FICA, VOL. 01, NO. 1, JULIO 2014

.

IMPLEMENTATION OF A SILO WEIGHING FOR MINERAL USED IN THE PROCESS OF SCRAP IN THE ENTERPRISE "ADELCA C.A.

Diego Terán[1], Edgar Taimal[2].

[1]Teacher of Faculty of Engineering in Applied Science at the Técnica del Norte University, Otavalo, Imbabura
[2]Student of Faculty of Engineering in Applied Science at the Técnica del Norte University, Ibarra, Imbabura
dfteran@utn.edu.ec, edotaimal@gmail.com

RESUMEN*: *La empresa Adelca se encuentra ubicada en la Parroquia de Aloag, Provincia de Pichincha, la empresa cuenta con el negocio de procesamiento de chatarra para la obtención de acero para la construcción.
En el presente documento, se detalla la problemática en el proceso de pesajes de minerales, en donde los trabajadores de la empresa Adelca C.A, realizan tareas de gran esfuerzo físico y expuestos a una excesiva contaminación. Mediante la automatización de los procesos se logra obtener el control de información, y además suministrar las cantidades correctas de los minerales utilizados en el proceso de la fundición de chatarra. Obteniendo así mejorar el entorno de trabajo par los empleados destinados a realizar las tareas de pesaje.

ABSTRACT: ***The enterprise Adelca is located in Aloag town, Pichincha Province, the company enjoys the business of processing scrap for producing construction steel***
In this document, the problems detailed in the weighing process of minerals, where company workers Adelca CA, perform physically demanding tasks and exposure to excessive pollution. By automating processes is achieved gain control of information, and also provide the right amounts of minerals used in the process of the melting of scrap. Achieving and improving the work environment couple employees to perform tasks for weighing.

KEYWORDS: Silo, Automatic Weighing, Load Cells, Profibus.

1 INTRODUCTIÓN

Knowing quantify the amount of raw material used in certain process is very important. Basically you can say that everything that can be measured can also be controlled. Currently in the business section Steelworks Adelca CA, has a manual dosing of minerals, to the charge of scrap baskets. The current system is a rudimentary manual weighing, using shovels and a scale, which is used to obtain the required by the process of melting of scrap quantity, this process involves a lot of physical effort and imminent risk to bless you.

Figure 1.1 Weighing coal by using shovels and a balance

The function of the adherent elements like carbon, calcium lime and dolomitic lime in the process of scrap melting through Electric Arc Furnace, is to capture the slag melting scrap, performing the function of a filter as long as the metered quantities in the baskets is adequate.

1.1 Weighing Systems

New technology in weight controllers allows us to monitor the process in real time. Features like vibration immunity despite allowing even the most difficult process. The electronic calibration allows us to implement a system in less time and without errors.

1.2 Weighing System Components

A weighing system consists of one or more load cells, an adder and a controller box weight. Systems typically three or four points that facilitate mechanical arrangement used.

1.3 Mechanical actuators

A mechanical actuator is a device capable of converting hydraulic, pneumatic or electric power in the activation of a process in order to produce an effect on an automated process.

.

Two types of actuators; pneumatic and hydraulic systems, are widely used as a basis to construct a robot, allowing the rotational movement (motor) and translation (cylinder).

1.3.1 Mechanical Pneumatic Actuators

For mechanisms that convert the energy of compressed air into mechanical work are called pneumatic actuators. Although they are essentially identical to the hydraulic actuators,

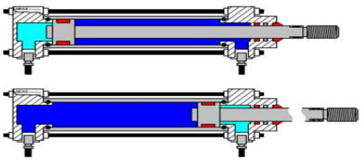


Figure 1.2 Double acting cylinder

1.3.1.1 Pneumatic Linear Actuators.

The tire consists of a closed cylinder with a piston sliding inside and transmits its motion to the outside by a cylinder rod. The double-acting cylinders are those that perform both its forward and backward by the action of compressed air. Its name comes from employing the two sides of the piston (air in both chambers). Rotating or rotary actuators are responsible for transforming the pneumatic energy into mechanical energy of rotation.

1.4 Defining electrical actuator

Actuators are the devices that perform physical actions, ordered by a control system. This physical action can be a linear movement or a circular motion as the case. It is given the name of electric actuators when electrical energy is used to run their movements.

1.4.1 DC motors

The DC motor is a machine that converts electrical energy into mechanical energy, mainly through the rotary motion.

The main feature is the ability to adjust the speed from no load to full load.

