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(REVIEW ARTICLE)

Study and design of a poultry feed crusher-calibrator

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Abstract

This work focuses on improving the technical and economic performance of the poultry farming sub-sector in Benin. We were specifically interested in the study and design of a grinder-grader for poultry feed.

Indeed, two different technologies for controlling the particle size are combined into one to form the crusher-sizer. This is the fragmentation of food particles, carried out by the mobile hammer mill and the dimensional classification carried out by a vibrating sieve or sizer. These two technologies are well developed in industries, especially in quarries, but their applications in the field of agro-food processing in Benin are rare or practically non-existent. This technology will allow an increase in the production time and cost of poultry feed. The grinder-grader is then a new technology, a new piece of equipment designed with the aim of allowing poultry farms in general and traditional poultry farmers in particular, the self-production of poultry feed. It is then that they will be able to efficiently minimize the time and cost of poultry production to finally optimize the economic performance of farms.

Keywords: Granulometry; Poultry feed; Agro-food processing; New technology; Poultry feed grinder-grader

1. Introduction

Poultry farming represents a food and economic pillar that should not be neglected in West Africa, where poultry production continues to increase. In Benin, the number of poultry, all species combined, increased from 16,941,000 in 2012 to 17,483,000 in 2013 (FAO, 2015). Nowadays, the numbers have increased due to the increase in food needs and the development of peri-urban poultry farming. Poultry farming is mainly practiced in rural areas using relatively undeveloped livestock systems (Bebay, 2006). With the demographic explosion and the boom in the rural exodus, poultry farming has become an urban or peri-urban activity with 47.55% of the total workforce in Benin, produced in the Atlantique-Littoral in 2012 (FAO, 2015).

In Benin, the level of animal protein consumption is estimated at 12 kg per capita per year (FAO, 2015). This value is below the threshold of 20 kg of minimum protein consumption per year recommended by the FAO. About 22% of this total protein consumption is provided by poultry products. According to statistics from the livestock department, reported by FAO (2015), poultry is the second source of meat, after cattle (21% for poultry against 58% for cattle, 13% for sheep/ goats and 7% for pork).

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Traditional poultry farming is seen as a strategic tool in the fight against rural poverty (Sodjinou, 2011). However, its production remains insufficient to meet the needs of the population in animal protein. Between 2015 and 2016, the livestock sub-sector provided local meat production estimated at between 68,692 tonnes and 70,327 tonnes, of which 19.3% represents the share of poultry (Dognon et al., 2018). On the other hand, the quantities of imported meat, 187,627 tonnes in 2015 and 113,394 tonnes in 2016, greatly exceed those produced locally (Dognon et al., 2018). Thus, the consumer market is largely unsatisfied and appears as a huge potential to boost poultry production.

For better poultry production, two important parameters must be taken into account: the quality of the feed on the one hand and the quantity which must be reasonable.

In the first case, the animals need a balanced food ration (rich in vitamins and energetic). The second case implies the quantity of the food and especially the physical aspect of the food. The studies of NGA OMBEDE Sabine Ninelle in 2009 on '' Effects of the nature of cereals and particle size on the zootechnical performance of broiler chickens '' in Senegal proved that the grain size is a determining parameter in the good development of poultry; their digestions as well as their zootechnical performances. It is in this perspective that we have directed the subject of our study towards ''the study and design of a grinder-grader for poultry feed'' in order to contribute to the improvement of feed rations in terms of concerns the particle or particle size structure of feed consumed by poultry.

Indeed, two different particle size control technologies are combined into one: particle fragmentation, carried out by the mobile hammer mill and dimensional classification carried out by a vibrating screen or sizer. These two technologies are well developed in industries, especially in quarries, but their applications in the field of agro-food processing in Benin are rare or practically non-existent. This technology will allow an increase in the production time and cost of poultry feed. The grinder-grader is then a new technology, a new piece of equipment designed with the aim of allowing poultry farms in general and traditional poultry farmers in particular, the self-production of poultry feed. It is then that they will be able to efficiently minimize the time and cost of poultry production to finally optimize the economic performance of farms.

2. Material and methods

2.1. Description of the proposed machine

The following figure N°1 is the 3D and 2D design of the Crusher-Calibrator carried out using the Computer Aided Design (CAD) software Topsolid 2006.

