UNIVERSITY OF EDUCATION, WINNEBA

EXPERIMENTAL EVALUATION OF A POULTRY MIXER MACHINE

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DECEMBER, 2021

DECLARATION

STUDENT'S DECLARTION

I, JABIBU HUSEINI, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE ……………………………………..

DATE;…………………………………………..

SUPERVISOR'S DECLARATION

We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis/dissertation/project as laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Kumasi

DR. SHERRY K. AMEDORME

SIGNATURE ……………………………………..

DATE;…………………………………………..

DEDICATION

This thesis is dedicated to my family and to all friends for their love and support that has brought me this far.

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ABSTRACT

The challenges facing the local poultry farmers in Ghana is alarming. Only a few have access to poultry feed mixer. However, the Government of the day has an interest in self-employment. A poultry feed mixer was designed, and constructed, for the low-income farmers using local materials in order to reduce cost-effectively and make it available and accessible to all small-scale poultry farmers. The mixer was evaluated by using five feed ingredients; maize, wheat bran, soya meal, oyster shell, and concentrate. The measurement comparison of feed rate, time, speed, moisture content, morphology, feed losses percentage, and mixer efficiency were performed on the mixer-machine. The mixer was characterized and analyzed using a feed component of three different measures of 4.5kg, 9.0kg, and 14.5kg with their respective time of 3 minutes, 6 minutes and 9 minutes respectively. Regression analysis was carried out on the test results collated during the evaluation of the mixer and the analysis contributed to the determination of the effectiveness and efficiency of the machine with different feed rates and times. The machine efficiency, percentage loss, moisture content, and production rate were 92.07%, 7.95%, 15%, and 90%, respectively. However, the results indicated that variation in percentage loss among samples tested ranges from 5.56% to 9.33% with and an average percentage of 7.95%. This was due to levels of moisture content of produce and the mixing processing levels which confirmed by the morphology of surfaces and texture of the mixed produce. Again, the results significantly revealed that the mixing capability of the proposed machine is effective and efficient compared to the existing machine used by small scale farmers. It is therefore recommended that poultry farmers should be encourage to use the proposed mixing machine.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Food is one of the most important basic needs in the life of animal for survival. Machines are needed in terms of food production, preparation and other processing. Machine is a well-known structure consisting of frame works with various moving parts for doing the job easier, faster and more quality output, (Cajindos, 2014). Victor (2013), defined feed production as the process by which feed ingredients are mixed proportionally to produce compound feed, in the face of high costs of compounded feeds combined with their thoughtful quality/quantity, most poultry and pig farmers would want to produce their own feed.

The beginning of industrial scale production of animal feeds can be traced back to the late 1800s, this is around the time that the advancement in human and animal nutrition was able to identify the benefits of a balanced diet, and the importance or role the processing of certain raw materials played in this. William H Danforth in 1894 established Purina which is the world's leading producer of feed (Chime *et al.,* 2018). He added that, in the early 1900s, the animal feed industry expanded rapidly. Purina, the leader in the industry, expanded operations from the US into neighbouring Canada. They opened their first feed mill in 1927. This marked the beginning of the mechanization and industrial production of animal feed.

The electric standing mixer was invented in 1908 by Herbert Johnson, an engineer for the Hobart manufacturing company. The idea for creating this machine came from an incident in which he saw a baker mixing bread dough with a metal spoon (Rufus *et al.,* 2015). He further used his engineering skills and intelligence to simulate the mixing action of the baker and came out with a mechanical tool simulating the process. The 80-

quart mixer which he invented became the standard equipment by 1915. Rufus *et al.,* (2018), also observed that, in 1908, the feed industry was revolutionized by the introduction of the first feed mixer used for mixing pelleted feeds. Since then, there has been development in the area of designing and fabricating feed machines for commercial farmers.

There are a wide variety of mixers currently available for use in mixing components of animal feed. Selecting a particular feed mixer will depend mainly on the phase or phases which the components exist such as solid, liquid or gaseous phases. Some commonly used solid mixers include: Tumbler mixers, horizontal trough mixers, Vertical screw mixers etc. These are quite quick and efficient particularly in mixing small quantities of additives into large masses of materials. The results on mixer efficiency of different mixer types showed that the horizontal-type had a higher percentage of coefficient of variations (CVs) below 10% than the vertical-type. This could be due to mixing against the force of gravity such that dense materials like limestone and phosphates are difficult to elevate because of sliding and have the tendency to go to the bottom because of the height factor Dimaiwat et al (2018). They further indicated that, the physical properties of raw materials can also affect mixing efficiency. Some of these factors include particle size, density, hygroscopicity and liquid addition.

New (2007) observed that, regardless of the type of mixer, the ultimate aim of using a mixing device is to achieve a uniform distribution of the components by means of flow, which is generated by mechanical means. Nevertheless, the control of these processes by electromechanical means (guided by the micro-controllers) gives rise to more efficient and faster feed mix and throughput of the feed mill at minimal cost and labor.

The mixing process is one of the most important steps in feed manufacturing. The goal of mixing is to meet label guarantees and produce a uniform feed that provides similar nutrient content to all animals consuming the feed, Stark (2017). Improper mixing of feed will result in poor quality products. Poor quality feed affects the growth and development of the animal hence affecting viability of the enterprise. Large quantities of feed will be very difficult to mix by hand if not impossible; this will inevitably lead to the production of poor-quality products and reducing production rate. This lowers the profits margin of the products. However, the cost of importation of foreign machine for mixing feed is very high compared to the producer's meagre resources. Generally, this affects the country's foreign exchange.

Moreover, locally produced machine will reduce cost of importation and transportation to the small-scale farmer. In addition, the design may also bring down the cost of the machine to the reach of the small-scale poultry farmers. Beside creating employment opportunities for the farmers, this design was also chosen for reliability and among other things. Locally designing and fabricating the feed mixer will also eventually lead to the creation of employment opportunities for the farmers, youth and the country as a whole to cartel the unemployment situation in the country, since the Government of the day has an interest in self-employment. The design does not need any special skills for its operation and also does not call for any elaborate production environment before it becomes operational and so many others.

1.2 Statement of the Problem

The small-scale poultry farmers in the country find it difficult to sustain in the business due to lack of access to quality feed at the right time and cost of implication. They are unable to purchase the needed tools and machines to increase their production and compute with other counterparts in the market. However, the rate of production does not meet the total human population growth and demand in the country due to the high cost of acquiring mixing machine or feed at the local market, Balami *et al.,* (2013).

The traditional way of preparing animal feed mainly by the small- scale poultry farmer uses manual or the hand to mix, crush and measure the feed. In the medium scale production, feed mixing can be done either manually or mechanically. The manual method of mixing feed entails the use of shovel to intersperse the feed's constituents into one another on open concrete floors. However, the manual method of mixing feed ingredients is generally characterized by low output, less efficient, labor intensive and may prove unsafe, hence, hazardous to the health of the intended animals, birds or fishes for which the feed is prepared.

The machinery and equipment that are used for this purpose are usually imported and hence out of reach for the average small-scale or low-income poultry farmer. The challenge, therefore, is to construct, fabricate and evaluate a poultry feed mixer using local materials in order to reduce cost and hence make it available and accessible to the small poultry farmer. This machine should be simple to assemble, use and make handling easier and more comfortable for the illiterate farmer.

1.3 Purpose of the Study

The main purpose of the study is to design, construct, and evaluate the performance of the feed mixing machine. This will be achieved through the following specific objectives:

1. To determine the technical operation principles of the modified poultry feed machine and the economic importance;
2. To establish design and construction parameters of the poultry feed machine;

3. To evaluate the effectiveness and efficiency of the machine on the bases of the produce and the equipment performance with regards to the effectiveness of the mixing quality;
4. To conduct comparative analysis of the existing and the modified poultry feed machine;

1.4 Justification of the Study

The high cost of poultry feed machine in the country is pushing most of the small poultry farmers out of business. Currently, most small-scale farmers are at the verge of collapsing due to the inability of the farmers to purchase or have access to the imported feed mixers in order to reduce cost and also make it accessible to the small poultry farmer. Therefore, this research will construct and evaluate the performance of a poultry feed mixer using local materials. This will help reduce cost of producing poultry feed, and eventually reduce cost of poultry products if small scale poultry farmers are able to afford feed mixers. This means that poultry birds and eggs will be affordable and so people will have the daily requirement of proteins the body needs. Poultry production would also earn the country more foreign exchange through exportation.

1.5 Scope of the Study

The study covered the small-scale poultry farmers in two districts in the northern region of Ghana, these include Tamale metropolis and Sagnarigu municipality. The study was conducted within the frame work of construction and evaluation of the performance of poultry feed mixing machine. The researcher used experimental approach and was not able to cover other districts in the region to reflect the entire industries. Hence, the result was generalized and findings would be placed within the context of the entire firm studied.

1.6 Organization of the Study

This thesis is organized into five chapters. The first chapter deal with introduction which covers background to this study, the problem statement, purpose of the study, justification of the study. It also looks at the scope, and organization of the study. The second chapter provides an overview of the key literature, looking at mechanical aspect of the poultry feed mixer with emphasis on the principles of operations. Chapter three details the materials and methods use for study. Chapter four presents the results and discusses the key findings in relation to existing literature, and the final chapter draws on the summary of findings conclusions and provides policy implications.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

A lot of research has been carried out on the feed mixing machine particularly in the areas of mechanical systems, process control systems as well as full automation and control systems. This chapter presents a review of literature on manual feed mixing process, mechanical mixing process, Near Infrared NIR Spectrometer Controlled, as well as multi-check. Automation with programmable controller was also looked at together with principles of machine operation and manufacturing in this chapter.

2.2 Manual Feed Mixing Process

Most of the poultry farmers in Ghana are small scale farmers. They employ simple tools and equipment in farming activities. They employ manual and crude techniques for processing their poultry feeds. This is mainly due to the lack of financial wherewithal to purchase sophisticated machines and tools to aid them in their work. For example, some still use hand and basins to mix already crushed poultry, some also use shovel to intersperse the feeds constituents into one another on open concrete floors all of which are labour intensive and potentially hazardous to their health as represented in Figure 2.1.

Figure 2.1: Manual mixing

According to (Peter 2013), other categories of local farmers use drum mixer to mix their poultry feed as shown in figure 2.2 (a) and); manual mechanical mixer. This aspect of manual mixing is much healthier for the birds and better in efficiency and output, than the use of shovel or hands and basin. Nevertheless, their outputs and efficiencies are not to be reckoned with in the production of poultry feed in a proper commercial poultry farm. Besides, the drum mixer encourages segregation of feed particles.