1.4.1.1 Principle of operation.

It is based on the second law Lorentz.

$$F = B * l * I$$

Equation 1 1. Electric motor Force

F: force in newton

I: Intensity Walking the driver in Amps

L: Linear conductor length in meters

B: induction into teslas

1.4.2 Stepper Motors

It is an electromechanical device that converts a series of electrical pulses into discrete angular displacements, which means that it is able to access a number of degrees (step) depending on its control inputs.

1.4.3 Ac motors.

Alternating current is one in which the intensity changes periodically in a conducting direction. As a result of the periodic change of polarity of the voltage applied at the ends of said conduit.

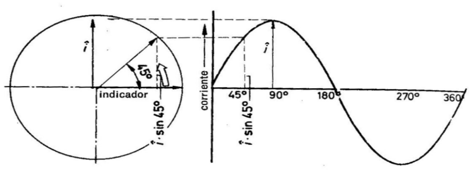


Figure 1. 4 alternating current sine

1.5 Weight sensors.

Weight sensors are those electronic devices developed in order to detect the electric changes brought about by a variation in the intensity of an applied load on the scale or scales, information which in turn transmits to a weight indicator or weight controller.

1.5.1 Load cells.

The basic principle of a load cell is based on the operation of four strain gages (strain gauge), arranged in a particular configuration.

A strain gauge is a sensor based on the piezo effect - resistive. A strain gauge which deforms and produce a variation in its electrical resistance, therefore the strain gauge is basically an electrical resistance

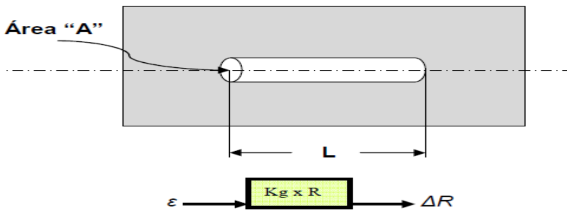


Figure 1. 5 Linear and deformations undergone Conductor

If we consider a wire of length "L", "A" section and resistivity "ρ" electrical resistance "R" would be given by:

.

$$R = \rho * \left(\frac{L}{A}\right) = \rho * \left(\frac{L}{\pi * r^2}\right) [\Omega]$$

Equation 1.2 deformation resistance

1.5.2 Materials of construction of the load cell.

According to the applications that are already carrying the environments to which the cells are exposed load a list of materials which are manufactured detailed load cells

1.5.2.1 Aluminum load cells

Load cell components of aluminum are used primarily in applications in a single point and low capacity

1.5.2.2 Load Cells carbon steel.

Load cell elements made of carbon steel is by far the most popular load cells.

1.5.2.3 Load Cells stainless steel

Cells of stainless steel are more expensive than load cells carbon steel. Some come equipped with hermetically sealed cavities tissue which makes them ideal for high humidity and corrosive environments selection.

1.5.3 Classification of load cells according to their morphology.

In this case we can divide the load cells in different groups:

1.5.3.1 cells single-pan.

Also called single cell. The internal working of the system is bending strain gauge. They are used in small balnce and platforms

1.5.3.2 Simple Shear cells:

They get used to riding 2 or more load cells. The internal operation is cut. In this case support larger capacities up to 5000 kg. The cells are connected to each other through the junction box

Figure 1. 6 load cell shear beam type.

1.5.3.3 Dual Load Cell Shear.

It is the same case as above, for multi - cell; with the difference that they can withstand higher loads.

1.5.3.4 Traction Cells.

This type of cells, also called S, operating in both tension and compression. Internally typically operate to cut and can be found in capacities from 30 kg to 10000 kg.

1.6 Quality control.

Process followed by a business firm to ensure that its products or services meet the minimum quality requirements set by the company. With policy management (or administration) Best Quality (GCO) throughout the organization and activity of the company is subject to a strict quality control, whether the production processes and final products.

1.7 Analysis of metering systems [1]

For this section the study of different solid weighing systems and the operation of these systems is, which allow you to choose a particular weighing system for our purpose

1.7.1 Based on weighing hopper system[1]

Figure 1. 7 Silo hopper (Aviles. M, 2011)

This system provides ease of weighing hopper any product, regardless of form, only the simple need for the implementation of load cells, and its application is directed to liquid, viscous materials powders and granular solids.

[1]Avilés. M. Caviedes. G (2011). Implementación Del Sistema De Dosificación Y Control De Pesaje Dinámico Para Empaquetamiento De Comestibles Sólidos (tesis de pregrado). Repositorio EPN

.

