ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 5, Issue 12,December 2020

Automation of a production line, distribution of boxes to different areas within a company with light content

[1] Juan David Leon Gutierrez
[1] ECCI University-Bogota D.C-Colombia

Abstract:-- **One of the most common problems in a plant is the proper use of the end effector of a robotic arm, as well as its movement itself, since the sudden movement of these has caused damage to the content of the products handled in the line, As well as in conveyor belts that receive a constant impact from products, the objective of this study is to apply a PID controller with an ideal architecture that smooths the movements of the gripper and the arm, so that it carries the boxes or products in an ideal way. to the next line, releasing them properly on the belt avoiding damaging it, in short, the importance of doing this is to reduce the damage in the processes and take care of the integrity of the belt as well as the content that is transported. Observing if it is possible to transfer this type of tuning to the entire production line acquiring smooth movements.**

Index Terms:- Control, PID, plant.

1. INTRODUCTION

It is intended to show the importance of what is an adequate control in a production line in the movement and loosening of a product, and how a bad handling of an end effector can damage or accelerate the maintenance process of a conveyor belt, correcting this problem through a PID controller of ideal architecture, having clear the working space of the robotic arm and speed in the work of sanches A.calros in his article. *Impact of breakdowns and interruptions in the production processes. (paragraph 1),* where failure is discussed in a machine in the industrial sector, and the average operation of these is 70% availability throughout its useful life, and the remaining 30% when there is damage or requires maintenance, and in the work of Solange Denis and Valdovno Molina in his thesis, *Technical analysis of conveyor belts in a salmonid process plant. (paragraph 3. page 15*), applying a corrective to the gripper (clamps) by adjusting the poles of the system, finding stability, preventing it from causing damage to the content after abrupt transitions and when releasing it on the belt, (avoiding damage to these, minimizing criticality analysis, where only wear over time is an impediment), optimizing that 70% of the useful life of the automated system and in the area where it performs (since being movements more fluids, you may experience increased results).

Practical framework

The abrupt handling of an industrial gripper can be catastrophic when transferring loads from a point “A” to a point “B”, that is why the analysis of a movement will be made through a prototype of an end effector mounted on a RPRR configuration robotic arm prototype where the action of releasing something requires a smooth movement:

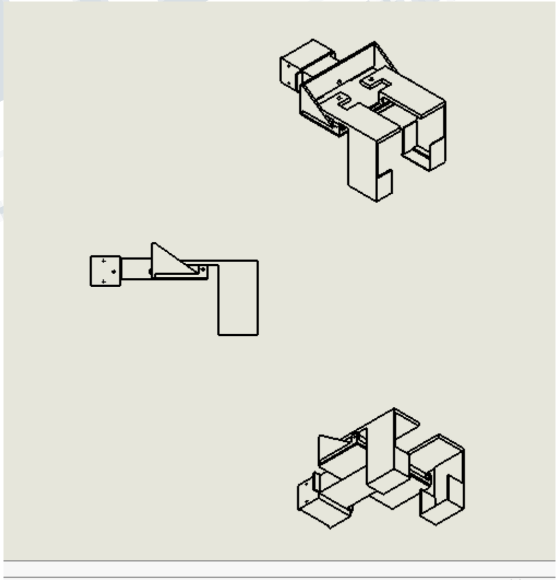

Fig 1. Gripper Perspective, Source: Own.

In this case, the opening and closing system of the clamps is by means of a rack guided by a pinion, where the axis of this is subject to a gearmotor N20-298 6v 100 rpm 1.5 kg.cm which is anchored to the left arm of the gripper, so that when the motor turns it is pulled and thus closes the clamps.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 5, Issue 12, December 2020

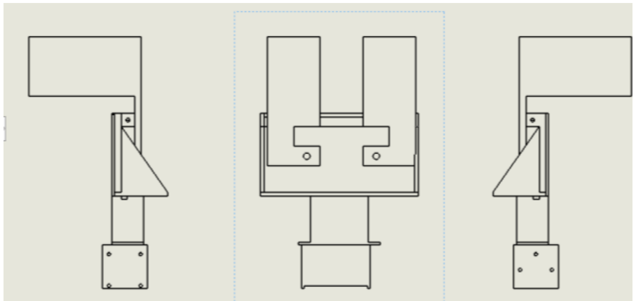

Fig 2. Gripper top view. Own source.