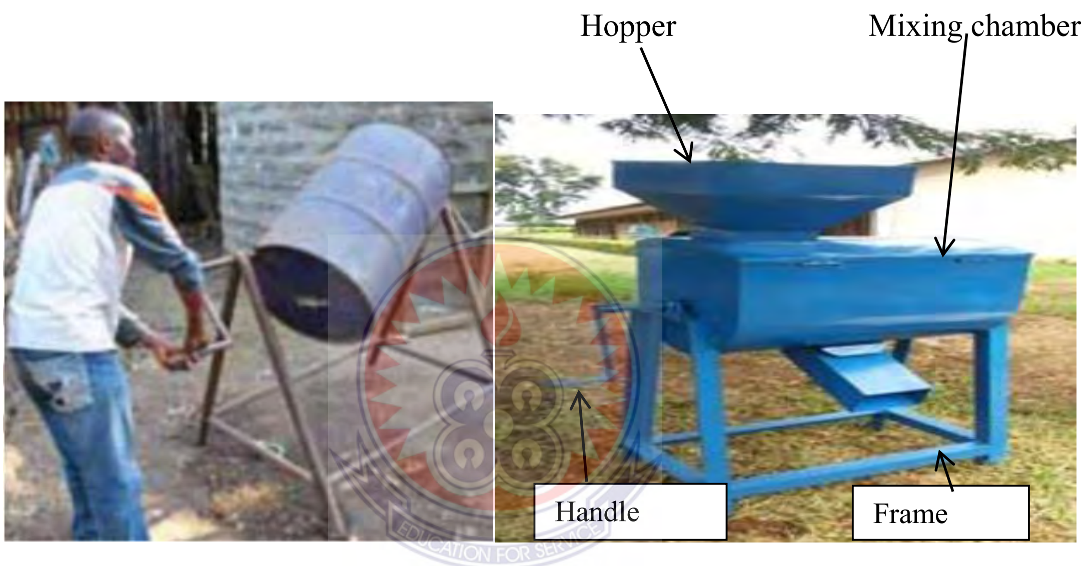


Figure 2. 2: (a) Drum mixer (b) Manual mixing machines

2.3 Mechanical Mixing Process

In livestock feed manufacturing, the process of mechanical mixing is one of the most important unit operations. The purposes of which, after size reduction of different feed ingredients, is to aid palatability of feed, minimizes waste during animal feeding, facilitates easy packaging, and enhances post-production storage and preservation. The mechanical method of mixing as described earlier is achieved by using mechanical mixers or machinery for the purpose of mixing feed. According to Lawal (2019), small sized mixer was designed and tested. The machine was used by small scale farmers to tend to their needs of produced feed for their poultry livestock. The machine was able to crush the grains and also mixes it efficiently. The machine has an efficiency of 80% and a capacity of 12kg/hr. Also, the machine was developed from cheap local materials which make the machine to be relatively effectively, simple, cheap and easy to maintain. Brennan (2008), observed that regardless of the type of mixer, the ultimate aim of using a mixing device is to achieve a uniform distribution of the components by means of flow, which is generated by mechanical means.

The mixer is classified into two, namely; continuous and batch mixer. Continuous mixer procedure is more satisfactory for large, extensive operation. The ingredients are usually added by auger, steer wheel or other device to a screw conveyor. If more accurate continuous mixing is required, automatic weighing machine may be used Lawal, (2019). He added that, the continuous mixing operation is carried out in a screw conveyor that may have special flight to ensure a thorough mixing. If the blended product is conveying at some distance, no special mixing unit may be required since the conveying operation will satisfactorily mix the feed. The Batch mixer is used for moderate small operation where overhead cost must be low and labour cost are not critical. The ingredient may be weighed or measured. A rotating drum, box or barrel perhaps with no symmetrically located support is satisfactory for small operation.

Balami *et al.,* (2013), developed and tested an animal feed mixing machine which was tested using feed components divided into three equal measures of 50 kg for ground corn, 0.265 kg for cassava flour and 2.65 kg for shelled corn replicated thrice at four mixing duration of 5, 10, 15 and 20 min. A mixing performance of up to 95.31% was attained in 20 minutes of operation and evacuation of mixed materials from the mixer was observed to be almost complete and was accomplished in 9 minutes with the mixer at full capacity (60 kg of feed ingredients or two third of the mixing chamber filled) while the average value of coefficient of variation for the three replicates was 4.69%. The performance test at the end of each test run, ten samples of 500 g were drawn from the mixed components and the coefficient of variation among blended samples and mixing levels, were computed using the expressions below, (Ibrahim, 2004).

$$CV = \frac{S}{X} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$\%D_M = (1\text{-}CV) \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$S = \sqrt{\frac{\Sigma(X-x)^2}{(n-1)}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where:

CV = Coefficient of variability;

D_M = Percent mixing level;

S = Standard deviation;

X = Weight of shelled corn in the samples;

x = Mean value of shelled corn in the samples;

n = Number of samples

Chime *et al.,* (2018), worked on the design, modelling and simulation of feed mixing machine in Nigeria. They observed that idea of mixing various feed materials such as grains, feed supplements and other animal feeds to produce a homogeneous mix ready for dispensing for animal consumption as being part of man's activities since the creation of man. This has always been done using crude method such as hands, sticks etc. However, in recent times, the advancement in technology has brought about the use of machines to perform the same function much faster, more accurately and expending less energy. It is for this purpose that the feed mixing machine has been designed.

He further added that, the objective of their project was to design a small feed fixing machine, to model and simulate the machine before production, to fabricate component of feed mixing machine based on design specifications and to test the machine after fabrication, while in designing and in material selection consideration was given to the "techeconomic" status of the micro scale industries who are intended users of the machine. Feed mixing machines are used in feed mills for the mixing of feed ingredients. The machine plays a vital role in the feed production process, with efficient mixing being key to good feed production. If feed is not mixed properly, ingredients and nutrients will not be properly distributed within a precise time. This means that the feed will not have even nutritional benefit which would be bad for the birds that are feeding on the feed.

Feed mixing machine comprises a frame structure, the mixing chamber (a cylinder and cone structure) where other components such as electric motor, shaft and hopper are mounted on. The mixing of feed to form a uniform ration is a regular need on large stock poultry purposes. The mixing is performed by a vertical shaft which revolves continuously in a cylindrical cone suspended by an iron bar. The relative motion of the shaft about the frame (body) is achieved by the use of knuckle bearing. Mixing is done in the mixing chamber. The mixer is constructed to take a capacity of 30kg, but the excess capacity of 40kg was provided to take care of overloading their machine which was powered by 1hp power motor.

Daniyan *et al.,* (2018), worked on the development and performance of livestock feed mixer in Nigeria, they observed that feed need to be mixed very well, in order to achieve the best quality out of the livestock. In her study, a horizontal livestock feed mixer with a capacity of 100kg was designed and a model of it was fabricated. The aim was to provide a base for commercial production of feed mixers in Nigeria using locally available materials with low cost of procurement.

They further explained that, the machine was designed based on its power requirements, tension of belt, load on shaft pulley and belt tension, shaft diameter and weight of mixing drum. The materials were selected based on their flexibility, chemical compatibility, availability, simplicity and low maintenance cost. The performance evaluation of the machine was carried out to determine the mixing efficiency using different feed capacity at different time intervals and percentage recovery rate on the feed rate. The mixing time and degree of mixing was observed to increase with increase in feed weight. The horizontal feed mixer developed is highly efficient, cost effective and solves problems associated with manual mixing during livestock feed production.

Makange *et al.,* (2016) also worked on the “Design and Fabrication of Animal Feed Mixing Machine” in India. In their work, an animal feed mixing machine was designed, fabricated and tested. The machine was designed using Creo Parametric design software and proper material selection was done before the assembling and fabrication of parts. The efficiency of the machine, its associated cost of production and the product obtained after few minutes of mixing were outstanding, thereby, making the design acceptable and cost effective. The machine was tested using a feed component divided into 3.5 kg for Maize bran, 1.25 kg for Cotton/Sunflower cake, 0.15 kg for Lime, 0.075 kg for Bone meal and 0.018 kg for Salt replicated thrice at two mixing duration of 10 and 20 min. The average coefficient of variation (CV) was 5.93 % which shows a significant reduction in feed components for the samples tested. The degree of mixing attained was 94.06%.

Process control refers to the methods used to maintain the output of process variables- such as temperature, pressure, flow, or level- within a desired range. It is part of a closed loop system in which a process variable is measured, compared to a set point, and action is taken to correct any deviation from the set point. Closed loop control is feedback-dependent; receiving feedback from sensors monitoring the process variable and providing feedback to the final control element that corrects any deviation from the set point. By carefully monitoring and correcting process variables, controllers greatly assist in reducing variability, increasing efficiency, and ensuring safety. Any equipment that requires constant monitoring of a process variable can benefit from a process controller.

2.4 Near Infrared (NIR) Spectrometer Controlled

Two kinds of analytical techniques are seen in powder blending research. The first set of monitoring technique is used for monitoring powder flow behavior in blenders and they include techniques like positron emission and particle tracking and magnetic resonance imaging. These complicated monitoring techniques usually are unfavorable to be used in control systems for industrial application but are useful research tools for understanding the fundamental behavior of powders in blenders, Isife et al., (2019).

Another set of analytical techniques are those that can be implemented as a process analytical tool in an industrial manufacturing line process. These include technologies like light induced fluorescence (LIF), NIR spectrometry and optical reflectance (Lakshman, 2008). NIR is a useful analytical tool for both qualitative and quantitative analyses, i.e., it has the ability not only to identify a certain compound, by comparing it with that existent in the "spectral library" (qualitative method), but also to determine the amount of compound present in a sample (quantitative method).

2.5 Multi Check NIR

The multi check NIR is a near-infrared spectrometer which is used to analyze the composition of samples using infrared absorbency characteristics of the sample spectra. The NIR multicheck is a compact unit with display at the front end. The instrument control and calculation is performed by the integrated PC and menu driven OMEGA software, running under windows. An integrated dialog display serves as user interface with interactive touch screen. It is suitable for compositional analysis of a wide variety of products like grain, oil seeds and meal. An unlimited number of chemicals and physical parameters and properties of products, such as protein, moisture and fat can be analyzed simultaneously, (Isife et al., 2019).

The pouring of the mixed feed sample into the sample thief or cup and then positioning well the cup onto the optical lens of the NIRSTM DS2500 F for analysis. The cup is covered and light of full wavelength range of 850 to 2500nm is passed across the sample for analysis (Foss, 2018). The light passes through the cup window, strikes the sample surface, interacts with sample molecules and partly absorbed and partly reflected. The reflected light is collected in an integrating sphere beneath the sample window and finally measured by a detector located in the sphere (Oghene, 2018).

The detector measures the spectral absorbance or reflectance of a sample. Identification involves comparing this unknown spectrum to a reference spectrum, the differences between the unknown and the reference spectrum are then evaluated according to given criteria and a decision is made on the identity of the unknown (Debanian, 2010). The amount of light absorbed by the sample at different wavelengths is directly related to the concentration of chemical functional groups, such as C-H, O-H and N-H. As these concentrations are in turn related to concentrations of the properties of interest, for example fat, protein, moisture etc., property values can be determined.

2.6 Automation with Programmable Controllers (PLC)

A Programmable Controller as a specialized computer has all the basic component parts that any other computer has. The Central Processing Unit (CPU) is the control portion of the PLC. It interprets the program commands retrieved from memory and acts on these commands. Memory in the system is generally of two types; ROM and RAM. The ROM memory contains the program information that allows the CPU to interpret and act on the Ladder logic program stored in the RAM memory. RAM memory is generally kept alive with an on-board battery so that ladder programming is not lost when the system power is removed (John and Frederick, 2004).

2.7 Principles of Machine Operations

The principle of operation is a very simple one. Already crushed poultry feed ingredients are placed between stationary drum and the rotating inclined blades agitates the feeds which mixes the various poultry feed ingredients and as a result, forces between the poultry feeds and the stationary drum on one hand and the frictional forces between neighboring feeds. The making of poultry feeds which has hitherto been regarded as an exclusive function of the poultry farmer can be done by anybody who will need a little training on the operation of the machine, in addition time and space is a major advantage as not only that the long duration normally involved has been reduced but the numerous containers ranging from mortar, pestle, basin etc, have been limited to the machine Onyegu et al (2012).