1.7.2 Bagger weigher [1]

The bagging weigher has a varying capacity depending on their characteristics. In its automatic versions, as Figure

Figura 1. 8 bagging weigher (Aviles. M, 2011)

1.7.3 Weigh multihead[1]

The multihead weighing uses the principle of combination of weights across different scales that are downloaded randomly selected according to the weight. The use of multiple hoppers allows high precision weighing.

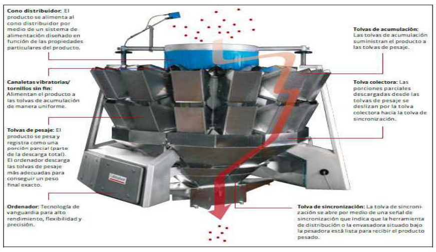


Figure 1. 9 wieigh multihead (Aviles. M, 2011)

1.8 Carbon properties

Carbon is a dark solid, stratified fuel result of the accumulation and burial of plant matter from primitive eras. These deposits become Carbon through some initial biological changes and then mechanical effects of pressure and temperature within the sediments.

Figura 1. 10 Angle of repose of carbon

In the previous figure (1.10) one can observe the angle of repose formed by the type coal basket, this angle is formed by dropping a lot of coal on a flat surface, how to measure this angle, is through experimentation.

2 MECHANICAL DESIGN SILO.

2.1 Analysis of the capacity of Silo

According to presentations to acquire the company acquires mineral coal and lime, they come in submissions for 1000 kg. According to the characteristics of mineral density will determine the volume occupied by each mineral, therefore we have.

2.2 Density.

The density "δ" is the result of comparing, by division, the mass "m" of a body to its volume "V".

$$\sigma = m/V$$

Ecuatión 2. 1 Density

In this case of carbon, which has a density of between 1.3 and 1.6 g/cm3, the end of the project the maximum value is used, and solving the above equation (2.1), we have:

$$m = \sigma . V$$

As units are coal density g / cm^3, we transform the units kg / m^3

With what we have

$$1{,}6\,\frac{gr}{cm3}\cdot\frac{kg}{1000\ gr}\cdot\frac{1000000cm3}{1m3}$$

Where the value of the density in kg/m^3 is

ɗ = 1600 kg/m^3

2.3 Design of the silo.

To start with the construction of the silo, we take as a starting point presentations acquisition by the company of the materials, in the case of coal and lime, is made in submissions for 1000 kg, then as data for the calculation of silo we consider that the silo must be at least 1m^3,

2.3.1 Calculating the total volume of the silo.

Due to the geometry of the silo, and as we have chosen the hopper silo, the total volume of the silo entail the separate calculation of the regular ways that the silo, this means that the total volume is the sum of all sub-volumes calculated separately.

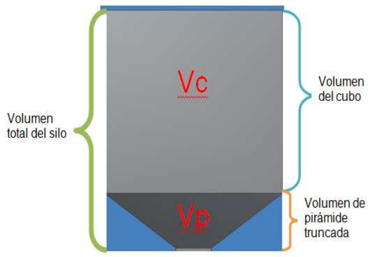


Figure 2.1 Silo Container Reference Volume

The mathematical expression for calculating the volume of the silo remain as follows:

.

$$Vc + Vp = Vts$$

Equation 2. 2Volumen Silo

From where:

Vc = volume of the cube.

Vp = volume of a truncated pyramid

Vts = total volume silo

$$S_L = 4a^2$$
$$S_T = 6a^2$$
$$V = a^3$$
$$d = a\sqrt{3}$$

Figure 2. 2 Table formulations regarding the cube

$$S_L = Ap\,(p + p_1)$$
$$S_T = S_L + S_1 + S_b$$
$$V = \frac{h\left(S_1 + S_b + \sqrt{S_1 \cdot S_b}\right)}{3}$$

Figure 2. 3 Table formulations regarding the pyramid

Taking as data the silo has 1m side and the height of the hopper is 0.3 m and the discharge outlet of the mineral is 0.2 m have the total volume of the silo by replacing in equation 2.2

$$Vc+Vp= Vts$$
$$Vts = 1 + 0.165$$
$$Vts = 1.165\ m^3$$

Since the total volume of 1,165 m3 silo is the same to house a total mass of about 1864 kg, with reference to the density equation.