OPENING AND CLOSING SYSTEM

Fig.3Gripper.

In Figure 3 you can see the drive of the system, where it begins to take into account different factors such as the force necessary to break the inertia or the duty cycle of the motor so that it rotates at a considered speed and does not damage the harmony of the system, (engine speed will be measured in revolutions per minute, RPM).

With these data it can be thought that it is enough to have control over the gripper to perform the clamping action with extreme care.

Because with a proper duty cycle and a motor interruption at the time of closing the end effector does the job, However, the purpose of this work is to perform smooth movements and discharge very carefully onto a conveyor belt to avoid damaging it, the calculations are more detailed.

SYSTEM AND CONTROL

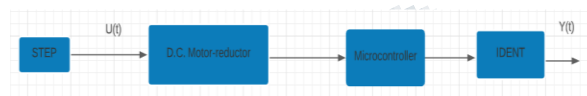

Fig 4. System Process. Own Source.

V. MODELING MOTOR GEAR D.C

Modeling of the D.C gearmotor is necessary to find the ideal transfer function of the system as a first step. For this article, it will be neglected where the transfer functions come from, since it is assumed that the reader has previous knowledge in industrial control and multivariate control, therefore we will proceed to write the equations in function of output over input in relation to Torque-Voltage, Counter EMF-Voltage, Armature Current-Voltage, Angular Velocity-Voltage, Angular Position-Voltage.

- **TORQUE-VOLTAGE:**

$$\frac{T_m(s)}{V_{(s)}} = \frac{K_m(Js+B)}{L*Js^2+(RJ+LB)s+RB+K_mK_a} \quad (1)$$

- **BACK ELEC. FORCE-VOLTAGE:**

$$\frac{E_a(S)}{V(S)} = \frac{K_mK_a}{L*Js^2+(RJ+LB)s+RB+K_mK_a} \quad (2)$$

- **ARMOR CURRENT-VOLTAGE:**

$$\frac{i(S)}{V(S)} = \frac{JS+B}{L*Js^2+(RJ+LB)s+RB+K_mK_a} \quad (3)$$

- **ANGULAR VELOCITY-VOLTAGE:**

$$\frac{\omega(S)}{V(S)} = \frac{k_m}{L*Js^2+(RJ+LB)s+RB+K_mK_a} \quad (4)$$

- **POSITION -VOLTAGE:**

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 5, Issue 12, December 2020

$$\frac{\theta(S)}{V(S)} = \frac{k_m}{S(L*Js^2+(RJ+LB)s+RB+K_mK_a)} \quad (5)$$

Where:

$Tm = Motor\ torque.$
$B = Coeff.friction\ equiv.to\ motor\ load$
$J = Total\ rotor\ moment\ of\ inertia.$
$\omega = Angular\ speed\ of\ the\ motor$
$\theta = Angular\ Position.$
$L = Armature\ Inductance.$
$R = Armor\ strength$

k_a=Proportional relationship, between the voltage induced in the armature and the angular velocity of the motor shaft.

k_m= Electromechanical relationship where the torque is proportional to the electric current.

All passed to Laplace's domain.

In this case, equation 4 and equation 5 are necessary to control the system.

