MANUFACTURING AND ASSESMENT OF A LOCAL RING DIE EXTRUDER FOR PRODUCING DIFFERENT KINDS OF ANIMAL FEED PELLETS

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ABSTRACT

The present research was carried out to manufacture and evaluate the performance of a ring die animal feed pellet extruder to produce two different kinds of cylindrical shape pellets (cattle feed pellets and rabbit feed pellets). The extruder performance was studied as a function of change in ring die hole diameter; formula feed rate and moisture content. Performance evaluation of the manufactured extruder was carried out in terms of extruder productivity, pelleting efficiency, pellets durability, required power, specific mechanical energy and operational cost.

The experimental results revealed that extruder productivity, pelleting efficiency, pellets durability, specific mechanical energy and operational cost are in the optimum region under the following conditions:

- *Case of cattle feed pellets: 6 mm ring die hole diameter, 3.0 Mg/h formula feed rate and 14% (w.b.) formula moisture content.*
- *Case of rabbit feed pellets: 2.5 mm ring die hole diameter, 2.0 Mg/h formula feed rate and 14% (w.b.) formula moisture content.*

INTRODUCTION

Pelleting is a process of forcing and shaping bulk material through die with specific dimensions of openings and thickness. Although, with cost of approximately 60% higher when comparing with mash feed, pelleting process has numerous advantages such as: better flow properties, higher bulk density, no segregation, improve storability, reduce transportation costs and enables easier handling with proper storage equipment. In addition, densification of biomass into pellet improved animal performance. Aim of pelleting process is to obtain feed pellets with improved physical and nutritional quality, in order to meet the requirements for specific animal category (in terms of better feed intake and improved nutritional value).

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In addition, depending on type of transportation and handling it is necessary to obtain pellets of certain integrity without fines produced by attrition stresses. This could be achieved by varying diet formulation and its physical quality, or, when this is not possible, by changing technological parameters in pelleting process, such as: conditioning time and temperature, dosing speed, roller speed, distance between die and roller, die thickness, die openings diameter, etc. It is very important that highly skilled personnel runs pellet press in order to optimize parameters for achieving the least possible cost in terms of energy consumption.

Zatari et al. (1990) showed that animals fed with good-quality pellets have better growth performance and feed conversion than those fed with mash, reground pellets, or pellets with more fines. **Watfa (1999)** stated that increasing extruder die hole from 4 to 8 mm, reduced specific energy by 42%, pelleting pressure by 35% and bulk density by 15%. **Kaddour (2003)** found that pellets durability increased by 16.2% by increasing screw speed from 1.01 to 2.20 m/s. He added that an increase in pellets durability by increasing screw speed could be due to the high temperature in the pelleting unit, which tends to dry pellets and increase their hardness. **McMullen et al. (2004)** indicated that the durability of the pellets from poultry litter varied from about 28 to 46% within moisture content range of 6 to 22%. Durability of the pellets increased initially with moisture content reaching a maximum at 10.4%. Further increase in moisture content reduced durability**. Čolović et al. (2010)** investigated the effects of die length channel press way on physical quality of pelleted cattle feed. The complete mixture for dairy cows was acquired. Mixture was pelleted on flat die pellet press. Three dies with different die thicknesses were used. Diameter of die openings of all three dies was 6 mm, and die press ways were 18, 36 and 48 mm respectively (D/L 1:3, 1:6, and 1:8). Increase of die length channel press way improved the pellet quality in terms of hardness. Thus, pellets made at D/L of 1:8 die had the highest value of hardness. Pellet durability results are not in correlation with press way length. This is presumably due to the difference in moisture content because moisture has lubricating effect. Moisture content had higher influence on the pellet durability when comparing with the die press way length. **Fahrenholz (2012)** conducted a series of experiments to compare methods used to evaluate the durability of animal feed pellets. Seven different factors, including ground corn particle size, added fat level, inclusion of distillers dried grains with solubles (DDGS), feed rate, steam conditioning temperature, conditioner retention time, and pellet die thickness (L:D ratio) were examined. Physical attributes of feed pellets, such as pellet hardness, bulk density, and moisture content were found to have significant, but weak correlations with pellet quality. Pellet quality was found to be significantly influenced by all mentioned factors other than ground corn particle size and feed rate. **Zainuddin et al. (2014)** converted pineapple residues into animal feed by densification process. The evaluation of the moisture content effect on the physical properties of pineapple residues pellets was carried out at four moisture levels of (35%, 40%, 45% and 50%). The range of pellet's friability, bulk density, true density and porosity are between 0.85 - 1.22%, 303.31 - 345.24 kg/m^3, 1502.65 - 1520.35 kg/m^3 and 77.022 - 80.05%, respectively. Thus, from the analysis, the best moisture level to produce pellets from pineapple plant waste was 35%. **Oduntan and Koya (2015)** investigated the effect of pre-processing conditions such as speed, die sizes and moisture content on durability of cassava flour. The flour was mixed with water at different blend ratios to form cassava mash of different moisture contents. The pellet quality was evaluated in terms of the pellets durability against the mash moisture content, die size and the screw speed. Test results showed that high durability of 84.437% was recorded at 20% (w.b.) moisture content using 4 mm die and low durability of 61.26% with using 8 mm die at 18% (w.b.) moisture content. The durability result shows that it decreased with increase in die size.