2.3.2 Forces in Silos and Hoppers.

Analysis efforts in silos and hoppers seeks to determine possible faults in the mechanical construction thereof

2.3.2.1 Method Janssen

In 1895. H.A Janssen studied the static pressures in silos due to stored material. His theory is based on the equilibrium of a differential section of the silo with the material at rest. This analysis was able to derive the expression for the vertical pressure of the material, the lateral pressure and the friction force on the silo wall.

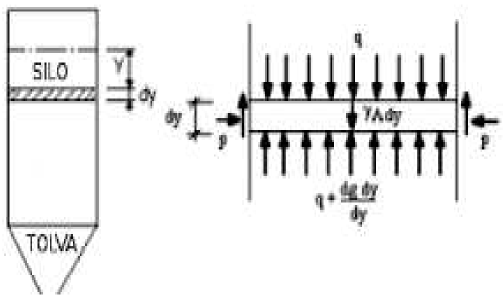


Figure 2. 4 Reference of forces and pressures

The terms reached by Janssen are as follows[2]:

$$K = \frac{Ph}{Pv} = \frac{1 = \sin\varphi}{1 + \sin\varphi}$$

Equation 2. 3 Coefficient of Rankine

$$U' = \tan\varphi'$$

Equation 2. 4Coeficiente friction material stored

$$R = A/U$$

Equation 2. 5 Hydraulic Radio

$$Pv = \frac{wR}{U'\,k} + \left(1 - e^{-\frac{U' kh}{R}}\right)$$

Equation 2. 6 Vertical Pressure

$$Ph = k * Pv$$

Equation 2. 2 Horizontal Pressure

Where:
K = coefficient of Rankine.
w = density of the stored material.
h = height
A = area
U = circumference
R = hydraulic radius
Φ = angle of repose of the material stored
Φ '= angle of friction between the material stored
U '= coefficient of friction of the material stored
Ph = horizontal pressure in kg/m^2
Pv = vertical pressure in kg/m^2
To apply Janssen expressions have the following data
W = material density = 1600 kg/m^3 ɗ
Silo height h = 1 m
Silo area A = 1 m^2
Perimeter of the silo U = 4m
U '= 0.475

$$R = \frac{A}{U}$$
$$R = \frac{1}{4}$$

[2]Echeverría. A. Sandoval. L. (2013), Dosificación automática de sólidos, para el laboratorio del AIM de la Escuela Politécnica del Ejercito. (Tesis Pregrado). Repositorio ESPE

.

R = 0,25 m
Since U '= tan Φ'

$$\Phi' = arctang\ U'$$

Then solving for
Φ' = arctang 0.475
Φ' = 33
Φ = 39
Replacing the expressions we have

$$K = \frac{1 = \sin 45}{1 + \sin 45}$$

K= 0,32172586

For the horizontal pressure

$$Pv = \frac{wR}{U'k} + \left(1 - e^{-\frac{U'kh}{R}}\right)$$

Replacing and performing computation expression have

Pv = 1486,91579 kg/m^2

For the horizontal pressure, we solve the expression

$$K = \frac{Ph}{Pv}$$

$$Ph = K * Pv$$

Replacing values have

$$Ph = 0{,}32172586 * 1486{,}91579$$

Ph = 116,163284 kg/m^2

2.4 Selection of material for the construction of the silo

The material used for manufacturing the steel silo SAE A-36, which by their mechanical characteristics and the ease of acquisition of this kind of steel.

2.4.1 Chemistry A-36 Steel

The A-36 is a low carbon steel with very few alloys. Its chemical composition of 0.26% carbon, 0.75% manganese, 0.2% copper, 0.04% phosphorus and 0.05% sulfur, while the rest is iron. Manganese and copper give the steel the strength and hardness.

2.4.2 Mechanical properties Steel A-36

In terms of mechanical, steel A-36 is designed to be rugged and strong. It has a high tensile strength (the amount of pressure needed to deform the material) of 58000-79800 pounds per square inch (psi) (10355-14247 kg/cm^2).

By the above especially in the mechanical part of the steel, and comparing the values of pressures that requires this type of steel to deform, 14,247 kg/cm2 is much higher pressures calculated Janssen expressions whose values are: Pv = 1486.91579 kg/m^2: Ph = 116.163284 kg/m^2 and therefore steel plate a-36 with a thickness of 6mm was used for ease of finding the local market and easy to operate.