VI. SYSTEM REALIZATION

In this type of practice, it is usual to have Experimental data to find the transfer function, but due to the current health situation, since it is a conceptual design, the data provided by *the engine datasheet and the ident de tool will be used. MATLAB for the assignment of poles and obtain the desired system.*

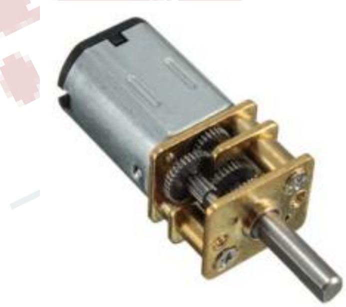

Fig5. N20-g12 gear motor, Source: www.handsontec.com

Table 1. Data Specifications

Data	**Value**
Rated Voltage:	6-12v
Revolving Speed-Angular speed	100 RPM
No-Load Speed-Angular speed	80 RPM
Rated Torque	2 Kg* Cm
Rated Current:	0.07A
Reduction Ratio:	1:10
L	0.5 H
R	1Ω
k_m	0.01
k_a	0.01
B	0.1 N*m
J	0.01 Juls

For this case, the values of L, R, J and $k_a = k_m$ were assumed, since there are no measurement artifacts, these values being ideal according *to Sergio A. Castaño on his website https://controlautomaticoeducacion.com.*

VII. SIMULATION IN SIMUKINK

For practical purposes, the second-order transfer function will be written in the windows command and called with the LTI System block.
As mentioned before, the transfer function to be used, since it is the opening and closing of the end effector, are equations 4 and 5.

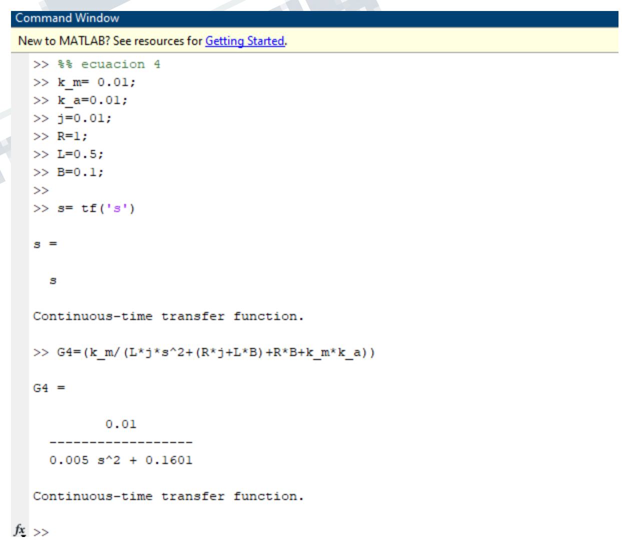

Fig 6. Equation 4. Own Source.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 5, Issue 12, December 2020

```
Continuous-time transfer function.

>> G5=(k_m/(s*(L*j*s^2+(R*j+L*B)+R*B+k_m*k_

G5 =

          0.01
  --------------------
  0.005 s^3 + 0.1601 s

Continuous-time transfer function.
```

Fig 7. Equation 5. Own Source.

In this case, both equations 4 and 5 are unstable, especially 4 because it is the motor shaft rotating (there is no control) and equation 5 because it reflects a positional slope that does not exist, that is why adjustment will be made using the ident tool, capturing the data of these two transfer functions through the to work space block.

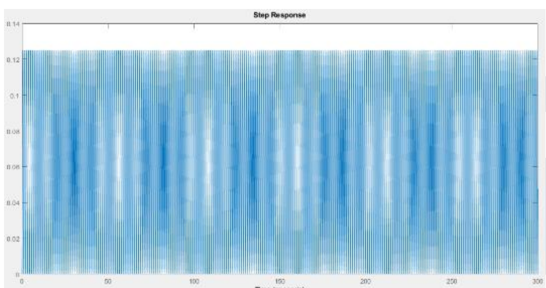

Fig 8. Equation 4 (top) and Equation 5 (bottom). Own Source.

It's proceed to make the block diagram in Simulink.

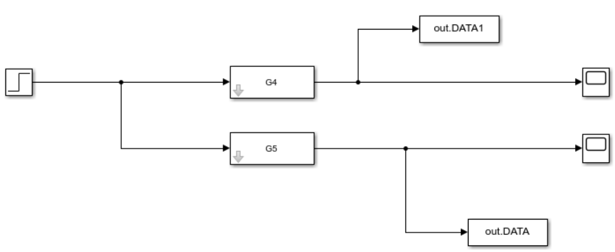

Fig 9. Block Diagram. Own Source.