The science of grain processing has now reached a point that, by knowing the characteristics of the feed and using machinery with accurate measurements, the guesswork has been removed from pelleting. As a result, much more is required of the pellet mill operator in the way of knowledge and ability. The skill of the pellet mill operator, through his ability or mistakes, influences plant profitability.

So, the objectives of the present study are to:

- Manufacture of a local ring die extruder for producing two different kinds of animal feed pellets.
- Optimize some operating parameters affecting the performance of the manufactured extruder (ring die hole diameter, formula feed rate and formula moisture content).
- Evaluate the used extruder from the economic point of view.

MATERIALS AND METHODS

The main experiments were carried out through the year of 2016 in a local factory in Alexandria Governorate to study the effect of some operating parameters on the performance of the ring die animal feed pellets extruder.

1. Materials

1.1. Experimental animal feed pellets

Two kinds of cylindrical shaped animal feed pellets were produced (Cattle feed pellets and rabbit feed pellets). Compositions of the experimental cattle feed pellets (6 mm diameter) and rabbit feed pellets (2.5 mm diameter) are tabulated in Table (1).

Prior to extrusion, the experimental compositions were blended in a horizontal batch mixer. Then, cylindrical shaped animal feed pellets were produced on a ring die single-screw extruder.

1.2. The manufactured ring die animal feed pellets extruder

A local ring die animal feed pellets extruder (Fig. 1) was manufactured from low cost, local material to overcome the problems of high power and high cost requirements under the use of the imported extruders. The local extruder was manufactured at a small workshop in Alexandria Governorate.

1.2.1. Working principle of ring die animal feed pellets extruder

The basic pelleting principle of the ring die animal feed pellets extruder is a simple operation where feed mass is distributed over the inner surface of a rotating, perforated die ahead of each roll, which compresses the feed mass and compress it into the die holes to form pellets.

Table (1): The experimental formulas for producing animal feed pellets

Composition	Rabbit feed pellets	Composition	Cattle feed pellets
	%		%
Soybean meal 44%, kg	18.0	Extract cotton seed, kg	10.0
Yellow corn, kg	7.0	Yellow corn, kg	44.6
Barley, kg	9.1	Soybean meal 44%, kg	7.0
Coarse wheat bran, kg	28.0	Coarse wheat bran, kg	28.0
Fennel and caraway straw, kg	9.0	Earn sunflower, kg	6.0
Alfalfa dehydrated meal, kg	25.0	Mineral salt, kg	1.0
Dicalcium phosphate, kg	1.0	salt, kg	0.5
Salt, kg	0.4	Lime stone, kg	2.0
Lime stone, kg	1.5	Premix, kg	0.3
Premix, kg	0.3	Sodium bicarbonate, kg	0.4
Disodium phosphate, kg	0.3	Non-Food additives, kg	0.2
Non-Food additives, kg	0.4		
	100		100