Adenigba et al., (2019), stated that, mixing is a case where more is not necessarily better. There is usually an optimal mix time, which must be determined experimentally. The experiment is tedious because mixing is determined by measuring the standard deviation of some critical component. This requires taking multiple samples, at least ten, from various parts of the mixer at a succession of times. He further explain that the average power and electrical energy consumed during mixing was observed to be significantly dependent on the retention time while speed does not have a significant effect on the average power and energy consumed during mixing. The vertical mixer works by the principle of convectional mixing. The mixer is fed from the hopper and can be operated by an electric motor of 5hp. The mixing starts with the charging of a desired proportion of feed ingredients via the hopper into the mixer which is simultaneously followed by addition of additives. The mixer is allowed to run for a period of time to effect proper mixing of the feed ingredients. The mechanism of mixing involves the conveyance of feed materials from the lower part to the upper part of mixer by the auger conveyor working at the desired operating speed (Gbadamosi and Magaji, 2005). Onyegu et al. (2012) designed and fabricated an automated industrial poultry feed tumble mixer with 0.78 m^2 collector area to be used in experimental mixing tests. The fabricated mixer was used to mix poultry feed ingredients under controlled conditions. The fabricated mixer yielded an acceptable output thereby saving time and energy. There are factors that control the performance of the feed mixing machines. Some of these factors include mixer speed, mixing duration, particles sizes and feed volume. These factors affect directly on the feed homogeneity, energy requirements, efficiency, productivity and operational cost. The manufacturers can control some of these variables through operation and machine maintenance.

Morad and Hend, (2014) also reported that, on-farm feed systems normally use three types of mixers: vertical, horizontal, or rotating drum. Mixing times on vertical mixers normally run 10 to 15 min. Horizontal and rotating drum mixers can mix in 5 to 10 min. Although Morad and Hend described three types of mixers in the mixing industry, others also reported various designs of mixers, these include vertical screw mixers, horizontal auger mixers, reel mixers, chain and paddle mixers etc.

The vertical mixer is composed of an upright tank, usually round, with a vertical auger in the centre to mix the feed. Smaller, less costly mixers are usually of the vertical type. Typical vertical mixers are available in models ranging in size from a 1/2-ton model requiring a 3-horsepower motor up to a 4-ton model requiring a 25-horsepower motor.

Figure 2.3: Electric vertical mixer

Larger mixers are usually of the horizontal type with a horizontal shaft in the centre carrying paddles or ribbons for the mixing. Power requirements range from 3 to 5 horsepower for an l/2-ton mixer up to 20 to 30 horsepower for a 3-ton model Kammel, D. W. (2008). The researchers also explained that, there are many factors that control the performance of the horizontal animal feed mixer. These factors include mixer speed, mixing time and batch size. The mentioned factors affect directly on the feed homogeneity, energy requirements, efficiency, productivity, and the total operational cost. Feed manufacturers can control most of these variables through equipment maintenance and operation.

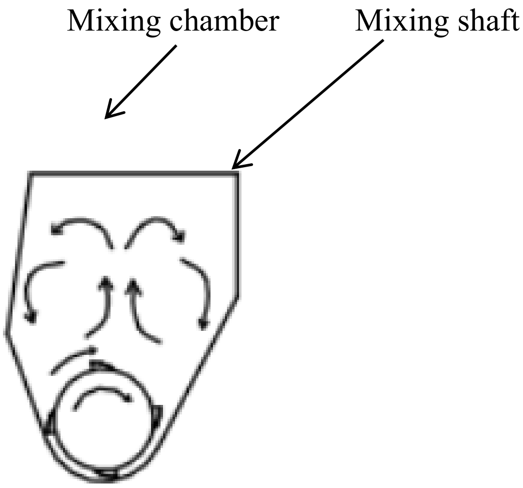


Figure 2.4: Horizontal Electric mixer

Chain and Paddle mixer uses a tub or box containing a chain and paddles or slat conveyor to tumble the feed ingredients within the tub end to end. Figure 2.5, an auger at the front of the mixer provides additional mixing and moves material to the discharge.

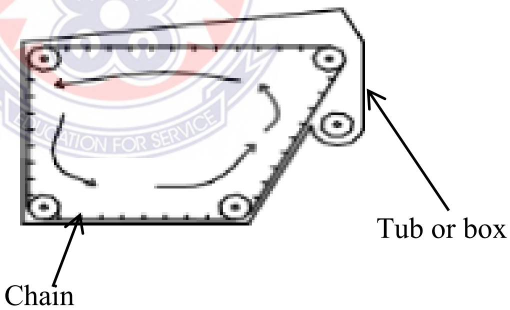


Figure 2.5: Chain and Paddle Electric mixer

Reel Mixer combines a set of augers and a reel similar to a combine reel in a hopper. (Figure 2.6). Feed is lifted and tumbled by the reel moving it to the rotating augers, which provide a mixing action, moves feed from end to end, and to the discharge door. Knife sections on the auger flights cut or tear long dry hay into 3-4-inch pieces and incorporate it into the ration. An optional hay pan allows the hay to be metered into the mixer providing the ability to break up large portions of dry hay or baleage, Kammel, D. W. (2008).

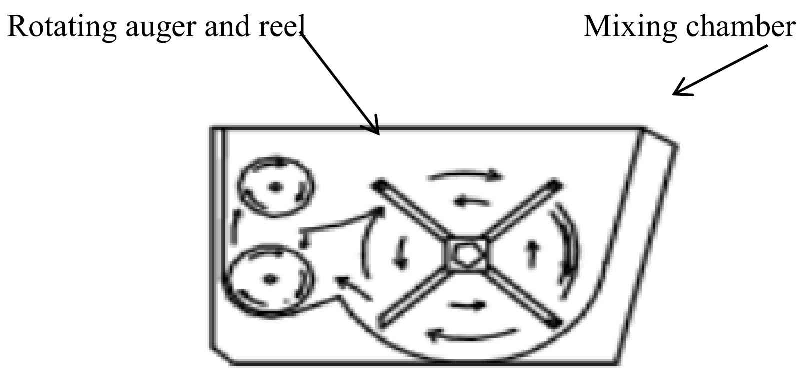


Figure 2.6: Reel Electric mixer

Albright, (2008) shows that, the general principle of a vertical mixer auger is to Sweep materials onto the front edge of the lower flighting section, where it is elevated upwards, sliding on top of the flighting sections, to the trailing edge of the upper lighting. As the feed material is carried upwards by the auger flighting, a void is created between the auger flighting and the sidewall of the mixer. The material from above falls downward into this Void, causing a continuous boiling action of the material inside the mixer.

Although several researchers (Ojo et al., 2014; Olugboji et al., 2015) have worked on designing and fabrication of this machine, it is necessary to develop using another conceptualized design of a fish meal pelletizer for improved production of feed meals. Therefore, this study has highlighted the design, fabrication and the performance evaluation of poultry feed mixer. More so, the discharge efficiency, percentage loss due to residue ingredients, and production rate were evaluated. Likewise, the percentage moisture content removal was also investigated after drying for some days.

Daniyan et al (2018) observed that, the horizontal livestock feed mixer was designed, fabricated and the performance evaluation was successfully carried out on the mixer. It is relatively cheaper than the machines available at present used for the same purpose in the market and its performance evaluation shows that it is an efficient machine. The machine was designed and fabricated with a view of reducing human effort and time by exploring the various principles associated with machine design reported by (Makange, 2016).

Osokam et al., (2012), design and fabricate a multi-purpose industrial tumble drum mixer at a cheaper and more affordable prices to our farmers, this work aims at producing feeds for poultry birds. He also seeks to develop a model that will use electrically operated industrial poultry feed tumble mixer which arises from the fact that most of the locally produced feeds have undergone primitive and inefficient means of manual processing. Poultry feed mixer play a major role in poultry farm. The expenditures on the feeding of poultry species constituted about 75% of the cost of producing eggs and the species. With poultry feed mixer, the farmer can mix rations himself, be self-reliant and sure of the quality of the feed and can make some savings also since he/she is not buying an already prepared poultry feed (Ekeocha, 1984) as cited in Victor (2013). Fox, (2014) observed that, mixers with horizontal augers typically have one or more horizontal augers for mixing the feed ingredients. With multiple auger mixers, the mixing action occurs when one or two of the augers counter-rotates, moving the feed in opposition to an adjacent auger. Knife sections are often attached to auger flights to cut or tear long stemmed alfalfa hay into pieces of three to four inches in length. However, many horizontal auger mixers do not handle grass hay or baleage well in that these types of feeds tend to wrap around the augers.

Ashwin and Shaik, conducted a research on design, development and evaluation of a hand operated Bean Sheller. The Bean Sheller consisted of a cylinder and a concave. . It was observed by the author that for hand operated Bean Sheller at a moisture content of 12% wet and at a feed rate of 130kg/h, the shelling efficiency, unshelled percentage and visible damage was found to be 99.56%, 0.44% and 1.07%, respectively as cited in Anthony et al., (2017).

2.8 Manufacturing

Manufacturing is the means by which the technical and industrial capability of a nation is harnessed to transform innovative designs into well-made products that meet customer needs. This activity occurs through the action of an integrated network that links many different participants with the goals of developing, making, and selling useful things. Manufacturing is the conversion of raw materials into desired end products. The word derives from two Latin roots meaning, 'hand' and 'make'. Manufacturing, in the broad sense, begins during the design phase when judgments are made concerning part geometry, tolerances, material choices, and so on.

The small-scale industries in the country are in dire need of a highly nutritious poultry feed for their birds to increase production output. The necessity to boost and sustain the economy which require a well-planned industrialization to suit local conditions and demand could accelerate the pace and scope of industrialization by increasing the level of our designing

2.9 Summary of and manufacturing (computer-aided) rather than mere assembling activities such an effort would reduce importation of machines, spare parts and components that can be produced locally, Osokam et al., (2012).

According to Medallaine et al., (2016), mixing time also affects mixer efficiency. The vertical-type is generally slower than a comparably sized horizontal-type. Horizontal mixer requires shorter mixing time and higher percentages of liquid may be added to the feed compared to vertical mixer. They further added, horizontal mixers with either paddles or ribbons typically require about 5 to 10 minutes mixing time to get a coefficient of variation below 10% while vertical mixers require approximately 15 minutes for optimum feed homogeneity. Fox, (2014) reported that, a problem exists with stationary mixers of the vertical auger type, in that, they must be especially designed to accommodate a placement relative to in-feed and discharge conveyors commonly used with Such mixers. Also, surrounding building structures must also be taken into account. This presents a problem for the mixer manufacturer in that the location of the discharge door of the mixer tub must conform to a customer's particular layout.

2.9 Literature Review

The review show that, there are many challenges facing the small-scale poultry farmers in Ghana, specifically northern region. Poultry feed mixing has been a problem to the poultry farmers who could not have access to the imported mixing machine on their own. The research project developed was based on the empirical literature developed in the reviewed because all the researchers shared the same view in terms of challenges affecting the small-scale poultry farmers at the districts in the northern region.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

In this chapter, various methods adopted materials/equipment and operation principles used are presented.

3.2 Methods

Experiments were carried out to construct and evaluate the performance of the manufactured poultry feed mixer to optimize values of the main operating parameters during feed processing. The feed mixer consists a mixer supporting frame (stand), mixing chamber which contained a shaft with blades attachment which rotate as a result of the action of the driven sprocket that is connected to the driving sprocket of the electric motor by means of a chain. As soon as the machine is switched ON, the driving sprocket rotate the driven sprocket which set the machine ready to receive the ingredients to be mixed. The ingredients are feed from the point of entrance of the mixing chamber. The blades then turn the ingredients up and down continuously in the mixing chamber until the feed is complete uniformly mixed.

3.3 Test Performance

The experiments were carried out at the experimental laboratory of Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAM-USTED) as the machine shown in Figure 3.1.

Figure 3.1: shows poultry mixer machine

3.3.1 Field Test

The test was performed in the following stages; General test, No load and Load test.

3.3.2 General Test

The dimensions of the major components of the machine were taken. The results of these were recorded. The observations were made on the following:

- The marking of the feeding inlet and the direction of rotation of the shaft.
- The adequacy of bearing protection and safety especially at moving parts.
- The lubrication of moving parts.
- The tightness of bolts and nuts and chain/belt.
- Transportation of machine to the mixing bay.
- The ease of changing component requiring frequent replacement.
- Feeding rate as well as concave clearance.