2.5 Distribution of the points of support for the load cells

The recommended number of carriers depends on the geometry, the gross weight, and structural strength and stability of the silo. Obviously the number of carriers is chosen to affect a silo capacity load cells required in our case is 4 by the geometry of the silo

2.5.1 Capacity load cell

Regardless of the shape of the load cell will be used to select the way your ability will always be linked with the amount of support to be used in the weighing system

2.5.2 Estimating deadweight silo

Is an estimate of the weight of more silo and all other mechanical structure supports our case we consider the material of which is to make the silo

The silo will be built in steel plates with a thickness of 6 mm, with a density of 7.87 g/cm3.

Then to calculate the total area of the silo have the following expression:

$$Sts = Sc + Sp$$

Equation 2. 8 Total area of the silo

where:
Sts = total area of the silo
Sc = lateral surface of the cube
Sp = lateral surface of the truncated pyramid
It should be noted that the silo is made up of a cube and the truncated pyramid (Hopper).
Lateral surface prescribed by.

$$S = 4a2$$

Formula box taken relative to cube

$$S = 4x1m2$$

S= 4m^2

Lateral surface of the truncated pyramid formulas given by box truncated pyramid

$$S = 0.5m^2$$

$$Sts = Sc + Sp$$

Sts = 4 + 0,5

Sts = 4,5 m^2

The surface of the silo is multiplied by the thickness of the sheet

we have

Volume of material silo = Sts x 6 mm

Material silo volume = 0.027 m3

Since these data we calculated the amount of estimated mass of silo no charge

$$m = \partial x V$$

$$m = 7870x\ 0{,}027$$

m = 212,5 Kg.

With this we have estimated the system's largest body, which is also considered additional small bodies.

.

Weighing about 300 kg, which is the dead load (Cm) is estimated.

The live load is the net value of the ore, Cv = 1600 Kg

2.5.3 Gross charge

The net charge is the sum of the dead load plus live load. For the calculation of the gross load the following expression is established by definition.

$$Cb = Cm + Cv$$

$$Cb = 1900 \text{ Kg}$$

By dividing the bulk charging silo to the number of carriers that have the system.

Capacity load cell is = 1900/4

Cell capacity = 541 kg = 1190.2 lb.

2.6 Mechanism of the Silo

For the mechanism of the silo has given a moving mechanism Rotating because the physical and granulometric conditions of the material to be weighed, the gate opening will be driven by a linear pneumatic cylinder, the same that will swing in bocines gate .

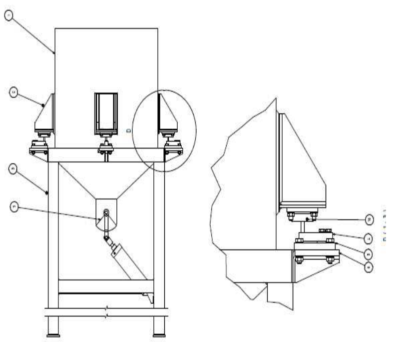


Figure 2.5 silo Weighing

2.7 Selecting pneumatic actuator

For the selection of the air cylinder must be taken into account that the force is the material stored in the silo in just the output thereof, which we know how hard you have to overcome to achieve balance and break open the lid of the bin, which equals out to 823 N.

With the help of actuators have standardized tables

Ø VASTAGO [mm]	Ø EMBOLO [mm]	FUERZA NETA [N] a P=6 bar	LONGITUDES DE CARRERAS NORMALIZADAS [mm]
—	6	15	10, 25, 40, 80
4	12	60	10, 25, 40, 80, 140, 200
6	16	106	10, 25, 40, 80, 140, 200, 300
10	25	260	25, 40, 80, 140, 200, 300
12	35	509	70, 140, 200, 300
16	40	665	40, 80, 140, 200, 300
18	50	1039	70, 140, 200, 300
22	70	2037	70, 140, 200, 300
25	100	4156	70, 140, 200, 300
30	140	8146	70, 140, 200, 300
40	200	16625	70, 140, 200, 300
50	250	25977	70, 140, 200, 300

Table 2.1 Standardized sizes and lengths Cylinder Racing.

3 ELECTROMECHANICAL SYSTEM IMPLEMENTATION WEIGHING

3.1 Implementation of a Weighing

For the implementation of the weighing system after studying the types of load cells, load cells most commonly used in the market, in our case beam load cells were used to cut,

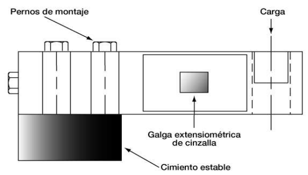


Figure 3. 1 Beam Shear

Load cells Shear Beam offer many advantages when used in well-designed modules weighing.

