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Optimization and Performance Evaluation of Poultry Feed Mixer

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Abstract: ***A motorized vertical poultry feed mixer was optimized, fabricated and its performance was evaluated. An appropriate mixing ratio or quality of a good poultry feeds are based on the correct application of the properties of granular materials. These properties, which include maximum particle size, moisture content, bulk density, angle of repose, fineness modulus of granular material, coefficient of friction with their standard parameters are given as 6.5 mm, 9.3 %, 548.6*** Kg/m^3***, 35º, 2.4 and 0.5 respectively. The optimized fabricated mixer compounded feed at 7.44 mm, 9.6 %, 571.6*** Kg/m^3***, 39º, 2.6 and 0.6 respectively. The coefficient of variation of standard poultry feed mixing parameter to the fabricated mixer was 17.2 %. The fabricated machine was evaluated using 400, 480 and 560 rpm speed of mixing auger to produce 250 Kg of feed and its mixing efficiency were given as 74 %, 83.6 % and 78.2 % respectively. A homogeneous feed was obtained at 105 minutes. The feeds produced were used to breed some day old chicks to maturity and proximate analysis of feed nutrients was carried out on each feed compounded and it was satisfactory. Starter's mash, grower's mash, finisher's mash and layer's mash were compounded using the fabricated machine and its best performance efficiency was at 480 rpm which is 83.6 %. It was found that the cost of producing a bag of feed was reduced by 40 % as compared to the market price at the time the experiment was performed. The mixer produces good quality or homogeneous feed by correct application of the properties of granular materials.***

Keywords: optimization, performance, evaluation, poultry feed, mixer

1. Introduction

As mill became multistoried structures, gravity spouting was used to direct the meal and grain flow from the top of the elevator legs. However, gravity spouting could neither reach the locations desired nor handle the various textures of grains selected by mill customers to meet their own individual needs. Horizontal devices were merely shaft with short pegs fastened in a spiral pattern which advanced the grain when the shaft rotated, all housed in long wooden boxes. With an invention of electric motor, sweeping changes in mill design took place. A specialized type of conveyor was developed called a feeder. The construction was similar to the material handling conveyor, except it was shorter and by a motor and a speed reduction device called a gear box. This allowed for the achievement of variable speeds, which afforded mill operators added flexibility of operation (Culpin, 2000).

As the list of available ingredients increased, the mill operator was forced to reserve a bin or box for each ingredient. This process was accelerated as scientific research began to show the advantages of feeding balanced diets. The feeders were designed to empty into a large, slow-moving, collecting conveyor, which usually included a method to impede or separate part of the flow in an effort to improve blending. The storage of whole and ground grains has changed little since the construction of the first mill bins. This was the key component of the first so-called feeder line for the production of formula feeds on the American continents. Demand for higher production output led to the development of the feeder line plants. It has become obvious that acceptable weight control was difficult to achieve due to the variable densities of the individual ingredients that were being routinely used (George, 2009).

Each feeder was located under a single ingredient or premix bin which was put through the hopper and spouted to provide constant, uniform flows regardless of the rate demanded by the feeder. The inconsistencies of the volumetric feeder, resulting from variable ingredients, led to the development of the gravimetric feeder. This device allowed for continuous weight checks and provided automatic adjustment of the gate control mechanism. With the advent of drug and antibiotic use, it became obvious that the feeder line was incapable of accurately handling and mixing products with an inclusion rate of less than 1% of mix. This led to the premixing of these micro ingredients to a level above 1% with a diluents or carrier. This was usually accomplished at alternative site by more sophisticated equipment than described above (George, 2009).

In the early days on small family farm, the mixing of home grown grains with supplements purchased from the local miller began with a smooth floor, shovel and knowledge of quartering. Local village and commercial operators were more refined and had the advantage of both grinding and screening facilities to increase the efficacy of the formulas that were being prepared for animal feeds. In time, operators duplicated the action of the shovel by fashioning crude plows or paddles fastened to slowly rotating horizontal shafts contained in a wooden box with curved bottom (Culpin, 2000).