3.3.3 No Load Test

The mixing machine was run-on no-load test for a total time of 50 minutes, of ten (10) minute duration on a run to determine with a tachometer (instrument for indicating speed of rotation) the range of shaft speeds obtainable from the range gear/pulley size available. During the idle running period, time was taken to observe the following:

- The smooth running of the shafts in their respective bearing.
- Any heating up of bearing.
- The presence of any undue knocking or rattling sound.
- Slackness of any component.

3.3.4 Load Testing

Shaft speed was selected at the time the engine was started and allowed to warm up for five minutes and the ingredients were fed into the machine. The ingredients which were discharged at the outlet points were collected separately and analyzed to determine the performance characteristic of the machine at a set shaft speed.

However, the following ingredients were used for the conduct of the test, they include maize, wheat bran, soya meal, oyster shell and concentrate. The test run of the machine was carried out to determine the mixing efficiency through using different capacity at different time intervals. Tables 1,2 and 3 indicate the weight of the ingredient and percentage of the mixer in chapter four.

The machine was first tested with 2.5 kg of maize, 1 kg of wheat brand, 0.5 kg of soya meal and 0.25 kg each of oyster shell and concentrate, sum up to 4.5 kg weight as input feed for the first test-run. Also, 5 kg of maize, 2 kg of wheat brand, 1 kg of soya meal and concentrate and oyster shell were also added with 0.5 kg each. And the third test measurement were as follows; maize 7.5 kg, wheat brand 2.5 kg, soya meal 1.5 kg and 0.75 kg each for concentrate and oyster shell.

The first test of the experiment was allowed to run for three (3) minutes, six (6) minutes and nine (9) minutes for the second and third test respectively. The output of the machine, during the experimental test weighed 4.08 kg, 8.5 kg and 13.8 kg for the input of 4.5 kg, 9.0 kg and 14.5 kg for first, second, and third test respectively, and the efficiency of the machine was determined.

3.4 Grain Mixed Surfaces and Particles Morphologies Observation

The fractured end of the bracken ingredients and grain outward layer was observed after the machine mixed the test and was kept for the normal dried chamber after careful studies captured by digital microscope, 5x digital zoom compatible with USB 2.0 and USB 1.1 as shown in Figure 3.2.

Figure 3.2: Digital microscope

3.5 Machine tools and Equipment Used for the Construction

Tools and equipment used during the construction of the machine are; electric arc welding, drilling machine, portable hand grinding machine, lathe machine, hammer, try square, hacksaw, table vice, spanner, chisel, and so on.

3.6 Fabrication Processes of the Frame

The frame is made up of mild steel angle iron of thickness 3 mm, the main frame is the component that provides structural support. Using hand grinding machine with disc, four pieces of length 65 mm each and two pieces of length 20 mm each were cut from the standard length. Two holes were drilled on the 65mm angle plate by using hand drill machine. These components were welded together, using a welding machine, to form the main frame (structural support) of the machine. Four metal rods 160 mm x 10 mm were cut and welded bolts and nuts at each end of the rods to support the stand of the machine.

3.6.1 Fabrication Processes of the Shaft

A solid rod of 70mm was measured and cut using hand grinding machine with its cutting disc. A lathe machine was used for facing, smooth surface and good finishing was carried out on the rod and a desired diameter of 25mm was obtained.

3.6.2 Fabrication Processes of the Collector

A 1mm plate was measured, marked and cut to the size of 54 mm x 29 mm length. The plate was then folder in a rectangular shape with height of 6 mm using sheet metal work tools.

3.7 Design Components Description

The machine which has been produced from the assemble of various components were designed based on the properties of materials including the frame, shaft, bearing, mixing chamber, chain and sprocket and mixing blades. The design considerations for each component were discussed below;

3.7.1 The Frame

This component is the primary part of the machine made of angle mild steel shown in Figure 3.3.

Figure 3.3: The frame

It is a ferrous metal material that possessed the required properties such as ductility, plasticity, and also some considerable strength which are capable of being fabricated to the required degree of functional tolerance. Other selected factors are being cheap and most abundant in the market in case of replacement, machinability and workability.

3.7.2 Mixing Cylinder

The mixing cylinder of this machine used mild steel metal sheet which are of considerable strength and are capable of being fabricated to the required degree of functional tolerance which are preferably used for reliability of operation and lessened frequency maintenance. It is also used because of its abundant in the market and weldability. Figure 3.4 shows the mixing cylinder of the machine.

Figure 3.4: The Mixing Chamber

3.7.2.1 Volume of Mixing Chamber

The design calculations which was used for the construction and fabrication of the poultry feed mixer for the small-scale farmers was hereby presented. The volume V of the cylinder is given by Equation (3.1) as shown.

$$V = \pi \frac{d^2}{4} h \quad \text{.. ....} \quad (3.1)$$

Where;

d is the diameter of the circular base (0.68m) and h is the height of the cylinder (0.4m).

From equation (3.1), the volume is given as;

$$V = 3.142 \times \frac{0.68^2}{4} \times 0.4$$

$$V = 0.145 m^3$$

3.7.3 Shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up with the shaft permit the power to be transferred to various machines link up to the shaft. In order to transfer the power from one shaft to another, the various members such as sprocket and chain, etc. are mounted on it. The maximum permissible working stress for transmission shaft include:

(a) 112 MPa for shaft without allowance for keyways

(b) 84 MPa for shaft with allowance for keyways. According to America Society of Mechanical Engineers;

3.7.3.1 Mixing Shaft

This is also made of mild steel besides the considerations mentioned above, the researcher considered its toughness properties which can be improved through heat treatment, shown figure 3.5. This shaft goes through the mixing chamber, a metal ribbon blade is mounted on this shaft which performs the mixing action. The ribbon blade is made spiral and joined to the shaft with the aid of thick plate.

Figure 3.5: Mixing shaft

3.7.3.2 Torque of Shaft

According to Khurmi and Gupta (2005), shafts may be designed on the basis of rigidity and strength. When subjected to twisting moment only, the torque developed in the shaft is given by equation (3.2).

$$T = \frac{\pi \tau d^3}{16} \quad \ldots\ldots\ldots\ldots \quad (3.2)$$

Where;

T is the torque, **τ** is the maximum shear stress and ***d*** is the diameter of the shaft (m) in (equation 3.3)

$$\tau = \frac{F}{A} \quad \text{.. (3.3)}$$

F is the force acting on the body (N) and ***A*** is the cross-sectional area of the body (m^2)

$$A = \frac{\pi d^3}{4} \quad \text{... (3.4)}$$

$$F = mg \quad \text{... (3.5)}$$

Where; ***m*** is the mass of the body (kg) and ***g*** is the acceleration due to gravity (m/s^2)

$$m = \rho v \quad \text{...(3.6)}$$

The density is 1042kg/m^3, hence the volume of the cylinder is calculated as 0.145m^3.

Therefore,

$$m = \frac{1042kg}{m^3} \times 0.145m^3 = 151.09kg$$

$$F = 151.09 \times 9.81$$

$$F = 1482.19N$$

$$\tau = \frac{4F}{\pi d^2} \quad \text{... (3.7)}$$

$$\tau = \frac{4 \times 1482.19}{3.142 \times 0.68^2} = 4080.75N/m^2$$

From equation (3.2), the shaft torque is calculated as

$$T = \frac{3.142 \times 4080.75}{16} = 801.25Nm$$

The torque of the shaft is 801.25Nm

3.7.4 Mixing Ribbon:

Ribbon is a thick sheet metal made of stainless steel which is made up of a shaft and helical blade. The helical blade is coiled around a cylindrical drum attached to the shaft and hence the helical blade forms a spiral shape on the shaft Figure 3.6 shows the shaft and mixing ribbon.

Figure 3.6: The mixing chamber

3.7.5 Power Transmission

Power transmission by the shaft is given as shown in Equation (3.8):

$$p = T\frac{(2\pi N)}{60} \quad \text{...} \quad (3.8)$$

Where;

P = power rating of the electric motor (Watt)

T = torque transmitted in Nm and

N =number of revolutions per minute (Assume the number of revolutions per minute is 100).

$$p = \frac{801.25 \times 2 \times 3.142 \times 100}{60}$$

$$p = 8391.75833W$$

$$p = 8.391758kW$$

Using a power factor of 1.2, the required power is calculated as 9.988kW. Hence, a 4kW electric motor will produce sufficient motion for the chain and shafts.

3.7.6 Chain and Sprockets

Chain and sprockets are used to transmit motion and power from one shaft to another, when the centre distance between their shafts is short. The mixer shaft is supported by two bearings. Chains are made up of number of rigid links which are hinged together by pin joints in order to provide the necessary flexibility for wrapping around the driving and driven wheel. Chain and sprocket were chosen for this work to transmit power from the electric motor to the shaft of the mixing unit. It also selected over belt and rope in order to avoid slipping during load operation. The driving and driven sprocket have 14 teeth each, this implies that there is a constant in speed at a ratio of 1:1 at the chain and sprocket drives.

3.7.7 Bearing:

It exists as a standard component, it is of various types- cone bearing, roller, knuckle bearing and from steels-chromium steel. Among these types mentioned above, some are sealed while some are not. For this design, the researcher opted for the knuckle bearing with sealed ball bearing to avoid grease contamination on the feed. The selection of knuckle bearing is that it balances itself and possesses the required hardness and toughness.

3.7.8 Electric Motor:

Electric motor is the source of power for the design and it exists in a standard component. It has a single phase and three phases, but for this design, the researcher used the single phase. It has one-third horse power (1/3hp) and the speed of the electric motor is constant.

3.8 Material used for the Proposed Design

The selection of proper material for engineering purpose is one of the difficult problems for the designer. The best material is the one which serves the desired objectives at a minimal cost. The materials for each component of the poultry feed mixer were selected based on the desired objective at the minimum cost without compromising the availability and suitability of the materials for the working conditions in services were also considered. The major properties of material which were considered in the design are; strength, stiffness, ductility, toughness, fatigue, resilience, hardness, creep and machinability, cast ability, weld ability, the material visual appearance, frictional properties and internal vibration damping properties.

The machine was constructed from metallic materials, this metal is divided into two categories which include ferrous metals and non-ferrous metals. Ferrous metals are those metals which contain iron as their main constituent such as steel, cast iron, wrought iron etc., whilst nonferrous metals are metals which have a metal other than iron as their main constituent e.g., aluminium, copper, tin, zinc etc. The selection of proper material for engineering purpose is one of the difficult problems for the designer. The best material is the one which serves the desired objectives at a minimal cost. The materials for each component of the poultry feed mixer were selected based on the desired objective at the minimum cost without compromising the availability and suitability of the materials for the working conditions in services were also considered Victor (2013).

The following factors were considered during the selection of the material:

- The cost of the materials
- Availability of the material
- Suitability of the materials for the working conditions in service.