1.2.2. The components of animal feed pellets extruder

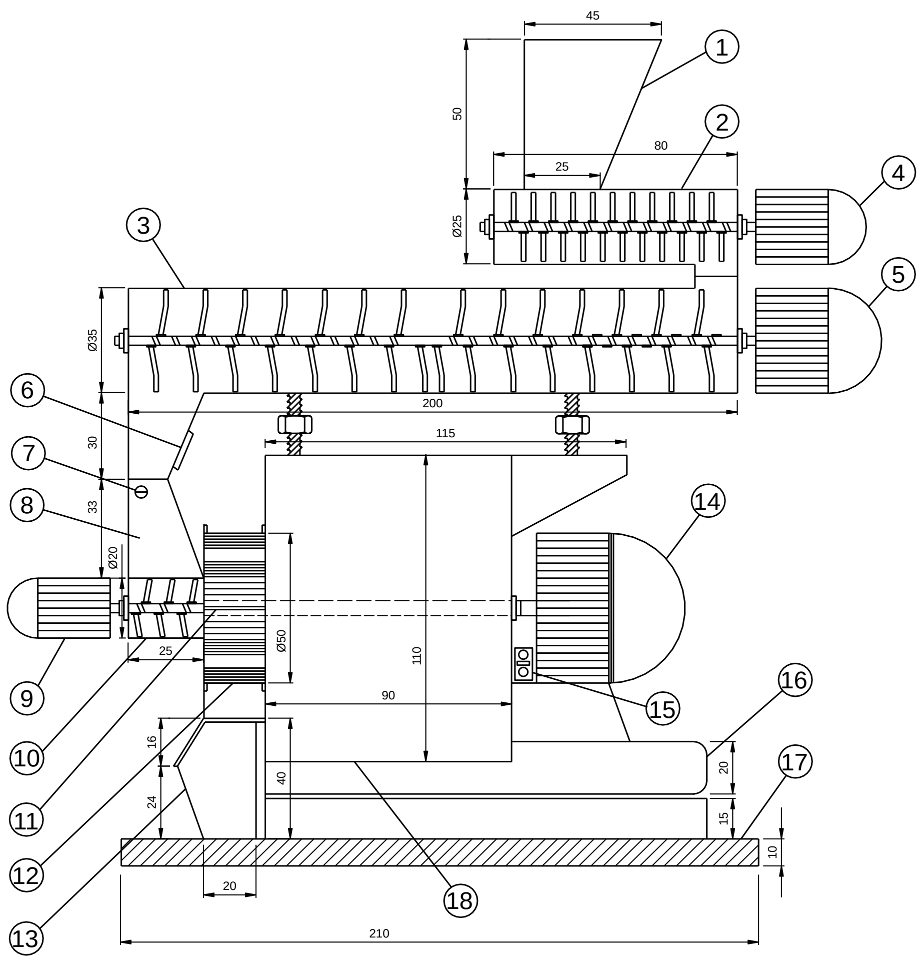
The manufactured ring die animal feed pellets extruder mainly consists of the following main parts: Extruder transfer gates, screw-feeding system, conditioning system, pelleting system, bearings, transmission system and overload protection system.

- Extruder transfer gates:

A transfer gate at the entrance of the extruder is used to allow animal feed formula to flow through it to the extruder. Another gate at the end of the extruder is used to collect the output pellets.

- The screw-feeding system:

The main function of the screw-feeder is to adjust the speed in order to control animal feed formula feeding rate precisely. The feeding system controls the amount of raw material that passes through the pelleting system. The screw-feeder (80 cm length and 25 cm diameter) was powered by an electric motor 0.74 kW (1 hp) with different rotational speed ratios for operating the feeding system.



No.	Part name	No.off	No.	Part name	No.off
1	Feed port	1	10	Modulator (2)	1
2	Speed adjustable feeder	1	11	Press roller & Main shaft	1
3	Modulator (1)	1	12	Ring die	1
4	Electric motor (1)	1	13	Operating door	1
5	Electric motor (2)	1	14	Main electric motor	1
6	Magnetic board	1	15	Overload protection device	1
7	Reset switch	1	16	Machinery base	1
8	Feeding throught	1	17	Pedstal	1
9	Electric motor (3)	1	18	Drive box	1

All dimensions im, cm

Fig. (1): The schematic drawing of the ring die animal feed pellets extruder.

- The conditioning system:

The conditioning system is an enclosed continuous mixing chamber in which the dry formula materials and water are blended together to make a wet formula to be transported to the pelleting system for making feed pellets (Fig. 2). It has two functions, first to fully blend the materials and water, and second to be long and large enough to provide the desired time for that function to fully occur before entering the pelleting system. The conditioning chamber is made of milled steel with a thickness of 8 mm. The conditioning chamber dimensions are 200 cm length and 35 cm diameter. A rotating iron steel shaft (with a length of 200 cm and a diameter of 7 cm) is mounted in the center of the conditioning chamber and supported by two rolling bearings. A screw is mounted on the conditioning shaft to mix formula with water. The conditioner shaft was powered by an electric motor 2.6 kW (3.5 hp) at a rotating speed of 900 rpm by means of pulley and belt for operating the conditioning system.

Fig. (2): The ring die animal feed pellets extruder.

- The pelleting system:

The main part of the pelleting system is a drive box with dimensions of (90 cm length, 110 cm width and 110 cm height) it contains feeding gate, driving shaft, pressing roller and ring die. The driving iron steel shaft (with a length of 100 cm and a diameter of 15 cm) is fixed in the center of the driving box and supported by two rolling bearings. A screw (25 cm length and 20 cm diameter) was mounted on the driving shaft for pushing the raw material into the die. The driving shaft was powered by an electric motor 91.9 kW (125 hp) at a rotating speed of 900 rpm. Pelleting process actually occurs when the feed formula materials are pressed between the ring die (46 cm outer diameter and 36 cm inner diameter) and the two pressing rollers with (diameter of 17.5 cm) for each. Both the pellet ring die and the pressing roller cooperate to push the formula material through the holes of the pellet ring die. The formula materials under high pressure, brought by mechanical interlocking, increased adhesion between the materials to form intermolecular bonds in the contact area to form pellets. Two ring dies were used: the first one (with 6 mm hole diameter) was mounted in the pelleting system in the case of producing cattle feed pellets, while the second die (with 2.5 mm hole diameter) was mounted in the case of producing rabbit feed pellets. A cutting mechanism was used to control the length of pellets by stretching in radial direction.