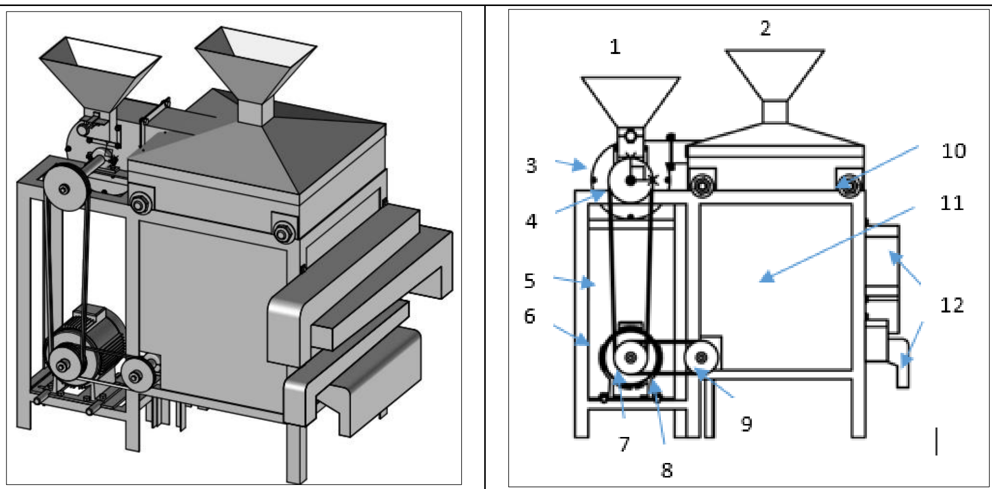


Figure 1-a | Figure 1-b

1: Crusher hopper; 2: Calibrator hopper; 3: Grinding chamber; 4: Pulley with two trapezoidal grooves of the crusher shaft; 5: Belts of transmission n ° 1; 6: Electric motor; 7: Three-groove driving pulley; 8: Transmission belt n ° 2; 9: Pulley with one groove trapezoidal eccentric carrier shaft; 10: Axes carrying the calibration chamber; 11: Calibration chamber; 12: Chutes

Figure 1 Le Crusher-Calibrator (a- 3D view and b- 2D view)

The main elements of the machine are among others: the hoppers, the crushing chamber, the hammers, the trap, the screens, the calibration chamber, the eccentric shaft, the crusher shaft and the collection chutes.

2.1.1. Feed hoppers

The hoppers in the form of a truncated pyramid are used to supply the machine with cereal products on the crusher side and floury products on the grader side. The useful volume of each hopper is 2587322.122 mm^3.

2.1.2. The grinding chamber

This is the space reserved for grinding grain. It contains the hammers and the hammer-carrying hub as well as the product admitted within it to be crushed. Its diameter is 350mm and its height is 220mm and it is made of food grade stainless steel.

2.1.3. Hammers

The hammers in rectangular parallelepiped shape, are designed in food grade stainless steel with dimensions 100x15x10mm3. These hammers, sixteen in number, are mounted on four axes parallel and symmetrical (two consecutive hammers) from each other by the 90° angle rotation with respect to the middle line of the crusher shaft and are carried in turn by the hammer-carrying hub.

2.1.4. The hatch

The hatch designed in stainless steel is used to regulate the flow of the product feeding the grinding chamber from the hopper.

2.1.5. Grates

The grids designed in this study are intended for the dimensional classification of the product crushed at four different levels: the crusher is fitted with an 8mm grid. On the other hand, in the calibration chamber, we design three 6mm mesh grids; 4mm and 1.5mm successively mounted in parallel from top to bottom and inclined at an angle of 10 ° from the horizontal. The screening area of these screens is 596mmx596mm and 3mm thick. The vibration of these grids with their inclination makes it possible to calibrate the crushed product.

2.1.6. The calibration chamber

Designed in ordinary steel, the calibration chamber houses the three screens mounted parallel and fixed on supports making one with the chamber. It is of a rectangular parallelepiped shape measuring 500mmx600mmx800mm. It is articulated to the frame, which promotes vibration (negligible amplitude oscillation).

2.1.7. The shaft bearing eccentric

It is the whole formed by the tree and the eccentric. The eccentric is a piece of general-purpose steel, cylindrical in shape (100mm in diameter and 80mm in height) offset, rotatably linked by keying and axially on the shaft (40mm in diameter) by a set screw. The rotation of the shaft is communicated to the eccentric which converts it to discontinuous and periodic rotation. This periodic movement is transmitted to the calibration chamber in the form of shocks.

2.1.8. The crusher shaft

In shelf form (diameter 30mm, 40mm and 35mm successively), this general-purpose steel shaft carries at one end where the diameter is 30mm, the keyed hammer-holder hub. At the other end where the diameter is 35mm is made a class A keyway allowing the drive of the shaft by a trapezoidal groove pulley. By con

