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Article

Feed pellet machine poultry

Peletizadora de alimento avícola

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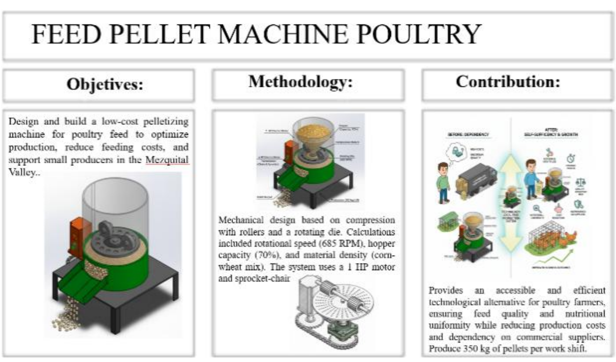
Abstract

The production of poultry feed is a key process in the poultry industry, as it requires proper nutrition to ensure the growth and welfare of the birds. In this regard, the manufacturing of poultry feed pellets represents a fundamental stage to guarantee both quality and efficiency in bird feeding.This study focuses on the design and construction of a poultry feed pelletizing machine, with the purpose of developing an efficient and effective solution for the production of high-quality pellets. The different components that make up the machine are analyzed, evaluating their characteristics and performance to identify potential opportunities for optimization.



Pellet mill, Production processes, Poultry industry

Resumen

La producción de alimento para pollo constituye un proceso esencial dentro de la industria avícola, ya que requiere una nutrición adecuada para garantizar el crecimiento y el bienestar de las aves. En este sentido, la fabricación de pellets de alimento para pollo representa una etapa fundamental para asegurar la calidad y la eficiencia en su alimentación. El presente trabajo aborda el diseño y la construcción de una máquina peletizadora de alimento para pollo, con el propósito de desarrollar una solución eficiente y efectiva para la producción de pellets de alta calidad. Se analizan los diferentes componentes que integran la máquina, evaluando sus características y desempeño con el fin de identificar oportunidades de optimización.

Peletizadora, Procesos productivos, Industria avícola

Area: Promotion of frontier research and basic science in all fields of knowledge.

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I. Introduction

During the past decade, global chicken meat production maintained an average annual growth rate of 2.1%, reaching a record high volume of 103.5 million tons [mdt] in 2023.

In Mexico, chicken meat production in 2023 reached a historic high of 3.89 million tons. According to data from the Secretariat of Agriculture and Rural Development in Mexico, for 2024, national production is estimated to grow by 2.4%, reaching a new high of 3.98 million tons.

Chicken meat is the most produced type of meat in Mexico, representing nearly half of the total volume. Chicken meat accounts for 48.1% of meat consumption in Mexico, as it continues to be the most affordable source of meat compared to pork and beef. [FIRA. 2024]. For the Mezquital Valley, in the state of Hidalgo, Mexico, in a study conducted in 2021 for one of its communities, the population considers poultry farming as the most important activity compared to other activities in their family production units, reaching a 63% importance rate, compared to 25.9% for dairy cattle and the rest for sheep and rabbits. [Romero, 2021].

In the Sectoral Program for Agricultural and Rural Development, Hidalgo 2023 – 2028, the results indicate a repetitive need for technological equipment [Gobierno del Estado de Hidalgo 2023], this being one of the main reasons for this work.

The demand for nutritionally quality food is concerning, because the supply becomes insufficient, leading to the need to accelerate, modernize, and improve the meat production process.

In the state of Hidalgo, according to the 2022 agricultural census, it is reported that, of the total cost of poultry production, feed represents 66.99% of the expenses [SAGARPA 2012], a situation that directly affects small producers.

These producers seek new alternatives for animal feed, which allow them to reduce costs and obtain greater profits from their production system.

As the demand for animal feed increased, many farmers are having problems acquiring feed with the right quality, cost, and sustainability. Furthermore, considering that a 5-kilogram bag of poultry feed costs between $200 and $250 pesos, small farm owners do not have access to a reliable source nor the financial means to acquire feed that meets their specific needs. The manufacturing of a pelletizing machine aims to minimize costs and increase feed productivity.

Today, more than 60% of farmers in the Mezquital Valley do not have access to these machines due to their high market price, which ranges from $50,000.00 to $72,000.00 pesos.