- Bearings

All shafts (feeding shaft, conditioning shaft and driving shaft) are supported by two rolling bearings. The manufacturer's catalogue is used to select the suitable type of the rolling bearings. According to the manufacturer's catalogue, the anti friction ball bearing is selected.

- The transmission system:

The transmission system provides kinetic energy. Gearboxes with different speed ratios transmit the power from the motors pulleys to the machine shafts (feeding, conditioning and driving shafts).

- The overload protection system:

An overload protection device is used to prevent damage to the pellet extruder in the occurrence of an overload.

2. Methods

Experiments were carried out to evaluate the performance of the manufactured ring die animal feed pellets extruder to choose the proper operational parameters.

2.1. Experimental conditions

The performance of the manufactured ring die animal feed pellets extruder was experimentally measured under the following parameters:

- Two values of ring die hole diameter (6 and 2.5 mm) for cattle and rabbit feed pellets, respectively.
- Four values of formula feed rate of (1.0, 2.0, 3.0 and 4.0 Mg/h).
- Three values of formula moisture content of (12, 14 and 16 %).

2.2. Moisture content determination

The formula moisture content is crucial because it can affect the physico-chemical and stability of the pellets **(Mahapatra et al., 2010)**. The evaluation of the effect of moisture content on the physical properties of pellets was carried out under the above-mentioned three moisture levels (12%, 14% and 16%). The chosen range of moisture content used is due to the fact that the extruder only operate if the moisture content for the sample exceeds 12%. The moisture content of the sample was measured on a wet basis (w.b.). The formula samples with the desired moisture contents were prepared by adding an amount of distilled water as calculated from the following relation **(Coşkun et al., 2005):**

$$Q = W_i \ (M_f - M_i) \ / \ (100 - M_f)$$

Where: Q - the mass of distilled water added, kg;

W_i - the initial mass of the sample, kg;

M_i - the initial moisture content of the sample, % (dry basis);

M_f - the final moisture content of the sample (dry basis.).

2.3. Measurements and determinations

Performance evaluation of the manufactured extruder was based on the following indicators:

-Extruder productivity:

Extruder productivity was calculated from the following equation:

$$Extruder\ \ productivity\ (kg/h) = \frac{W_p}{T}$$

Where: Wp - Pellets sample mass, kg,

T - Consumed time, h.

-Pelleting efficiency:

Pelleting efficiency was calculated from the following equation:

$$Pelleting\ \ efficiency\ \ (\%) = \frac{W_p}{W_s}$$

Where: W_s - Formula sample mass, kg.

- Pellets durability:

One kilogram of the produced pellets is shaked in a sieve shaker for ten minutes. After that, the cracked and the damaged pellets are subtracted from the treated sample. So, pellets durability can be calculated as follows:

$$Pellets\ \ durability\ = \frac{W_a}{W_b} \times 100$$

Where: W_a - Pellets mass after shaking treatment, g,

W_b - Pellets mass before shaking treatment, g.

- Specific mechanical energy

Specific mechanical energy for the extruding operation can be calculated as follows:

$$\text{Specific mechanical energy (kW.h/Mg)} = \frac{\text{Required power (kW)}}{\text{Extruder productivity (Mg/h)}}$$

The following formula was used to estimate the required extruding power **(Kurt, 1979):**

$$P = \sqrt{3} \times \cos \varphi \times I \times V / 1000$$

Where: P - Required power, kW,

I - Current intensity, Ampere,

V - Voltage, (380 V),

$\cos \varphi$ - 0.7

- Pelleting cost

The extruder hourly cost is estimated according to the conventional method of estimating both fixed and variable costs. While pelleting cost was calculated using the following formula:

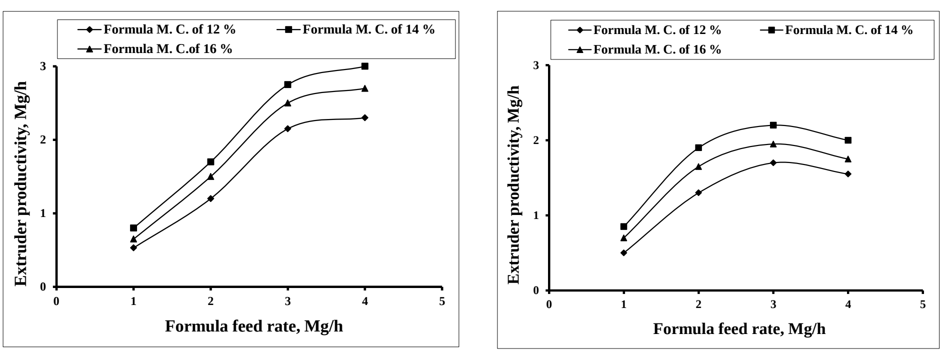
$$\text{Pelleting cost (L.E./Mg)} = \frac{\text{Extruder hourly cost (L.E./h)}}{\text{Extruder productivity (Mg/h)}}$$

