# DESIGN OF A SEMI-AUTOMATIC DOSING SCREW ENDLESS UCHU UNOPAC JACÚ IN THE ORGANIZATION OF THE CHURCH OF CANTON AYORA CAYAMBE.

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***ABSTRACT***

*This article presents the design and construction of a metering screw machine for Uchu Jacu flour in UNOPAC organization.*

*The design of each component of the dispenser done analytically and exposing each of the more critical parameters is detailed. The data obtained was compared analytically and verified with the help of Solid Works, software that provides a geometric approach of the machine. The data obtained in the design phase served to the geometric design and construction of each of the components of the machine, obtaining so a correct and assembly according to the requirements, both mechanical and control part.*

*Finally the necessary parameters are entered in the controller as required dosage and proceeded to perform the calibration of all components down to meet the required dosage.*

**KEYWORDS**

Dispenser, servo motor, Uchu Jacu flour, servo-drive, semi-automatic.

## I. SITUATION PROBLEMS

Uchu Jacu is a powder of six traditional grains of indigenous peoples of Cayambe Canton, north of the province of Pichincha.After the recipe was forgotten for years, again today flour is produced in mills UNOPAC (non-governmental entity of grassroots organizations in the canton Cayambe) organization.A lthough the product is still not well known in the country, it is quite popular among members of the communities of the sector.

The development of Uchu Jacu is a painstaking process, one must know and comply with various procedures from the collection of raw materials to shipping the final product in order to meet all quality requirements than the current market demand for a foodstuff. In the process of making flour Uchu Jacu involved multiple threads shown in Figure.1.


***Figure.1: Production process of Uchu Jacu***

## II. OBJECTIVES

## GENERAL PURPOSE

Build a semi-automatic machine for dosing by endless screw on Uchu Jacu UNOPAC Ayora parish organization that allows the reduction in the workload of the person responsible for the preparation of flour, reducing time and improving packaging production

## SPECIFIC OBJECTIVES

- Determine appropriate parameters for dosing flour and develop Uchu Jacu system design.
- Optimize dosing flour Uchu Jacu looking for a wide standardized production weight.

- Check the correct functioning of the entire dispensing system to comply with the parameters established in the design.

- Perform manual and maintenance manual of the machine.

## III. SELECTION CRITERIA AND CALCULATION OF MECHANICAL ASPECT

Taking into account the parameters linked to our limitations and requirements designs each of the elements of a dispenser developed by worm, develop the necessary models to confirm the performance and viability of the machine.

## DESIGN AND SELECTION OF STORAGE SYSTEM FOR THE DOSAGE

Different types of dispensers must have a storage system, which receives the product of the production line either by a conveyor band, a screw conveyor or manually in order to keep the product inside to dosing.

## HOPPER DESIGN

For system storage hopper truncated cone with α = 30 ○ tilt was chosen, because the hoppers section recommended circulate since exert a gradual compression of the material while the square section exert uneven compression.

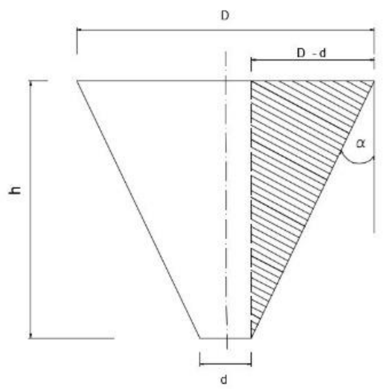


***Figure 2: Basic dimensions of a truncated cone.***

The geometric volume of the hopper is given by equation 1.

***Equation 1: geometric volume of a truncated cone***

$$V = \frac{\pi}{12}\,\mathrm{h}(D^2 + dD + d^2)$$

The dimensions meeting the storage requirements of the metering obtained after solving the equations relating to a hopper of a truncated cone are:

D = 72 cm

d = 4,4 cm

h = 60 cm

$\alpha = 30°$

## *CALCULATING THE THICKNESS OF HOPPER*

As stated earlier, the stresses to which the hopper is subject resemble a thin walled conical dome which are represented by Equation 2

***Equation 2: Stresses in a long conical dome, uniform internal pressure (Pisarenko Yakovlev, & MATVIEEV, 1979)***

$$\sigma_m = \frac{p.x.tan\alpha}{2t}, \sigma_t = \frac{p.x.tan\alpha}{t}$$

It replacing the values in the equations is obtained:

$$\sigma_t = \frac{784,27}{t}\,Pa$$

$$\sigma_m = \frac{392,14}{t}\,Pa$$

To calculate the thickness of the maximum shear stress theory represented in Equation 3 is used.

