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TECHNICAL REPORT

THEME:

MACHINE CONTROL SYSTEM FOR CRUSHER PLANT WASTE ORGANIC FERTILIZER PRODUCTION IN THE AGRICULTURAL SECTOR

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Machine control system for crusher plant waste organic fertilizer production in the agricultural sector

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***Abstract* - This degree project work , which is detailed below is done from the need to reduce the physical strain on farms and ranches that use cutting tools for chopping the same branches and plants that underwent their last harvest , which serves as an organic fertilizer to other plants found in the cultures.**

For the implementation of the TRAPP system TRF 300 machine is suitable grinding mill for the solution of the problem will be used. As the control system contained in an electronic board, the power and control circuits are implemented respectively by the main element of the system is a frequency SIEMENS Micromaster MM440 brand , which will act to vary the speed of the motor built the grinding mill to three fixed speeds which three types of crushing will be achieved in three different sizes for composting or animal feed , at your convenience using the operators of the agricultural sector.

I. INTRODUCTION

The idea of implementing a system of control to a crusher plant products harvested or organic waste for composting, arises from the need to reduce the physical work, save time and establish a quality improvement in production fertilizer; because in the past and very little in the present in some agricultural sectors perform cutting plants with sharp instruments, such as machete, manually.

Current situation encountered in agriculture is that it is very convenient for farmers to produce fertilizer from organic waste which serve as fertilizer for other plants, but the problem is that produce compost manually requires a lot of effort and time to get what you want. Also when harvested in large numbers certain vegetables, the farmer proceeds to burn the stems and branches, which pollutes the environment and the aim is to improve it by crushing the same serving of organic fertilizer.

II. MACHINE COMPONENTS AND FEATURES

A. Introduction

This section describes the different elements that make up the shredder, both the mechanical part is the machine and the control system to be designed will be mentioned. It should be noted that the machine is a brand crusher TRAPP TRF 300.

Besides the different elements that form part of the control system for the speed control of the machine will be mentioned. This type of controller, which will be included in the variable speed motor that will perform its function from a selector positions are also mentioned.

B. The Feed

Compost, or act of fertilizing plants is a system by which man modifies soil concentrations of ions artificially, in order to increase crop production. This modification is usually clearly shaped positive increase, and products that are used range from natural manure until blended fertilizers or chemical synthesis, through the import of minerals rich in nutrients. Points

C. The Grinding

A crusher, crusher or crusher is a machine that processes a material such that the material produces a smaller chunk size to the original size.

Shredders are machines generally used for breaking hard products and large, and can perform operations of coarse, medium and fine crushing. Its working principle is based on the slow compression forces application that can be compression, shear, impact and attrition; shredders fall into acting compression, cut and percussion.

D. Electric Motor

The electric motor is most often used to transform electrical energy into mechanical energy machine, combining the advantages of the use of electricity (low cost, portability, ease of cleaning and command) with its simple and robust construction with a low cost versatility to adapt to the most varied types of loads.

In this case for this project has chosen a motor 3HP Siemens because it is the most suitable for grinding machines, perform more work, will operate much longer with respect to a 2 HP motor has more strength, more reliability and more torque; since the function of the machine is grinding a certain amount of different types of branches and organic waste, it will support a maximum of up to 60% of the total area of the waste inlet to the machine.

Engines 2 and 4 poles are the best sellers in the market and according to label contained in the engine of the machine mentioned in this draft working paper grade to 60 Hz is approximately 3600 rpm rotation which is says it has 2 poles and this data is provided by the manufacturer.

E. Blades and Hammers

The blades and hammers having this machine are subject to a common shaft by which revolve in the same manner as the motor rotates, namely, have the same transmission rate.

Power transmission is made through the two webs A-45 that are provided by the manufacturer.

The machine contains 10 movable type hammers and 2 blades applied anticorrosion treatment on all parts subject to oxidation.
The maximum output of the machine is about 1000 kg / h under operating manual.

Fig 1. Grinding mill TRAPP TRF 300

Source: (see [38])

F. Transmission Belts or Bands

Flexible elements are used to machine the transmission power over comparatively large distances. When employed usually

groups replacing gears, shafts and bearings or similar transmission devices.

They are also resilient and generally very long, so they have an important role in absorbing shock loads and damping effects vibrant force function.

