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Fuzzy Logic Sequence Control for Batch Sugar Centrifugal Machines

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Abstract: *This paper is proposing a solution to the rapid oscillation of the current which happened due to the cyclic operation of the batch sugar centrifugal machines. The current oscillation affects the stability of electrical generation produce by steam turbine alternators at Factory. The proposed solution focuses on sequencing these machines. Fuzzy logic control and Matlab Simulink are used to design a model of three batch sugar machines, the real time data is taken from Broadbent C46M batch centrifuge. Organizing the operation of these machines with sequence control is done by selecting the suitable delay time between machines. Two parameters in fuzzy logic control are used to obtain the desired delay time, the first parameter depends on the previous machine spinning time duration and the second depends on the time between the previous machine permission times to the current machine requesting permission from sequence control. When the default values of feed time, spin time & plough time are taken equal to (20s, 40s & 20s) respectively to and be identical for three machines, the total current oscillation has been minimized to 43.75% (compared with peak oscillation of only one machine) and in repeated form, and the total current of the three machines is being less than the current of one machine. And in other cases when these parameters has different values the sequence control program also regulate the operation of the machines and the total current will not exceed the current taken by one machine.*

Keywords: *fuzzy logic, cyclic operation, Ziegler–Nichols, Optimization*

1. Introduction

Almost in sugar production power is generated in the factory by steam turbine alternators , the rapid fluctuation due to the cyclic operation of the batch centrifugal machines cause instability in the generated power that produce by steam turbine alternator, so that the governor and actuator of the generator cannot easily compensate the large variation of the loads, the power house operator always keep looking at this fluctuations and sometimes load is reduced manually to solve situation.

It is a challenge to obtain mathematical solution to organize the sequence operation of batch sugar machines because there are many variables affecting their work, these parameters varies from one machine to another and also from time to time in the machine itself (i.e. Load, cycle time, speed & etc), in this paper Fuzzy Logic Control (FLC) has been used to organize the operation of the machines, rather than constant delay time sequence control, FLC become a common and well known in machine control. However, fuzzy logic is actually very straight forward. And it has a way of interfacing inherently analog processes that move through a continuous range of values, a digital or discrete numeric values (FAQS.ORG 2003). Fuzzy Logic Control methods represent a rather new approach to solve the problems of controlling complex nonlinear systems, the systems whose mathematical model is difficult or impossible to describe, and with the systems which had multiple inputs and outputs and characterized by hardly defined internal interference. It must be said that Fuzzy Logic Control techniques earned more respect from the engineering population after numerous applications on technical and non-technical systems.

2. Sequence of Centrifugal Machines

Sequence control refers to user actions and computer logic that initiate, interrupt, or terminate transactions, Sequence control governs the transition from one transaction to the next (Sidney 1986), sequence control is used to coordinate the various actions of the production system (e.g., transfer of parts, changing of the tool, feeding of the metal cutting tool, etc.).

Typically the control problem is to cause/ prevent occurrence of

- Particular values of outputs process variables
- Particular values of outputs obeying timing restrictions
- Given sequences of discrete outputs

The basic idea of the sequence control is used here to organize the work of the centrifugal machines ,was base on a constant delay time , every machines is wait to take permission either before spinning to cure sugar at high speed, or before discharge to drop the product (plough). Broadbent is British Company specialist on sugar centrifugal machines manufacturing, applied three types of sequence control in Assalaya Sugar Factory, all these controls based on the method of delay time, the early one use moving contacts (cams) rotate with constant speed, which is adjust by the operator to control the time delay between machines, the user have a chance to select the request signal of the specific machine to be send when the machine start accelerate to high (spin) speed i.e. sequence at acceleration, or when the machine begin discharge sugar (sequence at plough), if sequence at acceleration is selected the request signal is send to the controller after machine complete feeding, it wait rotating at speed of 500 rpm until the desired contact is closed this let the machine accelerate to 1000 rpm (spin speed) and continue the remaining operations , if sequence at plough is chosen the controller check if the sugar conveyor running or not, in case of conveyor stoppages the machine rotate at 50 rpm (plough speed) and sugar will not be drop until the conveyor running signal come back to the sequence controller, after checking the conveyor signal the machine stay at plough speed until the permission signal send from the sequence controller, beside all these the sequence control can be override by switch inside the machine itself. The second type of sequence control has the same function of the early one but it used electromechanical relays and on/off-delay timers, the wiring connection of these devices made the desired control, timers is used for the purpose of adjusting the interval times between machines. The last application is used Microcontroller, functionally has the same previous method and behavior, more over the machines can be sequentially operate In ascending or arbitrary order. The sequence control is connected with the programmable logic controller (PLC) of the machine control, and the feature of this application which is cold 5/10 is shown and explained below.