The mixing of feedstuffs to form a ration is a regular need on the large stock farms. There have been few official tests of the evenness of mix of the various types of machine. Table below shows the nominal capacities, range of gross volumes and power requirement for typical bottom fed mixers of conical shape. Such mixers usually operate at a speed of 400 – 600 rpm and require more power for a given capacity than top feed machines, which usually operate on

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only 150 – 200 rpm. Capacities and power requirement of typical vertical auger mixers are tabulated below.

Table 1: Different Density of Material and Power Required

Batch size (tones)	*Ration (m^3)*	*High density ration (m^3)*	*Power requirement (hp)*	*Power requirement (kw)*
0.5	1.6	1.2	3 – 4	2.2 – 3.0
1.0	3.2	2.5	4 – 5	3.0 – 3.7
1.5	4.8	3.6	5 – 7.5	3.7 – 5.6
2.0	6.4	5.0	7.5 - 10	5.6 – 7.5

(Culpin, 2000).

2. Materials and Method

2.1 Description of the Mixer

A motorized vertical poultry feed mixer,(fig. 2) efficient and economically viable was optimized and fabricated with readily available and cheap materials (suitable engineering materials that could give optimum performance in service). Materials for fabricating the machine and for feed compoundments were chosen on the basis of their availability, suitability, economic consideration, viability in service etc. The major components of the machine are as follows: Cylinder case (3), Inner casing covering the auger (6), Discharge gate (4), Hopper (8), Shaft (9), tripod stand (5) and electric motor (1).

2.2 Methods and Optimization of poultry feed mixer

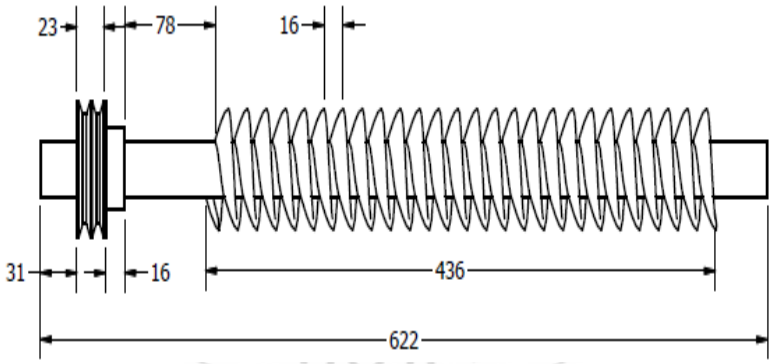


Figure 1: Feed Mixer Auger

For mixing auger, the capacity was determined using the formula below;

$$Q = 60\ n\Phi\ \gamma\ p\ (D - d)\ \frac{\pi}{4}$$

Where :
Q = capacity of conveyor, t/h;
γ = bulk density of conveyed material, 800 kg/m3;
n = number of screw rotations, 800 rpm;
p = conveyor pitch, 0.16 m;
D = pitch diameter of conveyor, 0.145 m;
d = diameter of shaft, 17.62 m,
π = constant, 3.142,
Φ = factor introduced for inclined conveyor, 0.33 (Okojie, 2011).

The machine was optimized by extrapolate the design and fabrication of three pulleys whose diameters are 97mm, 90mm and 83mm, which produced rotor speeds of 400rpm, 480rpm and 560rpm respectively. The rotor speeds were then used to test the designed machine and its efficiency were calculated.

The shaft is a cylindrical solid rod for transmitting motion through a set of load carried on it. The shaft uses for the mixing is loaded by a press screw auger, bearings, pulley, and belt tension. All these forces act on the shaft. The design is based on fluctuating torque, bending moment and shearing force. These called for knowing the combined shock and fatigue on the shaft. To determine the shaft diameter, we adopt the formula;

$$d^3 = \frac{16}{\pi\delta_{sy}}[(K_b M_b)^2 + (K_t M_t)^2]^{\frac{1}{2}}$$

Where;
d = diameter of shaft (mm)
K_b = combined shock and fatigue factor for bending moment.
K_t = combined shock and fatigue factor for torsional moment.
M_b = Resultant bending moment (Nm)
M_t = Resultant torsional moment (Nm)
δ_{sy} = Allowable shear stress (MN/m^2)
π = constant, 3.142

Capacity of the Conveyor

A vertical mixing auger conveyor (Fig.1) which operates inside a close fitted tube to effect blending and conveying of feed components was designed for the machine. The auger is designed with helices of uniform diameter of 145 mm and a pitch 16 mm.