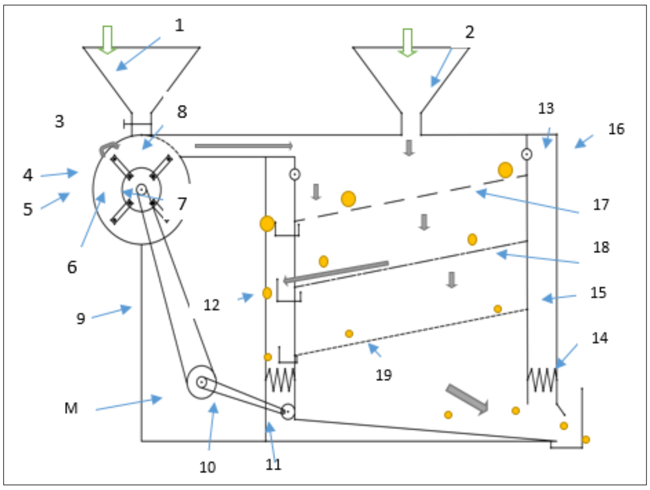
2.1.9. Recovery chutes

The 3mm thick chutes are made of food grade stainless steel and allow the recovery of the crushed and / or calibrated product. Thus, each grid of the calibrator has a collection grid.

2.1.10. The chassis

The frame or frame is the element serving as a support for the two functional parts of the machine, which are the crusher and the calibrator. It is made by welding and arc welding with a base of 60, 40 cm iron. Its overall dimensions are: 1300mm in length, 800mm in width and 1300mm in height.

2.2. Working principle of the Crusher-Calibrator



1: Crusher feed hopper; 2: Calibrator feed hopper; 3: Hatch; 4: Hammer; 5: Grinding chamber; 6: Crusher shaft; 7: Hammer holder plate; 8: Grinder screen (8mm); 9: Motor-crusher transmission belt; 10: Motor-shaft transmission belt eccentric holder; 11: Eccentric; 12: Recovery tank; 13: Articulation; 14: Spring; 15: Calibration chamber; 16: Chassis; 17: Large mesh grid (6mm); 18: Medium mesh grid (4mm); 19: Small mesh grid (1.5mm); M: Electrical motor

Figure 2 Operating diagram of the Crusher-Calibrator

2.3. Description of the operating principle

The machine is made up of two functional parts: the part relating to grinding and the part relating to calibration.

Once the motor M is started, the crusher shaft, thanks to the pulley belt transmission mechanism 9, starts to move. The shaft, keyed to the hub (made up of the plate, hammer axles and hammers) communicates its movement to the latter.

The transmission ratio between the driving pulley and the shredder pulley (D / D1 = 075) means that the speed of the latter is three quarters of that of the driving pulley, i.e. 750 rpm.

The hub carries four image axes relative to each other (two consecutive axes) by the 90 ° angle rotation. Each of the four axes carries four hammers movable around the axis and interposed by spacers. Corn kernels, like any other product entering the crusher feed hopper, are subjected to the action of rotating hammers. The grinding is carried out by the effect of the impact between the grains and the hammers on the one hand and between the projected grains and the internal wall of the grinding chamber 5 on the other hand. The hub is equipped with pallets at the rate of a pallet between two hammer-holder axles which gives the hub-pallet assembly the capacity of a fan ensuring the evacuation of the crushed product, the size of which is at most 8mm, from pass through the grinder grid 8 to end up in the calibration cage 15.

At the same time as the motor is started, it transmits its movement to the shaft carrying the eccentric. In reality, the eccentric 11 is an offset cylinder, keyed to its shaft which in its periodic and discontinuous rotation communicates to the calibration chamber a vibratory movement, shocks of a given frequency. In addition, the ground product coming from the crusher or directly from the feed hopper of calibrator 2 is found on the first grid of calibrator 17. Product calibration is provided by the combined action of the vibration of the calibration chamber and the 10° inclination of the screens accelerating the passage of the product through the three screens successively. In reality, at the level of each grid, the particles of size less than or equal to the mesh of the grid cross it while the largest (the rejects) thanks to the slope go down towards the collection tank provided for this purpose.

A set of springs (14) is used (four identical springs) between the frame and the vibrating cage to dampen the shock produced by the eccentric on the one hand and amplify the vibration on the other hand.

Apart from using the machine as a calibrating mill, it can be used as a simple calibrator and as such calibrate other products (eg gari). To do this, a three-dimensional mobility of the motor is provided, making it possible to reduce the center distance and then relax the crusher belts and therefore easily undo them. It should be noted that this displacement of the motor also makes it possible to adjust the tension of the belts.

2.4. Medialization

This section entitled modeling highlights all the mathematical models and all the physical principles giving rise to the dimensioning of our machine. For the sizing as well as the determination of the characteristics and parameters of the various parts and mechanisms of the equipment, we will follow the Rhemogram (or even the path) of the power. The path of the mechanical power is then in the order made up of: The engine, the pulley-belt transmission and the rotation shafts.

Although the first element of the power path is the electric motor, we successively approach this section by sizing the transmissions; the choice of electric motor; the sizing of the shafts and axis of the machine and finally, the study and sizing of the mechanism of vibration of the calibrator.

