 hari. Set ketiga 39 °C sehingga hari ke-14 dan ditingkatkan kepada 40 °C selama 3 hari, setiap set suhu tetapan diulang tiga kali bersamaan dengan 9 ujian dimana suhu dan kelembapan pengeraman yang sama, dua jenis pergerakan telur dijalankan serentak di ruang pengeraman, 40 telur diletakkan dalam ayunan 45 ° dan berguling 360 °. Telur yang tidak menetas akan dipecahkan dan diperiksa untuk melihat kenapa tidak menetas. Telur mula menetas pada hari ke-14 dan berakhir pada hari ke-16, untuk suhu 37 °C $_{14hari}$ 38 °C $_{3hari}$ menghasilkan 89.17 % penetasan secara purata dari 3 ujian dan purata penetasan pada hari 14 ialah 5.42 %. Dengan meningkatkan suhu 1 darjah, purata menetas menurun kepada 84.17% dan penetasan pada hari ke 14 ialah 6.67%. Dengan meningkatkan suhu 2 darjah menghasilkan purata 76.67 % penetasan dan purata penetasan hari ke 14 ialah 12.91 %. Oleh itu, membuktikan bahawa dengan meningkatkan suhu kepada 39°C tidak meningkatkan peratusan penetasan sebaik 37 °C. Peningkatan suhu dapat memendekkan masa penetasan yang mungkin boleh membantutkan kepada perkembangan telur. Secara purata mesin ini menghasilkan 83.16%, kaedah berguling 360 ° penetasan lebih tinggi 83.33% berbanding 83% dengan ayunan 45°.

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LIST OF ABBREVIATIONS

CAD	-	Computer Aided Design
DOQ	-	Day One Quails
IKTA	-	Institut Kemahiran Ternakan Ayam
CFX	-	Computational Fluid Dynamic Simulation and Modelling
CFD	-	Computational Fluid Dynamic
VI	-	Virtual Instruments
CPU	-	Central Processing Unit
ROM	-	Read Only Memory
RAM	-	Random-Access Memory
DIG	-	Early Embryonic Mortality
DIS	-	Late Embryonic Mortality

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CHAPTER 1

INTRODUCTION

1.1 Eggs Incubation

Nowadays, more importance are put on agriculture and livestock farming as the field continues to grow with advanced technology developments. More technologies are created to further develop especially in the poultry industries. Eggs incubation refers to the process through which certain oviparous (egg-laying) animals hatch their eggs; it also refers to the development of the embryo within the egg (Abiola et al, 1999). Multiple factors are vital to the successful incubation of various animal species (Benjamin*& Oye*, 2012).

The obvious difference between natural and artificial incubation is that a hen provides natural heat and environmental humidity to the egg through body warmth (Ar and Rahn, 1980), while an incubator uses a set of heater and humidifier to supply sufficient and ideal setting parameters (Givisiez, et al., 2000). The act of turning avian eggs during incubation affects the physical aspects of the embryo and extra-embryonic membranes including the formation of sub embryonic fluid, utilization of albumen, and embryonic growth according to (Elibol *and Brake*, 2004).

Eggs incubator is an alternative technology to hatch poultry eggs without involving a brooding parent. It is designed to improve the available eggs incubator in order to change the traditional farming methods to the advanced and modern farming methods (Dutta and Allen, 1991). Introducing the automatic quail eggs incubator may help our country to achieve a food trade balance surplus and could help expose farmers to the latest technology in incubating quail eggs.

An embryo begins development even before the egg leaves the hen's body, and continues its development with the help of optimum environmental factors. There are numerous factors that influence embryonic development throughout incubation

(Dahouda et al., 2013), including environmental temperature, humidity, air movement, and turning of the egg (French, 1997). These factors are altered depending on the number of eggs set, the age of the egg in the set, the age of the hen at lay, and the breed of the hen (Jobling, 2010).

Turning is one of the factors that can have detrimental and beneficial effects (Frank, 1969). This factor will be discussed in more detail in this study. Air movement through the incubator is essential for the removal of metabolic heat and carbon dioxide from around the egg (Jeffrey, 2008). Turning alters this air movement, causes varying microclimates deviating from the set point in the air around some of the eggs. This can lead to a wider hatch window and a variance in chick quality (Laseinde, 1994). The angle and frequency of turning, orientation of the egg, and age of the embryo during which the egg is turned during incubation all influence embryo growth and normal development (Sophie *et al*., 2010). Alternatively, the incubator is designed to improve the available eggs incubator in order to change the traditional farming method to a more advanced and modern farming method.