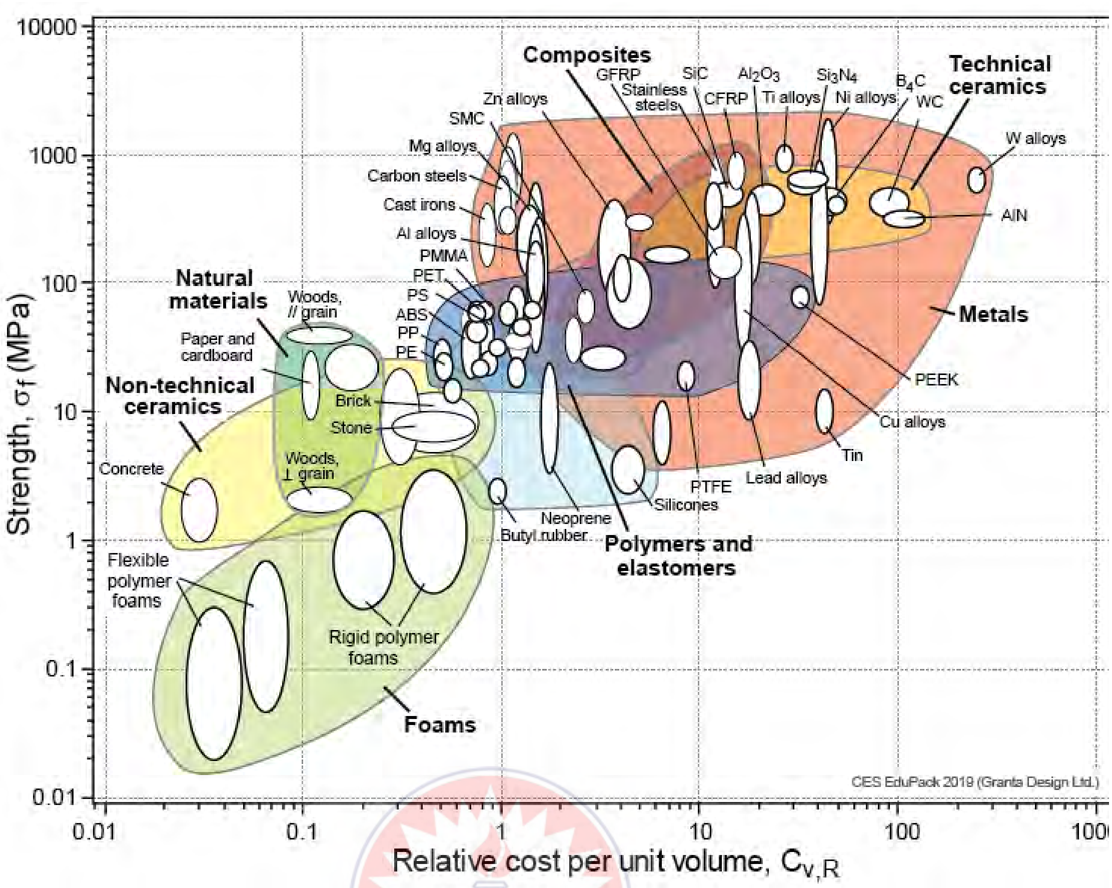


Figure 3.7: Materials selection chart

The chart in figure 3.7 shows the appropriate selection for the index place on it and it identifies five classes of materials. These include; forms, polymers, natural materials and metals. The following materials were selected from the chart for the proposed design, such as steel, aluminiun, cast iron and stainless steel. The reason been that, they can be used in machine parts for many purposes. Other materials in the chart were eliminated due to their porosity, brittle, low value of toughness nature.

The final choice materials for the proposed design were centred on steel and cast iron based on their properties, whichinclude toughness, tensile strength, ductile, hardness, etc. The selected materials in the chart shows that the cost of selected materials is less expensive, available in the market, best performance at reasonable price and environmental friendly.

3.9 Design Considerations

Cost: cost has always been the major factor of consideration while constructing the machine elements of machine. The best machine design is the one which helps to get the finished product with all the major functionalities and highest possible quality at the lowest possible cost.

Effective and efficiency: Machines expected to be fully functional, consuming low power giving high output in terms of the number of times the feed produces with respect to time.

Strength: the machine parts should be strong enough to sustain all the forces if designed, so that, it is not damaged or permanently deformed during its life time.

Stiffness or rigidity: The machine should be rigid enough so that under the effect of applied forces for which it is designed there is no deformation of the machine or machine elements beyond the specified limits.

Wear resistance: Wear is the removal of the material from the metallic surface when two surfaces rub each other. If there is more removal of the material, the component will become weaker and eventually break.

Operational safety: For the safety of the operator of the machine, the hazard producing things from the machine should be eliminated.

3.10 Machine Description and Working Principles

The machine is made of the frame, mixing chamber, shaft, and chain and sprocket. The mixing cylinder is welded to a short thick plate of 3mm to support the cylinder to the main frame. The frame was fabricated from a standard length of mild steel angle plate of dimension at (40 x 40 x 3) mm. Using a portable hand grinding machine, four pieces of length 65 mm each and two pieces of length 20 mm each were cut from the standard length. These components were welded together, using a welding machine, to form the main frame (structural support) of the machine. In the cylinder, which houses the shaft attached with the mixing blade known as auger. The shaft is placed horizontal at the center of the machine cylinder and passes through to allow its free movement during operation. A feeding gate is made on top of the mixing cylinder through which feed ingredients are fed into the machine. Another gate is also created at the bottom part of the mixing cylinder for the mixed feed discharged and the mixing chamber of the machine is mounted on a rigid frame platform which carries the whole weight of the machine and provides the structural support and stability for the machine. Mixing ribbons was made by welding 3mm thick aluminium plate to the shaft. The power unit which consist of chain, and sprocket to transmit power from the variable electric motor rated 8kW rotates at a maximum speed of 1425rpm and the ratio of 1:1.

3.11 Principle of Operation of the Machine

The machine is made up of a cylinder welded to the short thick plate of 3mm to support the cylinder to the main frame. Inside the cylinder, where shaft and the mixing blade known as auger, houses the short and mixing blades. The switch of the electric motor of the mixer is set at the ON position. The feed ingredients are introduced into the mixer through the feed gate located at the upper part of the mixing chamber. The ingredients introduce into the chamber is in order of quantity. With the ingredients inside the mixing chamber, rotating action of the central based horizontal acting ribbon, lift it up from the lower of the cylinder through the helical plate and drops it up at the upper end of the chamber. After thorough mixing is achieved, the flap of the charge channel is open to allow the mixed component out of the chamber.

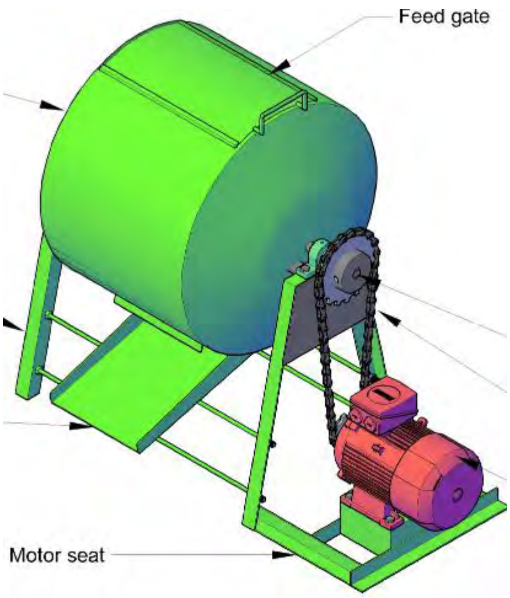
3.12 Existing machine

Existing poultry feed mixer is always a disadvantage to the small-scale farmers in the region and it is under pressure as a result of a number of customers who always queue for their poultry feed to be mixed. The increasing number of small-scale poultry farmers in the two districts is a challenge to the existing machines by putting more pressure on to the facility. It is also very difficult to mix small quantity of feed on the existing machine due to the voluminous size of the mixing chamber. Many small-scale poultry farmers prefer to prepare their feed at home than using the bigger machine.

Power outage is another factor which affects feed during processing, and this usually led to improper feed mixer. Also, the cost of existing machine is a hinderance to the individual farmer to own. Another challenge is the expertise who will work on the machine when develops a fault. This could affect the efficiency of the machine.

3.13 Modified of Machine

Upon the researcher's investigation, he observed that, the poultry farmers always spend a lot of time at the mixing centre. At the end, because of the inconsistent running of the mixer, they hardly obtain proper mixture of their feed. The adopted machine was modified and designed with double power sources of both electric motor drive mixing, and manual (handle/pedal) operating type with different variations of a selected speed. However, the driven shaft end gear can be changed and replaced by a pulley to suit both electric motor, and manual operating (handle/pedal). This improvement had significantly reduced in variation of feed components, particle sizes and suitable for variations of moisture contents and suitable for variations of humidity environmental levels.



(a) **(b)**

Figure 3.8: Poultry feed mixing machine (a) Electric mixer (b) manual mixer

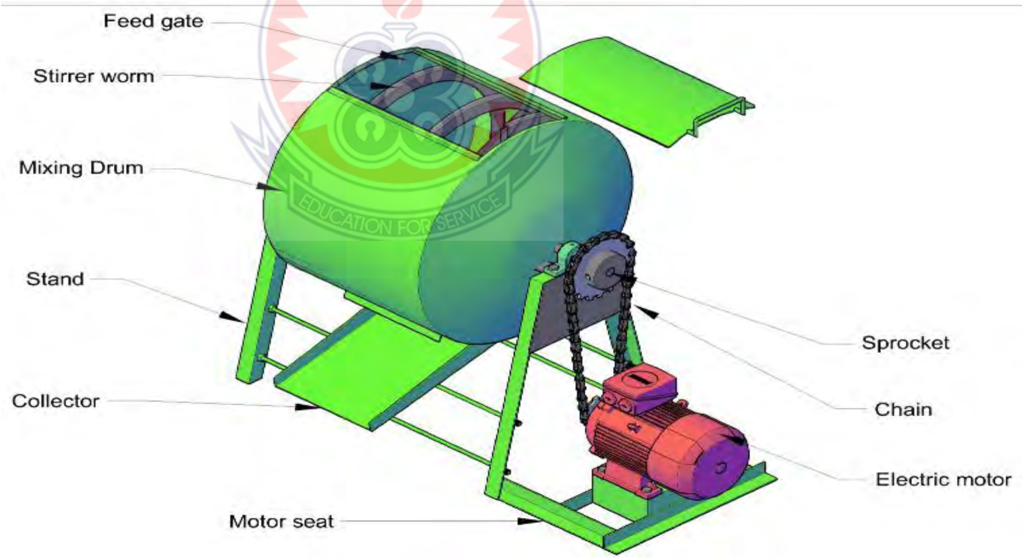


Figure 3.9: View of the poultry feed mixing machine

Figures 3.9, show the Isometric, 3.10 orthographic view and 3.10 for exploded view of the machine.

