CONSTRUCTION OF PELLETS DRYING MACHINE

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ABSTRACT

The work detailed below is based on heat transfer and the need to solve the problem of high moisture content in the pellets after its formation, trying to improve the drying process through automation.

The job was performed the mechanical design of the drying, to subsequently implement control elements, both sensors and actuators. Performing a process to carry out the necessary operation.

For proper operation of automated pellet drying machine, was implemented a system where can be manipulated the temperature variable, giving us the option to choose the operating set point. It will be processed by the control system which is responsible for sending signals to the actuators depending on its state.

By having an automatic control of the drying machine, moisture is reduced to 12% which is an acceptable value for proper storage, improving product quality.

1. INTRODUCTION

The drying process is carried out thousands years ago. The most important purpose of it, it is in the specific case of the aliments, is by keeping fresh them as natural as possible. The drying carries to the dehydration in the aliments, it means no bacteria at all. The dehydrated food could last long, without refreshing them

The sequence of the products are important, such as the drying, because it is made in grains, plants, to prevent the decomposition for enzymes, decrease the quantity, do the storage of grains, facilitate the transport, like a part of a process of production, to get equality of a product, stop the development of oxidation reactions in the hydrolysis.

The pellets must be treated through of drying production to get final quality product, nowadays the pellets should have to pass through a manual drying to outside, which it is a problem as everybody knows the time is very long, there is a probability of spread the micro-organisms, producing a loss of quality and proteins.

With this past history, it is going to be establishing to join the pellets drying process with the installation of a rotatory automatic dryer.

The implementation of rotary dryer to the pellets, contemplate the following steps.

- Analysis of alternatives of the dryers.
- Design of the constitutive elements of dryer.
- Elaboration of the planes of construction.
- Elaboration of the mechanical part of the dryer.

- Elaboration of the installations to have fresh air.
- Elaboration of the control system.
- Tests about mechanical part and of control

CONTENT

PARTS OF DRYING MACHINE OF THE PELLETS OF BALANCED

The parameters to the dimensioning are gotten in a base to the specific, needs.

Parameters to mechanic design.

Where it gets:

- Average capacity = 16000 Kg/mes
- Humidity at in to the pellet = 2,33 Kgwater/Kgproduct
- Humidity at out to the pellet = 0,1363 Kgwater/Kgproduct
- Maximum temperature of the drying air = 100°C = 212°F
- Density of the air = 1 kg/m3
- Caloric capacity of the air $Cp_{aire} = 0{,}24\ \frac{Btu}{lbR} = 1{,}005\ \frac{kJ}{kgK}$
- Temperature of wet bulb= 18°C = 64,4 °F

SIZEMENT OF ROTARY DRYER

To find the flow of the product for hour, it is considered that in a month it is worked 4 weeks, the 5 days and 8 hours a day.

$$\dot{m}_p = 16000\frac{kg}{mes} * \frac{1\text{mes}}{4*5*8\text{ horas}}$$

$$\dot{m}_p = 100\left[\frac{kg}{h}\right]$$

By having the diameter and the length of the cylinder that will get with the requirements before mentioned, it is established with an interactive table by getting the next data.

$\text{D} = 0{,}38\text{m}$

$\text{L} = 2\text{m}$

Taking into account, this is made to calculate the time of the retention inside of the cylinder, the product with the help of the next formula

$$\text{t} = \frac{60 * \pi * \text{D}^2 * \text{L} * \text{f} * \delta_\text{P}}{4 * \text{mp}}\,[\text{mim}]$$

Giving us a time of:

$$\mathbf{t = 8{,}846[min]}$$

To continue with the design and with the help of the next formula we will find the angle of the inclination of rotary cylinder

$$\mathbf{t = \frac{L}{N.D.tan\theta}}$$ [1]

$\text{N}: 20[\text{rpm}]$

$\theta: 1{,}079°$

SELECTION OF THE ROTARY ENGINE OF THE CYLINDER

[1] Handbook of Industrial Drying; Mujumdar Arun, MarcelDekker Inc.New York, 1995, PP. 171,175

To select some engines it is necessary to know the quantity of movement to win to produce the appropriate moment and the drying cylinder rotates.