G. General Characteristics TRAPP TRF 300 (see [27])

Force transmission across 2 straps.
Body constructed of sheet 4,25 mm.
Cutting blades (blade) of special steel.
Key bipolar chopper in single phase and three-pole models for three-phase models that offer full independent isolated position Plug taken.
Temperature of 40° C and relative humidity 80%.
It also contains an upper outlet forage screwed peak power, a system output of milled grain, fixing the sheets, key switch, blade steel that ensures greater security.
Accompanies 1 hopper for grain tank (capacity 13 liters), 5 sieves (4 fixed in the sieve box and one "0" into the disposer smooth) 4 pads.
Length of about 1,20 m height including the hopper.
Length of about 0,30 cm wide.
Maximum area of 80 cm^2 material input.

H. The Drive Frequency

According Schoneck (2002): "*A variable frequency drive (VFD for acronyms in English: Variable Frequency Drive) is a system of alternating current (AC) by controlling the frequency of power supplied to the motor. Variable frequency drives are also known as adjustable-frequency drivers. Since the voltage is varied while the frequency, sometimes are called drivers VVVF (variable frequency inverter voltage), frequency inverters operate on the principle of: the synchronous speed of an AC motor is determined by supplied AC frequency (alternating current) and the number of poles in the stator.* "

I. SIEMENS Micromaster 440

The drive frequency SIEMENS MM440 micromaster is used in this project work degree, which is described below.

The MICROMASTER 440 series is a range of frequency (also called drives) to change the speed of AC motors. A special method of pulse width modulation with selectable Pulse frequency permits quiet motor operation.

The MICROMASTER 440 with its default settings made at the factory, is ideal for a wide range of simple motor control applications. It can be used both in applications where it is isolated as integrated automation systems.

Fig 2. Drive Frequency

J. Tachometer

Tachometer is a device that is responsible for measuring the number of revolutions of a shaft. By measuring the number of revolutions, also it measures the speed with rotating shaft (rotating speed of an engine).

Tachometers usually measure the revolutions per minute (or, according to its acronym, RPM). Originally, tachometers were measured mechanical and centrifugal force. Currently most tachometers are digital and they are much more accurate.

Fig 3. Digital tachometer

III. CALCULATION OF MACHINE ELEMENTS AND CONTROL SYSTEM

A. Introduction

Then all calculations performed detailed machine. Calculations are approximate to reality when dealing with the mechanical elements (for example number of bands).

This section calculations of machine elements and control system based on formulas and data provided by various authors of books and websites are developed.

B. Power Engine

In this case the engine with a power of 3 HP has been chosen to meet the needs of this project ensuring operator safety, using the following evaluation criteria:

1. Safety
2. Serviceability
3. Ease of replacement components
4. Ease of operation
5. Ease of installation
6. Low initial cost
7. Low operating costs and maintenance
8. Small size and light weight
9. Quiet and low vibration
10. Looks attractive and appropriate to the application

C. Characteristics of Motor

According to data from the following table in motor crusher which represents the characteristics of a three phase motor 3 Hp have:

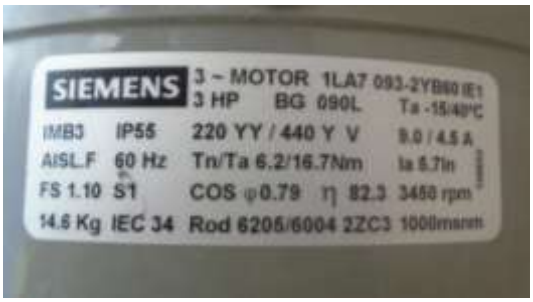

Fig 4. Plate machine motor

Table I
CHARACTERISTICS OF MOTOR

Description	Value	Unit
Number of phases	3	-
Nominal operating voltage	220 / 440	V
Service mode	S1	-
Certifications	IEC 34	-
Degree of protection	IP 55	-
Class of Insulation	F	-
Maximum ambient temperature	40°	C
Frequency	60	Hz
Rated motor power	3	Hp
Nominal speed	3450	Rpm
Rated operating current	9 / 4.5	A
Service factor	1.10	-
Altitude	1000	-
Weight of motor	14.6	Kg
Specifying the front bearing	6205	-
Specifying the rear bearing	6004	-
Serial	ILA7	-
Performance	82.3	%
Power Factor	0.79	-
Rated torque	6.2	N.m
Starting torque	16.7	N.m

$$Vel = w * r$$

Equation 1. Linear speed

Source:
http://www.uclm.es/profesorado/porrasysoriano/elementos/Tema05.pdf

where

Vel is the linear speed of the web

w is the angular velocity of the motor

R is the radius of the pulley

Using the specified data we have: Vel = (377 rad/seg)*(0,05 m) = 18,85 m/seg.