2.3 Feed Compounding Process

After development of the mixer, performance test was carried out to fulfill the aims and objectives of the work and also to make an improvement where necessary. The material needed for the compoundment include maize, wheat offal, groundnut cake, salt, lysine, methionine premix, palm kernel cake, furaltazone and bone meal. After grinding the material with hammer mill, then each of the materials was weighed. The ground grain was first introduced into the mixer through the hopper and after some minutes of recycle, then other ingredients were introduced through the same hopper. The mixer was allowed to recycle the materials for about 30

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minutes before opening the discharge gate for feed collection. An electric motor of 3hp was supplying power to the mixer through belt and pulleys to the auger at the centre, the auger that conveys and mixed the material was provided with rotational motion through the electric motor. The ingredients to be mixed are conveyed into the mixer via the hopper and the mixing continues until a homogeneous material was obtained and the mixed products are collected through the discharge outlet

2.4 Evaluation of the Mixer

A comparison was made about the cost of producing a bag of feed to the market price survey carried out. We used eight six (86) day old chicks of different types to test the potency and the nutrient ration of the feeds produced. Proximate analysis of each feed compounded with the machine was checked through the animal feed nutritionist.

2.5 Homogeneous Mixing

Difficulty in mixing may result if the solids have the same size and shape but different specific gravity or if they are of different size and shape. Heavier particles tend to remain near the bottom of the container during mixing operation. Round or small particles tend toward the top. This tendency can be overcome by lifting the materials, more or less in mass, from the bottom of the mixing container and turning them onto and with the top portion. Satisfactory mixing processes are: to produces a uniform mixture, at a minimum time, with a maximum cost for overhead power and labour. An appropriate mixing ratio or quality of a good poultry feeds are based on the correct application of the properties of granular materials. These properties, which include maximum particle size, moisture content, bulk density, angle of repose, fineness modulus of granular material, coefficient of friction and fluidization characteristics of granular material are presented in Table 2.1. Based on the correct application of the properties of granular materials, the mixer will produce 250 Kg of homogeneous feed at 105 minutes with calculated power of 3hp and 480 rpm speed of mixing auger.