RESULTS AND DISCUSSIONS

The discussion will cover the obtained results under the following heads:

1. Effect of some operating parameters on extruder productivity

Concerning the effect of formula feed rate on the extruder productivity, The obtained results in Fig. 3 show that increasing formula feed rate from 1.0 to 3.0 Mg/h, the extruder productivity is followed with an increase from 0.53 to 2.15, from 0.80 to 2.75 and from 0.65 to 2.50 Mg/h for cattle feed pellets and from 0.50 to 1.70, from 0.85 to 2.20 and from 0.70 to 1.95 Mg/h for rabbit feed pellets under formula moisture contents of 12, 14, and 16 %. Any further increase in formula feed rate more than 3.0 up to 4.0 Mg/h for cattle feed pellets and more than 2.0 up to 3.0 Mg/h for rabbit feed pellets caused slightly increase in extruder productivity. While further increase in formula feed rate more than 3.0 up to 4.0 Mg/h for rabbit feed pellets tends to decrease extruder productivity.



Cattle feed pellets Rabbit feed pellets

Fig. (3): Effect of formula feed rate and formula moisture content on extruder productivity under different kinds of animal feed pellets

The change in the behavior of extruder productivity by increasing formula feed rate more than 3.0 Mg/h for cattle feed pellets and more than 2.0 Mg/h for rabbit feed pellets is attributed to the excessive formula load on the die zone which tends to block extruder cylinder, resulting in exiting less pellets at the unit time. So, time is required to remove the blocked formula to reproducing feed pellets. The extruder productivity values of cattle feed pellets are higher than extruder productivity values of rabbit feed pellets because of the large die hole diameter of cattle feed pellets (6 mm) comparing with small die hole diameter of rabbit feed pellets (2.5 mm). The large die hole diameter helps to increase the pellets output quickly, resulting in remarkable increase in productivity.

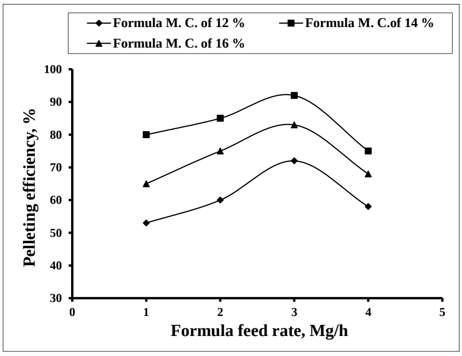
Relating to the effect of formula moisture content on extruder productivity, obtained results in Fig. 3 show that formula moisture content of 14 % gave the highest values of extruder productivity of 2.75 and 2.2 Mg/h for cattle feed pellets and rabbit feed pellets respectively compared to other ones.

2. Effect of some operating parameters on pelleting efficiency

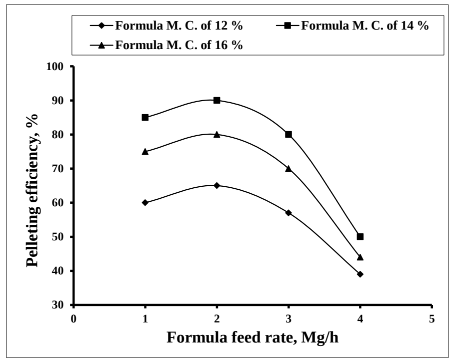
The effect of formula feed rate on pelleting efficiency is illustrated in Fig. 4. It is noticed that the increase of formula feed rate from 1.0 to 3.0 Mg/h accompanied with an increase in pelleting efficiency from 53 to 72, from 80 to 92 and from 65 to 83 % for cattle feed pellets at formula moisture contents of 12, 14, and 16 %, respectively. Also, the obtained results show that increasing formula feed rate from 1.0 to 2.0 Mg/h; the pelleting efficiency increased from 60 to 56, from 85 to 90 and from 75 to 80 % for rabbit feed pellets under the same mentioned formula moisture contents. Any further increase in formula feed rate more than 3.0 up to 4.0 Mg/h for cattle feed pellets and more than 2.0 up to 4.0 Mg/h for rabbit feed pellets, pelleting efficiency decreased.

Decreasing pelleting efficiency by increasing formula feed rate more than 3.0 Mg/h for cattle feed pellets and more than 2.0 Mg/h for rabbit feed pellets is attributed to the excessive formula load on the die zone which blocked the die, resulting in exiting less pellets at the unit time. The pelleting efficiency values of cattle feed pellets are higher than pelleting efficiency values of rabbit feed pellets because of the large die hole diameter of cattle feed pellets (6 mm) comparing with small die hole diameter of rabbit feed pellets (2.5 mm).