The quantity of movement to win is the conformed by:

- The movement of drying spindle.
- The movement the jointly binding motoring.
- The movement of the pellet
- The movement of the cylinder of dried.

To determine the moment of the drying cylinder, it is used the equation

$\Sigma M = \Sigma I * \alpha$

Where:

$M: momento\ [N * m]$

The movement of the elements of system $[kg * m^2]$

The total friction of the system is the addition of the all the movements of the differents elements of the drying cylinder.

$$\Sigma I = I_{eje} + I_{cilindro} + I_{pellet} + I_{volantes}$$

After to have the total of the frictions, it is replaced in the equation 4

$\Sigma I = 3{,}697 * 10^{-3} + 0{,}6857 + 0{,}04049 + 0{,}831$

$\mathbf{\Sigma I = 1{,}562\ [kg.m^2]}$

With the total friction, it is developed the equation 3, with the object to find the moment the engine makes on the spindle.

$\mathbf{M_T = 217{,}45[Nm]}$

Where it is gotten the theory potency of the engine is about:

$P_{motor} = M_T * n_2$

Where:

$P_{motor}: Potencia\ motor\ [W]$

$M_T: Momento\ torsor\ o\ par\ de\ torción\ \ 217{,}45[Nm]$

$n_2: Velocidad\ angular\ del\ cilindro\ de\ secado,\ \ 2{,}094[rad/s]$

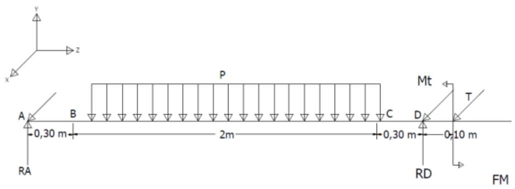
Like a result

$$\mathbf{P_{motor} = 455{,}42[W]\ o\ 0{,}61[Hp]}$$

Like in the market it is not easy to find an engine with this potency, it is caught a of 1 HP tryfasic, it is needed of this forced feeding, it will be leaded for varied switch of frequency. From here ahead it will be used this potency to the next calculation.

Transmission spindle design.

To obtain the spindle dimensions,. It will be used the SODERBEG method, because this one is used to size an element of machine, which one must support a constant effort, and a changing one.



Picture 1: Diagram of spindle free body.

Where it could calculate:

$$\Sigma MA = 0$$

$$\Sigma MA = 1.15 * 984.002 - RB * 2.30 + 3738 * 240$$

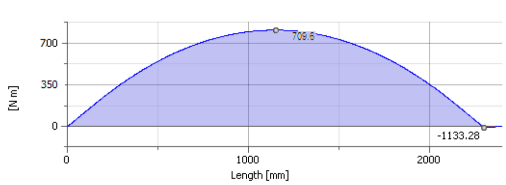
$$\mathbf{R_B = 4392,52N}$$

$$\Sigma MB = 0$$

$$\Sigma MA = 3738 * 10 + 984.002 * 1.15 - RA * 240$$

$$\mathbf{R_A = 654,522N}$$

Picture 2: Diagrams about flector moment in the spindle.



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It is easy to look at in the last picture, gotten with the help of the Inventor program 2010, the flector maximum moment is:

$$\mathbf{M_{max} = 709.6\ [N.m]}$$

By knowing the charges that it is submitted the transmission spindle; it must elect a hypothetic spindle that exists in the market and carry out the requirements.

