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Manufacturing and Evaluation of Local Animal Feed Mixing Machine

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ABSTRACT

This investigation was carried out to develop and manufacture small animal feed mixing machine. Feed mixing machines are used in feed mills for the mixing of feed ingredients and premixes. The mixing machine is essential part in the feed manufacture, with accurate mixing being the key to good feed manufacture. The machine is small and works by very small power if compared with other machines. The goal of this experiment was to determine the optimum mixing duration at which the highest degree of mixing (homogeneity) is achieved. Experimental and designing studies were confined to determine the effect of mixing duration at constant speed of mixing drum, 228 rpm on coefficient of variation, degree of mixing (homogeneity), machine productivity, specific energy and mixing cost and the effect of moisture content of feed mixture on Pelleting efficiency. The machine was experimented and evaluated using four different mixing durations (5, 10, 15 and 20 minutes) and using different moisture contents of feed mixture (25, 28 and 31%). Results indicated that the mixer shaft was designed at a diameter of 20mm. The highest value of the performance parameters of the mixing machine and the optimum mixing duration was 5 minutes. The suitable moisture content of feed mixture for the following process which is pelleting process was 28%.

INTRODUCTION

Mixing is one of the most vital and serious procedures in the process of animal feed industrial. The objective of mixing is to produce a totally homogeneous mixture. If feed is mixed inaccurately, ingredients and nutrients will not be perfectly distributed when feed comes to be extruded and pelletized, or if it is to be used as mash, so that the feed would not have nutritional value and would be bad for the animals that are eating it. Lindley (1991) cleared that a satisfactory mixing process produces a uniform feed in a minimum time with a minimum cost of overhead, power, and labor. Some differences between samples would be predictable, but a perfect blend would be one with least variation in composition. Clark (2005) showed that mixing is a case where more is not necessarily better. There is usually an optimal mix time, which must be determined experimentally. The test is boring because mixing is determined by measuring the standard deviation of some critical component. This involves taking many samples, at minimum ten, from several positions of the mixing chamber at a sequence of periods. Makange *et al.* (2016) tested an animal feed mixing machine using a feed components divided into 3.5 kg for maize bran, 1.25kg for cotton/sunflower cake, 0.15kg for lime, 0.075kg for bone meal and 0.018kg for salt replicated thrice at two mixing durations of 10 and 20 min. the average CV was 5.93% which shows a significant reduction in feed components for the samples tested. The degree of mixing attained was 94.06%. Brennan *et al.* (1998) observed that regardless of the category of mixing machine, the vital purpose of using a mixing machine is to attain a homogeneous distribution of the materials by means of flow, which is produced by mechanical means. Bhienki (2000) found that that the size uniformity of the various ingredients that comprise the finished feed can directly impact final ingredient dispersion. Coates and Tanaka (1992) reported that the coefficient of variation under 10% is considered excellent, of between 10-15% is good, of between 15-20% is fair. While with value more than 20% is poor. Allen (1997) observed that measuring uniformity involves evaluation of the physical, chemical and visual properties of a mix. These are critical for maintaining product consistency as well as for improving product quality and mixer performance. The aim of this research is to manufacture and evaluate small animal feed mixing machine.

MATERIALS AND METHODS

The Design and analysis of mixing machine shaft under combined bending and torsion has been conducted using Autodesk inventor program. As a result of that the diameter of mixing shaft should be not less than 20mm.

Description of the machine:

The mixing unit consists of horizontal box (mixing chamber), 16-mixing rackets, the main shaft, electric motor of about 0.25 kW, reduction unite (helical gears 1: 6), flexible coupling and the frame. as shown in Figures (1a and 1b).

