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TECHNICAL REPORTE

TOPIC:

DESIGN AND CONSTRUCTION OF DOSING MACHINE OF ICE CREAM FOR CRAFT INDUSTRY

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“DESIGN AND CONSTRUCTION OF DOSING MACHINE OF ICE CREAM FOR CRAFT INDUSTRY”

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ABSTRACT:

This project is focused on the sector that is engaged in handicraft production and marketing of ice cream in the Caranqui parish of the city of Ibarra; the project contributes to the development of the productive matrix of the country to improve time and human resources in the manufacturing process, by applying knowledge of engineering and the use of industrial elements.

The machine consists of three main parts which are: the structure, the hopper and the dosing system. The final purpose is to optimize time and production of the manufacturing process of the ice cream, for which initially the parts of the machine was designed in 3D using the CAD Inventor Professional software to display form, subsequently the mechanical design was done and the results are compared with data obtained from simulations efforts and safety factor simulations that were performed on the software, thus to verify the accuracy of the mechanical design. The machine is in the ability to dose up to 13 liters of ice cream cones in each process in 45ml.

I. INTRODUCTION AND BACKGROUND

The process of making ice cream is currently slightly elevated and performed daily becomes a tiresome and repetitive process.

The current market offers machines for dispensing ice cream or creams but are aimed at industrial level with a view to large companies as their capacities exceed 40 liters products involving therefore extremely high prices, which are not available to the handicraft industry.

It would be impossible, and sometimes destructive, check each and every one of the products made to ensure that they meet all safety requirements and quality " (University, Tecnología de los alimentos, 2007).

II. ARTISAN PROCESS FOR PRODUCING CREAM ICE CREAM

REMOVAL OF FRUIT PULP

The first step for ice cream craftsmanship is obtaining the fruit pulp. The pulp is subjected to the process detailed below

ICE CREAM SHAKE PROCESS

For the ice cream is used an industrial mixer with capacity 13 liters in the mixer bowl cream, fruit pulp obtained from the above process, milk, sweeteners, thickeners or flavoring stands for artificial flavors.

Once placed proceeds to beat until a homogeneous mixture which is ready to be dosed into molds.

DOSAGE MANUAL PROCESS

This is the process that takes longer in making ice cream, mix about 13 liters obtained is placed into individual jars of 2 liters from it dose every ice cream, this process takes about 15 minutes per tray of 35 ice creams, as well as noted above, resulting in a non-uniform dosage of which makes the outcome of the final product is a larger than other ice cream and variations between production and production of about 8 to 10 ice cream per average production of 70 ice creams are obtained.

FIGURE 1. Manual dosing ice cream

Source: Author

III. DESIGN AND CONSTRUCTION OF DOSING MACHINE

Introduction

To optimize the manufacturing time and the quality of the final product is chosen to design and build a dosing machine ice cream. It takes as its starting point the health criteria to ensure safety during cleaning, the materials of the components of the machine should not react to the cleaning or disinfecting therefore must be corrosion resistant, and designed so the surface of the material remains unchanged. (Wager), therefore Aisi 304 stainless steel used in the construction of the machine.

Design of the feed hopper

For the metering process you need to use a hopper that is the same as has the bowl of the mixer as ideal in the future is to make the batter and immediately start the dispensing process.

According to formula

$$d = \frac{m}{v}$$

Equation 1: Formula for calculating the density of a substance

Source: (Martín, 2011)

$$mh = mt - mb$$

Equation 2 Mass calculation icecream

The bowl without containing any amount of product has mb = 1.59 Kg.Making the calculations the following average density is obtained

Dh= 395.22 Kg/ m^3

Then the hopper design must support a weight of 4,546 kg is the weight of the ice cream to be dosed.