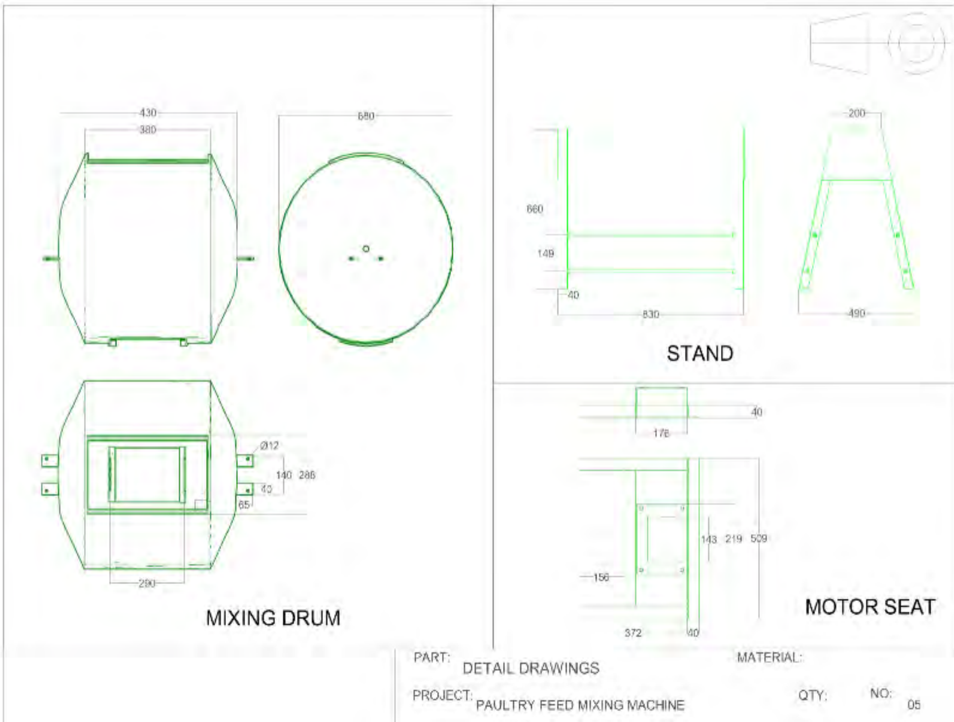


Figure 3.10: Orthographic view

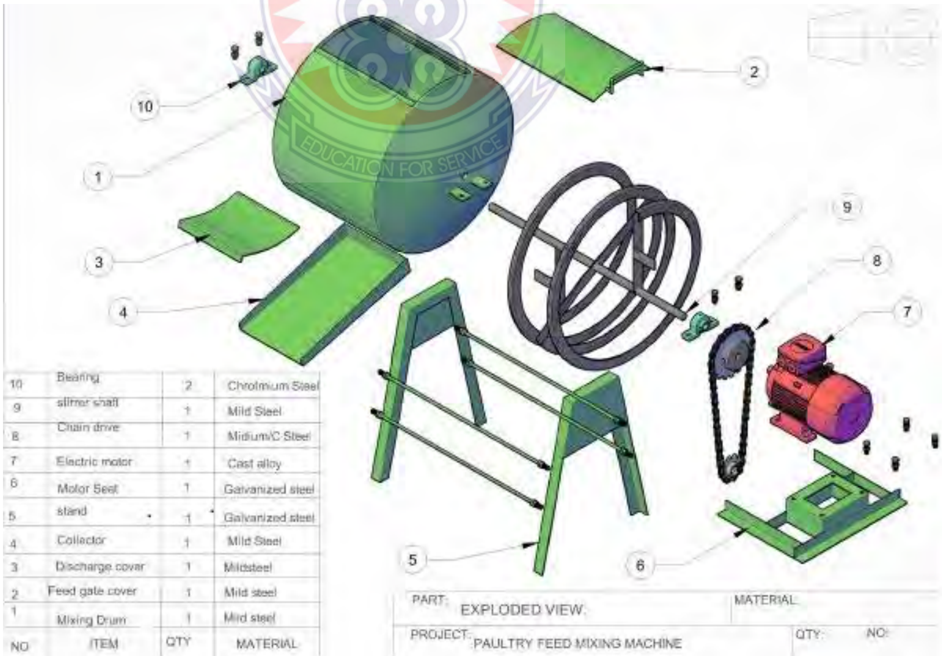


Figure 3.11: Exploded View

3.14 Parameters Determination

3.14.1 Determine of Moisture Content

Moisture content (wet basis) %, moisture content = Mo – Mi × 100/Mi

Mi = mass in grams of the dry test portion

3.14.2 Formula for Peripheral Speeds

Peripheral speed is given by Vp = W × R…………………………………(3.1)

$$Vp = \frac{2n\pi}{60}\ \frac{(d + 2h)}{2}\ m/s \qquad \ldots\ldots(3.2)$$

Where n = drum speed (rpm)

h = height of stirrer worm (m)

3.14.3 Determination of Losses

% of unmixed produce = (quantity of unmixed produced from all leakage outlets) x100……(3.3)
Total produced yield.

% of blown loss = (produced obtained at input-outlet + produced blown overboard)x100
Total produced yield ……………………………………………..(3.4)

Yield = produced stacked in the machine + produced blown overboard + produced obtained at all outlets.

3.14.4 Determination of Efficiencies

Mixing efficiency = 100% - percentage of unmixed produced (grains and ingredients) -(3.5)

Machine efficiency = (mixed grains and ingredients received at produced spout) × 100%
Total mixed grains and ingredients received at spout……(3.6)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter deal with the results obtained and discussions of the study. The analysis was centred on the weight and percentages of material, mixed at different weight of the ingredients, summary of the result and percentage loss due to the non-mixed ingredients and others. It also presents the mixed produced with constant moisture content and efficiency, mixed produce losses with constant moisture content and machine efficiency mixed produce with different test and machine efficiency as well as mixed produce surface particles structure. The analysis was centred on the duration of mixing, effectiveness and efficiency of the machine on the bases of the produce and the equipment performance of the poultry feed.

4.2 Technical Operation Principles of the Modified Machine

Test one was a mixture of 4.5 kg and the result is represented in Table 4.1. At first, the machine was set on to run for about 3 minutes and mass of the product obtained at the outlet was recorded. The value was obtained for the weight of the ingredients, mixing time, efficiency of the machine and production rate were 4.5 kg, 3 minutes, 90.67% and 90 kg/h respectively. This means that, 4.5 kg of ingredients were processed for 3 minutes, the production rate was 90 kg/h and the efficiency of the machine is 90.67% during the first run test. Morad and Hend, (2014), indicated that, on-farm feed system normally use three types of mixers; vertically, horizontal and rotating drum. The mixing time on vertical mixers normally run 10 to 15 minutes and horizontal or rotating drum mixers can mix in 5 to 10 minutes. Therefore, the degree of mixing in 3 minutes achieved was 90.67%.

Table 4.1: Weight and percentage of materials mixed to achieve 4.5kg of feed

S/N	Ingredients (kg)	Weight of Ingredients (Kg)	Percentage of mixer (%)
1	Maize	2.5	55.6
2	Soya meal	0.5	11.1
3	Wheat brand	1.0	22.2
4	Oyster shell	0.25	5.6
5	Concentrate	0.25	5.6
Total		**4.5**	**100**

Source: Field test, (2020).

From Table 4.2, 9.0 kg, weight of ingredients were loaded into the machine and was allowed to run for about 6 minutes, after that, the mass of the product obtained at the discharged unit was 8.5 kg as recorded. The efficiency and production rate were determined as 94.44% and 90 kg/hr respectively. Therefore, the result in table 4.2 shows an improvement in efficiency when the mixer was allowed to run for 6 minutes with the appreciable increase in capacity of 9.0 kg.

Table 4.2: Weight and percentage of materials mixed to achieved 9.0kg of feed

S/N	Ingredient (kg)	Weight of Ingredient (Kg)	Percentage of mixer (%)
1	Maize	5	55.6
2	Soya meal	1	11.1
3	Wheat bran	2	22.2
4	Oyster shell	0.5	5.6
5	Concentrate	0.5	5.6
Total		**9.0**	**100**

Source: Field test, (2020).

Table 4.3 shows 14.5 kg, weight of ingredients fed into the machine, which was then allowed for about 9 minutes to run, after that, the mass of the product obtained at the discharged unit was 13.2 kg as recorded. The efficiency and production rates were determined as 91.44% and 90 kg/hour respectively. However, the amount of mixing increased with increase in time from 6 to 9 minutes while there was a negligible reduction in degree of mixing, as time increases to 9 minutes. According to Balami et al., (2013), a mixing performance of up to 95.31% was attained in 20 minutes of operation and evacuation of mixed materials from the mixer was at full capacity (60 kg) while the average value of coefficient of variation for the three replicates was 4.69%. Therefore, the result in table 4.3 shows a significant reduction in efficient percentage by 3.41% resulting from the increase in feed capacity with respect to the duration time of 9 minutes. Hence, the machine could not perform effectively when 14.5 kg weight was loaded. It also indicated that increasing mixing time for more than 9 minutes decreases the discharge rate and the efficiency of the machine.

Table 4.3: The weight and percentage of materials mixed to achieve 14.5kg of feed

S/N	Ingredient (kg)	Weight of Ingredient (Kg)	Percentage of mixer (%)
1	Maize	7.5	51.7
2	Soya meal	2.5	17.2
3	Wheat bran	3.0	20.7
4	Oyster shell	0.75	5.2
5	Concentrate	0.75	5.2
Total		**14.5**	**100**

Source: Field test, (2020).

There is an increase in the uniformity of mixing as shown in Table 4.4, as the time of duration increases from 3, 6, and 9 minutes at a constant speed with respect to increase in weight, the mixer was able to achieve effective mixing between 6 to 9 minutes. Despite the quality uniformity of the mixture, there was a reduction in efficiency of the machine during the third test due to the increase in feed rate, as more ingredients were compacted in the mixing chamber and this caused a drop in pressure, henceforth causes a reduction in efficient of the machine.

Table 4.4: Summary of the results

Test	Ingredients Weight (kg)	Mixing Time (minutes)	Mixture Weight/Output(k)	Efficiency (%)
First test	4.5	3	4.08	90.7
Second test	9.0	6	8.5	94.4
Third test	14.5	9	13.2	91.0
Total	**28**		**25.78**	**92.1**

Source: Field test, (2020).

4.3 The Effectiveness and Efficiency of the Machine on the Bases of the Produce and Equipment Performance

Table 4.5 shows mixing weight and mixing time of different weight of feed for which different tests were carried out. These included 4.5 kg, 9.0 kg and 14.5 kg of feed at different mixing time intervals of 3, 6 and 9 minutes with respect to the recorded mixing weights of 4.0 8kg, 8.5 kg and 13.2 kg respectively. This was used to determine the efficiency and mixing rate of the machine. The results obtained show that, the machine slightly mixed the ingredients of 4.5 kg at 3 minutes. However, when the weight was increased to 9.0 kg with respect to 6 minutes, the ingredients were fully mixed and also equally mixed when the weight was increased to 14.5 kg with respect to its corresponding time intervals. Peter (2013) "observed that, the aspect of manual mixing is much healthier for birds and better in efficiency and output, than the use of shovel or hand and basin. Their outputs and efficiencies are not to be reckoned with in production of poultry feed in a proper commercial poultry farm". Daniyan et al., (2018), "also indicated that, the performance evaluation of the machine was carried out to determine the mixing efficiency using different feed capacity at different time intervals and percentage recovery rate on the feed rate". The mixing time and degree of mixing was observed to increase with increase in feed weight. The horizontal feed mixer developed was highly efficient, cost effective and solves problems associated with manual mixing during livestock feed production. Therefore, the results showed that, the mixing capability of the machine is effective and efficient.

Table 4.5: Mixing weight and mixing time of different weights of feed

Test	Mixing Weight (Kg)	Time (s)	Mixing Rate
Test 1	4.08	3	Slightly mixed
Test 2	8.5	6	Fully mixed
Test 3	13.2	9	Fully mixed
Total	**25.78**	**18**	

Source: Field test, (2020).

4.4 The Comparative Analysis of the Existing and Modified Machine

The result in Table 4.6 indicates the percentage loss of ingredients during the experiment tests for each operation, thus, experiment 1, 2 and 3, were 9.33%, 5.56% and 8.97% respectively. The results also indicated variation in percentage loss among the samples tested ranging from 5.56% to 9.33% with an average percentage of 7.95%. This percentage loss was due to the non-mixed ingredients and leakages from the mixing chamber of the machine.

Table 4.6: Percentage (%) Loss Due to Non-mixed ingredients5.56

Test	Ingredient Weight (Kg)	Mixing Weight (Kg)	Percentage Lost (%)
Test 1	4.5	4.08	9.33
Test 2	9.0	8.5	8.97
Test 3	14.5	13.2	5.56
Average Total	**9.33**	**6.59**	**7.95**

Source: Field test, (2020)

The constructed modified machine was tested and the results showed high machine efficiency of 92.07%. When the efficiency of the modified new machine was compared to that of the existing machine, it was discovered that, the efficiency of the existing machine was 2.6% lower and also compared to the 3.0% (Ikubanni *et al.*, 2019). He reported that, the increase of the discharge time led to an increase in the discharge efficiency of the machine thereby reducing weight of residue ingredients. Henceforth, this might be due to the number of minutes allowed to run for each test. If more time is allowed for the machine to run, the efficiency will increase more.