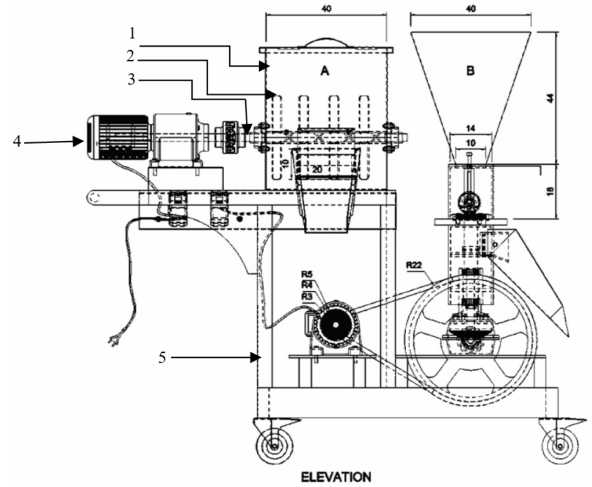

Figure 1a. A schematic diagram of mixing machine
A. Mixing unit
1. Horizontal box (Mixing chamber). 2.Mixing rackets.
3. The main shaft. 4. Electric motor of about 0.25 kW. 5. The frame.

Fig. 1b. Photographed of the mixing rackets

The experimental studies were confined to determine the effect of mixing duration (5, 10, 15 & 20 min.) on some parameters of the study:

1. Percent Mixing Level (Mixing Homogeneity): (ASAE, 1975)

$$CV = \frac{S}{X} \quad \text{------(1)}$$

$$\%D_M = (1 - CV) * 100 \quad \text{------(2)}$$

$$S = \sqrt{\frac{\sum (X-x)^2}{(n-1)}} \quad \text{------(3)}$$

Where: CV = coefficient of variation.
D_M = percent mixing level.
S = standard deviation.
X = weight of tracer in the samples.
x= mean value of tracer in the samples.
n= number of samples.

2. **Mixer productivity:** (Morad and Elmaghawry, 2014)

Mixer productivity was calculated from the following relation:

$$\text{Mixer productivity (kg/h)} = \frac{W_p}{T} \times 3600 \quad \text{------(4)}$$

Where: W_p = mixed mass, kg.
T = consumed time, S.

3. **Samples moisture content, %:** Electric oven was used to determine moisture content of feed mixture. The samples placed in the drying oven at 103°C for 24 hours and weighted after cooling.

The following equation used to determine the moisture content:

$$Mc(w_b\%) = \frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{weight of wet sample}} \times 100 \quad \text{--(5)}$$

Where: Mc (Wb %) = moisture content in wet basis, %.

4. **Pelleting efficiency, %:** was calculated according to (Abdel Wahab *et al*., 2011).

$$\text{Pelleting efficiency (\%)} = (Wp / Wm) \times 100 \quad \text{------(6)}$$

Where: Wp : pellets mass (g).
Wm : feed mixture mass (g).

5. Power requirements:

$$P = (I \times V \times \cos\theta), \quad W \quad \text{------(7)}$$

Where: P : The consumed power, W.
I : Line current strength, Amperes .
V : Potential difference, Volts .
Cos θ : Power factor, equal 0.7.

The specific energy requirements in (W.h/kg) were calculated by using the following equation:

Specific energy requirements = (consumed power, W /productivity, kg/h) ------(8)

RESULTS AND DISCUSSION

1- Effect of mixing duration on the coefficient of variation and degree of mixing (mixing homogeneity):

Figures 2&3 show the effect of mixing duration on coefficient of variation and degree of mixing (homogeneity). For mixing duration 5 min., the average coefficient of variation (CV) is 4.63% and the average degree of mixing achieved is 95.37%. These results increased by increasing mixing duration to 20 min. therefore, the average coefficient of Variation (CV) is 1.21%. The degree of mixing achieved is 98.99%. The results show that that the mixing duration of between 5 to 20 min is recommended as these mixing durations recorded minimum values of C.V.