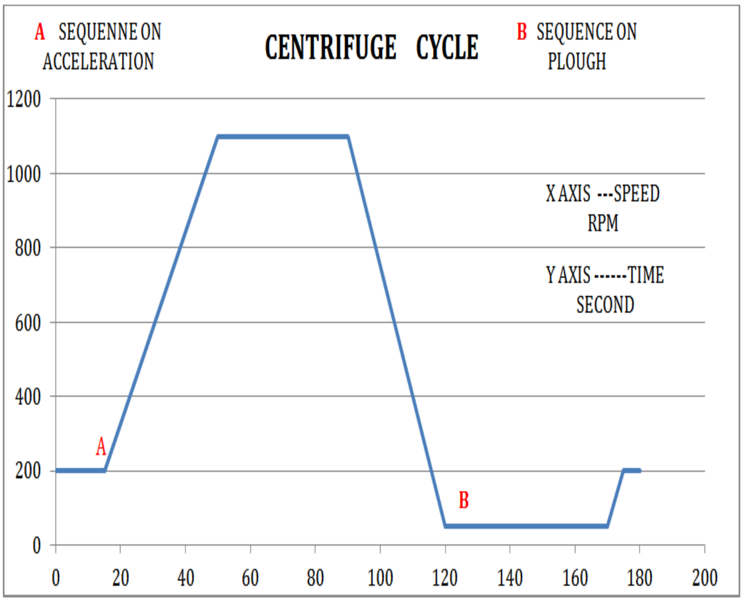

Fig1. *Centrifuge cycle time*

3. Fuzzy Logic Implementation

MATLAB provides inbuilt fuzzy logic toolbox that provides Graphical User Interface (GUI) based implementation of fuzzy systems. The coming is steps for building sequence control model using fuzzy logic. The method used in this model was Sugeno method with two input variables i.e. spin-time & last-request and only one output called delay-time, as shown in figure 3. The range and type of input/output variable parameters is selected in the membership functions editor in order to make the suitable desired sequence control model. The sequence control includes the functions mentioned below.

Spin time: It is the time taken to dry the crystal cake to the desired level when the centrifuge rotates at spinning speed, it is a factor to be controlled by the operator. As from Operator Controllable Parameters table, the spin time had a value from 0 to 999 seconds but in normal operation not exceed more than 50 seconds, and the default setting 25 seconds. The spin time variable had only one membership functions which is "normal", with the universe

U= [0,500 seconds] €Z can be defined as below figure (2):

Membership of "normal"

$\mu_n(x)= 0 \quad x \leq 0$

$\mu_n(x)= x \quad 0 < x< 500$

$\mu_n(x)=1 \quad x \geq 500$

B. last request:- Last request is a time taken since the previous machine send a signal requesting sequence control permission, the membership functions "positive" and "negative" were used, positive it mean that the previous machine had given a permission and passed to accelerate to high speed, in negative case the previous machine still waiting to complete the sequencing delay time.

