APPROVAL SHEET

DESIGN AND TESTING OF A PELLETING MACHINE FOR

RECYCLING AGRICULTURAL RESIDUES OF ANIMAL FEED

By

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صفحة الموافقة على الرسالة

تصميم وأختبار آلة لتصنيع المصبعات لتدوير المخلفات الزراعية كعلف حيوانى

رسالة مقدمة من الطالب

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بكالوريوس العلوم الزراعية (صناعات غذائية) جامعة عين شمس (1989)

لاستكمال متطلبات الحصول على درجة الماجستير
فى العلوم البيئية
قسم العلوم الزراعية

و قد تمت مناقشة الرسالة و الموافقة عليها

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Abstract.

Ahmed Ahmed Mahmoud El Attar, studies on “Design and testing of a pelleting machine for recycling agricultural residues of animal feed.“ Unpublished Master of Science, Ain Shams University, Institute of Environmental Studies and Research (2009).

The aim of this study was the design, construction and testing of pelleting machine for agricultural residues recycling to conserve the environment. The obtained results can be summarized as follows:

The maximum machine pellet-productivity of 247 kg/h was obtained with die speed of 250 rpm, die-hole diameter of 12 mm and clearance between rollers and die of 0.5 mm. Meanwhile, the minimum machine pellet-productivity of 95 kg/h was obtained with die speed of 320 rpm, die-hole diameter of 5 mm and clearance between rollers and die of 1.5 mm.

The maximum pellet-mass of 0.87 g was obtained with die speed of 100 rpm and die hole diameter of 12 mm. Meanwhile, the minimum pellet-mass of 0.26 g was obtained with die speed of 320 rpm, die-hole diameter of 5 mm and clearance between die and rollers of 1.5 mm.

The maximum durability of 97.2 % was obtained with_die speed of 100 rpm, clearance between die of 0 mm and die-hole diameter of 5 mm. Meanwhile, the minimum durability of 77.5 % was obtained with die speed of 320 rpm, clearance between die and rollers of 1.5 mm and die-hole diameter of 12 mm.

The maximum power of 9.33 kW % was obtained with die speed of 320 rpm, clearance between rollers and die of 0 mm and die-hole diameter of 5 mm. Meanwhile, the minimum power of 4.67 kW was obtained with die speed of 100 rpm, clearance between rollers and die of 1.5 mm and die-hole diameter of 12 mm.

The operation and production costs were ranged between 11.04 – 11.71 L.E./h and 44.69 – 62.29 L.E./ton respectively.

<u>Keywords</u>: Pelleting machine, horizontal die, die speed, die-hole diameter, pressing roller speed, clearance between rollers and die, fodder moisture content, molasses percentages, pellets productivity, pellets density. Pellets durability, consumed power, cost of pelleting machine.

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1 - INTRODUCTION.

The amounts of plant residues in Egypt reach about 25 - 35 million ton / year **(Ismael, 2001)**, and percentage of used as energy with direct burning is about 12.5 – 17.5 million ton / year when using primitive ovens with a low quality of less more than 10 %. Which presents a great in energy, in addition to its direct effect in environment population and public health damage **(Awady et al., 2001)**.

On the other hand, storing residues in farms and on roofs of village houses, makes a favorable environment for insects, rats and disease carriers which affect people, animals and plants, in addition to the great possibility of destructive fire **(Abd El Mottaleb, 1996).**

Awady (1989) mentioned that appropriate mechanization technologies should fulfill the three following parameters: (1) Proper functioning in handling the job for which it is designed, (2) Economical aspects, and (3) Matching with the present technological status while maintaining sustainability and safety requirements. So, various agricultural machines must be designed and manufactured to save time and work, and to protect the environment. The pelleting machine is the machine used to recycling crop residues. The designed machine must not be expensive, simple in construction and operation in all environmental conditions.

Packaging technology of voluminous forage or fodder materials into dense stable units is presently widely spreading throughout the farmworld due to its versatile benefits. This technique prevents segregation of the feed components and facilitates handling and feeding conditions associated with increasing production of animals fed in compact units.

Two main principles are applied in this technique, which are closed and open-end forming dies. The latter allows for continuous production of such agglomerated units. Many parameters influence densification technology, and they in general concern the material properties and machine capacity.

This research aims to design and evaluate the proficiency of a pelleting machine used with rice straw residues in fodder meals. This byproduct, when stored in heaps under open conditions, may cause serious problems due to inflammation and self ignition in hot days, occupies large space, difficult in handling, cheap selling price and prone to pests and rodent aggression. Water and molasses are added as bonding materials.

The objectives of this study are to design, construct and test of pelleting machine. In addition, some factors affecting the performance and power consumed such as die speed, die-hole diameter, clearance between rollers and die, fodder moisture-content and molasses percentage were studied.

2- REVIEW OF LITERATURE.

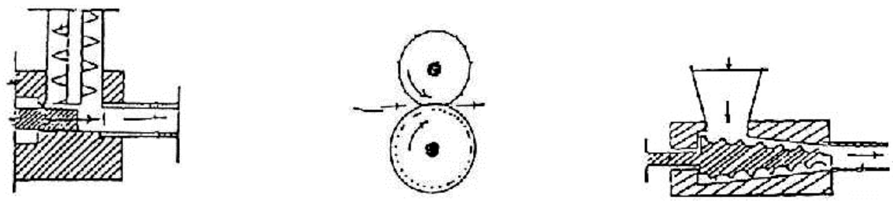
2-1 Difinition of pelleting.