2. Methodology

2.1. The pellet and the characteristics of a pelletizer

Currently, if a poultry or swine company wants to improve its productive parameters and profitability, it must optimize feed use, since this represents 60–70% of the total production cost. For this reason, the use of pelleted feed in the animal industry has become very important in recent decades, as studies indicate that it leads to better feed efficiency.

Pelleting is defined as a process that uses pressure, moisture, and heat to cause small feed particles to agglomerate with each other to form a larger granule or "pellet," making it sufficiently moldable to be compacted to achieve greater density. [Loor 2016].

Depending on the physical characteristics of the balanced feed, greater or lesser compression is used. For example, if the formula contains a high level of fibrous ingredients such as bagasse, bran, or ground alfalfa, the pelletizer will spend a large amount of energy compressing the meal to the pellet density. On the other hand, for a relatively dense feed, such as one high in grains and soybean meal, the pelletizer will spend less energy on compression and a greater amount on production. [Behnke, 2010]. A pelletizer is a machine whose job or activity is to transform and/or convert raw material into pellets, which are smaller pieces, roughly spherical or cylindrical in shape. There are various types of pelletizers, for example, ring die pelletizer, disc pelletizer, and counterflow pelletizer.

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This means that pelletizing is the process that allows us to shape the mixture of ingredients, which are compacted through given holes to turn it into cylinders or spheres; these are also agglomerated foods. This form is achieved through a mechanical process with moisture, pressure, and temperature. [Loor 2016].

For the design of a pelletizer, it is necessary to consider a series of factors such as:

- Production Capacity: amount of pellets per hour or per day
- Size and Shape of the Pellets
- Feeding System• Cooling System
- Motor and Power
- Construction Materials: usually made of high-strength steel to withstand wear
- Adjustments and Control
- Pellet Ejection System
- Maintenance and Cleaning.

As is to be expected, the construction must be based on standards. For this work, the Mexican Official Standard NOM-Y-121-A-1979, the CEN/TS 14691 standard, and the ENplus standard, which is the European standard for pellet manufacturing, will be taken into account.

Therefore, there are three types of pelletizers: flat pellet mill, vertical ring mill, and horizontal ring mill. It has been decided to implement a compression pelletizing system using rollers and a rotating die, with a working capacity of 350 kg per shift. See Table 1.

Box 1

Table 1

Technical data sheet of the pelletizing machine

Chicken feed pellet	
Work capacity	350 kg/day
Rotation speed	685 rpm
Pelletizing system	Compression using rollers and a rotating die
Transmission system	1 HP single-phase electric motor with sprocket-chain
Dimensions	Height 0.5m, width 0.35m, length 0.35m
Net weight	35kg

Source: Table made by the authors

2.2 design of the pelletizing machine

For the machine design, the capacity per shift is calculated. A shift of 6.5 hours and a production of 54 kg of pellets per hour is considered. Therefore, with 54 kg per hour and considering 6.5 hours, we have 350 kg per shift. With a hopper capacity of 70%, it is obtained:

$V = \pi r^2 h$ [2.2.1]

With a height of 22.1 cm, a radius of 12.5 cm, replacing in [2.2.1]:

$$V = (3.14.16)[12.5cm]^2[22.10\ cm][0.7]$$
$$V = 7594.5cm^3$$
$$\frac{343cm^3}{1,000,000} = 7.5945x10^{-3}\ m^3$$

For the Volume of the dough we use:

$V_r = \frac{m}{\rho a}$ [2.2.2]

$$\frac{m}{\rho a} = \frac{food\ mass\ [kg]}{density\ of\ balanced\ feed}$$

On the other hand, the apparent densities of corn [450 kg/m³] and wheat [750 kg/m³] obtained from the density table published by the FAO [De Lucia, 1993] and considering a mixture with a proportion of 60% corn and 40% wheat:

$$corn\ by\ 60\% = 450kg/m^3[.6] = 270\frac{kg}{m^3}$$
$$Wheat\ at\ 40\% = 750kg/m^3[.4]$$
$$= 300kg/m^3$$
$$total\ density = 570\frac{kg}{m^3}$$
$$Vr = \frac{54kg}{570kg/m^3} = 0.094kg/m^3$$

The rotation speed with respect to the transmission system by means of pinion-chain is given by the following equation:

$VG = Rpm\frac{PE}{PM}$ [2.2.4]

If RPM = 1500 and PE = 16 [Number of pinions from the motor shaft] and PM = 35 [Number of pinions from the die shaft]

Then

$$VG = 1500\frac{16}{35}$$

VG=685.71 Rpm

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The angular velocity is related to the rotation speed of the machine, and is calculated using [2.2.5].