3.2 Mounting Considerations for shear beams

Because research conducted for the project found these possible considerations on installing this type of load cells, the same as those described below.

- The mounting surface must be flat and level.
- The mounting block should be large enough to provide enough threads for the mounting screws.
- The load should be applied vertically across the center line of the cargo bay.
- The introduction of load must provide the flexibility needed to prevent transmission of

.

outside forces and to tolerate the inevitable deflection of the load cell itself.

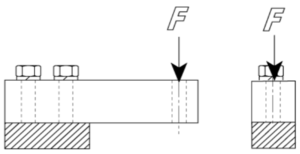


Figure 3 2. Force applied to the beam shear cells

3.3 Orientation of shear beams.

Figure 3.3 illustrates four different silos and recommended for weighing modules shear beam mounting configurations.

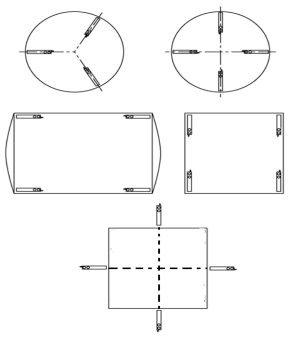


Figure 3. 3 Installation of cells according to their application

3.4 Application of load cell forces

Basically the load or force must be applied perpendicularly to the lateral forces preventing sensor. ¬ za When a container is used must find its center of gravity, weight and level at all points of support.

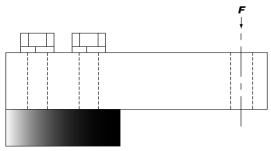


Figure 3. 4 Ideal Direction of force

Figure 3.4 shows a typical mounting arrangement for a beam shear. The fixed end is fastened to a "rigid" foundation while the free end is cantilevered to allow it to flex downward when a load (F) is applied.

3.5 Solenoid

A solenoid is an electromechanical valve, designed to control fluid flow through a conduit such as a pipe, the valve is controlled by an electric current through a solenoid coil.

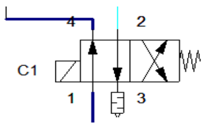


Figure 3. 5 Solenoid (schematic)

3.6 Electro-pneumatic diagram for activation of the pneumatic cylinder

In Figure 3.6 you can see the electro-pneumatic air cylinder control implementation. Wherein the source of air is at a pressure of 6 bar

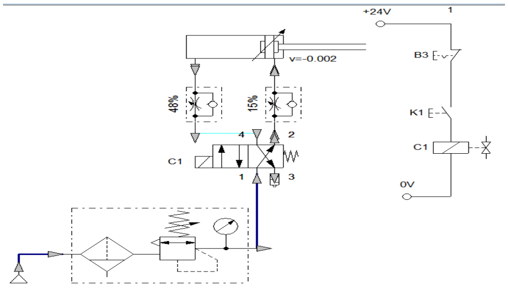


Figure 3. 6 pneumatic cylinder activation Diagram

3.7 Block diagram of the system

4 HARDWARE and SYSTEM CONTROL Softwrae WEIGHING

4.1 Hardware

For what is the system silo weight control has been decided to use the following hardware: SIEMENS PLC s7 of 300 series modules in conjunction with digital inputs and outputs, as the conversion of the analog signal digital a reading device weight is used as the dat Presice 400, 600DP ktp screen HMI siemens brand for the man-machine interface, most relevant for programming control of the silo weighing system elements, it should be emphasized that these elements will be communicated via Profibus

CPU s7 300 315 2dp

.

HMIktp 600 dp
Dat 400 presice

The use of these elements within the project, considered two very important points.

The weighing system of minerals, remain as an open system, therefore the use of a PLC which has excellent performances as those of the S300 family are appropriate, for its storage capacity and ease of incorporation of modules for other applications complement this project, and communication via Profibus, place and teams of the plant is based on this type of communication, and this project should complement the equipment already installed in the process, the HMI that will be used will help us intuitively using the weighing device.

4.2 Communication Networks

It is the transfer of data between two interlocutors with different benefits and control of one party by another, in addition to the query or interactive interrogation of the partner state. Communication is possible using different routes.