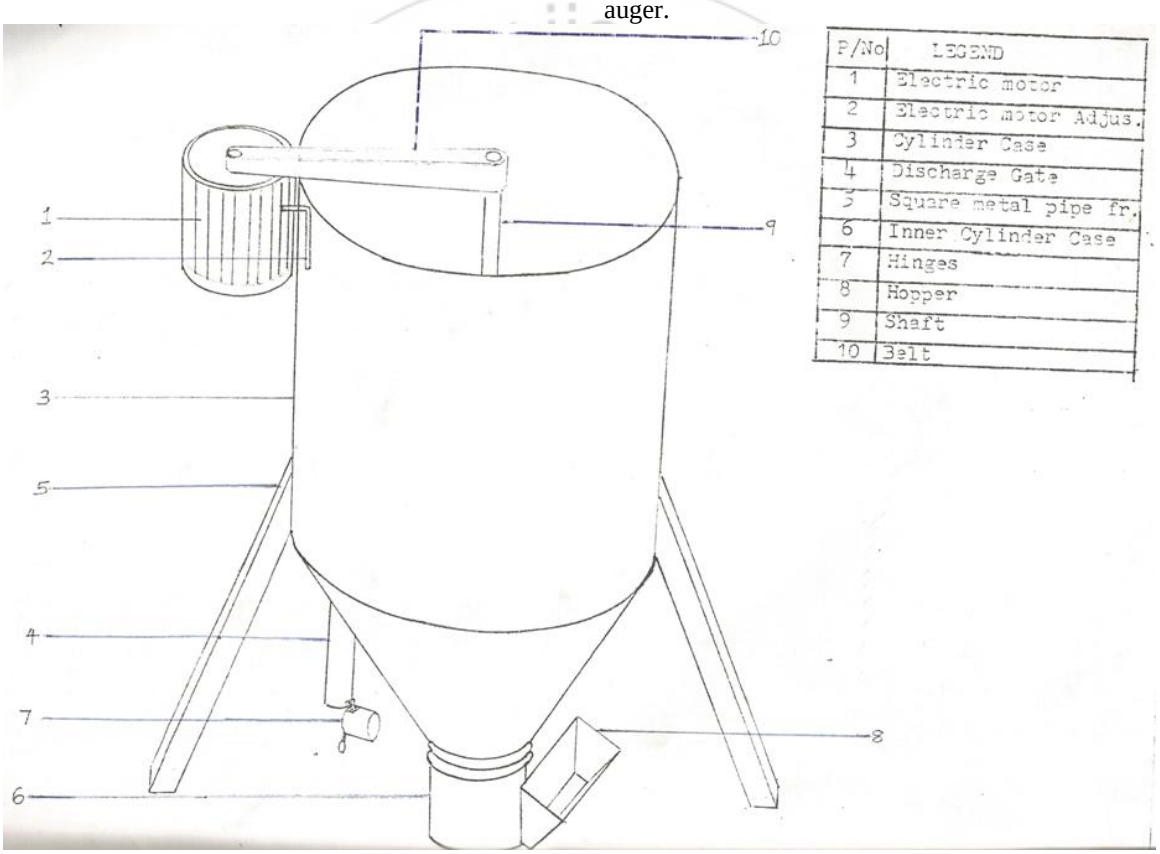


Figure 2: Isometric View of Vertical Poultry Feed Mixer

Table 2: Generated Table for an Appropriate Mixing Ratio

Materials	Maximum Particle Size (mm)	Moisture Content (%)	Bulk Density (Kg/m^3)	Angle of Repose (degree)	Fineness Modulus	Coefficient of Friction	Fluidization Characteristics of granular Materials
Wheat offal	3.18	7.3	208	30 – 45	2.3	0.5	Free Flowing, Abrasive and Contain Explosive Dust
Maize	3.18	7.3	721.3	30	2.4	0.5	Free Flowing, Abrasive and Contain Explosive Dust
Groundnut Cake	12.7	7.5	641.8	30	2.3	0.6	Free Flowing and non Abrasive
Palm Kernel Cake	12.7	5.8	641.8	30 – 45	2.5	0.5	Sluggish, Non Abrasive, Light and Fluffy and Interlocks
Bone meal	12.7	7.3	160.3	45	2.9	0.4	Sluggish, Non Abrasive, Light and Fluffy and Interlocks
Salt	3.18	-	801.4	30 – 45	2.7	0.7	Free Flowing and Non Abrasive

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Soyabean	3.18	7.1	801.4	30	2.4	0.5	Free Flowing, Abrasive and Contain Explosive Dust
Corn Bran	3.18	6.70	448.8	30	2.4	0.5	Free Flowing, Abrasive and Contain Explosive Dust
Sorghum	3.18	7.1	512.9	30 - 45	2.1	0.6	Free Flowing, and Abrasive

(Mohsenin, 1986)

3. Results and Discussion

Table 2 presents the properties of granular material for the compoundment of good quality or homogeneous feeds, if it is correctly applied and Table 3 presents the properties of granular materials used for the compoundment of feed by the fabricated mixer.

Table 4 shows the cost of producing 250 Kg of starter's mash. The unit prices of the materials are stated. The market price of 250 Kg of starter' mash was 12,000 as against 7807.50.

Table 5 to 7 show the compoundment of grower's, finisher's and layer's mash and their prices per 250 Kg. The market prices of the feeds are 8600, 13,500 and 11,000 as against 5,388, 8,364.5 and 6,867.50 production cost.

Table 8 presents the proximate analysis of feed nutrients. Proximate analysis of feeds is the standard practical feed formula for poultry. It was found out that the laboratory determinations of the proximate analysis of produced feeds are in line with the standard. It was from the proximate analysis that each feed ration was compounded.