Membership of Positive

$\mu_n(x) = 0 \quad x \leq 0$

$\mu_n(x) = x \quad 0 < x< 500$

$\mu_n(x)=1 \quad x \geq 500$

Membership of Negative

$\mu_n(x) = 1 \quad x \leq -500$

$\mu_n(x) = -x \quad 0 < x< -500$

$\mu_n(x) = 0 \quad x \geq 0$

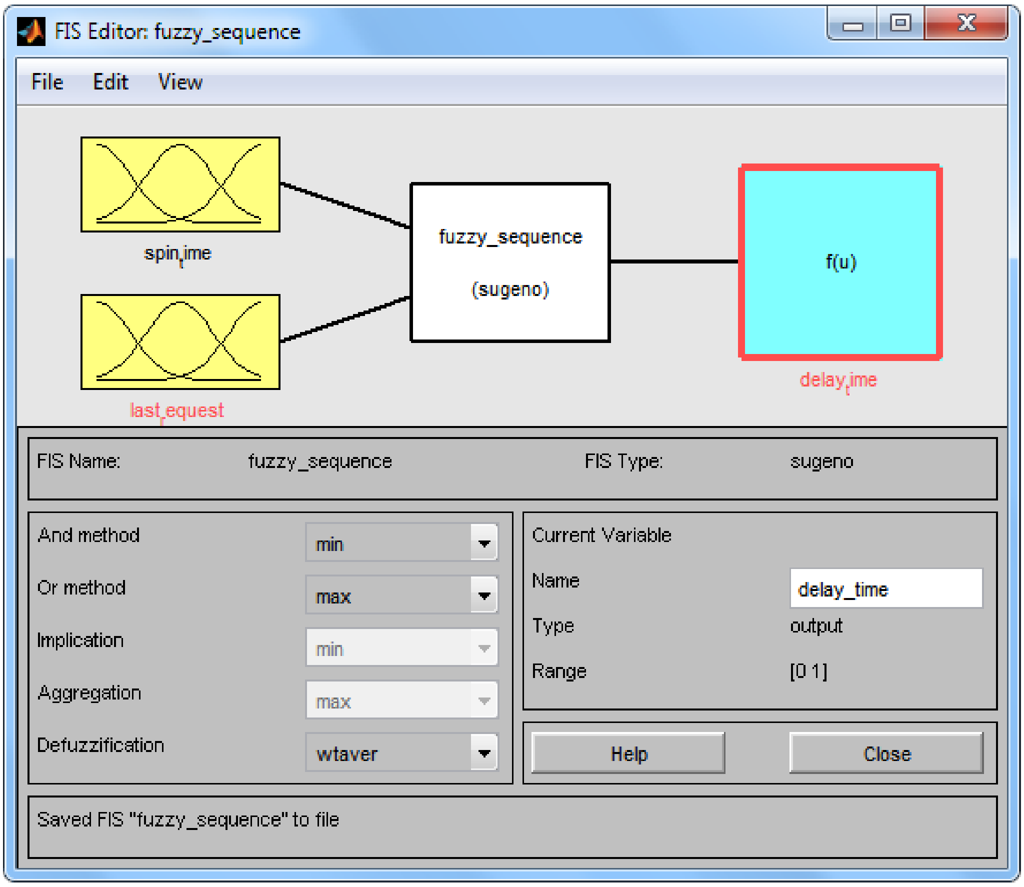

Fig2. *Input Variables*

4. Calculation of Delay Time

The main idea in order to calculate a delay time base on minimizing current shooting by coinciding the accelerate period of one machine with the electrical brake or the regenerative period of the previous centrifugal machine. With aid of the Curve of M/C Speed & Current Vs Time Figure 3,