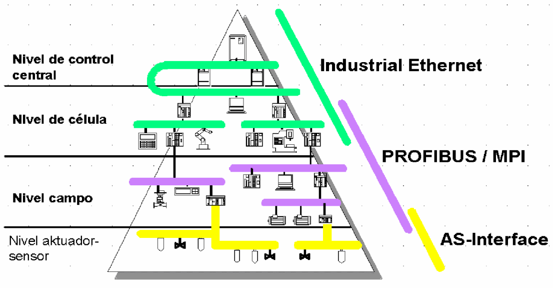
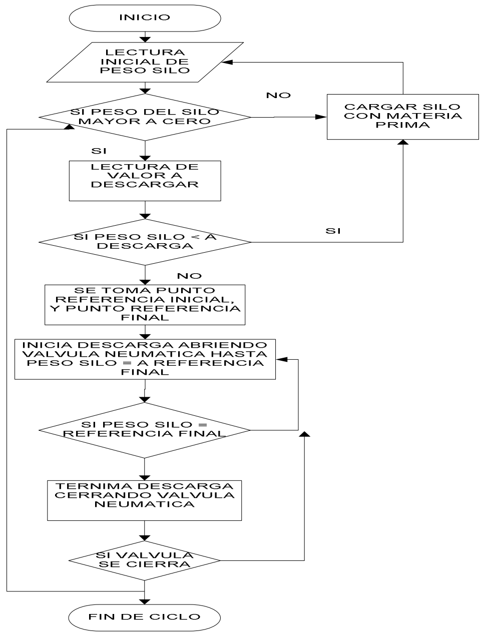


Figure 4. 1 Levels of automation.

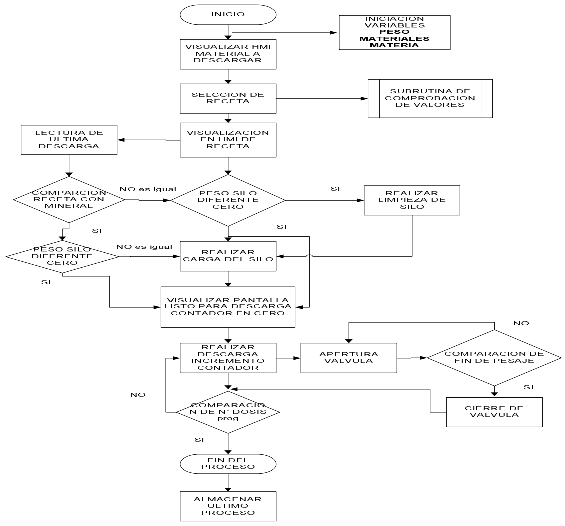
4.3 PROFIBUS DP

PROFIBUS-DP meets the stringent requirements imposed time for data exchange in the field of decentralized periphery and field devices. The typical DP configuration has a structure with a single teacher. The communication between the DP master and the DP slave is performed according to the master-slave principle. The teacher directs all data traffic on the bus, this means that the DP slaves can only act on the request after the bus master.

4.4 Flow diagram programming PLC



4.5 Flow diagram programming HMI



5 TESTING AND ANALYSIS

It checks that all system devices are turned on and not skip any alarm communication or any other type, revision of the sensors that are giving the signal according to its characteristics.

An initial test on the pneumatic actuator controlled opening and closing from the HMI, with this proper operation of the mechanical system and the actuator control is performed is determined

.

A first weight reading is done in the silo, not necessarily the value displayed on the HMI will be the actual weight, because as the first reading device reading will be wrong why is not calibrated.

Then for the calibration of the weighing system is chosen using a weight pattern, it has a known value, in this case the weight pattern has a weight of 100 kg.

No Calibración	Peso Patrón	Lectura Obtenida	Porcentaje de error	CAUSA	SOLUCION
0	100 kg	155 kg	+ 55%	Sin calibración	1era calibración
1	100 kg	85 kg	-15%	Cableado celdas flojo	Reajuste del cableado
2	100 kg	115 kg	+15%	Celdas de carga a desnivel	Nivelación de las celdas de carga
3	100 kg	110 kg	+ 10%	Peso patrón ubicado de manera excéntrica en el silo	Colocar peso patrón en el centro del silo
4	100 kg	102 kg	+ 2%	Sensibilidad a la lectura muy alta	Calibración de la sensibilidad del conversor
5	100 kg	100 kg	0%	Solución de problemas anteriores	

Table 5 1. Table silo calibration readings

Now with the actual reading of the weights proceeds to perform tests with dosing of minerals.

The dosage of minerals such as coal, lime, ferro silicon, are given in different measures, for purposes of the project will begin testing the type coal basket. The following results.