*Equation 3: maximum shear stress theory (Nisbett, 2008)*

$$\sigma_e = \sigma_1 + \sigma_2 \leq S_y$$

$$\frac{784,27}{t} + \frac{392,14}{t} = 276x10^6$$

$$t = 0,00426\ mm$$

When subjected hopper at very low stresses, the thickness of the plate was negligible, however should be considered a thickness that does not compromise the construction of the hopper, especially in the welding process and barolado, so it has chosen for the construction of the hopper with a plate thickness of 1.5 mm which is in commercial use.

## *SIMULATION OF EFFORTS IN THE HOPPER*

Figure 3 confirms as soon as exposed as shown have a high safety factor across the hopper, that it is not subject to high stresses and therefore the design of the hopper is reliable.

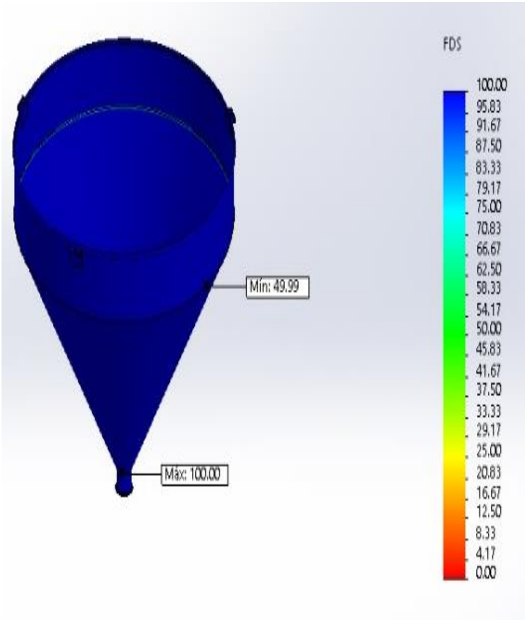


*Figure 3: Safety Factor Hopper*

## FEEDER DESIGN SYSTEM PRODUCT

The metering system is constituted by a worm without coupled by a shaft to the motor system, which will turn the screw for dosing occurs in the amounts already predetermined.

## ENDLESS SCREW

Because the dispenser is low capacity, the solution to the design problem of the worm was gathering information about industrial processes in which involved applications worm, so it was found that in the dairy industry used in the transport and dosing of powdered milk.

Metering system for a section of 0.35 cm in diameter of a screw conveyor used as milk powder whose dimensions meet the dosage requirements of the product will be used.

The main aspects to be taken into account in the development of other parameters involved in dosing are:

S: Step Screw

D: Screw diameter

In this case the screw diameter is 4.4 cm with a pitch of 2.2 cm, dimensions smaller diameter engage the hopper.

From the dimensions of the worm hereinafter they determine other factors involved in the process.

The volume filling of a plane of a helical worm to make one complete turnaround the axis is defined by equation 4.

*Equation 4: Filling volume of a helical flat*

$$V_h = \frac{\pi}{4} D^2 S$$

The volume is the volume that the worm dosed one complete revolution around the axis

Linking these volumes which meet the requirements of dosing and by reference to a time dosing sleeve t = 5 s can get the speed n to which you turn the screw to meet the dosage requirements posed.

## POWER REQUIREMENTS

The power required to drive the screw, is the sum of three partial power as shown in Equation 5.

***Equation 5: power required to drive the screw***

$$Pt = P_H + P_N + P_{st}$$

$P_H$: Power required for moving the material.

$P_N$: Power required to overcome the resistance due to the inclination.

$P_{st}$: Power required to overcome the resistance due to the inclination.

Replacing each of the partial powers in equation 5, the total power required to drive the metering screw is obtained.

$$.P_{Tornillo} = \frac{Q_m g(C_o L+L)}{3600} + \frac{DL}{20}$$

Obtaining:

$$P_{Tornillo} = 0{,}6830\ W$$

The system will require two additional powers, the first because it must take into account the total weight of the dosing system and the second is the drag force of agglomerated flour due to the implementation of a remover, which will have two scrapers, in which it will exert a drag on the front side.

Thus the first additional power is calculated in the ordinary way, taking into account the mass of flour as the total mass of the components of the dosing system

$$P = 140{,}45\ W$$

The second additional power is calculated taking into account the pressure of flour on the surface of the scrapers.

$$P = 287{,}58\ W$$

Finally, the torque and the total power required to operate all the dozer+ system before adding the three powers exposed.

$$\text{Tt} = 16{,}04\ Nm$$

$$Pt = 428{,}71\ W$$

## SHAFT DESIGN

To design the shaft takes the fastener, which generates an axial load, the torque produced by the servo motor, and also the weight evenly distributed along the same axis into account. Whereby the dosing shaft will be considered as a beam supported at one end with the three charges described above.