Calculating the volume of the hopper

hopper volume = cylinder volume + volume semi-sphere

$$Vc = \pi * r^2 * h$$

Equation 3 Volume of a cylinder

Source: (Colección Mi Academia)

$$Vc = \pi * 0.12^2 * 0.19$$

$$Vc = 0.0085954\ [m^3]$$

Calculation of volume of the sphere

$$Ve = \frac{4}{3}\pi * r^3$$

Equation 4 Volume of the sphere

Source: (Colección Mi Academia)

$$Ve = 0.007238\ [m^3]$$

As the shape of the hopper is half sphere:

$$Volume\ half\ sphere = 0.003619\ [m^3]$$

Hopper volume = Vcilinder + half sphere

$$Volumen\ tolva = 0.01221\ [m^3]$$

Calculation of internal pressure cylinder

$$\boldsymbol{P = \rho * g * h}$$

Equation 5 Calculation of internal pressure cylinder

Source: (Budinas & Nisbett, 2008)

$$P = 395.22 * 9.81 * 0.31$$

$$P = 1201.90\ [Pa]$$

Calculating the thickness of the material according theory effort

"The effort is defined as the force per unit area in units Mpa Psi or in a subject to certain forces element, it is distributed as a function that varies constantly within the continuum of material. Each infinitesimal element of material may undergo different efforts at the same time" (Norton, 2011)

Tangential stress:

$$\boldsymbol{\sigma t = \frac{p*(di)}{2t}}$$

Equation 6 tangential stress

Source: (Budinas & Nisbett, 2008)

Longitudinal stress:

$$\boldsymbol{\sigma L = \frac{p*di}{4t}}$$

Equation 7 Longitudinal Stress

Source: (Budinas & Nisbett, 2008)

Where

p = pressure [Pa]

di=average internal diameter [m]

$$di = \frac{0.24 + 0,0254}{2}$$

$$di = 0.1327\ [m]$$

t = thickness of the cylinder wall [m]

$$\sigma t = \frac{1201.90*0.1327}{4t}$$

$$\sigma L = \frac{1201.90 * 0.1327}{4t}$$

$$\sigma L = \frac{39.873}{t}$$

Applying the theory of maximum shear stress to determine the thickness of the cylinder, which according (Budinas & Nisbett, 2008)

Mentions that

$$\boldsymbol{\sigma e} = \boldsymbol{\sigma t} + \boldsymbol{\sigma L} \leq \frac{\boldsymbol{Sy}}{\boldsymbol{n}}$$

Equation 8 maximum shear stress

Source: (Budinas & Nisbett, 2008)

Sy= 241[Mpa], (Mott, 2006) In section 5.7 discloses the safety factors taking n = 2 for the design of structures under static loads, where there is a high degree of confidence in all design data.

σe = 79,746 / t + 39,873 / t ≤ (241 * 〖10〗 ^ 6) / 2

119,619 / t ≤120.5 * 〖10〗 ^ 6

t = 0.000992 mm

The plate being subjected to very low stresses the thickness of this is very small, but for purposes of welding and final surface finish 304 stainless steel 1.5mm thick material shall be used.

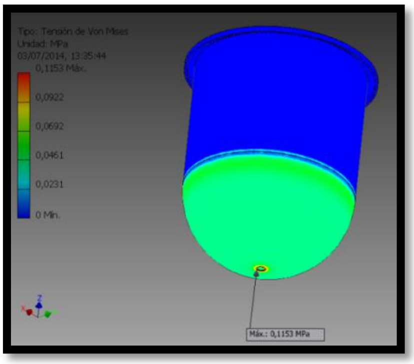

Figure 2 Stress analysis of Von Misses

Source: Author

There is no flow as no stipulated in fluence equation is satisfied.

$$0{,}1153 \geq 241$$

Calculation of the dosing cylinder

For calculating the volume of the mold the formula truncated cone volume is used;

$$\boldsymbol{Vct} = \frac{\mathbf{1}}{\mathbf{3}} * \left(\boldsymbol{\pi} * \boldsymbol{h} + \left(\boldsymbol{r}^{\mathbf{2}} + \boldsymbol{R}^{\mathbf{2}} + (\boldsymbol{R} * \boldsymbol{r})\right)\right)$$