In figure 5, you can see the block to Workspace for data capture, from there these will be saved in a matrix with the names DATA for equation 5 "G5" and DATA1 for equation 4 "G4".

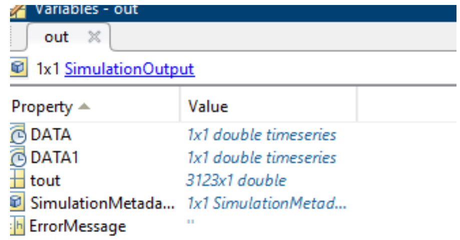

Fig 10. Matrix Data .Own Source.

VIII. IDENT IMPLEMENTATION AND STABLE SYSTEM

The DATA and DATA1 matrices were opened, where there are two columns that make up the matrix of the functions, for the use of IDENT, it is necessary to enter input elements, as well as output, therefore the variables that make *up G4 were assigned the names for voltaje and velocidad angular and for G5, voltaje1 and posicion.*

Fig 11. Variables G4. Own Source.

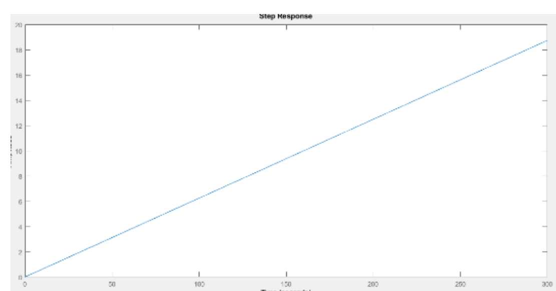

Fig 12. IDENT G4. Own Source.

In figure 12, you can see the sampling time (0-500 (1/1000) Seconds) and the graph of the transfer function being identical to that of figure 8.

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 5, Issue 12, December 2020

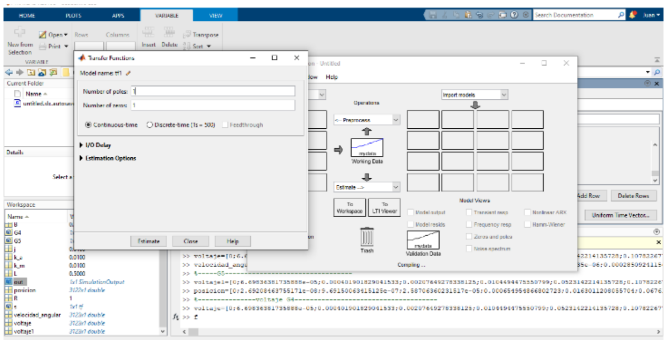

Fig 13. Model of the G4 transfer function of order 1. Own Source.

Analyzing the function obtained, for the reader who has previous knowledge, he will believe that it is an unnecessary step, however it is worth analyzing the data obtained since previously it was said that it was the motor shaft rotating without control, this means that there is no A desired position, if one wanted to control the opening and closing position of a gripper through this system, it would be possible, since there are already established values with which to work, in this case the time, and the given slope of the system, where it means in this case by the sampled time, its amplitude is 500 milliseconds, where already with the microcontroller used it is possible to smoothly control that desired position.

G5 data is imported.

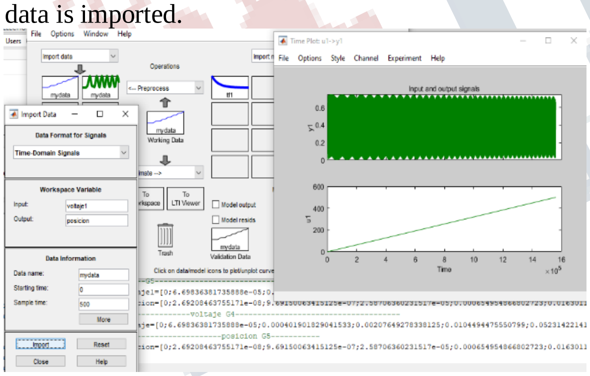

Fig 14. IDENT G5. Own Source.