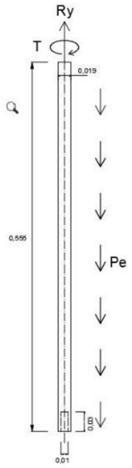


***Figure 4: Diagram free hub body***

The reaction caused by the clamping element will have little or no effect on the potential failure of our axis, so it is determined that the axis of the dispenser is subjected only to torsion and in this case the shear force by torsion is almost uniform and serve to determine the minimum shaft diameter to be considered for the system.

If the axis of the mixing not cause transverse bending forces are applied, leaving the equation for calculating the minimum diameter

***Equation 6: Shaft diameter mixer (Mott, 2006)***

$$D_e = \sqrt[3]{\frac{32FS}{\pi}\sqrt{\frac{3}{4}\left[\frac{T}{S_y}\right]^2}}$$

Replacing values equal to 2 used in typical designs of axes where an average confidence in the strength of the material data and loads.(Mott, 2006)

$$D_e = 0{,}01030 \text{ m}$$

We conclude that must use a shaft with a diameter greater than 10 mm, since the market is not round stainless steel bars of these dimensions is a commercial round bar, in this case 19 mm, for the shaft is chosen metering system.

## SHAFT SIMULATION

Figure 5 shows the safety factor in all elements of the dosing system to be subject to the charges described above, although the minimum safety factor is 2.17 remains above the values on which the rupture would occur .

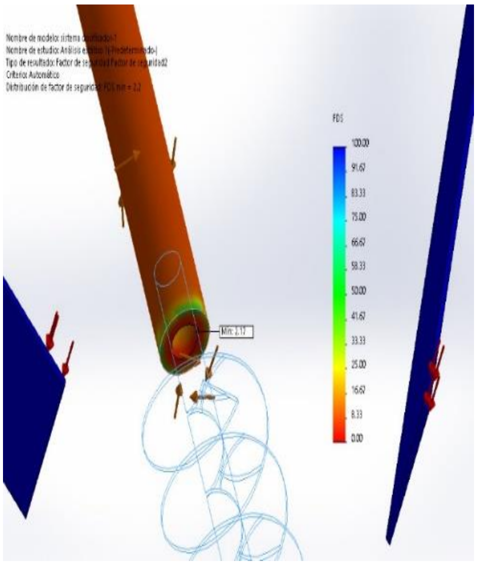

***Figure 5: Safety factor in the dosing system***

## IV. ACTUATOR SELECTION

Once selected and designed the most suitable for dispensing the product and obtained the power and torque needed for system operation system, it is necessary to select a variety of actuators.

the decision was taken to use servo motors because they provide more accurate motion control compared to other types of engines, resulting in a smaller margin of error at the time of dosing.

You have selected the servomotors SureServo brand because they offer higher power than required, they are also robust industrial use, size, and weight, are coupled to the other components of the system and have a very precise encoder with a reading of 10,000 pulses per second, has been chosen SureServo servo mark pattern SVL-207B which has the characteristics shown in table IV.1.

***Table 1: Features Servo Motor SVL-207B***

| Servomotor | $W_{max}$ [w] | $\tau_{no}$ [N.m] | $\tau_{max}$ [N.m] | $\omega$ [rpm] |
|---|---|---|---|---|
| **SVL-207B** | 750 | 2.39 | 7.16 | 3 000 |

As seen in Table 1 the servomotor chosen meets the requirements of power, but being low inertia offers lower the required torque, thus, the logical solution regarding serious torque choose a servomotor medium inertia same brand, but cost issues decided servomotor coupled to a reducer which allow greater torque at minimal cost.

Several proposals for reducing various brands were analyzed taking into account the system requirements, robustness and cost, of which a geared motor Motive endless-crown with the following characteristics were selected:

***Table 2: Characteristics Moto reducer BOX050***

| Moto reductor | $P$ [w] | $\tau_2$ [N.m] | $n_2$ [rpm] | $f_s$ | i |
|---|---|---|---|---|---|
| **BOX050** | 750 | 17,1 | 373,3 | 3 | 7,5 |

Table IV.2 shows that the chosen gear meets the requirements of output torque and speed required for proper dosage.

## V. CONTROL SYSTEM

The design of the control system it has been made according to the requirements of automation of the machine, so that the metering system by worm variables to control are: dispense time and the number of turns of the system dosing parameters provided by the gear-servo system.

It has been chosen as reducing drive system coupled to a servo motor brand SureServo SVL-207B model. The machine control is semi so a person will be responsible for activating the components to produce the dosage by a pedal that sends the signal to the Servo Drive by which will activate the servo motor-reducer as detailed in Figure 7.