Equation 9 Truncated cone volume

Source: (Colección Mi Academia)

$$Vct = \frac{1}{3} * \left(\pi * 8.697 + \left(1.498 + 3.0383^2 + (3.0383 * 1.498)\right)\right)$$

Substituting the values:

$$Vct = 145{,}96\ [cm^3]$$

Cilinder volume= 2vct

$$cilinder\ volume = 291{,}92\ [cm^3]$$

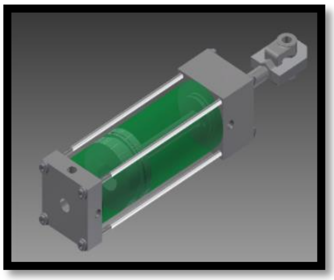

FIGURE 3 Design og dosing cilinder

Sourc: Author

Design Structure Using Machine Inventor Professional Cad

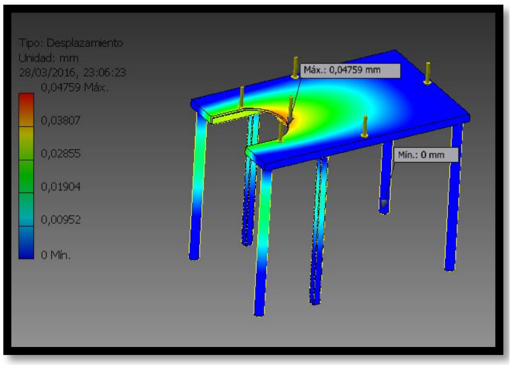

FIGURE 4 Inventor displacement analysis

Source: Autor

In analyzing the results of the simulation figure it shows that the shift in the square tube is 0.04759 mm, which is almost imperceptible. This is because there is the strength of the load on the structure.

To determine if occasionally happen creep into the structure theory fails Energy Distortion or Von Mises theory is fault with the CAD working Inventor Professional is used.

$$\sigma' = (\sigma_{x2} - \sigma_x * \sigma_y + \sigma_{y2} + 3T_{2xy})^{\frac{1}{2}}$$

Equation 10 Von Mises Stress

Source: (Budinas & Nisbett, 2008)

For design it provides that the normal stress in the X plane is on whether the bending stress (σF) in the same plane:

$$\sigma x = \sigma F, = \sigma'$$

Equation 11 Bendig stress

Source: (Budinas & Nisbett, 2008)

The value of this bending stress in the middle bracket of the machine, which is the place where the greatest load is applied is calculated.

$$\sigma F = \sigma' = (M * c) / I$$

Equation 12 Beending Stress

Source: (Budinas & Nisbett, 2008)

Where::

$$M = F * x$$

Equation 13 Bending moment

Source: (Budinas & Nisbett, 2008)

M= 220 N * 0.3375 m = 71.14 Nm

c= máximum magnitude of Y = 0,010414 m

I= second moment of area of square stainless steel tube

I= 4.20 cm4.

Transforming

I = 0,0000000420 m_4

Reeplace value

$\sigma_F = 18.3831 \ \text{MPa}$

$\sigma_x = \sigma_{F,} = \sigma' = 18.38 \ \text{Mpa}$

11.53 Mpa ≥ 241 Mpa.

The results of the simulation Effort Von Misses in Inventor Professional prove that the design of the structure meets the needs, thus ensuring structural stability

The theory of distortion energy or effort Von Mises stated that if the equation was fulfilled occurred creep. To design issues and FDS calculation of the equation becomes:

$$\boldsymbol{\sigma' = Sy / n}$$

Equation 14 Security factor

Source: (Budinas & Nisbett, 2008)

Where n is the security factor

$$n = Sy / \sigma'$$

$$n = 241 \ \text{MPa} / 18.38 \ \text{MPa}$$

$$n = 13.11 \ \text{Mpa}$$

The above result shows that the structure supports quietly 13.11 times the load to be applied thereto. It is demonstrating that the design ensures structural stability in the machine. FDS calculation using the Inventor CAD Professional. The Inventor Professional software can determine the safety factor should be the structure of the machine as shown in the following figure:

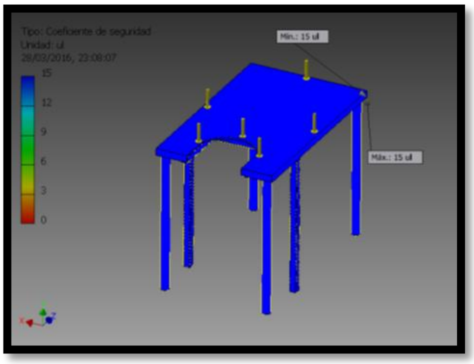

FIGURE 5 Analisyng of security factor in Cad Inventor

Source: Author

The analysis of the safety factor in the design software gives us a value of 15; similar values to that obtained in calculations of 13.11, so it is concluded that the design provides reliability; with a safety factor of the structure 15 it supports the applied

Selection of the conveyor belt

For efficiency, easy manufacturing, easy replacement of components and low cost band roller which is on the market easily selected. the material web cline type is selected as the environment will be a transport for alimentosSe selects the conveyor belt table below features:

	Tipo de banda	Cobertura superior					Cobertura inferior					Características especiales
		Material	Color	Espesor mm	Acabado	Dureza °ShA	Material	Color	Espesor mm	Acabado	Dureza °ShA	
Clina (PU)	C06 UF	PU	Ocre 01	0,30	Liso	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C06 K1F	PU	Ocre 01	0,32	Grabado K1	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C07 UF	PU	Blanco	0,30	Liso	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C07UFMT	PU	Blanco	0,30	Mate	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C07UFMS	PU	Blanco	0,30	Mate	88	PU	Crudo	0,10	Impregn.		FDA ● ▽ □
	C07 UU	PU	Verde 16	0,10	Impregn.		PU	Verde 16	0,10	Impregn.		FDA ● ▽
	C08 UF	PU	Blanco	0,40	Liso	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C08UFMT	PU	Blanco	0,30	Mate	93		Crudo		Tejido		FDA ● ▽ □
	C08 DF	PU	Blanco	0,60	Grabado D	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C09 UF	PU	Blanco	0,25	Liso	93	PU	Crudo	0,10	Impregn.		FDA ● ▽ □
	C09UFMT	PU	Blanco	0,25	Mate	93	PU	Crudo	0,10	Impregn.		FDA ● ▽ □
	C09UFMS	PU	Blanco	0,30	Mate	88		Crudo		Tejido		FDA ● ▽ □
	C10 FF		Crudo		Algodón-Poli			Crudo		Algodón-Poli		FDA ● ▽
	C10 UF	PU	Blanco	0,30	Liso	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C11 FF*	PU	Crudo	0,10	Impregn.		PU	Crudo	0,10	Impregn.		FDA ●
	C12 UF*	PU	Blanco	0,30	Liso	86	PU	Crudo	0,10	Impregn.		FDA ▽ □
	C20 UF	PU	Blanco	1,00	Liso	93	PU	Crudo	0,10	Impregn.		FDA ● ▽ □