Descarga No	Valor determinado	Valor Descargado	Porcentaje de error
1	50 kg	65 kg	+30%
2	100 kg	116 kg	+16%
3	150 kg	162 kg	+8%
4	200 kg	213 kg	+6.5%
5	300 kg	315 kg	+5%

Table 5 2. weight Vs determined values obtained

From these data it was observed that the main issue that emerged was primarily a failure of activation schedule of opening and closing of the discharge valve, for which the program is reviewed in the PLC and the problem is corrected

Descarga No	Valor determinado	Valor Descargado	Porcentaje de error
1	200 kg	199.6 kg	-0.2%
2	200 kg	200 kg	0%
3	200 kg	200 kg	0%
4	200 kg	201 kg	+0.5%
5	200 kg	200 kg	0%

Table 5 2. weight Vs determined values obtained 2

After making the correction software results in the above table, where, a great improvement on the desired weights and the weights obtained in the weighing system is observed is obtained, since some variations occur because during the cycle download also influence other variables, as in the case of irregularities in the mineral.

6 CONCLUSIONS

Through the implementation of this project the great physical effort being made by workers to perform the intended dosage of minerals, significantly lowering labor risk is decreased.

The silo weighing system is given for a certain particle size no greater than 30mm material though, because if the particle size of the material is greater than 30mm will cause the mechanism locks the gate.

The mechanical assembly of the system silo must be on a flat surface so that the load cells do not get false readings, and this will lead to erroneous and incorrect dosages have.

According to the capacity of the load cells used the automatic weighing system has a maximum capacity of 2000kg with live load

By implementing this project, I was able to determine that everything can be measured, can be controlled, and all that can be controlled can be improved.

REFERENCES

[1]. Viloria. J. (2005). *Neumática*, (2ª ed.) Editorial Thomson

[2]. Avilés. M. Caviedes. G (2011). Implementación Del Sistema De Dosificación Y Control De Pesaje Dinámico Para Empaquetamiento De Comestibles Sólidos (tesis de pregrado). Escuela Politécnica Nacional, Quito, Recuperada de http://bieec.epn.edu.ec:8180/dspace/handle/123456789/1316

[3]. Rice Lake, Load Cell and Weigh Module Handbook, A Comprehensive

[4]. Formulas Matemáticas. (2008). En Lexus Editores S.A. (1ª ed.). Lima.

[5]. Ayuga, F. (1995), *Los Empujes Del Material Almacenado En Silos*

[6]. Echeverria. A. Sandoval. L. (2013), Dosificación automática de sólidos, para el laboratorio del AIM de la Escuela Politécnica del Ejercito.(Tesis de Pregrado). Escuela Politécnica del Ejército, Campus Sangolqui,

[7]. Alciatore D G (2007). *Introducción a la Mecatrónica y los Sistemas de medición.* (3era ed.). México: McGraw-Hill

[8]. Shigley, J E., (2002). *Diseño en Ingeniería Mecánica. (*6ta ed.). México: McGraw-Hill

[9]. Ramón P, A. (2004). *Sensores y Acondicionadores de señal.* México:McGraw-Hill Interamericana

.

[10].Piedrafita. R. (2004). Ingeniería de la Automatización industrial (2ª ed.) México: Alfaomega.
[11].Pérez. M. (2005), Instrumentación Electrónica, 2da edición.
[12].Bolton, W. (2006). *Sistemas de control electrónico en la ingeniería mecánica y de Electricidad,* 3ª Edición.

Diego F. Terán P., nació en Otavalo-Ecuador el 13 de Noviembre de 1985. Realizo sus estudios secundarios en el Colegio Experimental Jacinto Collahuazo. Graduado en Ingeniería en Mecatrónica la Universidad Técnica del Norte el 2012. Estudio Energías Renovables en el 2006 en SEI (Solar Energy International)-EEUU. Actualmente como docente en la Universidad Técnica del norte y en proyectos de electricidad, energías renovables y automatización para la zona de Otavalo.
Área de Interés: Control y Automatización, Energías Renovables, Robótica e inteligencia artificial, Informática y microcontroladores. (ayllusck@gmail.com-dfteran@utn.edu.ec)

Edgar O. Taimal J. nació en San Gabriel – Carchi, Ecuador el 1 de Enero de 1984, Realizo sus estudios secundarios en el Colegio Nacional José Julián Andrade. Egresado de la Escuela de Ingeniería en Mecatrónica de la Universidad Técnica del Norte el 2014. Actualmente trabaja como técnico mantenimiento en empresa Adelca Acerías del Ecuador.
Área de Interés: Control y Automatización, Energías Renovables, Sistemas Hidráulicos y Pneumáticos. (edotaimal@gmail.com).