Development and Performance Evaluation of A Poultry Feed Mixer

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Abstract- The feed mixer which performs the combined job of milling the materials and then mixes it have been developed in this study. The machine contains two chambers which are the mixing and the milling chamber. The machine was fabricated using locally sourced materials like the square pipes, metal sheet. The equipment used for the design of the machine are the arc welding machine, angle grinder etc. The machine was tested, the efficiency and capacity of the machine was also determined. The machine has an efficiency of 80% and a capacity of 12kg/hr. The machine is able to crush the grains and also mixes it efficiently. The machine is useful for small scale farmers in producing feed for their poultry livestock at a very avoidable cost.

Indexed Terms- capacity, efficient, feed, machine, and mixer.

I. INTRODUCTION

Feed mixers are used in feed mills for the mixing of feed ingredients. The mixer plays a vital role in the feed production process, with efficient mixing being the key to good feed production. Essentially, 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. The manual method of mixing feed ingredients is generally characterized by low output, less efficient, labour intensive and may prove unsafe, hence, hazardous to the health of the intended animals, birds or fishes for which the feed is prepared. The mechanical method of mixing is achieved by using mechanical mixers developed over the years to alleviate the shortcomings associated with the manual method. [1] 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 diversity of physical form and density of individual feed ingredients complicate the preparation of uniform feed mixers [2]. The mixer are classified into two, namely; continuous and batch mixer. Continuous mixer procedure is more satisfactory for large, extensive operation. The ingredient 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. 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 to small operation where overhead cost must be low and labour cost are not critical. The ingredient may be weighted or measured. A rotating drum, box or barrel perhaps with no symmetrically located support is satisfactory for small operation. The batch method can be adapted to a semi-continuous process by using a number of batch mixers which empty into a common conveyor or storage [3]. Some existing poultry feed mixer are; Vertical cone mixer: this has a high efficiency. It can also accommodate low level liquid additives. In normal mixing, it provides very gentle mixing action. The vertical cone mixer is considered a highly versatile and effective mixer [4] Revolving drum mixer: the revolving drum mixer includes the twin cone as well as the drum. When the shell of the mixer revolves, the flight within the drum direct the material to produce mixing of dry materials but are less effective when liquid addition is necessary, Tumble mixer: the mixer is a large drum with spiral and/or pans on the interior circumference of the drum to lift and tumble the ration. A central auger moves feed from end to end and to the discharge. A large part of the drum opens like a door to allow loading with a skid steer or loader bucket [5], Reel mixer: the mixer combines asset of augers and a reel similar to a combined reel in a hopper. 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 knife sections on the auger flights cut or tear long dry hay into pieces and incorporate it into the ration and Vertical screw mixer: this consist of a vertical standing auger moving feed upward and down the sides to process feed [6, 7]. The manual method of mixing poultry feed was usually time consuming, strenuous, high labour cost and will not give an efficient mixing of the feed, Hence, the development of this poultry feed mixer will be useful to farmers who wishes to give the correct nutritional feed to their poultry livestock.

II. MACHINE DESCRIPTION

This machine is able to perform two different processes involved in the production of poultry feed. This processes are the milling and the mixing operations. The machine consist of two different unit one for milling after which the product is transferred through a screen to the mixing unit where the different components are mixed. The screen is made in such a size that the grinded materials can only be allowed to pass through when the materials has been milled to the required size. There is also an inlet for pouring in supplement feeds which does not require grinding before it is mixed. The machine consists of different component which has been fabricated and assembled together. The materials for this machine are sourced locally so as to be cheap to own and used by stock raisers.

2.1 DESIGN CONSIDERATION

- Cost: Cost has always been the major factor of consideration while designing the machine elements or machine. The best machine design is the one which helps get the finished product with all the major functionalities and highest possible quality at the lowest possible cost.
- High output and efficiency : machines are expected to be fully functional, consuming low power and giving high output in terms of the number of the of products manufactured and doing so in less time.
- Strength: The machine elements or the machine should be strong enough to sustain all the forces it is designed for 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 with 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.

2.2 MAIN FEATURES OF THE MACHINE

- Hopper: the hopper is a sheet metal structure shaped in the form of a frustum of a rectangular-base pyramid welded to the milling chamber. It serves as the inlet for materials to be milled.
- Milling chamber: this encloses the hammer. This is where the milling process is carried out. There is a screen at the base of this chamber which enables only the milled material to be passed to the mixing chamber.
- Hammer: this is main component that grinds the feed material. This consist of a horizontal driving shaft which suspends the swinging steel bars forcing ingredients against a circular screen.
- Mixing shaft: 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 thinning rods.
- Frame: the frame of the machine is the feature on which other parts of the machine are attached. It is made from angle iron welded together and other components of the machine are joined to it.
- Mixing chamber: this consists of two circular trough placed on each other to form a cylinder. The mixing shaft is placed concentric in the chamber. There is an outlet at the bottom where mixed feed are expelled out. There is also a supplement feed inlet at the top of this chamber which is designed integral with the upper trough.