Temperatura en continuo (puntual) del producto transportado°C	Tejidos		Espesor banda	Peso banda	a 20°C A	B	Carga de rotura	Carga de trabajo al 1% alargamiento	Carga de trabajo al 1,5% alargamiento	Ancho máx. de fabricac.	Tipo de banda
	Nº de telas	Trama	mm	kg/m2	⌀mm	⌀mm	N/mm	N/mm	N/mm	mm	
- 10 (-15) + 90 (110)	1	Rígida	0,80	0,90	10	30	60	6	8	2-3000	C06 UF
- 10 (-15) + 90 (110)	1	Rígida	0,82	0,90	10	30	60	6	8	2000	C06 K1F
- 10 (-15) + 90 (110)	1	Rígida	0,80	0,90	10	30	60	6	8	2-3000	C07 UF
- 10 (-15) + 90 (110)	1	Rígida	0,80	0,90	10	30	60	6	8	2000	C07UFMT
- 10 (-15) + 80 (100)	1	Rígida	0,80	0,80	5	15	50	5	7	3000	C07UFMS
- 15 (-25) + 90 (110)	1	Rígida	0,50	0,35	8	8	60	5	7	3000	C07 UU
- 10 (-15) + 90 (110)	1	Rígida	1,10	1,25	10	30	50	5	7	2000	C08 UF
- 10 (-15) + 90 (110)	1	Rígida	1,00	1,10	10	30	50	5	7	2000	C08UFMT
- 10 (-15) + 90 (110)	1	Rígida	1,30	1,25	10	30	50	5	7	2000	C08 DF
- 10 (-15) + 90 (110)	2	Rígida	1,25	1,45	15	40	100	9	15	2000	C09 UF
- 10 (-15) + 90 (110)	2	Rígida	1,25	1,45	15	40	100	9	15	2000	C09UFMT
-10 (-15) + 80 (100)	2	Rígida	1,30	1,40	15	40	80	6	8	3000	C09UFMS
- 15 (-25) + 90 (110)	2	Flexible	1,40	1,25	10	10	110	7	10	2200	C10 FF
- 10 (-15) + 90 (110)	2	Rígida	1,40	1,60	20	50	120	10	18	2000	C10 UF
- 15 (-25) + 80 (100)	2	Rígida	1,30	1,40	30	30	120	9	12	3000	C11 FF*
- 10 (-15) + 80 (105)	2	Rígida	1,60	1,80	40	60	120	10	16	2-3000	C12 UF*

FIGURE 6 Features material banda

Source: (Esbelt, 2008-2009)

Selection of motor for conveyor belt

The motor is selected according to the required speed in the metering process, for this we must determine the requirements for operation.

The approximate rate of 2 [cm / s] and each tray is 55 [cm], then the following relationship for the calculation is given:

$$2\ [cm] \rightarrow 1\ [seg]$$

$$55\ [cm] \quad \rightarrow\ ?$$

Where:

$$\frac{55[cm]}{27.5\ [seg]}$$

$$\frac{1\ bandeja}{27.5\ [seg]}$$

Then the velocity obtained in minutes is 2.1818 [Tray / min]; which the unit is obtained in [m / min)

$$s = 1.2\ [\frac{m}{min}]$$

To determine the speed [ft / min], 30% increases safety factor and is obtained:

$$1.2\ \left[\frac{m}{min}\right] + 30\%\ (safety\ ) = 5.12\ \left[\frac{ft}{min}\right]$$

$$s = 6\ [\frac{ft}{min}]$$

As a safety factor for the mass of the tray has a value of 2, where:

$$M\ bandeja = 2 * 1\ [Kg] = 2\ [Kg]$$

=4.4 lb

M tray= mass of tray [Kg]

To calculate the engine power table value manufacturer is taken to see the weight of the band where the previous figure:

Band wb = 1.10 weight [kg / m ^ 2] and the coefficient of friction given by the kind of band to use is f = 0.4

$$HP = \frac{(W + wb)(f)(s)}{33000}$$

Equation 15 Engine power

Source: Autor

$$Wb = 1.10 \frac{Kg}{m^2} * (1.15m * 0.25\ m)$$

$$= 0.31625[Kg]$$

$$Wb = 0{,}3162\ Kg * \frac{2.2\ lb}{1Kg}$$

$$Wb = 0{,}69575\ lb$$

$$HP = \frac{(6.5 + 0{,}69575\ )(0.4)(6)}{33000}$$

$$HP = 0.00032\ HP * (1.5\ service\ factor)$$

$$HP = 0.00065$$

$$T = 8.4795\ N.m$$

IV. CONTROL SYSTEM

To control the machine generally used Plc Logo 12/24 RC for ease of installation, being modular.