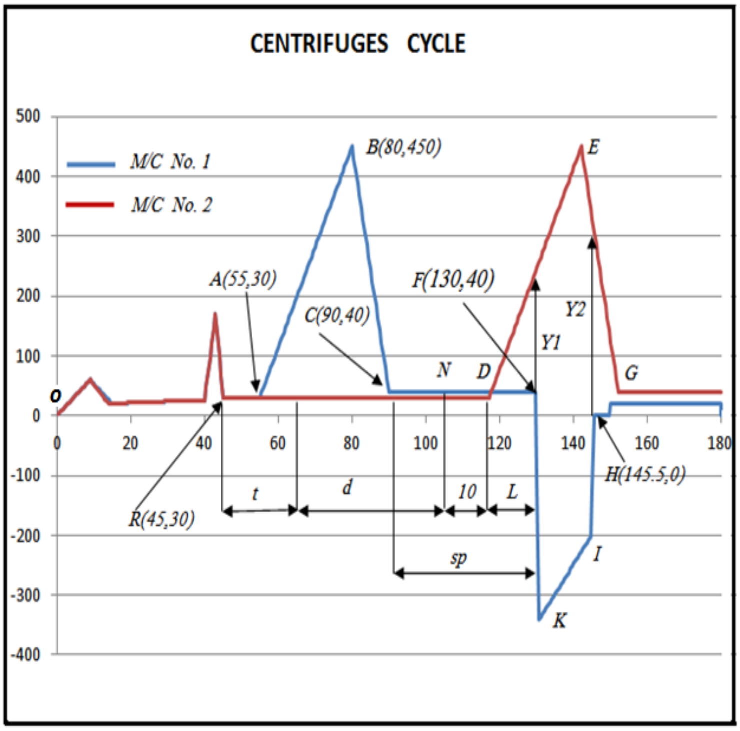

Fig3. *Centrifuges cycle*

From the above graph the 1st machine request permission at point R (45s) and start to accelerate from point A up to point B and then reach the rated speed the current fall after B and then be at constant value as between points C & F, then the 1st machine be at brake mode or a regenerative power at points F, K, I & H. For simplification the program has been made on the assumption that all machines had the same current speed characteristic curve, hence in order to get minimum current shooting, then the positive portion of the second machine (D E F) should over lab with negative portion of the 1st machine , above figure the below equation was obtain as:

$$OA + t + d + ND + L = OC + sp$$

According simulation data OA = 45s, ND =10s & OC = 90s then the above can be written as:

$$45 + t + d + 10 + L = 90 + sp$$

$$d = sp - t + (35 - L) \qquad (1)$$

The slope of line AB is equal to line DE

$$m1 = \frac{450 - 30}{80 - 55} = 16.8$$

The slope of line AB is equal to line DE

And similarly for lines BC & EG

$$m1 = \frac{450 - 40}{80 - 90} = -41$$

Equation (1) is linear and the value of the delay time d is varies proportionally depend on t and sp, L is assumed to constant and calculated as follows:

The equation of DE line is

$$y - 30 = 16.8(x - (130 - l))$$

$$y = 16.8(x + l - 130) + 30 \qquad (2)$$

The equation of EG line is

$$y - 450 = -41(x - (130 - l + 25))$$

$$y = -41(x + l - 155) + 450 \qquad (3)$$

In order to get minimum over shooting referring to above figure consider the coming equation

$$y_1 + 40 = y_2 \quad (4)$$

To obtain value of y1 substitute x=130 in equation-(2)

$$y_1 = 16.8(130 + l - 130) + 30$$

$$y_1 = 16.8l + 30 \quad (5)$$

For y_2, x=145.5

$$y_2 = -41(145.5 + l - 155) + 450$$

$$y_2 = -41l + 60.5 \quad (6)$$

Substitute equations (5) & (6) in (4) then

$$16.8l + 30 + 40 = -41l + 60.5$$

$$l = 13.31$$

Finally equation (1) can be written in the form

$$d = sp - t + 21.69$$

This equation used in FIS to represent the main formula for the solution of sequence control simulation

5. Results And Discussions

The sequence control simulation program show the working of three batch machines, the parameter values of these machines i.e.(feed, spin & plough) times has take the default values of (20s, 40s & 20s) respectively. The sequence delay time is obtained by overlap the positive spin acceleration current curve of one machine with negative portion of the proceeding one as shown in figure (4) below.