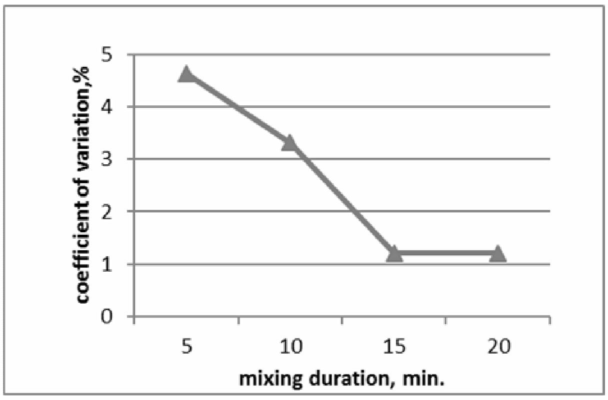

Figure 2. Effect of mixing duration on coefficient of variation.

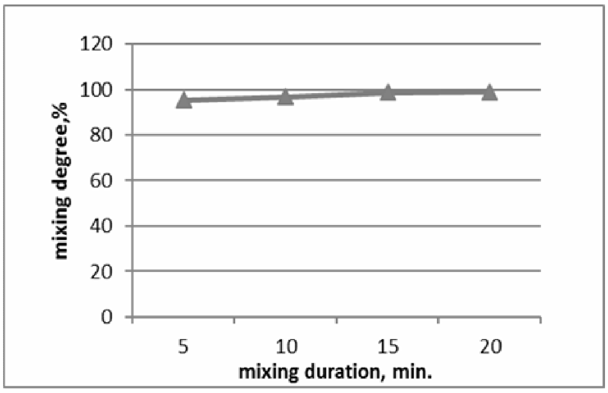

Figure 3. Effect of mixing duration on mixing degree (homogeneity).

2- Effect of mixing duration on mixer productivity:

Figure (4) shows the effect of mixing duration on the mixer productivity. The obtained results show that increasing mixing duration from 5 to 20 min, the mixer productivity decreased from 600 to 150 kg/h. The decrease in mixer productivity by increasing mixing duration is attributed to the long time required for mixing the same feed formula.

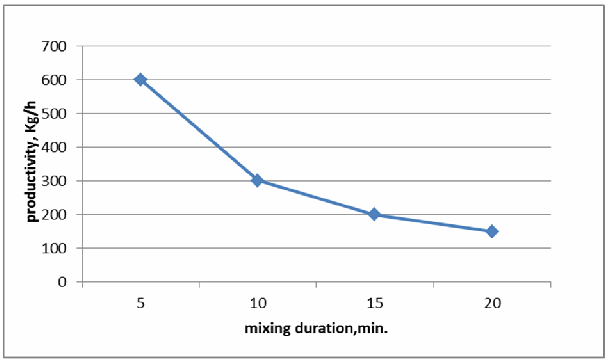

Figure 4. Effect of mixing duration on mixer productivity.

3- Effect of moisture content of feed mixture on pelleting efficiency:

Figure (5) shows the effect of moisture content (25, 28 and 31%) of feed mixture on pelleting efficiency. pelleting efficiency increases by increasing moisture content till a certain limit then it decreases with extra increase in feed moisture content. pelleting efficiency increases from 97.217 % to 98.082 % by increasing moisture content from 25% to 28% then it decreases to 97.530 % at 31% moisture content for die holes' diameter 5mm, using gelatin as binding material and die speed 190 rpm..

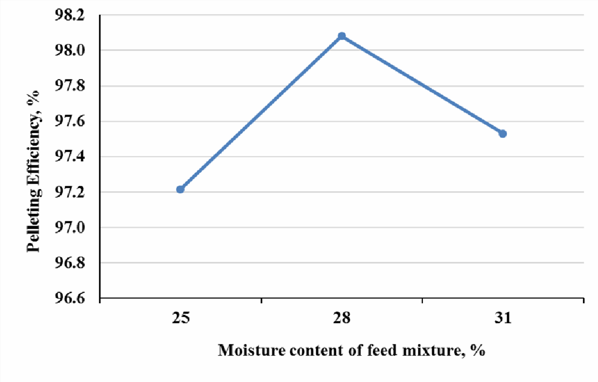

Figure 5. Effect of moisture content of feed mixture on pelleting efficiency.