2.4.1. Functional specifications

- Technical functions of the machine
  - Technical function n ° 1: grinding cereals, toned oilseeds, and shells to obtain products of sizes less than or equal to 08mm;
  - Technical function n ° 2: ensure the sizing of the ground product in 1.5mm calibers; 4m m and 6mm;
  - Technical function n ° 3: possibility of suppressing the action of the crusher at will;
- Desired grinding capacity: 0.6ton / hour
- Daily operating time: T = 8 hours / day;
- Driving force: supplied by a three-phase electric motor (input: 220/380, 50Htz);
- Cost $\leq$ 800 $000FCFA$.

The mechanical properties of the reference cereal (the OUYE variety of corn in Benin) for grinding in this study are shown in the following table:

Table 1 Physical and mechanical characteristics of reference corn

Product	Average diameter of corn seeds (mm)			Water content of seeds (%)	Breaking force (en N)
	Length	Width	Thickness		
Corn	10.834	9.039	4.161	15.06	206.304

Source : AKPOVI 2014

2.4.2. Sizing the transmission n°1

This is the pulley-belt transmission between the grinding shaft and the motor rotor.

Useful power to grinding

The grinding energy is based on the literature evaluated by three fundamental theories such as:

- RITTINGER's law (1867)

According to this law, the grinding energy of a material changing it from a state 1 where the size is x_1 to a state 2 where the size is x_2 is given by:

$$E_{1\text{-}2}= C(\frac{1}{x1} - \frac{1}{x2}) \text{ ………………… (8)}$$

- KICK's law (1885)

Under the same conditions as above, KICK estimates that the energy required for grinding the material is given by :

$$E_{1\text{-}2}= Cln\frac{x1}{x2} \text{…………….(9)}$$

- BOND's law (1951)

The energy required to grind a material by reducing the size of its particles from x1 to x2 according to BOND is given by:

$$E_{1\text{-}2} = C\left(\frac{1}{\sqrt{x2}} - \frac{1}{\sqrt{x1}}\right) \quad \ldots\ldots\ldots\ldots(10)$$

C is a constant characteristic of matter; x in mm and C in KWh.t^{-1}.

According to Vigneault et al. 1992, 10.0 <C <12.4 for grain corn. We use the average of its two terminals, i.e. C = 11.2 KWh.t^{-1}.

Moreover, the starting particle size and that after grinding of the corn which is the subject of this study are respectively x_1 = 10.83mm and x_2 = 1.5mm.

The energy required to grind the corn according to the BOND formula is then:

$$E_{1\text{-}2} = 5.75 \text{ kWht}^{-1}$$

The power required for grinding is given by:

$P_1 = E_{1\text{-}2} \times \frac{2}{3}\text{Cap}$ = 2,3kW and the corresponding mechanical torque is:

$$C_1 = \frac{60P_1}{2\pi N_1} = 29.28\text{N.m}$$

Cap is the hourly capacity of the crusher.

The mechanical power deployed by the hammers to break up the cereals is given by:

$$P_{\min} = \frac{1}{60}\pi D_m.F_b.N_1$$

Dm = diameter of the circle defined by the upper ends of the hammers; Fb = corn breaking force or breaking resistance force; N1 = 750rpm: rotational speed of the crusher shaft.

We find Pmin = 2.438KW and the corresponding mechanical torque is Cmin = 31.044N.m.

The grinding operation can be carried out successfully because, Cm> C1.

The useful power of the crusher is Pu = Pmin = 2.438KW and the useful torque is Cu = Cmin = 31.044N.m.

Determination of transmission parameters and dimensions

This will involve determining the speeds (linear and rotational) of the pulleys as well as their diameters, without forgetting the transmission ratio and the choice of the section and length of the belt.

- Transmission ratio R_1

The transmission ratio of the driving pulley of diameter D to the pulley of the shredder of diameter D1 is given by: $R = \frac{D}{D_1} = \frac{N_1}{N}\ \frac{750}{1000} = \frac{150}{200} = 0.75$

- Linear speed of the belt

The linear speed of the belt is given by:

$$V = \frac{2\pi DN}{2.60} = \frac{2\pi D1.N_1}{2.60} = 7.87\text{m/s}$$

- Détermining of the belt entraxe

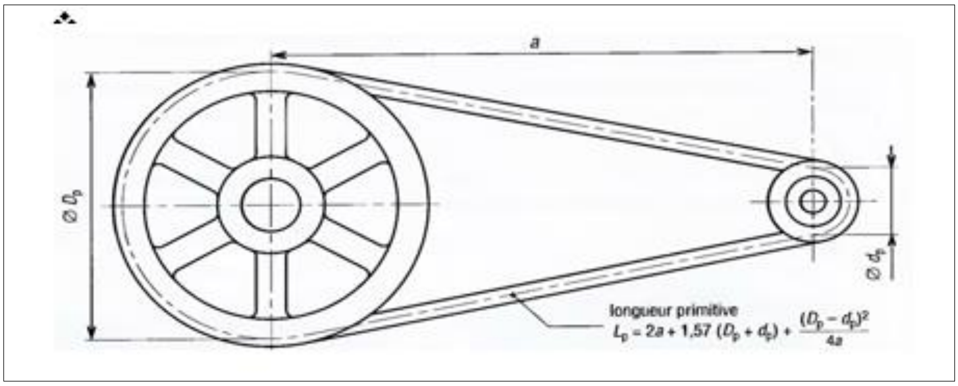


Figure 3 Trapezoidal belt-pulley transmission

The entrax must be chosen taking into account the overcrowding of pulleys, the possible interference and the wind angle. It should not be too big to avoid vibrations or rotating of the blend, nor too short to avoid reducing the contact angle; this helps to reduce the performance of transmission. The recommended value for the entrax a is given by the relationship:

$$(D+D1)/2+D1<a<3(D+D1) \ldots\ldots\ldots\ldots(1)$$

Soit 325 < a < 1050

We choose a = 789mm.

- Primitive length of the LP

The belt is uncrossed and pulleys axis are parallels. The length of the belt is given by the formula:

$$Lp=2a+ \pi/2\ (D+D1)+ (D-.D\_1)\hat{}2/4a \ldots\ldots\ldots\ldots (2)$$

Lp = 2133mm

- Cchoice of the belt

The choice of the belt is to choose its section and length. The choice of the section is made according to the speed of the belt, the corrected power of the engine which it depends on the motor power and the Ks service factor of the machine. This factor depends on the nature of the mechanical organs and the conditions of use of the machine. To this end, remember that the machine works 08H per day. The Factory Chart Table (Table 1, page 382), which allows us according to the conditions of use (08 hours per day), to choose a service factor Ks = 1.3.

We have:

$$Pc=Ks.〖P'〗\_1 \ldots\ldots\ldots\ldots(3)$$

And we find Pc = 3.302KW

- Calculating the number of belts
- Determination of the base power Pb

Data: d = 150mm, V = 7.85m / s.

Based on the table of the basic powers (Table 4 Page 383 GSTI), we have : 5 < V < 10, which implies the following system :

$$\begin{cases} 5 < V < 10 \\ 1.75 < Pb < 3.03 \end{cases}$$

We obtain through the linear interpolation method, Pb = 2,48KW

- Determination of the admissible power by a belt Pa

The eligible power of a belt is the power from which it will be able to operate without a major impact. Its formula is given by:

$$Pa=Pb.KL.K\Theta$$

Where; KLet KΘ are corrector that depend factors of the length and winding angle of belt.

Winding angle Θ

$$\Theta = 180 - 2\sin-1(D1\text{-}D)/2a \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

On obtain Θ = 179.94 which allows us thanks to the graph 2, page 381 of the GSTI to obtain K_Θ = 0.9997 by linear interpolation, solution of the système $\begin{cases} 160 < \Theta < 180 \\ 0.9 < K_\Theta < 1 \end{cases}$ ………..(5)

Knowing the primitive length of our belt which is Lp = 2133mm, the graph 3, page 381 of GUSTI allows us to obtain the system $\begin{cases} 2000 < Lp < 3000 \\ 1 < K_L < 1{,}2 \end{cases}$ whose resolution by linear interpolation gives us K_L = 1.0568.

It is deducted from the foregoing that the eligible power is Pa = 2.62KW.

- Determining of the number of belts

Nc = Pc/Pa, Pc = 3.302KW (corrected power); Pa = 2.62KW;

we obtain Nc = 1.26 = 2 belts.

- Calculation of operating tensions

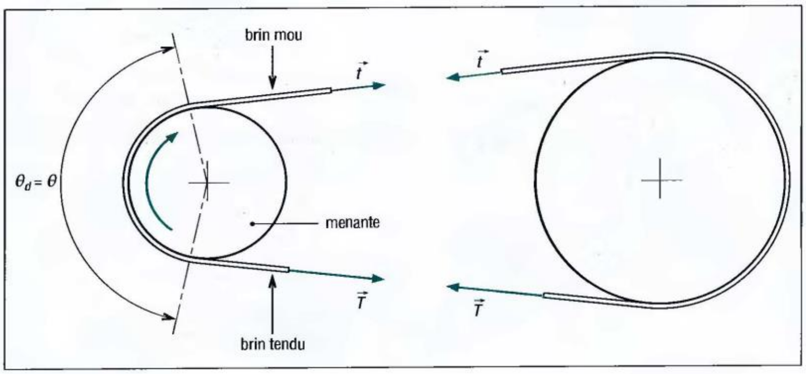


Figure 3 Tensions in the belt

When operating, each belt is under the action of two tensions: T in the stranded tender and t in the soft strand. We have:

$$\frac{T}{t} = e^{\Theta f} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Also, the couple transmitted by the motor pulley is defined by C_1' = (T – t).$\frac{D}{2}$ ………………… (7)

So from the relations (6) and (7), we have $t = \frac{2C1\prime}{D[exp(\Theta f)-1]}$

Θ = winding angle (Θ = 179.94° = 3.1441rad); f = 0.4 (friction coefficient for trapzoïdal belt-pulley transmission according to the Industrial Science and Technology Guide GSTI on page 377)

C_1' = 23.283Nm; D = 150mm

We obtain t = 123.33N. and T = t $e^{\theta f}$ and T = 433.77N.