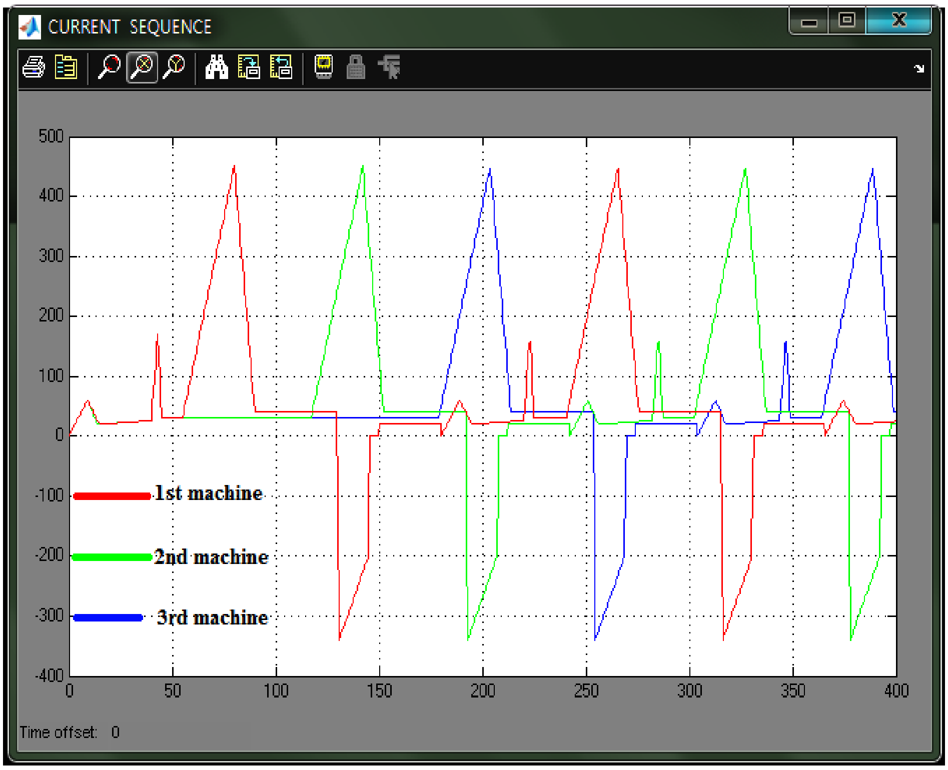

Fig4. *Machines sequence at equal values of spin, feed & plough times.*

The above figure shows equal interval between machines cycles at all the time after sequencing them, so machines ploughing has separated by equal time interval this prevent more than one machines to discharge at same time. Figure (5) show that the total current is being minimize and, the rapid oscillations and the power taken is appear less than the current of one machine.

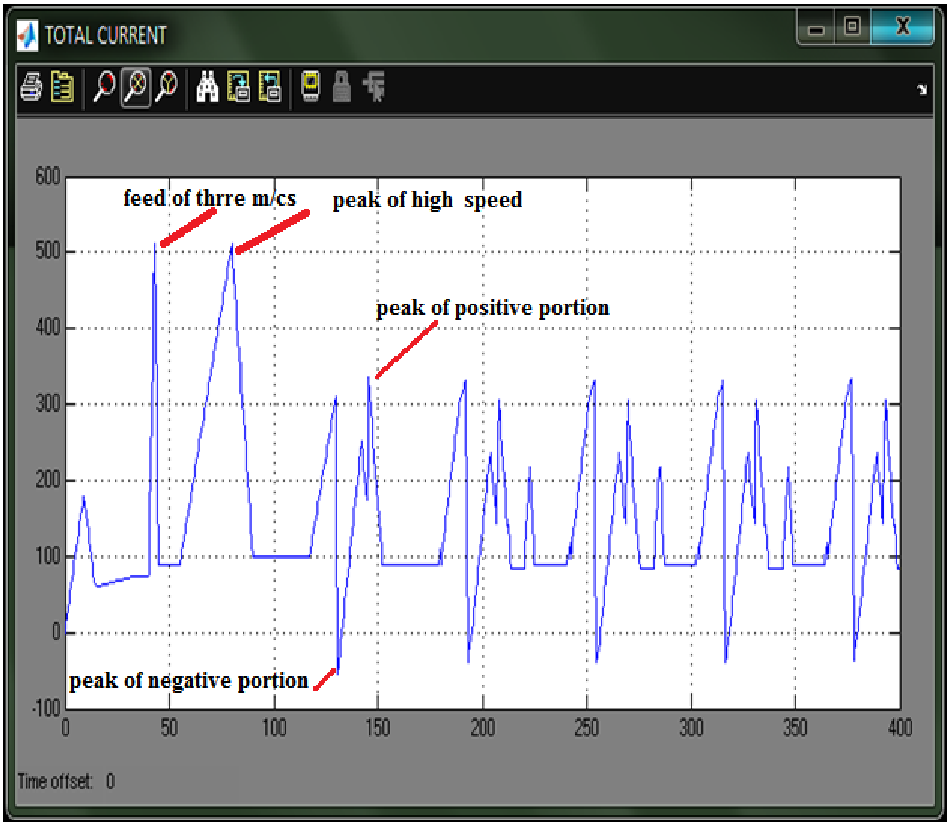

Fig5. *Total Current*

From figure(5) it's appear that the total current reach the maximum value 500A at first time due to the feeding of three machines at once and secondly increasing to 500A due to spin of the first machine, after that the peak in the positive portion is decrease from 450A (the positive peak current of high speed of one machine) to 325A, then sequence controlling the total current and the negative portion increase for -350A (the negative peak current of high speed of one machine) to -50A, this mean that the rapid oscillation of the current is minimized compared with oscillation of one machine and in repeated form, and the total current of the three machines is being less than one machine. The following figures give the total current of centrifugal machines for different values of feeding, spin and plough times in the simulation program,