Distribution of inputs and outputs plc.

in port	Description
I1	On
I2	Emergency Stop
I3	Optical sensor
I4	Pause
Out Salida	Description
Q1	Belt motor
Q2	Solenoid valve 1 control
Q3	Solenoid valve 2 control

V. FUNCIONALITY TEST

Time tests opening and closing valves The pneumatic valve that controls the dosing cylinder must remain open for five seconds to avoid errors in the dosage of the product. The following graph shows the amount of product dispensed into each mold is observed and remains constant at the value of 145 [ml]

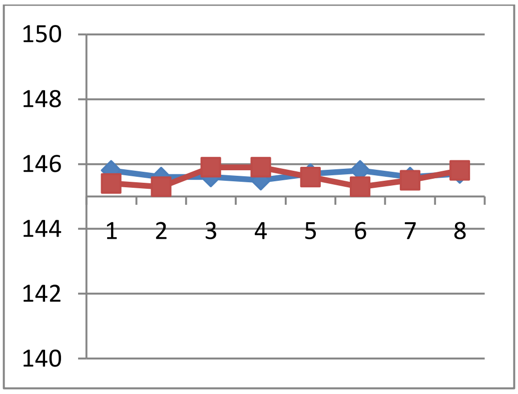

FIGURE 7 Graph of 5 seconds test

Author

The valve controls the cylinder for válvual dosage must remain open for 9 seconds to avoid errors in the dosage of the product. The following graph shows the amount of product dispensed into each mold is observed and remains constant at the value of 145 [ml]

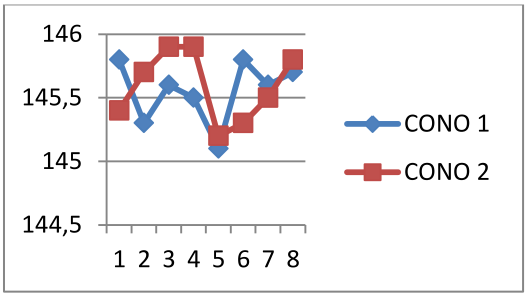

FIGURE 8 Graph of 9 seconds test

Author

VI. CONCLUSIONS AND RECOMMENDATIONS

CONCLUTIONS

-The selection of the technical design parameters directly affect the proper operation of the machine, with the help of professional CAD software Inventor able to select the right elements, simulate its operation and determine the appropriate components.

-Nowadays There are a number of electrical and electronic components, determination of each was made based on the costs of each and the functionality present differences between each correct operation also depends on other elements to work together.

-In The part of the implementation of the machine it was observed that the speed of the machine can be adapted to another production line depending on the need of production, or shape having the same.

-This System can be used to dispense other types of products, it was taken as showing a viscous product which presents problems when dosed by the density having, but when used with liquids substances this process becomes easier as the liquids tend to fall under its own gravity.

He obtained a better result when working elements at the same voltage, in this case 24 VDC, since most instruments tend to only use this voltage for powering the same.

RECOMMENDATIONS

-Try Electrical and control elements one to one to verify proper operation before adapting to the machine.

-Review The bridges of the terminal blocks and placement of terminals, development of test 1 game proved defective, and did not allow the passage of current in a solenoid valve which gave a result of machine errors.

-Each Some time must be adjusted mechanics, especially the optical sensor of the sensors because, as are in contact with the band can move and do not give the correct signal.

- To preventive maintenance cleaning of the mechanical elements, not to wear out more easily.

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VIII. BIOGRAPHY

Karen Alejandra Arevalo Simbaña (Author), was born in the city of Ibarra-Ecuador on 25 October 1990. He completed his primary education at school "Rafael Suarez Meneses". Their secondary studies were conducted at the Education Unit Ibarra. " Currently he is a graduate of the Technical University North of the city of Ibarra, in the career of Mechatronics Engineering in 2014.

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