The tension at rest into the belt is To = $\frac{T+t}{2}$ soit To = 278.55N. ………………… (8)

2.4.3. Dimensioning of the transmission N°2

This is the transmission by pulley-belt of the motor pulley towards the pulley of the eccentric shaft.

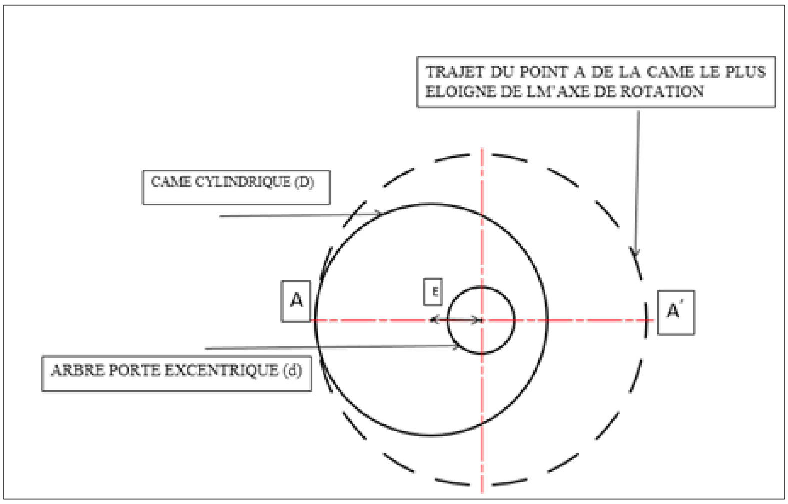


Figure 4 Shaft bearing the excentric

except for determining the useful power to calibration, determining the transmission parameters is made similarly to the process during the transmission N°1.

Détermining of the useful power for calibrating P'_u

The most distant point of eccentric is located at $\frac{D}{2} + E$. The more E becames smaller, the circumferential speed of point A becomes higher, the more the mechanical power is also thanks to the relationship

$$P'_u = M.W = F'\left(\frac{D}{2} + E\right).2\pi N \text{………………… (9)}$$

P = mechanical power needed to move the eccentric; M = couple available on the eccentric shaft; F = the weight of the eccentric; W = angular speed of eccentric or eccentric door tree; N = rotation speed of the eccentric door shaft. Reminder: The eccentric door tree turns at the same regime as the engine it is to say N = 1000rpm. This fact gives us on the belt pulley transmission report that is worth 1 and thus the diameter of the pulley conducted, that is to say, the pulley of the eccentric door tree is **$D_2 = D_1$ = 150mm**.

Since we do not know the outset the diameter of the eccentric shaft, we will consider the necessary maximum mechanical power required by the eccentric shaft. D'après la formule (9). According to the formula (9), the power is maximum when the eccentricity is worths t $E = \frac{D}{2}$. In this case, we have $Pmax = M.W = \frac{1}{60}F'D.2\pi N$ where M the mass of the full cylinder.

$$\text{The corresponding motor torque is } C_2 = M = F'D \text{ … … … … … … …. (10)}$$

F' = m'g = 49.4N.

The motor torque required to turn the eccentric door shaft is then. $C_2 = 4.94Nm$. the mechanical power required by the eccentric cam and therefore the eccentric shaft is P'_u = 517.32Watts.

2.5. Choice and features of the electric motor

The engine used will have to provide enough power for simultaneously obtaining grinding and calibration. That power $\mathbf{P_M}$ depends on both functional parts of the machine's power $\mathbf{P_u}$, on the transmission reports **R** and on the transmission performances ŋ. We have:

$$P_M = \frac{P_u}{\eta_1.R_1} + \frac{P'_u}{\eta_{2}.R_2} \text{ ………………… (11)}$$

P_u : useful power of grinding ; P'_u : useful power of calibration ; η_1 : transmission n°1performance (0,98) ; R_1 : transmission n°1 repport ; $\eta_{2.}$: transmission n°2 performance ; R_2: transmission n°2 repport ; $\eta_{2.}$ = η_1 = 0.98.

The motor turns 1000rpm. The other data on the motor are recorded in Table 8 of the results.