1.2 Research Background

According to *Jabatan Veterinar Negeri Johor*, the current local hatchery for quails in Johor has shown low hatching rates. It has been reported that the recent success rate is around 65%. Among the factors that contribute to low hatching are high heat loss during incubation period, bacterial cross contamination from the incubator machine to DOQ (day one quail), inconsistent incubation temperature, humidity etc. In addition is the fact that the existing incubation machine could not acquire data storage for further analysis. These factors contribute to the loss of profit in each cycle. Unstandardized temperature, humidity and turning frequency in each hatchery (Rader, 1988), these factors may lead to high percentages of embryonic mortality hence cause domino's effect to the supply and demand in quail's meat and eggs production (Oluyemi, 1979). Low hatchability of eggs causes revenue loss to the hatchery company, thus low DOQ results in less amount of quail meat in the market.

These situations have long been occurring in the quail's industry and no preventive action has been taken by the authorities. The independent local quail's breeder in Johore are in a dilemma due to the low hatching of eggs caused by

inefficient eggs incubator machine. Some of the machines are imported and some of them are made by local manufacturers. None of them has data acquisition capability to store previous incubation data such as incubation temperature, humidity and number of eggs movement. Previous incubation data from the control system of an incubation machine are important in investigating the trend, pattern, and behavior of eggs hatchability in each incubation machine system, as well as what actually happened during the last incubation period that could be the root cause of the low hatchability.

1.3 Problem Statement

There are a lot of eggs incubators in the market right now, imported or made locally. Most of commercial hatchery use imported incubator machine with high technology to ensure consistency of eggs hatching in each batch. Meanwhile smaller hatchery uses lower end to middle incubator in term of price and technology, because of that there are some issues on existing incubators in the market that lead to low hatching rates. Most of incubator use in Malaysia didn't gone through air and heat simulation analysis inside the incubation chamber, this factor may cause low hatchability because of uneven heat distribution through incubated eggs. Other factor that may contribute to lower hatch rates are, first most of these machines do not have accurate and consistent temperature and humidity control (Raven,1987), incubator didn't have a system to acquire setting parameter data storage for monitoring and further analysis. Secondly, bacterial built up and cross contamination between incubator to day one quail, this factor causes by low quality and less durable building components that can grow bacteria, default electrical devices and low-grade materials used also contribute to low hatchability. This problem becomes a pulling factor to the researcher to develop an experimental rig that can independently set the incubation parameter individually and differently for each incubation day. Third, nowadays there are no manufacturer produce incubator that consists of two different types of eggs movement in the same incubation chamber and able to monitor, acquire and log every data from the system.

Forth, there is no specific study on the best setting parameter or comparison made between slanting and rolling mechanisms in eggs incubation, so developers didn't know which system is the best in producing high hatching rates, equal hatching time, and good quality DOQ. Fifth, by collection of previous incubation data, will

enable researcher to form a better understanding on the flow of each incubation set and what happening if there is a problem occurred, with this study, researcher can identify main factors that contribute to high hatchability and what actually happens during the entire incubation period. The development of an experimental rig will provide full control on incubation setting that may offer a solution to lower incubation rates in Malaysia's eggs hatching industry. This research also recommends some improvements that need to be done in achieving high hatchability and increased DOQ quality in the experimental rig and further research.

1.4 Objectives of Study

i) To design and develop experimental rig as artificial incubation, with a system that able to control and store data on setting parameter such as temperature, humidity and eggs movement function.
ii) To investigate the effect of increasing incubation temperature on eggs hatchability properties, hatching time and eggs movement type.
iii) To evaluate the hatchability through experimental study on IKTA quail eggs species due to eggs movement at 45° slanting and 360° rolling by eggs rotation mechanism

1.5 Scope of Study

i) This research focus on developing an experimental rig that is able to record and manipulate data input of the eggs incubation.
ii) Analysis of heat and air distribution inside the incubation chamber through CFX analysis.
iii) Comparison on hatching percentages between 360° rolling and 45° slanting eggs rotation mechanism.
iv) Only quail eggs from IKTA species are to be used.

1.6 Rational of Research

The rational of this research is when the reported data from Veterinary institute shown the lower incubation rates of eggs from local quail's hatchery in Johor. This research aims to investigate the root cause of this problem and solve it through a set of experimental rig. Finding from this research can help increasing eggs hatchability of IKTA quails and increase production of quails' meat and profits to the quail's industry.

CHAPTER 2

LITERATURE REVIEW

2.0 Background

Artificial eggs hatching is a new way to hatch eggs into chicks without the present of a mother hen (Oluyemi, 1979). It includes the control of ideal incubation environment that surrounding the eggs inside the incubation chamber. Naturally, a mother hen has low hatching rates and inconsistence (French, 1997). Nowadays, bird egg hatchery has become an important asset to breeders especially in the quail breeding industry because it is a very lucrative business. Incubator technology is being used to hatch eggs into day one quails (DOQ) without any incubation involvement from the parent. This process has existed since a few thousand years ago, pioneered by the China and Egypt civilizations (Benjamin & Oye (2012). The difference between the natural and the incubation machine is that in the natural way, a parent uses its body temperature to hatch eggs while the incubator machine uses heating elements such as a bulb or an air type heater to heat up the air around the quail eggs (Meir *et al*., 1984).