4- Effect of mixing duration on specific energy:

Figure (6) shows the effect of mixing duration on the specific energy. Considering the effect of mixing duration on the specific energy, results show that increasing mixing duration from 5 to 20 min., the specific energy increased from 0.44 to 1.66 W.h/Kg. the increase in specific energy by increasing mixing duration is attributed to the increase in the consumed power to complete the mixing process.

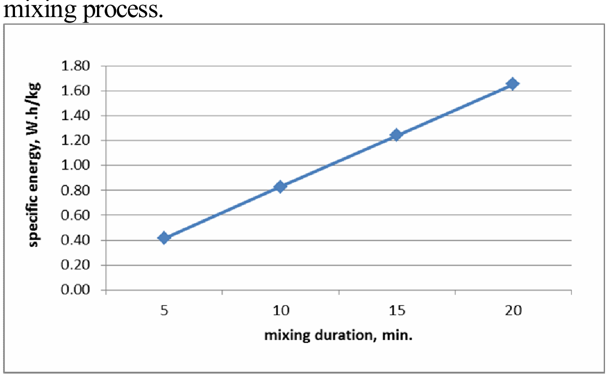

Figure 6. Effect of mixing duration on specific energy.

CONCLUSION

- The mixer shaft is designed according to the maximum shear stress theory. Accordingly, the diameter of the mixer shaft was calculated and was found to be of not less than 20mm.
- Mixing duration is considered very important variable affecting the performance of the manufactured animal feed horizontal mixer.
- The specific energy increased from 0.44 to 1.66 W.h/Kg. by increasing mixing duration from 5 to 20 minutes.
- The mixing duration of 5 minutes is recommended to control the performance of the manufactured mixer for small materials.
- The suitable moisture content of feed mixture for the following process which is pelleting process was 28% at which achieved maximum pelleting efficiency.

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تصنيع وتقييم الة خلط علف الحيوان محلية الصنع

مصطفى محمد ابوحباجة[1] ، احمد فوزي بهنسى[2] ، طارق حسني الشبراوى[1] و عبير وجدي الحداد[2]
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أجريت هذه الدراسة بمعهد بحوث الهندسة الزراعية – مركز ميكنة الأرز بكفر الشيخ بهدف: 1- تصميم وتصنيع الة خلط اعلاف محلية الصنع تعمل بقدرة صغيرة جدا 0,25 كيلو وات. 2- تحديد أفضل مدة لتشغيل الخلاط للحصول على خلط متجانس. 3- تحديد أفضل محتوى رطوبي لمخلوط العلف المستخدم ليناسب عملية الكبس التالية لعملية الخلط. أولا: تم تصميم عمود الإدارة الرئيسي بالة الخلط باستخدام نظرية الاجهادات وبمساعدة برنامج inventor لتحديد القطر المناسب للعمود لكي يستطيع مقاومة الاجهادات الواقعة عليه دون ان ينكسر. ثم تم اختبار أداء الة الخلط باستخدام: 1- أربع فترات زمنية للخلط (5 , 10 , 15 , 20) دقيقة. 2- ثلاث محتويات رطوبة لمخلوط العلف (25 و 28 و 31 %). وقد تم تقييم تأثير المعاملات السابقة على:1- تجانس الخلط. 2- إنتاجية الة الخلط. 3- الطاقة النوعية لعملية الخلط. 4- كفاءة عملية الكبس. أوضحت النتائج التجريبية ان تجانس الخلط لمادة العلف يكون مناسب للحدود المسموح بها علميا ويتناسب مع الطاقة اللازمة للتشغيل وذلك تحت ظروف التشغيل الاتية: 1- تصنيع عمود الإدارة الرئيسي بالة الخلط بقطر لا يقل عن20 مم. 2- زمن الخلط يكون 5 دقائق بالنسبة للمخلوط المجروش جيدا بحيث حجم المواد المخلوطة صغيرة جدا ومتجانسة.3- المحتوى الرطوبي الأفضل لمخلوط العلف هو 28% ليناسب عملية الكبس الى المصبعات.