2.6. Determining of the diameters of the shafts and two axes supporting the calibration chamber

Indeed, the calibration chamber is suspended and screwed then sealed around two parallel axis beard in their turn by the frame.

The two shafts and two axis are in steel of general use S355 (Rmin, = 490 MPa et Remi, = 355MPa); R= Resistance to la rupture and Re = elastic Resistance and we choose a coefficient of security s = 5.

As the shafts are solicited in bending and torsion, the calculations of the resistance of the materials, their minimum diameters to withstand safety are given by the expression:

$$d \geq \left(\frac{32Mfi}{\pi Rpe}\right)^{1/3} \text{……………(12)}$$

On the other hand, the axes or rods are only solicited in pure bending and the minimum diameter of these axes is given by:

$$d \geq \left(\frac{32Mf}{\pi Rpe}\right)^{1/3} \text{ ………………… (13)}$$

Mfi : idéal moment in flexion ; Rpe : élastic pratical resistance; Mf : flexing moment.

All results for those formulas are es table n°6 of résults.

2.7. Study and determining of mechanical oscillator parameters

The mechanical oscillator consists of: the calibration chamber suspended with these two axes and the eccentric shaft. The harmonic oscillator consists of four springs, of which only the two-two equivalents are represented in the following figure of the vibrating cage.

2.7.1. Description of the operating principle

The calibration cage at the beginning of the movement is in the equilibrium position (O). As soon as the electric motor started, the eccentric after shock moves the cage of a distance x_m = OA = 1.33mm and then its action is removed after point A. The distance x_m represents the amplitude of the oscillating movement of the center of gravity O of the cage around its balance position. The dynamic study of the movement is carried out when we surprise the calibration cage at a point B. thanks to the tension of the four springs, tends to return to the balance of position when the eccentric comes to print it again shock and the movement resumes and reproduces in the same way as before. The movement of point O is reproduced in the same way each time under the action of the eccentric which gives it a frequency No =N = 1000rpm or No =16.67Htz Htz.

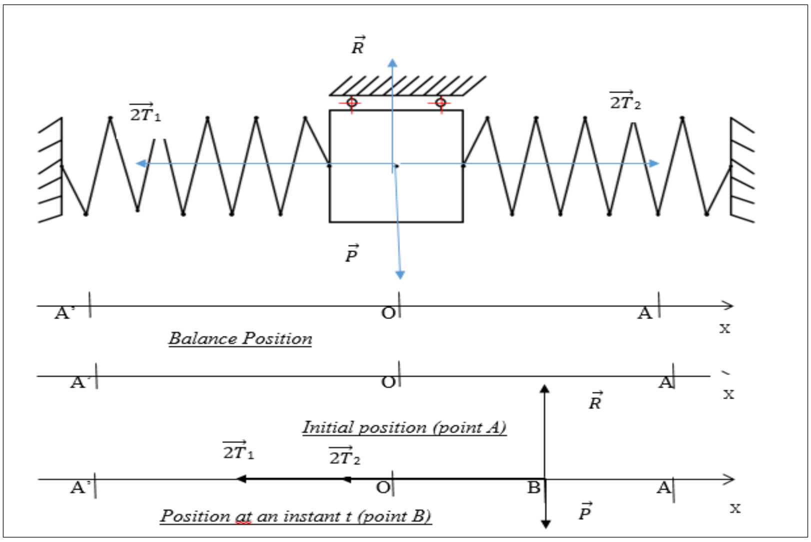


Figure 5 Operation of the mechanical oscillator

2.7.2. Mechanical characteristics of the oscillator

This is among other things, the clean pulsation of the mechanism, the stiffness of the springs and the dimensions of the springs.

The dynamic study of the oscillator allows us to have the expression of the clean pulsation which is: wo = $2\pi No$

while the stiffness of the springs is given by

$$K = \frac{wo^2}{2}\sqrt{m} \text{ ………………… (14)}$$

Wo is the pulsation clean; m is the mass of the calibration chamber. The results of these calculations as well as the dimensions of the springs are recorded in Table 8 of the results.

3. Results and discussion

We display all results from this study through the following tables: 2 to 8 8.