- Collector: this is an open container placed at the base of the frame directly below the outlet. The mixed product is collected inside this collector.

2.3 DESIGN ANALYSIS

Determination of the Shaft Speed

To calculate the shaft speed, the following parameters are used:

$$\frac{D1}{D2} = \frac{N2}{N1} \quad (1)$$

$$\frac{D1}{D3} = \frac{N3}{N1} \quad (2)$$

Where,

N 1 = revolution of the motor pulley, rpm.
N 2 = revolution of the hammer pulley, rpm.
N 3 = revolution of the auger pulley, rpm.
D 1 = motor pulley diameter
D 2 = hammer pulley diameter
D 3 = diameter of auger pulley
N2=N1 × D1/D2
Since D1=D2, N1=N2
N1=N2=1400rpm
N3=N1 × D1/D3, N3=1400 × 0.06/0.18
N3=466.67rpm

This shaft speed is only obtained when there is no slip condition of the belt over the pulley. When slip and creep condition is present, the value is reduced by 4% (Spolt 1988).

Determination of the Shaft Torque

$$T = {}^{60P}/_{2\pi N_1} \quad (3)$$

T=60 × 746/2 × 3.142 × 1400
T=5.1N-m
P = power rating of electric motor,
N1 = motor speed

Belt design for the belt joining the motor pulley and the hammer pulley:

Determination of Length of the Belt:

Assume the centre distance between the rotor pulley and the hammer pulley = 420mm, the pitch length of the belt is given by

$$L = 2C + 1.57(D2 + D1) + \frac{(D1-D2)^2}{4C} \quad (4)$$

Where,

L = length of the belt, mm
C = centre distance between the hammer pulley and the motor pulley, mm
C=0.32m
L=2 × 0.32 + 1.57(0.06+0.06) +$(0.06 - 0.06)^2/(4 \times 0.32)$
L=0.8284m = 828.4mm

Determination of the Belt Contact Angle

The belt contact angle is given by equation 4:

$$\alpha = \sin^{-1}\frac{(R-r)}{C} \quad (5)$$

Where,

R = radius of the motor pulley, mm
r = radius of the hammer pulley, mm
The angles of wrap for the pulleys are given by:

$$\alpha1 = 180 - \sin^{-1}\frac{(R-r)}{C} \quad (6)$$

$$\alpha2 = 180 + \sin^{-1}\frac{(R-r)}{C} \quad (7)$$

$$\theta = (180 - 2\alpha)\pi/180 \quad (8)$$

Where,

α 1 = angle of wrap for the motor pulley, deg
α 2 = angle of wrap for the hammer pulley, deg
θ = angle of contact in rad
$\alpha = \sin^{-1} 0$
α = 0
$\alpha1 = 180^\circ, \alpha2 = 180^\circ$
θ = π rad

Determination of the Belt Tension

The belt tension can use equation 6 below

$2.3\log(T_1/T_2) = \mu\theta$ (9)

$T1 = SA$ (10)

Where,

T 1 = the tension in the tight side of belt, N

T 2 = the tension in the slack side of belt, N

S = the maximum permissible belt stress, MN/m^2

A = area of belt,

$\mu = co - efficient\ of\ friction$

S=2.1MN/m^2, A=0.025*0.01

T1=525N

$$\frac{T_1}{T_2} = 10^{\left(0.25*\frac{\pi}{2.3}\right)}$$

T2=239.16N

Determination of the Torque and Power Transmitted to the Shaft

Power transmitted to the shaft is given by

$P = (T1 - T2)V$ (9)

Torque at the main shaft is given by Spolt (1988)

$T = (T1 - T2)R$ (10)

V= $\pi D_1 N_1/60$ (11)

V=$\pi * 0.06 * 1400/60$

V= 4.4m/s

P= (525-239.16)*4.4

P=1.26kw

Torque on hammer shaft T= (525-239.16)*0.06

T=17.15N-m

Belt design for the belt joining the auger pulley and the hammer pulley:

Determination of Length of the Belt:

Assume the center distance between the auger pulley and the hammer pulley =162mm

W_h=7850*9.81((π*0.0075^2*0.2) + (3π(0.03^2 – 0.0075^2)*0.0075) + 4(0.06*0.017*0.013))

M_h =1.16kg$W_h = 11.4N$

Determining the weight of auger

$W_a = M_a * g$ (14)

$M_a = \rho * V_a$ (15)

$$W_a = \text{weight of auger},$$

$$M_a = \text{mass of auger},$$

$$V_a = \text{volume of auger}$$

$$M_a = \rho\big((\pi * 0.0125^2 * 0.53) + (8\pi * (0.085^2 - 0.07^2) * 0.004\big) + (13\pi * 0.002^2 * 0.06)$$

$$M_a = 3.95kg$$

$$W_a = 38.8N$$

Determination of the Centrifugal Force Exerted by the Hammer

Centrifugal force exerted by the hammer can be calculated from equation 11 as given by:

$F_c = {}^{M_h V^2}/_{r}$ (16)

$$F_c = 1.16 * 4.4^2/0.0075$$

$$F_c = 3KN$$

The angular velocity of the hammer is given by

$\omega = {}^{2\pi rN}/_{60}$ (16)

$\omega = 2\pi * 0.0075 * 1400/60$

$$\omega = 1.1rad/s$$

Determination of the Centrifugal Force Exerted by the auger

$F_c = {}^{M_a V^2}/_{r}$ (17)

$$F_c = 3.95 * 4.4^2/0.0125$$

$$F_c = 6.118KN$$

Determination of the weight of small pulley

$$W_{sp} = \rho g V_{sp} \qquad (18)$$

Type equation here.
W_{sp} = weight of small pulley
V_{sp} = volume of pulley
$W_{sp} = 7850 * 9.81(\pi * (0.03^2 - 0.0075^2) * 0.02)$

$W_{sp} = 4.08N$

Determination of the weight of big pulley,
The weight of the small pulley can be approximated as

$$W_{bp} = \rho g V_{bp} \qquad (19)$$

W_{bp} = weight of big pulley,

V_{bp} = volume of big pulley.

$$W_{bp} = 7850 * 9.81(\pi * (0.09^2 - 0.0125^2 - 3 * 0.015^2) * 0.01)$$

$W_{bp} = 17.59N$

Shear force and bending moment diagram of the auger

The weight per unit length of the blade is given as
38.8/0.364= 106.59N/m
The weight at the pulley is given by
$T1+T2+W_a$ =525+363+38.6=905.6N

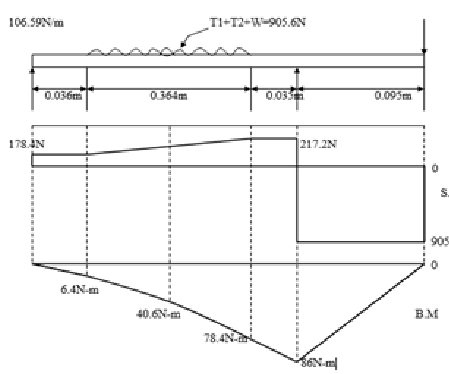

Figure 1: Shear force and bending moment

Determination of the auger Shaft Diameter

$$T_e = \sqrt{(K_m * M)^2 + (K_t * T)^2} \qquad (20)$$

$$T_e = \sqrt{1.5 * 86)^2 + (1 * 5.1)^2}$$

=129.1N-m =129.1*10^3N-mm

$$d^3 = 16 * T_e/\pi\tau \qquad (21)$$

=16*129.1*10^3/3.142*42 =15650
d=25mm.

Where,
d= diameter of shaft
T_e = equivalent torsional stress,
K_t =combined shock and fatigue factor for torsion,
K_b= combined shock and fatigue factor for bending

Determining the volume of mixing cylinder

The mixing cylinder consist of two trough placed over each other

$$V = \pi r^2 L \qquad (22)$$

$$V_c = 2V \qquad (23)$$

V = volume of trough
V_c = volume of cylinder
$V_c = 2 * \pi * 0.1^2 * 0.435 = 0.027m^3$

PERFORMANCE TEST

The machine was tested to determine the efficiency, capacity and to achieve optimum mixing. The machine was tested with 1.5kg of maize, 1.5kg of guinea-corn and 1kg of soya beans. All this materials are divided into two parts. At first, the machine was allowed to run for about ten minute and for the second test, the machine was allowed to run for about 20 min. After that the mass of the product obtained at the outlet was determined, the time of optimum mixing and the maximum efficiency of machine is determined (Table 1).

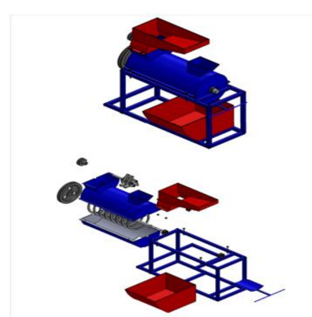

TABLE 1: Test parameters

Test	Samples	Input(kg)	Time(min)	Output(kg)	Remark
1	Maize, guinea-corn and soya bean	4	10	2.8	Mixed properly
2	Maize, guinea-corn and soya bean	4	20	3.6	Higher degree of mixing

Efficiency of the machine

Efficiency= $\frac{\text{input}}{\text{output}} * 100\%$

At 10 min, Efficiency = (2.8/4)*100 = 70%
At 20 min, Efficiency = (3.6/4)*100 = 80%

Capacity of the machine

Since the machine is able to process 4kg of feed at 20min, the capacity of the machine is 12kg/hr.

Therefore,
Efficiency at 10 min = 70%
Efficiency at 20 min = 80%

Time to attain optimum efficiency = 20 min

Capacity of machine = 12kg/hr

CONCLUSION

A small sized mixer is designed and tested. The machine can be used by small scale farmers to tend to their need of producing feed for their poultry livestock. The machine is 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 is developed from cheap local materials which makes the machine to be relatively effectively, simple, cheap and easy to maintain.

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