Transmission of iron: SAE 1018 sheeted in coldd$d_{eje} = 38{,}1\ [mm] = 1{,}5\ [pulg]$ Hypothetic spindle

$$Sy = 32\ [Kpsi] = 220.63\ [MPa]$$

$$Sut = 58[Kpsi] = 400\ [MPa]$$

With this data, it is calculated the effort for reflection:

$$\boldsymbol{\sigma_x = \frac{M_{max}C}{I}}$$

Ecuación 35

$$\mathbf{I = \frac{\pi {d_{eje}}^4}{64}}$$

Ecuación 36[2]

$$\mathbf{I = 1,034 * 10^{-7} [m^4]}$$

$$\boldsymbol{\sigma_x = 130,66MPa}$$

This effort of flexion varies of compression to tension and contrary, in the course of the spindle spins, it means this is an effort elliptical with complete inversion, as a result:

$$\sigma_x = \sigma_a$$

$$\sigma_m = 0$$

To calculate the effort for tension we will use the next formula:

[2] Gere J., Mecánica de materiales, Apéndice C, pág. 760.

$$\boldsymbol{\tau_{max}} = \frac{\mathbf{M_T d_{eje}}}{\mathbf{J}}$$

Ecuación 37[3]

$$\mathbf{J} = \frac{\boldsymbol{\pi} \mathbf{d_{eje}}^{\mathbf{4}}}{\mathbf{32}}$$

$$\mathbf{J} = \mathbf{2,068} * \mathbf{10^{-7}} [\mathbf{m^4}]$$

$$\boldsymbol{\tau_{max}} = \mathbf{65,586} [\mathbf{MPa}]$$

For the spindle that is designed for resistance to the durability, for that we user the next formula:

$$\mathrm{Sy} = 32\ [\mathrm{Kpsi}] = 220.63\ [\mathrm{MPa}]$$

$$\mathrm{Sut} = 58 [\mathrm{Kpsi}] = 400\ [\mathrm{MPa}]$$

$$\boldsymbol{s_n'} = \boldsymbol{S_n C_s C_m C_{st}}$$ **Ecuación 39**[4]

$$\mathbf{n} = \frac{\mathbf{2}}{\sqrt[3]{\left(\frac{2\tau_a}{S_e} + \frac{2\tau_m}{S_y}\right)^2 + \left(\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_y}\right)^2}}$$ [5]

Replacing the values it gets:

$$\mathbf{n} = \mathbf{1,49}$$

It is a good security factor, which is why it is decided to build the spindle with the last characteristics.

ENRGETIC DESIGN HEAT CONSUMED BY THE SYSTEM.

The quantity of consumed heat by the system it is determined for the next equation.

$$\mathrm{Q_{cs}} = \mathrm{Q_{pellet}} + \mathrm{Q_{perdido}}$$

Ecuación: 48

Where:

Q_{cs}: *heat consumed by the dryer*

HEAT CONSUMED BY THE PELLET.

With the masic flow of the pellet and the specific heat of the pellet could be obtained the heat required to increase the environment temperature to the temperature 100ºC.

$$\mathbf{Q_{pellet}} = \mathbf{m C_p} \left(\mathbf{T_f} - \mathbf{T_{ep}}\right)$$

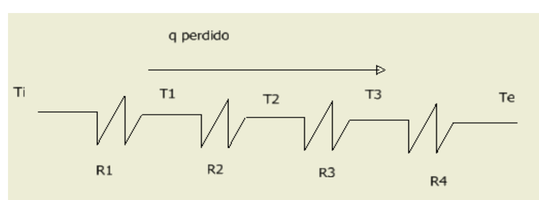
$$\mathrm{Q_{pellet}} = 13 * 1,6 * (100 - 28) = \mathbf{1497.6W}$$

Losing heat

To calculate the lost flow thickness that conform the drying cylinder, it is used the electric resistance method, as of convection as conduction

A thermic circuit represented in the next picture.