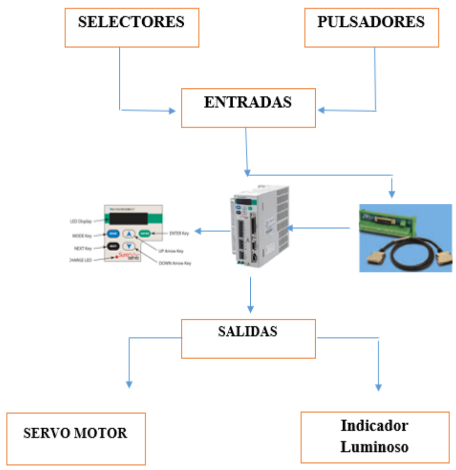


*Figure.7: Block diagram of the metering system*

## VI. ALIBRATION TESTS SYSTEMS IMPLEMENTED

In order to meet the precision that has the dose, to get the error when the dosage is necessary to perform different actions to a constant speed servo drive 800 rpm to 250 rev as shown in Table 4.

***Table 4. Measurements dosage constant speed of 800 rpm and 250 rpm get the arithmetic mean, data indicating the average weight of processed cases.***

| MEDICIONES PARA REVOLUCION CONSTANTE DEL SERVO MOTOR | | | | |
|---|---|---|---|---|
| MUESTRA | MASA MEDIDA (g) | TIEMPO DE DESCARGA (s) | $\sum_{k=0}^{n}(x_k-\bar{x})^2$ | ERROR % |
| 1 | 450 | 20,6 | 0,04 | 0 |
| 2 | 447 | 21,2 | 7,84 | 0,7 |
| 3 | 446 | 20,9 | 14,44 | 0,9 |
| 4 | 450 | 21,2 | 0,04 | 0 |
| 5 | 452 | 20,3 | 4,84 | 0,4 |
| 6 | 447 | 20 | 0,64 | 0,2 |
| 7 | 453 | 22,2 | 10,24 | 0,7 |
| 8 | 449 | 20 | 0,64 | 0,2 |
| 9 | 450 | 20,2 | 0,04 | 0 |
| 10 | 454 | 21,8 | 17,64 | 0,9 |
| **TOTAL** | **4498** | **208,4** | **56,4** | |

$$\bar{x} = \frac{\sum_{k=0}^{n} x_k}{n}$$

$$\bar{x} = \frac{4498}{10} = 449{,}8\ g$$

As the average value of the weight is observed is 449.8 g which is an acceptable value.

For a more accurate view of the dosage amount is to be calculated the standard deviation:

$$\sigma = \sqrt{\frac{\sum_{k=0}^{n}(x_k-\bar{x})^2}{n-1}}$$

$$\sigma = \sqrt{\frac{56.4}{9}} = \pm 2{,}5\ g$$

In addition to weight, one of the parameters for dosing is the time, so proceed to take the arithmetic mean of the times obtained for each sample.

$$\bar{t} = \frac{\sum_{k=0}^{n} t_k}{n}$$

$$\bar{t} = \frac{208{,}4}{10} = 20{,}8\ s$$

With the data obtained showed that the average weight per case is 449.8 g with a tendency to rise and fall of 2.5 g in a time of 20.8 s average dosing.

From the above it is noted that the dosing by worm enters an acceptable dosage range raised at the beginning of this project, which is a dosage of 450 g with error, Due to the characteristics of the product and as a reducing docked, due reduce the theoretical speed for rotation of the metering system with a metering time will be raised higher to t = 20.8 s, time which meets the objectives raised to reduce the current dispense time.

## VII. CONCLUSIONS

- After having carefully analyzed each option of different dosing systems, it was determined that a metering system vertical auger, is the most suitable for the process.

- Acer was used or inoxidable AISI 304 for each component of the machine, material that meets the requirements of resistance to the forces applied to the system, in addition to meeting the standards in li m i t a r as being a sanitary material.

- The simulation was performed on parts Solid Works 2014 which corroborated the results obtained in the conventional layout of the main components of the dispenser, giving viability design and construction.

- Through testing it was possible to correct mistakes or shortcomings presented in the metering machine, until a dosage error rate ± 1% required.

- The screw used was adjusted to the requirements of the dispenser and the physical characteristics of flour Uchu Jacu, incurring directly on the cost of the dispenser, against a screw exclusively designed for flour Uchu Jacu, due to the difficulty and use of specialized machinery for construction.

- The time set dosage has not been achieved due to the implementation of a geared motor, despite this the average dosing time meets the objective of reducing the current dosing period that is performed manually.

- Having made the relevant tests the operation of the dosing machine, manual and maintenance are carried out to ensure proper operation and long life of the dispenser.

# VIII. RECOMMENDATIONS

- Perform maintenance on the dispensing machine screw on schedule in the manual to prevent further damage in the long term.

- You should read the manual before operating the metering machine to avoid accidents and mishaps.
- In case of any malfunction in the metering auger machine he should seek qualified technical assistance.

- It is advisable to check all the connections during and after each test to be performed on the machine in addition to thoroughly review manuals for each component of the machine.

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