D. *Mathematical Model and Transfer Function of Plant*

With the data set of formulas that give us some different authors and other data obtained from the motor nameplate for the machine that is used is:

$$L = 0{,}0648 \text{ H and } R = 27{,}62\ \Omega$$

With this data is used in the differential equation for the current with a result of the transfer function of the system.

$$L\frac{di}{dt}(t) + Ri(t) = E(t)$$

$$\frac{di}{dt}(t) + \frac{Ri}{L}(t) = \frac{E}{L}(t)$$

Equation 2. Linear differential equation for the current

Source: (see [20])

For the solution of equation 2 we proceed to solve by the method of La Place transform of a derivative as follows and the transfer function of the plant is obtained:

$$\mathcal{L}\left\{\frac{di}{dt}\right\} + \frac{R}{L}\mathcal{L}\{i\} = \mathcal{L}\left\{\frac{V}{L}\right\}$$

$$I(s) = \frac{9s+V/L}{s(s+\frac{R}{L})} = \frac{9s+V/L}{s^2+\frac{R}{L}s}$$

Substituting the known values we have:

$$I(s) = \frac{9s+3393}{s^2+426{,}23s}$$

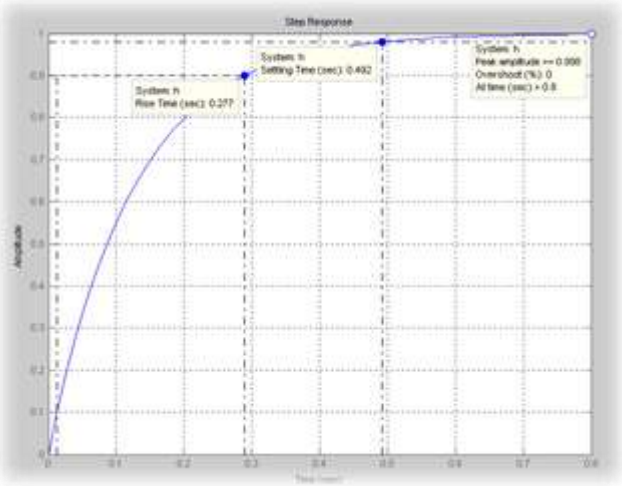

Fig 5. Response transfer function in closed loop

IV. SELECTION CRITERION ELEMENTS

The elements were chosen according to the required characteristics to the machine motor with are voltage, current and frequency are the most important couples.

A. Differential Switch (see [23])

Differential amperometric circuit breaker is a protective device that is disconnected when the system leaks a significant current to earth.

Fig 6. Differential Switch

B. Contactor (see [28])

The contactor is an electro-mechanical control device, which acts like a switch, and can be remote-controlled via the electromagnet is fitted.

Fig 7. Contactor NC1-12

Fig 8. Wiring the electronic board

Fig 9. Locations buttons and selector switch

Fig 10. Mounting System Total

Fig 11. Flowsheet

V. PERFORMANCE TESTING AND ANALYSIS OF RESULTS

A. Introduction

Since you have all the selected items and all proceeds properly calculated parameters to performance testing, having finished with the accompanying assembly of the components in the control panel and the correct connection based on the diagrams

B. Tests

After having installed and made the respective connections of the components, we proceed to perform the respective tests to verify the operation of the control system. The tests are done proceed to the 3 variations of speed that the inverter permits in their 3-pin digital inputs that are programmed for 3 different size crushed. Speed variations are activated by a 3-position selector.

Fig 12. Positions for the 3 fixed frequencies.

Testing and operation of the machine was made in a place where there is a connection to 220V, as is a crusher plants, branches and organic waste or plant was used as a sample of branches grinding alfalfa plants potato and beans; cornstalks, grass, tree branches avocado, sugarcane; and the following results were obtained