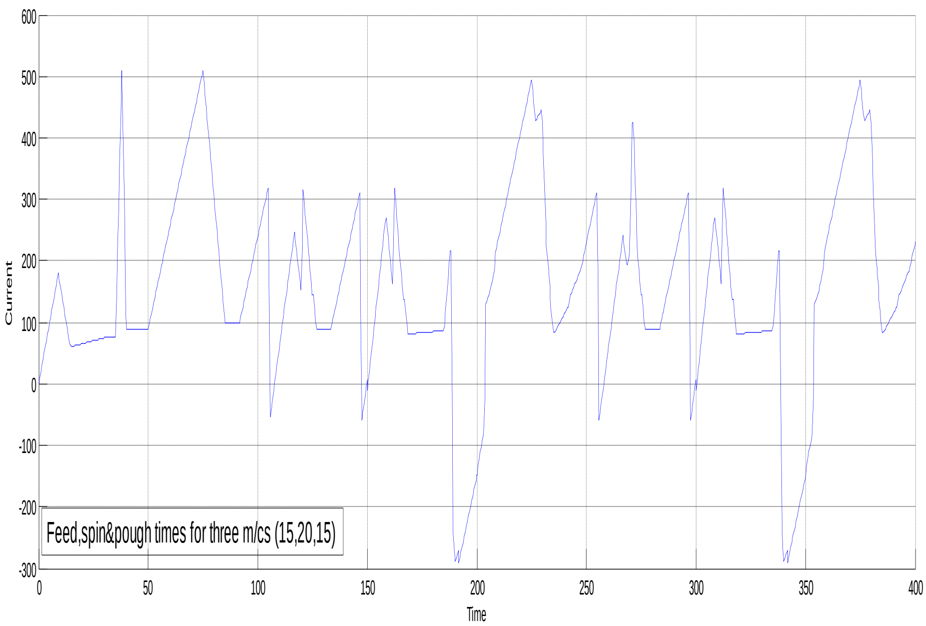

Fig6. *Machines current at (5s,5s,5s) values of feed, spin& plough times*

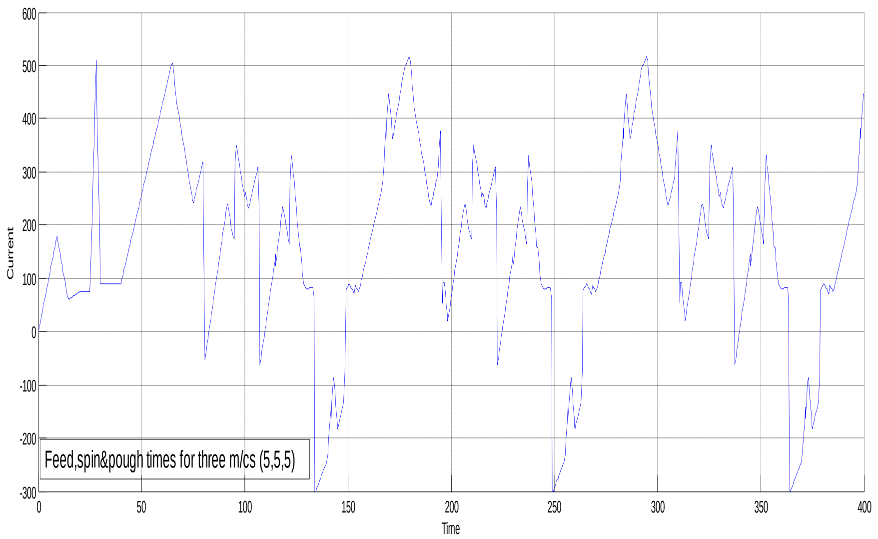

Fig7. *Machines current at (15s,20s,15s) values of feed, spin& plough*

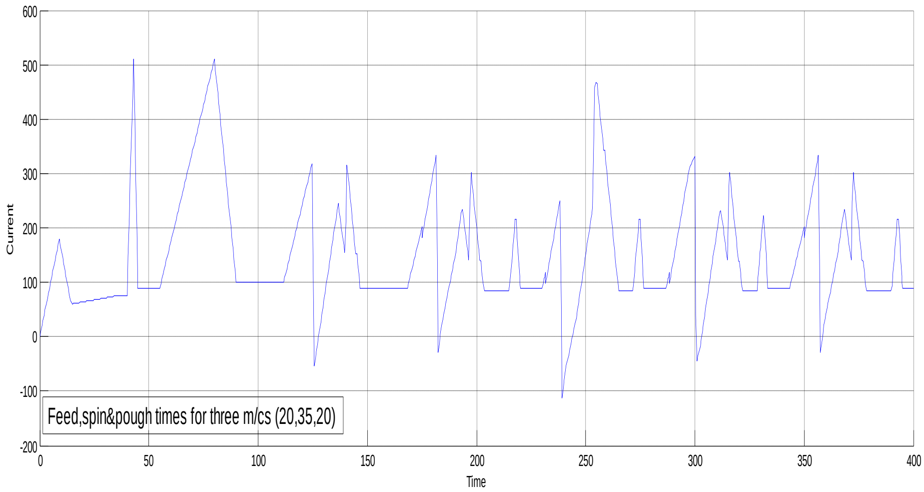

Fig8. *Machines current at (20s,35s,20s) values of feed, spin& plough times*

6. CONCLUSION

The delay time selected by the sequence control to regulate a machine is depending on its spin time, and the time interval between the required machine and the other left sequence control. Also this delay prevents many to drop sugar at the same time. The sequences control the centrifugal machines and the oscillations of these machines not exceed the oscillation of only one machine. The sequence control has better performance when the values feeding, spin, plough & cycle time for any machine is equal or nearly to the values of other machine.

RECOMMENDATIONS

1. The model of three machines can be generalize to include many machines in a battery and the regulation of the machines sequence can be obtain according to the number of the working machines at that battery.
2. In order to get more precise solution in addition to the two parameters used (i.e. spin time & last machine request) more parameters can be added like number of the machines working, other machines position in their cycles (request time taken for every machines) and the load of current of the machines, more over the current of the induction motor of the centrifugal machine can be representing by its equivalent circuit diagram.
3. Neural network can be used instead of fuzzy control in order more accurate solution in sequence control.