The compounded feeds were used as ration for 25 broilers, 35 cockerel and 26 layers day old chicks and they grew to maturity. This is to say that the compounded feeds are satisfactory. It could be deduced that the rate of mixing of the developed machine was efficient compared to the traditional method of mixing. The total time used for the mixing of 250 Kg of feed was 105 minutes ($1\frac{3}{4}$ hours) and it was used to calculate the amount of feed to be produced within a day, a week and a month with the developed machine. It could be deduced that the rate of mixing of the developed machine was efficient compared to the traditional method of mixing.

Table 3: Properties of granular materials used for the fabricated mixer

Materials	Maximum Particle Size (mm)	Moisture Content (%)	Bulk Density (Kg/m^3)	Angle of Repose (degree)	Fineness Modulus	Coefficient of Friction
Wheat offal	3.2	7.6	209	45	2.5	0.5
Maize	3.6	8.0	723	38	2.4	0.6
Groundnut Cake	12.9	7.5	648	33	2.4	0.6
Palm Kernel Cake	12.8	6.0	648	44	2.6	0.5
Bone meal	12.9	7.3	163	46	3.0	0.5
Salt	3.1	-	805	43	2.7	0.7
Soyabean	3.6	7.4	805	27	2.5	0.6

Table 4: 250 Kg of Starter's Mash Compoundment

Materials	Quantity(Kg)	Unit Price (#)	Total Price(#)
Wheat offal	65	15	975
Maize	87	28.02	2438
Soya bean meal	67	56	3752
Palm kernel cake	30	7	210
Methionine	0.25	800	200
Salt	1.25	26	32.50
Lysine	0.25	800	200
Total	250.75	1732.02	7,807.50

Table 5: 250 Kg of Grower's Mash Compoundment

Materials	Quantity (Kg)	Unit Price(#)	Total Price(#)
Wheat offal	53.6	15	804
Maize	53.6	28	1500.4
Groundnut cake	42.0	30	1260
Salt	1.35	26	35.1
Palm kernel cake	91.7	7	641.9
Bone meal	6.54	30	196.2
Lysine	0.25	800	200
Premix	1.25	440	550
Methionine	0.25	800	200
Total	250.54	2,176	5,388.00

Table 6: 250 Kg of Finisher's Mash Compoundment

Materials	Quantity(Kg)	Unit Price(#)	Total Price(#)
Maize	112.5	28	3150
Wheat offal	40	15	600
Soya bean meal	60	56	3360
Bone meal	10	30	300
Palm kernel cake	25	7	175
Lysine	0.295	800	236
Salt	1.25	26	32.5
Methionine	0.295	800	236
Premix	0.625	440	275
Total	250.00	2,202	8,364.5

Table 7: 250 Kg of Layer's Mash Compoundment

Materials	Quantity (Kg)	Unit Price(#)	Total Price(#)
Wheat offal	47.5	15	712.5
Soya bean meal	50	56	2800
Corn bran	87.5	20	1750
Groundnut cake	12.5	30	375
Lime stone	12.5	7	875
Methionine	0.25	800	200
Lysine	0.25	800	200
Salt	1.25	26	32.5
Premix	0.625	440	275
Palm kernel cake	30	7	210

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Bone meal	7.5	30	225
Total	250.00	2,231	6,867.5

Table 8: Proximate Analysis of the Feed Nutrients

Nutrients (%)	Starter's Mash	Grower's Mash	Finisher's Mash	Layer's Mash
Crude protein	20	15.00	19.00	18.00
Crude fat/oil	5.40	3.40	3.10	3.20
Crude fibre	5.20	5.80	4.30	5.80
Vitamin	26.00	31.00	27.90	30.00
Minerals	3.60	4.00	3.30	5.00
Energy	38.70	36.80	40.80	36.80
Additives	3.10	4.00	1.60	2.00

4. Conclusion

The developed machine reduced the labour cost of mixing by 40 % and the time involved by 60 % for compounding 250 Kg of feed. Different type of feed formulation and the production cost were stated above to enable farmers produce feed at cheaper rate. Poultry feed mixer can be fabricated vertically or horizontally, but the horizontal type requires much power to vertical type. The fabricated machine is batch process of mixing and continuous mixing type can be fabricated using the same principle. The efficiency of the machine will reduce, if the calculated power is not used for its operation. It will also delay the rate of mixing and lead to poor quality of feed.

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