$\omega = \frac{2\pi Rpm}{60}$ [2.2.5]

$$\omega = \frac{2\pi(685Rpm)}{60}$$

So:
$\omega = 71.73\, rads/s.$

Now, regarding the pellet, according to the CEN/TS 14691 standard, the desired diameter of the pellet is chosen.

$V = \pi r^2 h$ [2.2.6]

$$d = 4.76\, mm$$
$$r = 2.38\, mm$$
$$h = 6.35 mm$$
$$\pi = 3.1416$$
$$V = 3.1416[2.38mm]^2[6.35mm]$$
$$V = 112.999mm^3$$

To obtain the pellet density, it was weighed on an electronic scale, yielding a result of 50 grams.

To calculate the density of a pellet, use [2.2.7].

$\rho = \frac{mass}{volume}$ [2.2.7]

Of [2.2.7], The volume is 112.999 $mm^{3,}$ becomes to cm^3

$$112.990mm^3 = 0.113cm^3$$

Therefore.

$$\rho = 50gr/0.113cm^3$$
$$\rho = 442.477gr/cm^3$$

The force of the rollers is calculated..

$Fr = f\ x\ Fb$ [2.2.8]

Where:

Fr=Friction force [N], Fb=Balancing load [N], f=Friction coefficient.

The roller design was calculated considering the following parameters:

$Fr = f\ x\ Fb$ [2.2.9]

Where Fr = Friction force [N], Fb = Balancing load [N], f = Coefficient of friction.

According to the coefficients of static and dynamic friction of steel with steel [Serway& Jewett, 2008] and considering [2.2.10]

$Fb = \sigma_s x\ A_c$ [2.2.10]

σs = Coefficient of breaking strength [$N/mm^{2]}$
Ac = Contact area of the roller with the food[m^2]

$$\sigma_{s=10N/mm^2}$$

To calculate the contact area, the following was used: [2.2.11].

$Ac = tm\ x\ lr$ [2.2.11]

Where tm = Average width of the corn size; tm=1 cm

Ac = Contact area of the roller with the feed
Lr = Roller length [m]
$Ac = 0.01m\ x\ 0.05$
$Ac = 0.0005m^2$

Therefore,

$$Fb = \frac{1x10^7N}{m^2} x\ 0.0005m^2$$
$$Fb = 5000N$$

Then the friction force.

$$Fr = 0.57x\ 5000 = 2050N$$

Considering four vertical supports, made with 2”X1/82 steel angle and a weight to support of 30kg, there is a total force of 295 N, divided into each support, so in each one we have a force of 73N.

Results

With the information obtained, the design is carried out, thus making a subassembly 1 for the base as shown in figure 3.1.

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Box 2

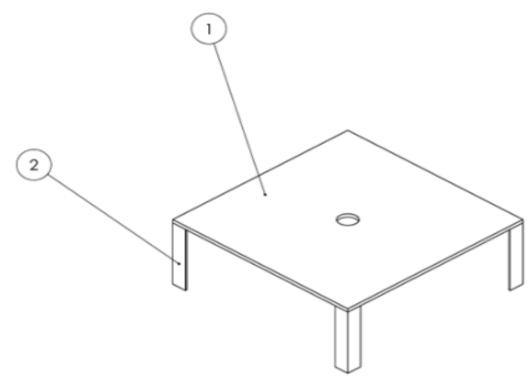

Figure 1
Base for the pellet mill, Number one represents the support and number 2 is the base
Source: Figure created by the authors

The subassembly 2 of the motor [7], the sprockets [1] [model 15T-520-S-Z, WEYINGSI], the chain [2] [525-Z8-H, DID brand], the transmission shaft [3] is carried out, likewise a bearing system [4] was added [F205-LDK wall bearing, FAG brand], the extractor plate with its respective matrix [5] and the rollers [6] [150-250-MKFD00P, MELKO brand]. This subassembly can be seen in figure 3.2.