Fig 13. Results crushed into large, medium and small respectively

VI. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

- The control system used in the shredding machine 300 TRAPP TRF has been helpful for the optimization and production of organic fertilizer in the agricultural sector as well as a profit and saving money for the sectors that are far from the city when They have to buy another type of fertilizer for their crops.
- In addition the environment because 100% of the plants and waste were to be burned (problem) is now used for crushing the remains.
- The motor used in the machine was found to be suitable because their characteristics (such as power, torque, etc.) are similar to the results obtained by analysis and calculations so it is very efficient to work on the grinding machine by control system.
- According to the theory advanced parameters and results of the graphs of the transfer function, we conclude that the system is critically damped. Therefore it is a stable system that does not oscillate and therefore can not employ a compensator, that is, the PID is not applicable in such a system even though the equation of the plant remains a transfer function second order. In addition to its application it is not necessary because the response time is very short, equivalent to half a second.
- The drive has more digital inputs that can be configured for more fixed frequencies in their programming, but with 3 having the drive (fixed frequencies) is right for the operation of the system and provides a solution to the problem.
- The machine performs the function of crushing plants and organic waste whose material is soft or while inserting a hard material like wood because wood supplies not occupy more than 60% of the inlet of the machine.
- If the filler is something hard as the cane crushing in three speeds are excellent for application of fertilizer in the agricultural sector.
- We must take into account that the speed displayed on the tachometer display is not the same as specified in the inverter because a margin of error occurs.

B. Recommendations

- It is advisable to use this type of machine in a perfectly suitable motor and preferably as recommended standards if any in his own case, by calculation or recent cases as recommended by the manufacturer.
- To prevent failures, damage and power consumption is advisable to turn off the entire system in general, ie, motor, contactor and switch when the machine is not in use and keep the board closed up with your respective key keeping the control board at a distance somewhat removed from the machine preferably two meters.
- The moment you are going to perform maintenance on the machine, you should do so in an open space and with the offline board. Perform preventive maintenance every weekend accordingly if the machine operates five days a week.
- Not suitable to enter the material to be ground in a greater amount in excess of 48 cm2 (60%) of entry area to the machine nor hard material like wood as it can get more wear on the part of the blades and severe damage to the shaft because the shear machine does not provide for that kind of material.
- For any worker who for first time will operate the machine please read due user manual before performing any operation with the machine.

REFERENCES

[1] ARIAN. (Enero, 2010). Industrial, Control & Instrumentación. Stgo de Chile, Chile: ARIAN.

[2] Barbosa Pérez, J. (s.a.). Mechanical Drawing. In Barbosa J. Perez, Mechanical Drafting (Ch. 19).

[3] Bauske, EM, Maqueda, KA, & Marinez Espinoza, AD (2008). Gardening Safety Hispanic workers. Georgia: University of Georgia.

[4] Chapman, S. J. (2005). Electrical Machines (Fourth Edition ed.). DF, Mexico: McGraw Hill.

[5] Chint. (January 2011). Technical catalog - Contactors, relays and starters. Madrid, Spain: Chint Electrics.

[6] Cobo, R. (s.a.). Variable speed or frequency converters. The ABC of Automation, 3.

[7] Enriquez Harper, G. (2004). Control of electric motors. DF, Mexico: Limusa.

[8] Faires, V. M. (s.a.). Design of Machine Elements (Fourth Edition ed.). Barcelona, Spain: Montaner y Simon.

[9] Garcia, J., & Pubill, J. (2005). Drives. Barcelona, Spain: Edcai.

[10] Gates. (2009). Master of Industrial Bands. Mexico: Rechnology Company.

[11] Granthman, W. J., & Vincent, T. L. (1998). Modern Control Systems. Analysis and Design. DF, Mexico: Limusa.

[12] Gaviño Hernández, R. (2010). Introduction to Control Systems (First Edition ed.). Juarez, Mexico: Pearson.

[13] Lorente Herrera, J. (2007). Library of agriculture. (Lexus, Ed.) Barcelona, Spain.

[14] Ogata, K. (1998). Modern Control Engineering (Third Edition ed.). Juares, Mexico: Pearson Education.

[15] Schaum. (2003). Electric Circuits (Fourth ed.). Mexico: McGaraw Hill.

[16] Schoneck, J. (2002). Variable Speed Drives (First Edition ed.). Barcelona, Spain: Schnneider Electric SA

[17] Shigley, J. E., & Mitchell, L. D. (1985). Mechanical Engineering Design (Fourth Edition ed.). Mexico, Mexico: Mc Graw Hill.

[18] Shirose, K. (2000). TPM for Middle Factory (Second edition ed.). Tokyo, Japan: TGM Hoshin.

[19] Weg, E. E. (br.s). Practical Guide Commercial Technical Training. Jaragua do Sul, Brazil: Module I.

[20] Zill, D. G., & Cullen, M. R. (2009). Differential Equations (Seventh Edition ed.). DF, Mexico: Cengage Learning.