Picture 3: Thermic circuit of the losing heating flow



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[3] Robert Mott, Diseño de elementos de máquinas, Segunda edición, PP. 68,78,149.
[4] Robert Mott, Diseño de elementos de máquinas, Segunda edición, PP. 145,149.
[5] Shigley J., Diseño en ingeniería mecánica, 6ta edición, pág. 322

Like the circuit is located in the addition series of the resistance will give the total thermic resistance, it is the equivalent like it is shown in the equations 2.1 and 2.42

$R_{total} = R_1 + R_2 + R_3 + R_4$

$$R_{total} = \frac{1}{h_i A_1} + \frac{ln\frac{r2}{r1}}{2 * \pi * K_2 * L} + \frac{ln\frac{r3}{r2}}{2 * \pi * K_3 * L} + \frac{1}{h_e * A_e}$$

By getting after the total resistance applying the equation as product:

$$\boldsymbol{R_{total} = 0,346397286}\ [°C/\boldsymbol{W}]$$

To know the quantity of losing heat, it is done the next equation (2.44).

$$\boldsymbol{Q_{perdido} = \frac{\Delta T}{R_{Ttotal}} = \frac{(T_i - T_o)}{R_{total}}}$$

$$\boldsymbol{Q_{perdido} = 225,433[W]}$$

TEMPERATURECONTROL DESIGN

To the energetic design has used like heating element a module of resistances, this one is located in the high school in the balanced plant. The heating resistance performs the role to increase the temperature of the air to control inside of the drying cylinder. All the connections

were done to get the needed potency, and it was isolated with wool of glass.

Characteristics of the resistances

- Forced feeding 220 V 3~
- Consumed maximum current : A
- Calibre of the conductor Nº 18

CALCULATIONS TO REQUIRED POTENCY OF THE SYSTEM

To get the heat required of the system we do the next:

$$\mathbf{P = I^2 * R}$$

$$\boldsymbol{P = 8^2 * 27.5 = 1760W}$$

CONTROL PRIMARY ELEMENT

It is used a sensor Pt100 that help us to make temperature control.

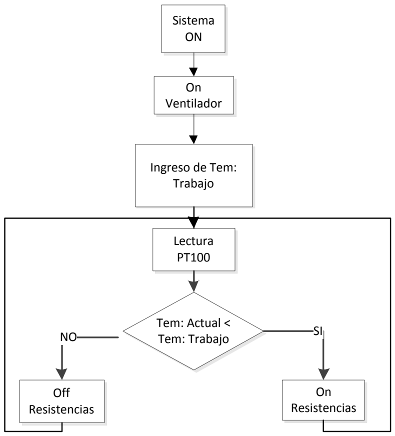
Pt100 Sensor.

This sensor Thermo-resisted lets to determine the temperature, which is going to work in the dryer. This is a sensor PT100 of 3 wires that is designed to operate between -100 and 482ºC.

This is a passive sensor, no lineal and requires a conditioning to the signal, this in the level required in the entrance of PLP, it is used analogic expansion module (AM2 RTD) of PC LOGO, which is uncharged of processing the signal of the sensor.

Coming on, it is detailed a diagram of flow the process of controlling temperature in the drying cylinder.

Diagram 1: Temperature control



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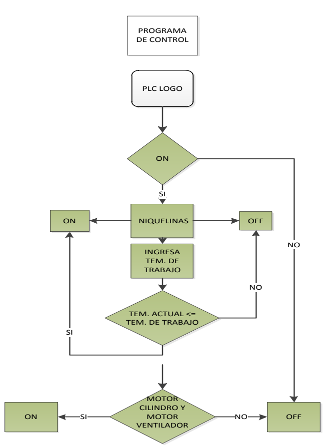
PLC Characteristics

The logo has a capacity of maximum enlargement of 24 digital entrances, 16 digital outs, 8 analogic entrances and 2 analogic outs, using the following modules.

DIAGRAM PROGRAM FLUX IN THE LOGO

Diagram 2. Diagram of program flux in the LOGO



Source: Diana Chamorro