Pelleting process is agglomerating feed by compacting and forcing through die openings with a mechanical process. Conditioning feed with water, steam or mixing with bonding agent usually takes place prior to pelleting. Pellets are then dried and cooled to dissipate heat.

Khankari et al. (1989) reported that densification is the process in which agricultural residues are compacted under compression or by extrusion with or without adding a binder to form a high density, cohesive agglomerate. Depending on the method used and size of the product, the densification process is called pelleting, briquetting, or cubing.

2-2 Types of compression devices.

Dobie (1960) indicated that there are three basic designs for wafering machines (fig. 2-1) as follows:



Plunger-type Roller-type Screw-type hay wafers.

Fig. 2-1: Schematic diagrams of compression devices **(Dobie, 1960)**.

1- Reciprocating or plunger:

The reciprocating machine operates on the same principle as most balers, except that the plunger and compression chamber are so designed as to provide the increased pressure necessary to produce a wafer. The hay is extruded through a die, which can be adjustable to control resistance to passage of hay. The die can be square or round, of single or multiple hole design.

2- Roller-type:

Wafers use the continuous-flow principle, gradually compressing a windrow of hay into area of 12.9 to 38.71 cm^2. It is not an extrusion process but does necessitate cut of the ribbon of hay after or during compression.

3- The screw-type:

This wafer provides continuous flow, but may develop excessive friction during compression, screw-type wafers extrude the hay through a die and require some devices to break the extruded hay into a suitable length.

Simmons (1963) divided cubing and pelleting machines into two classes:

1- Moulding machines:

The feed is moulded or compressed through two large rollers which have indentations or pockets in their outer surfaces and revolve inversely at 7 rpm. This type has been superseded by the modern extrusion type due to longer compression period in the latter.

2- Extrusion machines:

The scheduler type (the inventor's name) embodies two spur-toothed gear wheels run in opposite directions, each having radial holes at the root of the teeth where the compressed meal is extruded and cut off by stationary knives inside each wheel. Other machines have stationary or revolving, flat or ring type dies in a vertical or horizontal plane through which the meal is extruded by compression worms or revolving rollers, the resulting cubes or pellets being cut of by stationary or revolving knives.

Earliest and modern principal extrusion section layout is illustrated in fig. 2-2.

Molitorisz and McColly (1969) classified wafering systems into four categories:

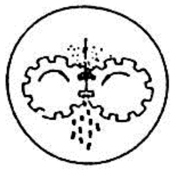
1- Closed and open-bottom plunger or arm devices.

2- External or internal roller devices.

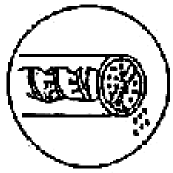
3- Extrusion devices.

4- Rolling-compression devices:

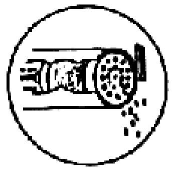
In rolling wafering, layers of loose long fibers or stems are rolled over each other in a channel or in a system of channels which is or are confined by rotating boundaries. Further exemplification of a basic channel consisting of wafer core and four boundary rollers is illustrated in fig. 2-3. Optimum density for grass-legume wafers from rolling system may be set at 320.37 to 481.1 kg/m^3 for moisture ranges between 20 and 40 %.



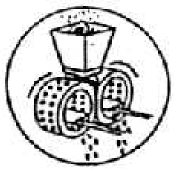
Cubes or Briquettes formed by compression between counter-rotating dies.



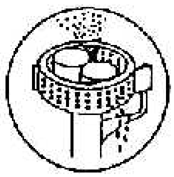
Material extruded through die by warm, then cut into pellets by rotary knife.



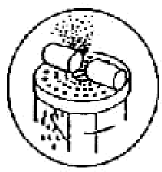
Material forced through stationary die by piston. Knife speed determines pellet length.



Material forced through holed in dies to inner surfaces, where it is cut into pellets by stationary knives.



Stationary die, rolls and knives rotate. Pellets extruded around outer circumference of die.



Stationary, horizontal die. Pellets extruded from under side of die, then cut by rotating knives.

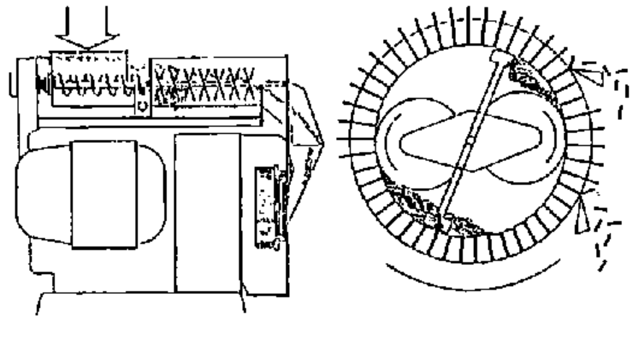


Fig. 2-2: Earliest and modern principles of cubing and pelleting **(Simmons, 1963)**.

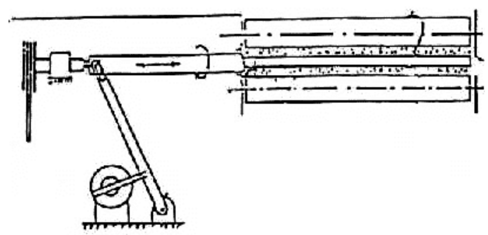


Fig. 2-3: A rolling-compressing system **(Molitorisz and McColly, 1969)**.

Bernacki et al. (1972) illustrated the principle of operation of wafering devices recently constructed in the United States and Soviet Union in fig. 2-4.