As to the effect of formula moisture content on pelleting efficiency, it observed in Fig. 4 that the highest values of pelleting efficiency of 92 and 90 % for cattle feed pellets and rabbit feed pellets respectively were recorded at moisture content of 14 %.



Cattle feed pellets



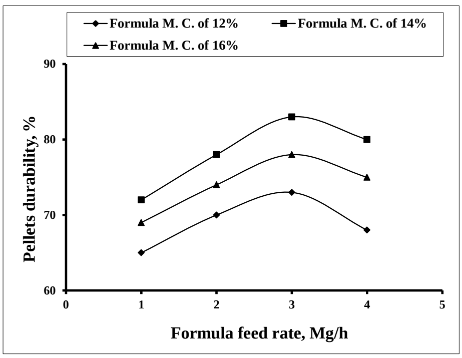
Rabbit feed pellets

Fig. (4): Effect of formula feed rate and formula moisture content on pelleting efficiency under different kinds of animal feed pellets

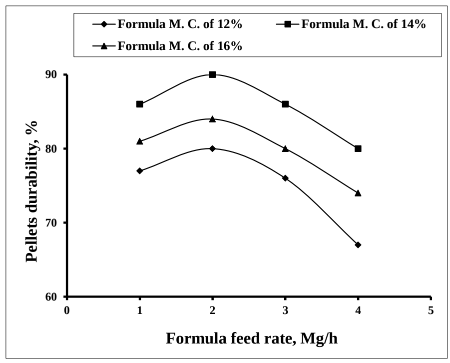
3. Effect of some operating parameters on pellets durability

Pellets durability is considered one of the most important indicators of pellets quality. Representative values of pellets durability versus formula feed rate are given for the two kinds of feed pellets through various formula moisture contents in Fig. 5. The obtained results show that increasing formula feed rate from 1.0 to 3.0 Mg/h, the pellets durability increased from 65 to 73, from 72 to 83 and from 69 to 78 % for cattle feed pellets at formula moisture contents of 12, 14, and 16 %, respectively. Also, the obtained results show that increasing formula feed rate from 1.0 to 2.0 Mg/h, the pellets durability increased from 77 to 80, from 86 to 90 and from 81 to 84 % for rabbit feed pellets under the same mentioned formula moisture contents. Any further increase in formula feed rate more than 3.0 up to 4.0 Mg/h for cattle feed pellets and more than 2.0 up to 4.0 Mg/h for rabbit feed pellets, pellets durability decreased.

The pellets durability values of rabbit feed pellets are higher than pellets durability values of cattle feed pellets because of the small diameter of rabbit feed pellets (2.5 mm) comparing with large diameter of large animal feed pellets (6 mm). The durability results show that it decreased with increase in die size. The binding forces in small size pellets strengthened the bond between individual particles in the pellets. While in the case of large size pellets, durability decreased due to the decrease of pressure in the die zone that means low level of compaction on the pellets.



Cattle feed pellets



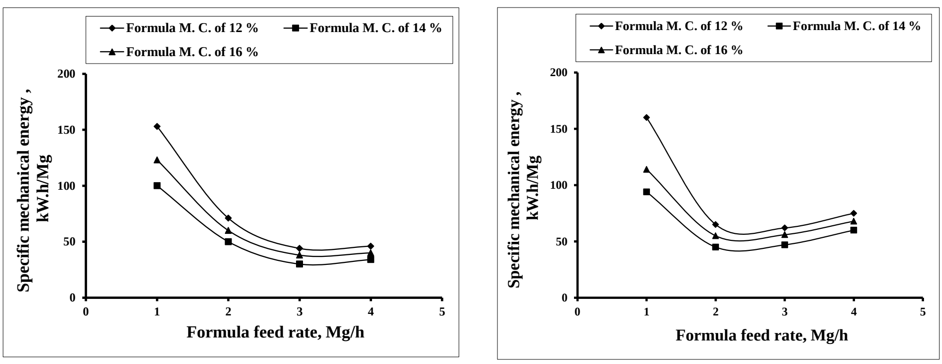
Rabbit feed pellets

Fig. (5): Effect of formula feed rate and formula moisture content on pellets durability under different kinds of animal feed pellets

Considering the effect of formula moisture content on the pellets durability, data in Fig. 5 show that the durability of the pellets is slightly affected by moisture content. The moisture increase in feed pellets is exponential to a point of disintegration. This is in agreement with **(Nelson 2002; McMullen et al. 2005; Fasina 2008).** The durability values increased initially with formula moisture content increase up to 14% then their values decreased with the further increase in formula moisture content. The highest values of durability of 83 % for cattle feed pellets and 90 % for rabbit feed pellet were achieved under formula moisture content of 14 %.