Like image 12, we proceeded to verify that the import of data is correct, in this case G5, it is the most important function because it is the function most used in the industry, it must be clear that being a DC gear motor , it is possible to make a first order approximation to achieve a stable system, which is what is sought.

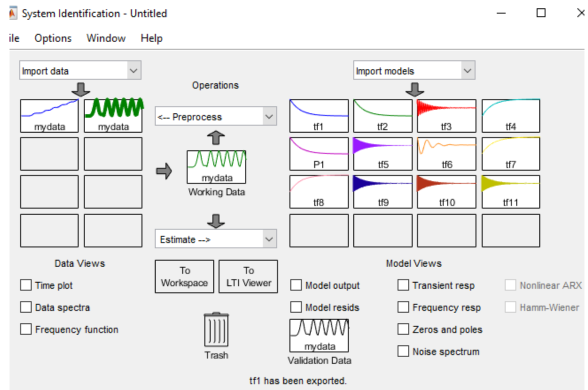

Fig 15. IDENT G5 Approximations. Own Source.

In this case, tf1 was chosen and it was imported into the windows command.

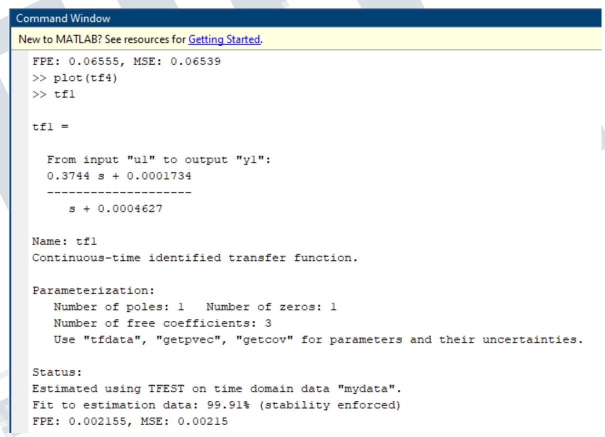

Fig 16. Approximate function tf1. Own , Source.

Which results in:

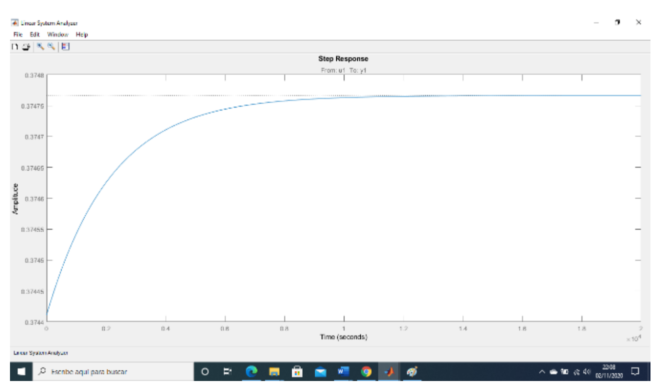

fig 17. Graph tf1. Own Source.

As can be seen in figure 16, this system of order 1 has an approximation of 99.91% to the system presented in G5, which was a system if damped with disturbances that do not stabilize. the stable system necessary for control has been reached.

IX. SMITH'S METHOD

It is understood that the reader knows the method of his courses in analog electronics that is why the subject will not be entered so much and an equivalent transfer function given by Smith will be presented for later control.

It must be clear that, since it is a data capture, it is necessary to know how to analyze the data obtained in figure 17, since it is known that the step block has a value of 6 volts, since that is the minimum at what the N20 motor works, then the aptitude of the graph is 0.375 which is equivalent to 6 volts. Having this clear, the method is applied.

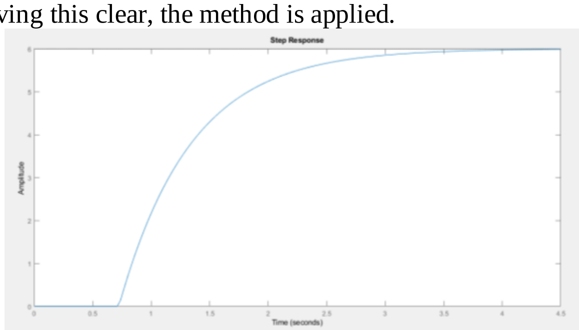

Fig 18. Graph G7, Smith's function, Own Source.