3.1. Results of the transmissions dimensioning

3.1.1. Transmission n°1 : from the motor to the crusher

Table 2 Dynamic and dimensional characteristics for the transmission n°1's pulleys

Elements	Diameter (mm)	Speed (rpm)	Torque (Nm)	Useful power (KW)
Motor's pulley	150	1000	23.283	2.540
Crusher's pulley	200	750	31.044	2.438
Crusher's pulley	Pulley with two trapezoidal grooves (diameter : 200mm ; thickness : e = 2f + g soit e = 33mm)			

Table 3 Dynamic and dimensional characteristics of the transmission n°1's belts

Belt	
Parameters	Values
Repport of the transmission	0.75
Useful power for crushin	2.54KW
Service facteor	1.3
Corrected power	3.302KW
Linear speed of belt	7.85m/s
Apparent section of belt $I_p$xh	11x8.7
Entraxe between motor and crusher pulleys	881mm
Length of one belt	2133mm
Basic power of one belt	2.48KW
Eligeble power of one belt	2.62KW
Type and number of belt	2 trapezoidal belts : types A
Tension in the stetched strand of one belt	433.77N
Tension in the soft strand of one belt	123.33N
Tension in one belt without movement	278.55N

3.1.2. Transmission n°2: from the motor to the calibrator

Table 4 Dynamic and dimensional characteristics for the transmission n°2's pulleys

Eléments	Diamet (mm)	Speed (rpm)	Torque (Nm)	Useful power (KW)
Motor's pulley	150	1000	4.94	0.518
Calibrator's pulley	150	1000	4.94	0.54
Calibrator's pulley	1 pulley with trapezoidal groove ; type A, Thickness, e = 2f = 18mm			

Table 5 Dynamic and dimensional characteristics of the transmission n°2's belts

Belt	
Paramètre	Values
Repport of the transmission	1
Useful power for calibrator	0.54KW
Service facteor	1.3
Corrected power	0.702KW
Apparent section of belt Ipxh	11x8.7

Linear speed of belt	7.85m/s
Entraxe between motor and crusher pulleys	300mm
Length of one belt	871mm
Basic power of one belt	2.48KW
Eligeble power of one belt	2.62KW
Type and number of belt	1 trapezoidal belt : types A
Tension in the stetched strand of one belt	92.2N
Tension in the soft strand of one belt	26.2N
Tension in one belt without movement	59.13N

3.2. Two shafts and two axes dimensions

Table 6 Shafts and axes dimensions

Dimensions of the crusher's shaft in mm		
Diameter on the portion AB = 77.5	Diameter on the portion BC = 340	Diameter on the portion CD = 155
30mm	40mm	35mm
Dimensions of the calibrator's shaft in mm		
Diameter on the portion AB = 138	Diameter on the portion BC = 408	Diameter on the portion CD = 52
40mm	40mm	35mm
The two axes bearing the calibrator's chamber are same withe diameter 40mm and length 668		

3.3. Results about the electrical motor

Followings are the characteristics of the motor:

Table 7 Electrical motor characteristics

Brand	WA
Useful power	4KW
Speed	1000rpm
Voltage	400V, 50Htz
Ventilation	exterior IC411, service S1, permanent diet
Isolation class	F, degree of protection IP55
Sound level	64 A
Mass	69 Kg

3.4. Results related to the mechanical oscillator

Table 8 Dynamic and dimensional characteristics of the mechanical oscillator

Proper pulsation (rad/s)			Amplitude (in mm)		
104.74			1.33		
Dimensions of the springs (in mm)					
Length	Number of turns	One turn's dimensions	Exterior diameter of one spring	Inside diameter of one spring	One spring step
96	6	12	36	60	14
One spring's stiffness			59584.89 N.m		

3.5. Cost of reaization of the machine

The overall cost of the machine is the sum of the fixed costs and variable costs of its operation. Thus, the cost of the machine's realization is 676000FCFA.

3.6. Analysis of results

The values of lengths and diameter selected after the different calculations in this study are not actually values exactly obtained after calculations. Indeed, taking into account length standards, on electric motors and power transmissions (sharp size, belts, keypads and bearings, the motor power) makes the resulting values of our calculations have been adjusted and replaced by acceptable standard values. The difference between these two values is so low that the influence of this gap on the functioning of the system is negligible.

4. Conclusion

Following this study, the production of poultry foods knows two significant operations: this is the dimensional reduction and the dimensional ranking of agricultural products and fierce products. Several means and technologies of realization of these operations exist. However, we choose the mobile hammer ship for the reduction and calibration to vibrating sieves for the dimensional ranking for their innumerable advantages in industry. The mechanization of these operations allows us to master the food size. In addition, note that the particle size is the heart of fragmentation theory and allows to provide birds with a quality diet by ensuring an improvement in the zoo technical parameters of the latter. Under these parameters, we can mention:

The Calibrator mill of this study will have to allow individuals poultry farms to produce their own provender and make them independent. In addition, it is a machine accessible to all farms that it only cuts 676000F CFA.

Compliance with ethical standards

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Disclosure of conflict of interest

The main author is Edmond Claude VODOUNNOU. The other authors Ayihaou Armand DJOSSOU, Jean Louis Comlan FANNOU, Guy Clarence SEMASSOU and Mahougnon Abednégo BALLO worked together with me on all aspects of the tool's design. Unanimously, we all agreed to publish the work in your precious journal. We declare that there is no conflict of interest regarding this work and its publication.

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