4. Effect of some operating parameters on specific mechanical energy

Power and specific mechanical energy are too related to formula feed rate under all formula moisture contents as shown in Fig. 6. Experimental data show that increasing formula feed rate increased the required power. While the same data show that the specific mechanical energy vary inversely with formula feed rate to a certain extent. It is clear that specific mechanical energy values decreased by increasing formula feed rate up to 3.0 Mg/h for cattle feed pellets and 2.0 Mg/h for rabbit feed pellets. Any further increase in formula feed rate up to 4.0 Mg/h, specific mechanical energy will increase. Obtained results show that increasing formula feed rate from 1.0 to 3.0 Mg/h for cattle feed pellets measured at different formula moisture contents of 12, 14 and 16 %, decreased specific mechanical energy from 153 to 44, from 100 to 30 and from 123 to 38 kW.h/Mg, respectively. The further increase in pellets feed rate more than 3.0 up to 4.0 Mg/h, measured at the same previous formula moisture contents, increased specific mechanical energy from 44 to 46, from 30 to 34 and from 38 to 40 kW.h/Mg.



Cattle feed pellets Rabbit feed pellets

Fig. (6): Effect of formula feed rate and formula moisture content on specific mechanical energy under different kinds of animal feed pellets

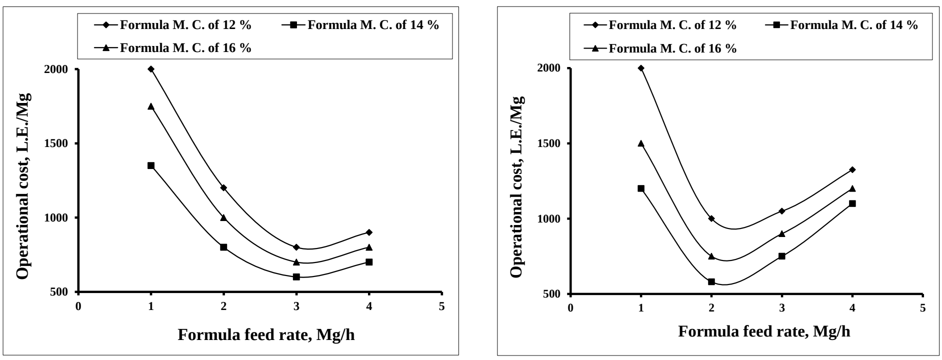
Also, the obtained results show that increasing formula feed rate from 1.0 to 2.0 Mg/h for rabbit feed pellets measured at different formula moisture contents of 12, 14 and 16 %, decreased specific mechanical energy from 160 to 65, from 94 to 45 and from 114 to 55 kW.h/Mg, respectively. The further increase in pellets feed rate more than 2.0 up to 4.0 Mg/h, measured at the same previous formula moisture contents, increased specific mechanical energy from 65 to 75, from 45 to 60 and from 55 to 68 kW.h/Mg. The required power increased by increasing formula feed rate because of the increase of formula flow through the extruder screw towards the die at the same time unit which represents extensive load on the screw shaft resulting in more power. The higher values of formula feed rate more than the optimum value (3.0 Mg/h for cattle feed pellets and 2.0 Mg/h for rabbit feed pellets) tends to increase energy because of the high increase in the required power comparing with the increase in extruder productivity.

Power and specific mechanical energy are also related to formula moisture content for the two kinds of pellets as shown in Fig.6. Experimental data show that minimum energy values of 30 and 45 kW.h/Mg for cattle feed pellets and rabbit feed pellets were achieved at formula moisture content of 14 %. The required power as well as specific mechanical energy increased by decreasing formula moisture content less than 14 % because of the increase in friction force between the extruder screw and the dry formula, added to that the friction force between formula particles tends to increase the required power resulting in high specific mechanical energy.

5. Effect of some operating parameters on pelleting cost

Pelleting cost is strongly related to formula feed rate under all formula moisture contents as shown in Fig. 7. The obtained data show that increasing formula feed rate decreased the pelleting cost up to 3.0 Mg/h for cattle feed pellets and 2.0 Mg/h for rabbit feed pellets. Any further increase in formula feed rate up to 4.0 Mg/h, pelleting cost will increase. Obtained results show that increasing formula feed rate from 1.0 to 3.0 Mg/h measured at different formula moisture contents of 12, 14 and 16 %, decreased pelleting cost from 2000 to 800, from 1350 to 600 and from 1750 to 700 L.E./Mg, respectively for cattle feed pellets. The further increase in formula feed rate more than 3.0 up to 4.0 Mg/h, measured at the same previous moisture contents, increased pelleting cost from 800 to 900, from 600 to 700 and from 700 to 800 L.E./Mg, respectively.