REFERENCES

[1] Andrew Kusiak, Fuzzy Logic, Intelligent Systems Laboratory, 2139 Seamans Center, The University of Iowa, Iowa City, Iowa 52242 - 1527

[2] IIT Kharagpur 2 (2008) Introduction to Sequence/Logic Control and programmable Logic Controllers, Basic Electrical Technology 01 Version II INSTITUTE OF TECHNOLOGY, KHARAGPUR India.

[3] International Sugar Journal Vol 101, No 1212, (Dec 1999). Variable and multi-speed batch centrifugal drives.

[4] Nivit Gill, Shailendra Singh. (July-2011). Biological Sequence Matching Using Fuzzy Logic. International Journal of Scientific & Engineering Research Volume 2, Issue 7, ISSN 2229-5518, IJSER © 2011

[5] Morteza Bagherpour, Kazem Noghondarian, Siamak Noori (January 2007) Applying Fuzzy Logic to Estimate Setup Times in Sequence

[6] Muriel Bowie Seminar Paper (2004) Fuzzy Clustering, Feature Selection, and Membership Function Optimization, DIUF – Department of Informatics University of Fribourg, Switzerland.

[7] Rao V. Dukkipati (2006) Analysis and Design of control Systems NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS.

[8] Robert H.Beshop (2008) Mechatronic System Control, Logic and data the University of Texas at Austin USA by Taylor & Francis group.

[9] R. Ramkumar, Dr. A. Tamilarasi and Dr. T. Devi, April (2011) Multi Criteria Job Shop Schedule Using Fuzzy Logic Control for Multiple Machines Multiple Jobs International Journal of Computer Theory and Engineering, Vol. 3, No. 2.

[10] Thomas Broadbent & Sons Ltd, Operating Manual for 5/10 sequence panel, Queen Street South Huddersfield HD1 3EA ENGLAND.