[21] April. Arpi Trujillo, J.E. & Calderón Toral, CS (2010). Designing a pelletizer machine based on the availability of wood residues from the city basin for energy use. Thesis for the degree in Mechanical Engineering with specialization in Machine Design, Faculty of Engineering, Salesian Polytechnic University, Cuenca, Ecuador.

[22] Cajas Arguero, D. B. (2011). Design of a crusher coir sprayer for the production of granular substrate. Prior to obtaining the degree in Mechanical Engineering Project. Faculty of Mechanical Engineering, National Polytechnic School, Quito, Ecuador.

[23] ABB. (S.F.). Products and Services. Retrieved December 27, 2013, from Differential Switches: *http://www.abb.es/product/es/9AAC100503.aspx*

[24] Agrogama. (September 20, 2010). Grinding mills. Retrieved November 22, 2013, from Mill Crusher Trapp JTFR 300: *http://www.agrogama.com.co/home/index.php?option=com_content&view=section&layout=blog&id=5&Itemid=41*

[25] Améstegui Moreno, M. (January 2001). Notes of PID Control. La Paz, Bolivia: Universidad Mayor de San Andrés.

[26] Automation, E. Electricity and Automation. Retrieved on December 10, 2013, of formulas AC motors: http://www.nichese.com/formulas3.html

[27] May. Automation, E. y. (s.d. of S.M. of a.s.). Industrial Automation. Retrieved December 3, 2013, from Formulas ac motors: *http://www.nichese.com/formulas3.html*

[28] Automation, E. y. (S.F.). The Contactor. Retrieved on January 4, 2014, of *http://www.nichese.com/contactor.html*

[29] Banggood. (S.F.). banggood.com. Retrieved on February 16, 2015, Red LED Tachometer RPM:http://www.banggood.com/Red-LED-Tachometer-RPM-Speed-Meter-with-Proximity-Switch-Sensor-NPN-p-928692.html

[30] Cabedo. (S.F.). Industrial and Agricultural Equipment. Retrieved on April 17, 2015, electric shredder: http://www.cabedovila.es/biotrituradoras_electricas?id=172&id_producto=242

[31] Cabedo. (S.F.). Industrial and Agricultural Equipment. Retrieved on April 18, 2015, Viking costacáped: http://www.cabedovila.es/productos.php?id=195&id_producto=352

[32] Definition. (S.F.). Definition Of. Retrieved on February 13, 2015, of http://definicion.de/tacometro/

[33] Infogarden. (S.F.). Gardening. Retrieved on April 17, 2015, of shredder: infojardin.com/showthread.php?t=158865
2013, belt drive: http://www.elprisma.com/apuntes/ingenieria_mecanica/transmisioncorrea/default3.asp

[36] Prisma, E. Portal for researchers and practitioners. Retrieved on December 17, 2013, belt drive: http://www.elprisma.com/apuntes/ingenieria_mecanica/transmisioncorrea/default5.asp

[37] Recovery. (S.F.). RECOVERY S.A. Retrieved on April 15, 2015, plastics Shredding: http://www.recovery.com.es/portfolio-view/trituracion-de-plasticos/

[38] TRAPP. (S.F.). TRAPP. Retrieved October 21, 2013, from TRF-300 Super: */trituradores-forrajeros/produto/trf-300---super*

[34] Ingemechanic. Transmission Belts Calculation and Design. Retrieved on November 13, 2013, No. 121 Tutorial: http://ingemecanica.com/tutorialsemanal/tutorialn121.html

[35] Prisma, E. Portal for researchers and practitioners. Retrieved on December 17,

[39] TRAPP. (S.F.). TRAPP. Retrieved on August 21 20014, TRP 40: http://www.trapp.com.br/es/produtos/rural/trituradores-forrajeros/produto/trp-40

[40] TRAPP. (S.F.). TRAPP. Retrieved on August 21, 2014, TR 200:http://www.trapp.com.br/es/produtos/compostaje/trituradores-de-ramas,-troncos-y-residuos-organicos./produto/tr-200

[41] TRAPP. (S.F.). TRAPP. Retrieved on August 21, 2014, TRF 60: http://www.trapp.com.br/es/produtos/rural/trituradores-forrajeros/produto/trf-60

[42] Virtual, T. Hoses and Pulleys. Retrieved December 16, 2013, from Straps Industrales in "V": *http://www.polmangueras.com/index.php?id=2,14,0,0,1,0*

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