The same results show that increasing formula feed rate from 1.0 to 2.0 Mg/h measured at different formula moisture contents of 12, 14 and 16 %, decreased pelleting cost from 2000 to 1000, from 1200 to 580 and from 1500 to 750 L.E./Mg, respectively for rabbit feed pellets. The further increase in formula feed rate more than 2.0 up to 4.0 Mg/h, measured at the same previous moisture contents, increased pelleting cost from 1000 to 1325, from 580 to 1100 and from 750 to 1200 L.E. /Mg, respectively. The pelleting cost decreased by increasing formula feed rate less than the optimum value (3.0 Mg/h for cattle feed pellets and 2.0 Mg/h for rabbit feed pellets) because of the high increase in extruder productivity comparing with the increase in the required power. The higher values of formula feed rates more than the optimum values tends to increase pelleting cost because of the high increase in the required power comparing with the increase in extruder productivity resulting in high pelleting cost.



Cattle feed pellets Rabbit feed pellets

Fig. (7): Effect of formula feed rate and formula moisture content on operational cost under different kinds of animal feed pellets

Pelleting cost is also related to formula moisture content under all formula feed rates as shown in Fig. 7. Obtained results show that minimum values of pelleting cost of 600 L.E./Mg for cattle feed pellets and 580 L.E./Mg for rabbit feed pellets were achieved at formula moisture content of 14 %.

CONCLUSION

The present research was carried out to manufacture and evaluate the performance of a local ring die extruder to produce different kinds of animal feed pellets.

From the obtained data it can be concluded that the highest values of productivity, pelleting efficiency, pellets durability, specific mechanical energy and pelleting cost are in the optimum region under conditions of: 6 mm ring die hole diameter, 3.0 Mg/h formula feed rate and 14 % (w.b.) formula moisture content in the case of pelleting cattle feed pellets. While these conditions are 2.5 mm ring die hole diameter, 2.0 Mg/h formula feed rate and 14 % (w.b.) formula moisture content in the case of pelleting rabbit feed pellets.

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الملخص العـربــي

تصنيع وتقييم أداء آلة بثق محلية لإنتاج أنواع مختلفة من مصبعات أعـــــلاف الحيوانات

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أجريت هذه الدراسة بمصنع لإنتاج الأعلاف بمدينـه الإسكندرية لدراسة العوامل المؤثرة على أداء آلة بثق أثناء إنتاج أنواع مختلفة من مصبعات أعلاف الحيوانات حيث تم تصنيع هذه الآلـة خصيصًا لهذه الدراسة وكذلك تحديد أنسب الظروف للوصول إلى أعلى جودة للمنتج تحت عوامل التشغيل المختلفة. وكانت أهداف الدراسة هي:

- تصنيع آلة بثق لإنتاج مصبعات أعلاف الحيوانات بغرض رفع جودة المنتج النهائى.
- تحديد أفضل عوامل التشغيل للحصول على أعلى كفاءة تشغيل للآلة المصنعة.
- تقييم أداء الآلة المصنعة اقتصادياً.

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تم إجراء مجموعة من التجارب لاختبار الآلة المصنعة تحت عوامل تشغيل مختلفة:

- نوعان من مصبعات أعلاف الحيوانات (مصبعات علف المواشى بقطر ٦ مم – مصبعات علف الأرانب بقطر ٢,٥ مم).
- أربع معدلات لتلقيم تركيبة العلف وهي (١.٠ ، ٢.٠ ، ٣.٠ ، ٤.٠ ميجاجرام/ساعة).
- ثلاث نسب لرطوبة تركيبة العلف (١٢ ، ١٤ ، ١٦ %).

وقد تم تقييم المعاملات السابقة أخذاً في الاعتبار كلاً من:

- إنتاجية الآلة.
- كفاءة البثق.
- مقاومة مصبعات العلف للنقل والصدمات.
- الطاقة اللازمة لعملية البثق.
- التكاليف اللازمة لإجراء عملية البثق.

أظهرت النتائج التجريبية أن كل من الطاقة اللازمة للتشغيل والتكاليف الكلية تكون فى أدنى قيمها وأن كفاءة البثق ومقاومة مصبعات العلف للنقل والصدمات تكون أعلى ما يمكن تحت ظروف التشغيل الآتية:

- أن يكون قطر ثقوب مكبس العلف الحلقي ٦ مم في حالة مصبعات علف المواشى و ٢.٥ مم في حالة مصبعات علف الأرانب.
- تلقيم المواد المراد تصبيعها بمعدل ٣ ميجاجرام/ساعة و ٢ ميجاجرام/ساعة بالنسبة لمصبعات علف المواشى وعلف الأرانب على التوالي.
- أن تكون نسبة الرطوبة للمواد المراد تصبيعها حوالى ١٤%.