Figure 4.1 shown the evaluation result on the mixed rate of ingredients with constant shaft speed of 25.27 r/s, and evaluation moisture content of experiment 1, experiment 2 and experiment 3 were 6%, 9% and 12% and that of mixed rate were also obtained as follows; 9%, 15% and 20% respectively. It is observed that, at a lower moisture content, mixed rate was lower but increases as the moisture content also increases with constant machine efficiency.

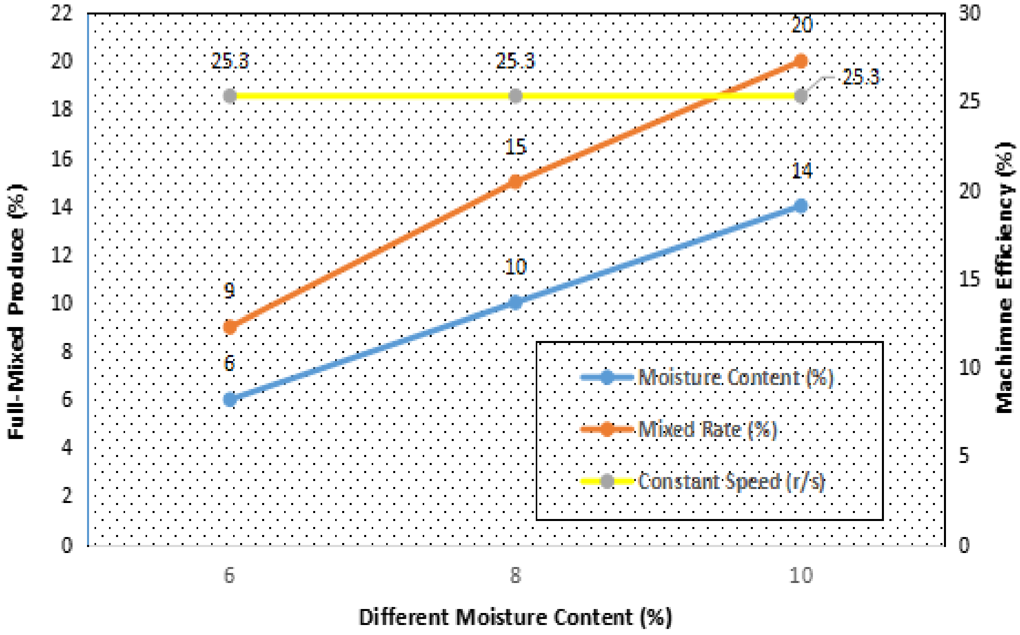


Figure 4.1: Mixed Produce with Constant Speed, moisture content and machine efficiency (Modified machine)

Figure 4.2 presents evaluation result of mixed rate and moisture content of the ingredients with constant shaft speed of 25.2 r/s. The mixed rate and the moisture content of experiment 1, experiment 2, and experiment 3 were 8% and 7%, 13% and 12% and 18% and 17% respectively. It was revealed that at lower moisture content, the mixed rate was also low and machine efficiency became constant.

In comparison, it was observed that the existing machine mixed rate and moisture content were lower than that of the modified machine with the same quantity of ingredients at a constant machine efficiency.

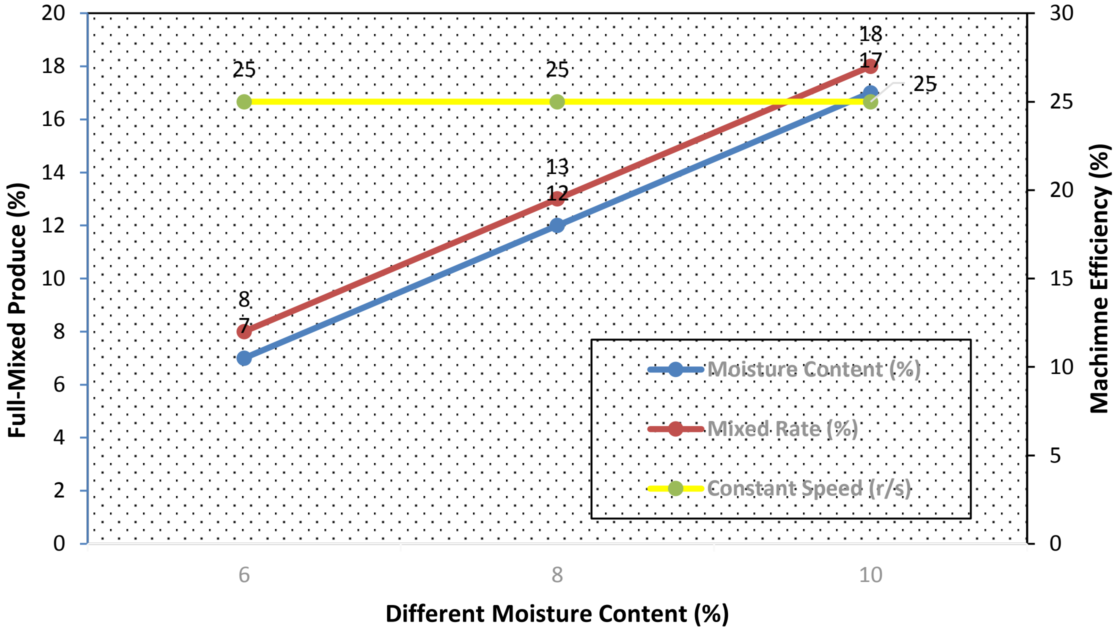


Figure 4.2: Mixed Produce with Constant Speed moisture content and machine efficiency (existing)

Figure 4.3 shows the chart on the evaluation results on the total losses with shaft speed of 21.59 r/s) and moisture content of 14.5(%) being constant respectively. The result correlated of the total losses percentage of under mixed, normal mixed and over mixed were 2(%), 6(%) and 20(%) respectively. It was observed that over mixed had the maximum losses followed by normal mixed and under mixed respectively.

At the point of intersection of the mixed rate with constant shaft speed, it is expected that, the efficiency of the machine at this point is at its peak. This indicates the effectiveness and efficiency of the machines and that culminate into effective mixture of the feed.

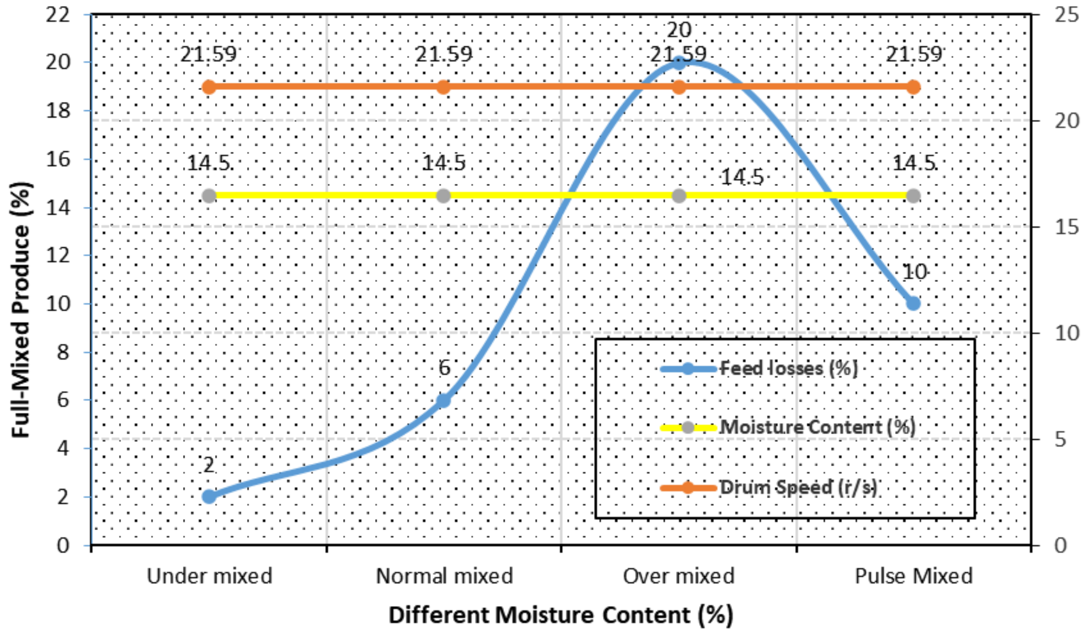


Figure 4.3: Mixed Produce Losses with Constant Speed moisture content and machine efficiency (Modified machine)

Figure 4.4 shows the evaluation results on total losses of the existing machine with constant speed of 21. r/s, moisture content of 13%. The result of total losses percentages of under mixed, normal mixed and over mixed were 2% in experiment 1, 7% and 22% in experiment 2 and 3 respectively. It was indicated that , over mixed had highest losses and under mixed also recorded lowest.

Comparing the two chats, both machines show the same pattern as indicated in figure 4.4 and 4.5, and also revealed that the loss rate of the two machines increased as the duration of time increased. However, the existing machine had the maximum losses of 22% compared to that of the modified machine.

Figure 4.4, also shows the intersected point on evaluation result on total losses with constant shaft speed of 20.5 rpm, at the under mixed, not much feed was lost as compared to normal mixed. However, at the over mixed stage, where the machine was run at its maximum, the lost graph intersected with constant shaft speed graph and this led to more feed lost at the point of intersection.

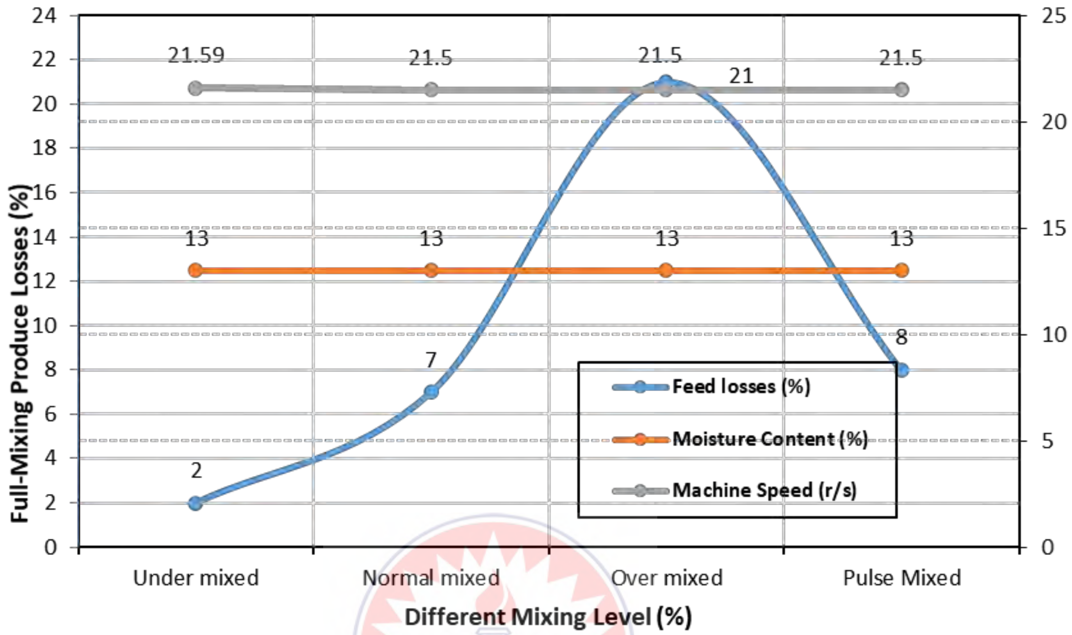


Figure 4.4: Mixed Produce Losses with Constant Speed moisture content and machine efficiency (Existing machine)

From Figure 4.5, it shows the evaluation results on the machine efficiency at different stages of tests with different evaluation of treated and measured ingredients, mixed rates, percentages and different moisture content and time of work. It was observed that in experiment 1, machine efficiency was 90.7%, experiment 2 was 94.4%, and experiment 3, 91.0% with different levels of produce weight respectively. In experiment 1, ingredient 4.5 (kg), mixing 4.08 (kg), moisture content 6%. With experiment 2 of ingredient 9 (kg), mixing weight 8.5 (kg), and moisture content 9(%). Test 3, ingredient 14.5 (kg), mixing weight 13.2 (kg), and moisture content 15% respectively.