This being a function that ranges from 0 to 6 volts as indicated by the system specifications as maximum amplitude.

X. PID CONTROLLER

We have the equation for a controller in ideal architecture. The ZIEGLER & NICHOLS method is applied to find the controller.

$$K_p(1 + \frac{1}{Ti * s} + Td * s) \quad (6)$$

Where:

$$k_p = 1.2\frac{T}{L} \ (7)$$

$$T_i = 2 * L \ (8)$$

$$T_d = 0.5 * L \ (9)$$

In this case, figure 18 was used and the following result was reached.

$$6.24(1 + \frac{1}{s} + 0.25 * s) \ (10)$$

Where the comparison is made in the Windows command through a step.

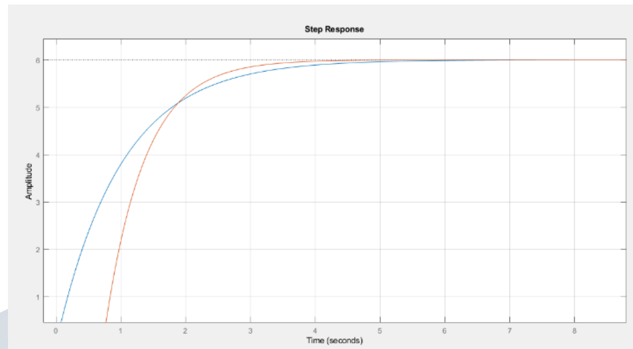

Fig 19. PID (Blue) - Smith function (red). Own Source

You can see the stabilization time, key in the smith method with its equivalent function, since it comes with a delay, however, the controller does not have these problems, its rapid stabilization is observed, which makes it have a function ideal for handling the gripper with smooth movements reaching the last part of the control.

XI. EMBEDDED SYSTEM

At the beginning of this article, we talked about programming a STM32F767ZI microcontroller in the MBEB programming environment, since it is an easy to understand language, although you can see other types of microcontrollers and programming languages such as Keil, or the use of the low cost hardware PIC18F4550 in master slave configuration.

However, due to the capacity of this embedded system and the option to improve the program in the future, they make it attractive above the others.

XII. CONCLUSIONS

- With the IDENT linear regression method, it was an easier way to control a system.

- The pole method is an efficient way to control a system

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 5, Issue 12, December 2020

REFERENCES

[1] Ogata K. (2002). *Ingeniería de control moderna* 4ta edición.

[2] Cote, ballesteros, J. (2020). *Sintonización de controladores PID, lazo abierto y lazo cerrado, Universidad ECCI.*

[3] Chen,Tsong C. (2002).Analysis and Synthesis of Linear Control Systems.

[4] Alfaro Ruiz M, Arrieta Orozco O. (2003, December *SINTONIZACIÓN DE CONTROLADORES PI Y PID UTILIZANDO LOS CRITERIOS INTEGRALES IAE E ITAE*,from https://www.researchgate.net/publication/255641510_SINTONIZACION_DE_CONTROLADORES_PI_Y_PID_UTILIZANDO_LOS_CRITERIOS_INTEGRALES_IAE_E_ITAE

[5] Valdovino Molina, Solange Denis. ANÁLISIS TÉCNICO DE CORREAS TRANSPORTADORAS ENPLANTA DE PROCESO DE SALMÓNIDOS. (2018):

[6] https://repositorio.usm.cl/bitstream/handle/11673/46112/3560900260934UTFSM.pdf?sequence=1&isAllowed=y

[7] Sanchez A.Carlos. IMPACTO DE LAS AVERÍAS E INTERRUPCIONES EN LOS PROCESOS. UNANÁLISIS DE LA VARIABILIDAD EN LOS PROCESOS DE PRODUCCIÓN. (2004):

[8] http://www.scielo.org.co/pdf/dyna/v72n145/a07v72n145.pdf