Box 3

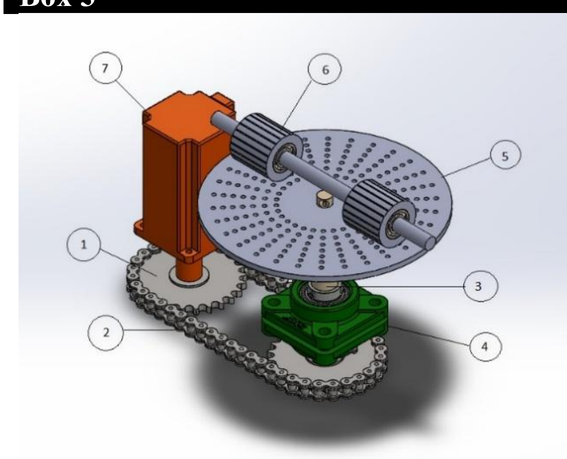

Figure 2
Subassembly 2. Motor, transmission system, rollers and extractor plate.
Source: Figure created by the authors

Once subassembly 2 is completed, proceed to complete subassembly 3, see figure 3.3, which consists of the discharge hopper [1], the pelletizing chamber [2], with its respective Grainger brand adjuster [3] [5-9-10] with nut.

Box 4

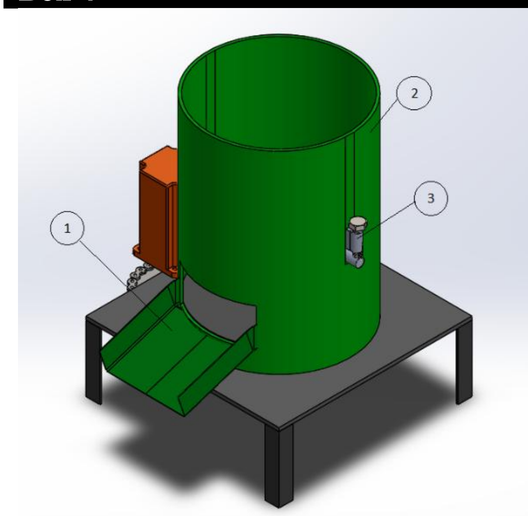

Figure 3
Subassembly 3. Pelletizing chamber, adjuster with nut and discharge Hopper.
Source: Figure created by the authors

With the last subassembly, all the elements are integrated, leaving the design of the pelletizing machine as can be seen in figure 3.4.

Box 5

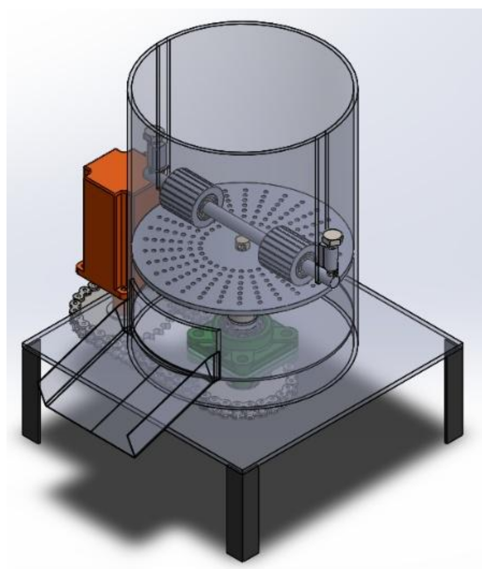

Figure 3.4
Pelletizing machine
Source: Figure created by the authors

3. Conclusions

The final product, the pellets, is characterized by their hardness and greater durability, as well as added value: when compressed, they become a more compact and balanced product, providing animals with nutritionally balanced feed. It also simplifies the distribution of rations based on the birds' nutritional consumption.

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The rotary die pelletizing machine has the advantage of being able to be installed anywhere; it does not require extensive space, which facilitates its operation and maintenance, thus ensuring lower operating costs for each owner.

This machine can benefit over 8,750 small and medium-sized chicken producers in the state of Hidalgo, generating an average of 350 kg of pellets per day.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no financial interests or personal relationships that could have influenced this work.

Author contribution:

Mariscal-Navarro, Fidel Alejandro: Contributed to the research technique, as well as the development and observations for future design recommendations.

Bravo-Cadena, Román: Contributed to the implementation of the research method for the study object.

Cardon-Angeles, Asael Jesse: Contributed to the idea and design of the project.

Téllez-Ramos, Jonathan Esaú: Provided fieldwork and advice on data processing.

Funding.

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Abbreviations

FIRA. Fideicomisos Instituidos en Relación con la Agricultura. México

SAGARPA. Secretaría de Agricultura, ganadería, desarrollo Rural, Pesca, México.

UNAM. Universidad Nacional Autónoma de México.

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