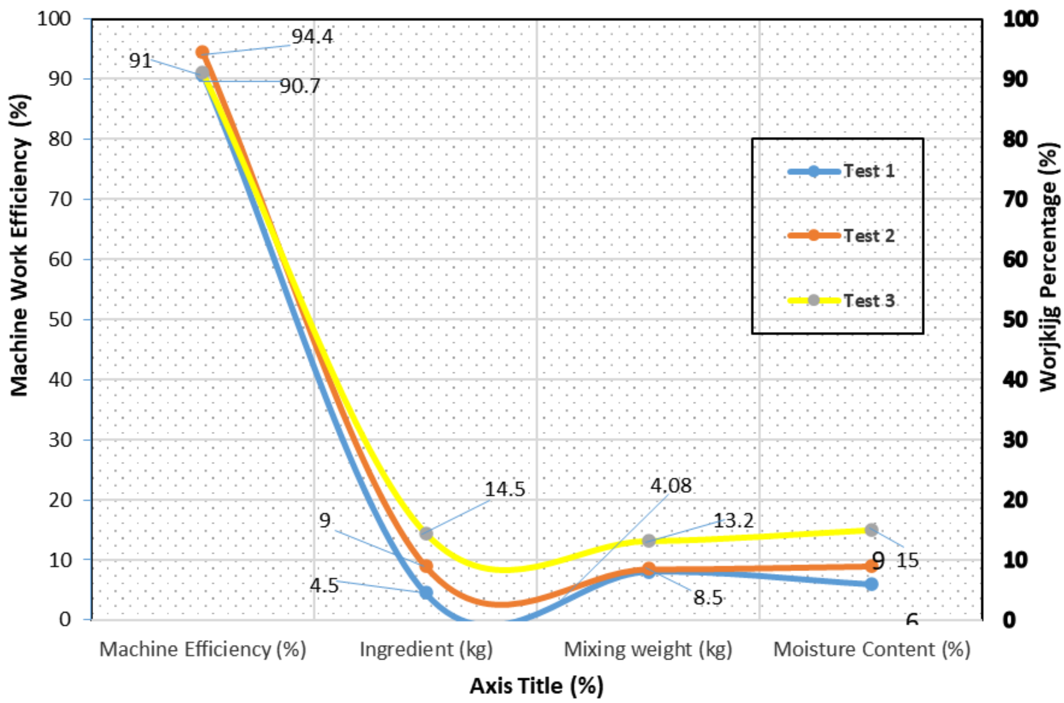


Figure 4.5: Mixed Produce with different tests and machine efficiency (Modified machine)

Figure 4.6 shows the evaluation results of the chat on machine efficiency and other stages of tests (experiments) with different evaluation of measured input ingredients, mixed rates in percentages and at different moisture content. It was observed that the machine efficiency for the three stages of tests were 83.5%, 89.0% and 87.3% for Test 1, Test 2 and Test 3 respectively with different produced weight.

Also, the input weight and moisture content were measured and evaluated as follows; Test 1, ingredient 4.5 (kg), mixed rate 4 (kg) and moisture content 10%, Test 2, ingredient 9kg, mixing rate 8.1kg and moisture content 13% and Test 3, ingredient 14.5kg, mixing rate 12.8kg and moisture content15% respectively.

In comparing the two machines, the mixing rate and efficiency of the modified machine is higher than that of the existing machine. The two chat showed that, the modified machine efficiency can performed effectively.

Note: Test 1,2 and 3 represent first, second and third experiment respectively.

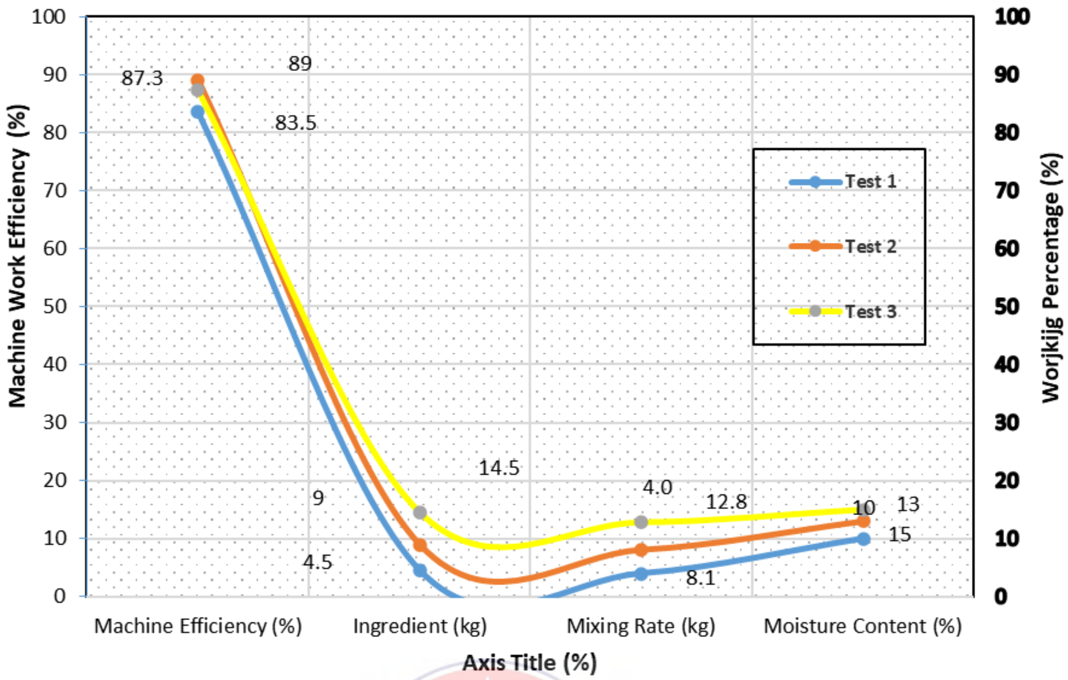


Figure 4.6: Mixed Produce with different tests and machine efficiency (existing)

The Morphology results in Fig.4.7 (a), (b) and (c) present a final mixed produce surface and interfaces of particles and regions of over mixed, under mixed and normal mixed respectively. It was observed that, the over mixed was done well, but the produce gathered large particles at one side and the smaller particles at the other side despite its good mixing mode in Figure 4.7 (a). Figure 4.7 (b) under mixed, was also observed that the grain and the ingredient were not good mixed, the big grains are skated. Figure 4.7 (c) normal mixed, it observed that, both the big and smaller grains and ingredients were well mixed, and it was observed again that the machine served as a milling machine because, both the grains and the ingredients were smoothly mixed, had reduced sizes and fewer loss of produce mixing.

Figure 4.7: Mixed produce surfaces particle structure (a) Over mixed (b) Under mixed (c) Normal mixed .

CHAPTER FIVE

SUMMARY OF FINDING, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents a summary of the main findings, draw conclusions drawn based on the results of the study, recommendations for the problems identified and suggestions for further research.

5.2 Summary of Findings

This study was on the performance of a poultry feed mixing machine, to construct, and evaluate the performance of a new modified mixing machine. During test runs of the poultry feed mixer, the ingredients used for the conduct of the test included maize, wheat bran, soya meal, oyster shell and concentrate.

Test run of the machine was carried out to determine the mixing efficiency through using different capacity at different time intervals. The poultry mixer designed for experimental work was noted to have different mixing capacities in relation to weight of feed and production rate.

In test one, a mixture of 4.5 kg was set on to run for about 3 minutes and value obtained for the weight of the ingredients, mixing time, efficiency of the machine and production rate were 4.5 kg, 3 minutes, 90.67% and 90kg/h, respectively.

There was an increase in the uniformity of mixing as the time of duration increases from 3, 6, and 9 minutes at a constant speed with respect to increase in weights of feed.

Despite the quality uniformity of the mixture, there was a reduction in efficiency of the machine during the third test due to the increase in feed rate, as more ingredients were compacted in the mixing chamber.

It was also discovered that, the loss of ingredients in the process of carried out the experiment indicated variation in percentage loss among the sample tested, ranges from 5.5% to 9.33%. This loss was as a result of non-mixed ingredients. The efficiency of the proposed machine shows high percentage when compared to the existing machine (2.6% - 3.0%).

5.3 Conclusion

The poultry feed mixer was designed, constructed and evaluated and it was concluded that the machine can be used by small scale farmers to tend to their need of producing feed for their poultry. During test runs of the poultry feed mixer, the ingredients used for the conduct of the test included maize, wheat bran, soya meal, oyster shell and concentrate. These ingredients were used because, there are the common ingredients the poultry fowls feed since they possess the necessary nutrition for their growth and health. The experiment was carried out to determine the mixing efficiency by using different capacities at different time intervals. This was to assess and evaluate the mixing rate and quality of feed recorded at the end when different weights of feed are fed into the mixer.

The poultry mixer designed for this project was noted to have different mixing capacities in relation to weight of feed and production rate. This is because, the working capacity of the mixer was designed to be capable of mixing different weights of feed to an extent since poultry farms across the north have different sizes with regard to the number of birds in the farms. Therefore, farmers stand the chance to feed the mixer with the amount of weights desired per farm. The value obtained for the weight of the ingredients, mixing time, efficiency of the machine and production rate were different because an efficient and quality poultry mixer should possess different mixing capacities when different weights of feeds are fed into the mixer.

The reduction in efficiency of the quality of mixing which also caused a drop in pressure due to the increased in feed rate as more ingredients were compacted in the mixing chamber happened as the result of the fact that the weight of feed influences the rate at which a mixer exerts pressure to accomplish a particular mixing of feed.

5.4 Recommendations

The common and most used poultry feeds among Ghanaian poultry farmers included maize, wheat bran, soya meal, oyster shell and concentrate. It is therefore imperative that the Ministry of Agriculture together with ministry of trade and industry, regional and district chief farmers should lease among themselves to enhance, sustain and support the manufacture of feed mixture and cultivation of these feeds across the country. This ensures availability of feed mixer and efficient of the feeds on the Ghanaian markets for poultry farmers.

The test run of poultry mixer machines are very important for quality records and it remains an important issue to address. Therefore, engineers of poultry mixers should test machines and provide manuals or labels alongside with poultry mixers so that poultry farmers can use them effectively.

The poultry mixer designed in this study has capacity in terms of mixing rate, weight of feed and durability, hence poultry farmers should be given the necessary education on the use and maintenance of the mixer in order to effectively and efficiently use the mixer.

5.5 Suggestions for Further Study

Further research should be carried out to allow the machine accommodate more volume of feed for the small-scale farmers. The machine should be fixed with anti-vibration, in order to reduce the vibration created during machine operations. The use of a conveyer belt system may be considered for use as this will ease the delivery of materials into the mixing chamber. The machine can be further improved and modified to increase its efficiency by making a rubber seal in-between the mixing shaft and mixing cylinder holes. For hygienic and better purpose, and a better quality of feed, a stainless-steel material is recommended.

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