There are two types of quail egg incubation process; the traditional method and the modern method. The traditional method has been used since a very long time ago and may still be in use. There are several elements in the incubation process that are important to produce DOQ. These elements are humidity, egg movement, air flow and temperature effect inside the incubation chamber. The elements are essential in ensuring that the incubation process ends up with a high percentage of eggs hatching. Traditional method uses heating elements to generate heat from sources of fire; for example, charcoal embers, lamps, and burning firewood. Eggs also need to be frequently rotated manually to ensure the egg surfaces are exposed evenly to heat. After thousands of years of using this method, humans have started considering a more effective way of hatching eggs artificially. Various incubator forms and versions were

created either manual, semi-automatic or fully automatic. The modern method uses bulbs or air type heaters to generate heat through electricity, egg turning tools to automatically rotate the eggs and automatic condition regulation to keep heat, humidity and air flow on the required levels. Two incubator models are available with regards to the air flow; still air and forced or coerced air. A still air model does not use any blower fan or also known as an exhaust fan to channel warm air. On the other hand, the forced air model has an exhaust fan to channel hot air to keep the heat, humidity and oxygen level balanced and is widely used (Nakage *et al*., 2003).

2.1 Embryo Formation

Embryo formation in an egg is a continuous process and can be categorized into three phases - formation, growth and maturity. Usually, embryo formation happened on the first day of the incubation process (Rice and Bots, 1986). Embryo growth and maturity take place in the embryo formation phase as shown in Figure 2.1. Each of this phase needs certain specific conditions. When an embryo grows, its metabolic rate will increase to match the increase in heat production produced by the egg (Benjamin & Oye (2012). Due to this, the embryo's natural pattern shows an increase at the end of the incubation process.

Inside the incubator, different temperature points need to be set depending on where the incubator operates (Rahn *et al*., 1981). At the beginning of the incubation process, the embryo produces little heat and the egg must be warmed. This means that the inside temperature of the incubation machine must be higher than the egg temperature, thus Metabolic heat production increases in line with embryo growth (Singh, 1990). The air that surrounded the egg needs to be chilled, so excessive heat can be eliminated from the egg (French, 1997). During the incubation process, water loss in eggs is a common thing, between usually 12 % to 14 % water content (Rahn & AR, 1974). Nevertheless, too low or too high-water loss will influence embryo development (Rahn *et al*., 1974) and egg hatchability (Meir *et al*., 1984). Hatching temperature above the optimum point will cause excessive water loss in eggs (higher than 14%), which in return will lead to embryonic death due to dehydration (Nakage *et al*., 2003). On the other hand, a temperature under the optimum point will reduce

the hatchability rate, for it lowers the rate of water loss under 12 % and declines gas exchange (Romanoff, 1930).

Figure 2.1: Embryo development of quails (Sophie *et al.*, 2010)

2.2 Eggs Incubation Process

Egg incubation is a technology that provides opportunity for farmers to produce chicks from eggs without the consent of the hen, and is also one of the fastest ways of transforming eggs into chicks. The artificial incubation is different than the natural incubation where eggs are surrounded by heat rather than having the natural parent provide warmth to the eggs through body contact (Benjamin. 2012). Every bird that lay eggs has their own incubation period, eggs movement, specific temperature and humidity to hatch their eggs.

An incubation machine is a machine that resembles a box, designed to replace the incubation process by animal parents. It is capable of keeping eggs safe for the incubation process and contains a system that controls and maintains the required temperature, humidity of the air, oxygen content and other circumstances needed to hatch the animal eggs (Sansomboonsuk, 2011). Temperature, humidity, eggs movement, air flow and bacteria contamination are the most crucial factors that contribute to a higher hatching rate, uniform hatching and quality day one quails. Uniform hatching environment encourages healthy embryo development. An automatic driver device turns the quail eggs at least twice a day. The incubation machine needs to be placed in a closed area, such as inside a room with good air flow. This can avoid dramatic temperature changes apart from making it easier to maintain uniformed temperature and humidity (Abu, 2008). This technique is important to ensure a high hatching rate.

The incubation characteristics of every egg is different according to bird species. The species that have high market demand and are most popular among farmers these days are chicken, ducks and quails. Today, incubation machines are widely used in the breeding industry whether in a small, medium, or large scale. According to *Pusat Transformasi Komuniti Universiti*, UPM, there are various advantages of using incubation machines. For example, the quantity of eggs produced can be increased because hens can lay eggs all year-round without the need to sit through incubation periods. Apart from that, the growth rate and quail chick hatching time can be standardized. Quail chicks that hatch together can also save upbringing space because no parent is needed. This will facilitate the animal husbandry process. Other positive benefits include being safe from dangerous predators like iguana, snake, monkey and fox, and away from the cold natural environment. Disease carrier threats

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