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Automated speed control for cane feeding in sugarcane crushing unit

G.Thenmozhi[1], A.Mythily[2], S.Swathi priya[3] ,P.Mohana selvi[4], P.Monika[5]

[1]Associate Professor, [2345] UG Scholar Department of EIE, Nandha Engineering College, Erode, Tamilnadu ,India

thenmozhi.gp@gmail.com

***Abstract*—In sugar factory there are a number of processes involved out of which, the crushing mill process which extracts the juice from sugarcane fibers is the key process which is complex and nonlinear in nature. For maximum juice extraction, maintaining the cane level in the chute at an optimum level is essential. The manipulated variable for controlling cane level is the speed of cane carrier motor. In the present paper, we have used PIC microcontroller for the purpose of controlling conveyor motor speed and software support is given by LabVIEW.**

***Index Terms*—*sugar mill, cane level, balanced crushing.*

I. INTRODUCTION

The input to the sugar factory is the sugarcane billets and the output is the crystal sugar. There are many sub processes with significant multivariable interaction involved within this process as shown in Fig.1.

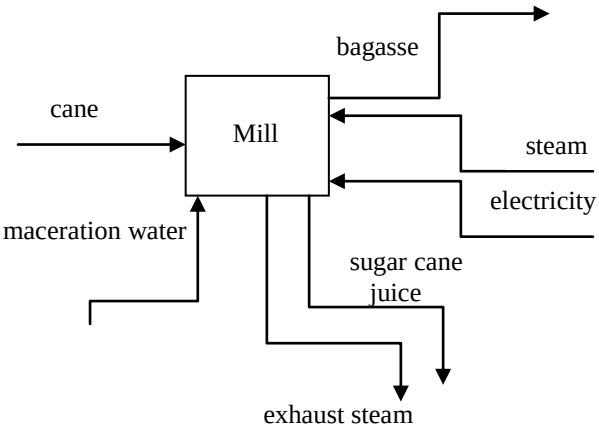


Fig.1: Block diagram of sugar input and output

First of all, the cane billets are carried by the cane carrier to the shredder which cuts the cane into pieces and transforms them into fibers which are around 1-2 cms.

These fibers are then fed to the Donnelly chute of height 3m(approx.).From the base of this chute, the fibers are passed through a sequence of 5 to 6 crushing mills which extract the raw juice After extraction, the residual waste product which is called Bagasse is sent to the boiler turbine plant where it is burnt to produce high pressure steam to run the turbine for generation of electricity.This raw juice contains some impurities hence it is sent to clarifier. In clarification process, the impurities are transformed to a thick paste of mud which settles down in the clarifier vessel. This mud which is also termed as filter cake can be used as fertilzizers.

This clarified juice which is very thin is passed through a series of boilers for evaporation and it gets transformed to heavy syrup which is also called mother liquor. This syrup is then subjected to crystallization process where a seed of crystal is added in the syrup and crystal growth takes place. The resulting mixture of mother liquor and grown crystals is known as massecuite.

At last, the separation of mother liquor and crystals is done by a process named molasses. These separated raw sugar crystals are first dried and then finally stored for use.

The torque control has significant influence on juice extraction and the height of the material in the buffer chute should be at a level to achieve an adequate degree of compression of the material for efficient smashing . It is noteworthy that the chute height and the roll torque are closely coupled. Here, the height control is achieved by changing the turbine speed and the torque control is maintained by geometrical changing of the chute via the flap Considering the interdependence of height and torque, on the one hand, and the differences in dry matter qualities fed, on the other, to design a controller that acts as decouple and is robust to dry matter of different qualities is of great significance.

Conventionally, the control key points in sugarcane crushing plant is basically accomplished by manual operation. However the main disadvantage in manual operation are as follows: (1) with excessive dependence on workers subjective personal judgement. A stable operation level in sugarcane crushing unit cannot be guaranteed. (2) manual operation increase labour work-intensity thus increase the management cost.(3)the working environment is noisy and it affect the health of the operators. Therefore a balanced and automatic control system is required in sugar industry.

II. PLANT MODEL

The considered mathematical model of the motor which is a separately excited dc motor armature voltage Va and output, angular speed presented in form of transfer function in relation(1)

$$G_m(s) = \frac{W_m(s)}{V_a(s)} = \frac{0.01}{0.005s^2+0.06s+0.1001} \quad (1)$$

Now, the speed of the cane carrier motor should be increased if the cane level in Donnelly chute goes below desired level. If the level goes up the desired level ,then the speed should be decreased .The motor speed to cane level dynamics is considered to be a first order dead time system as presented by relation (2)

$$G_n(s) = \frac{h(s)}{W_n(s)} = \frac{1.2\, e^{-s}}{10s+1} \quad (2)$$

Thus the overall transfer function of this process

$G_o(s) = G_m(s) * G_n(s)$

Which gives,

$$G_o(s) = \frac{0.012e^{-s}}{0.05s^3+0.605s^2+1.061s+.1001}$$

The open loop step response of the overall process Go(s) is shown in Fig.2.

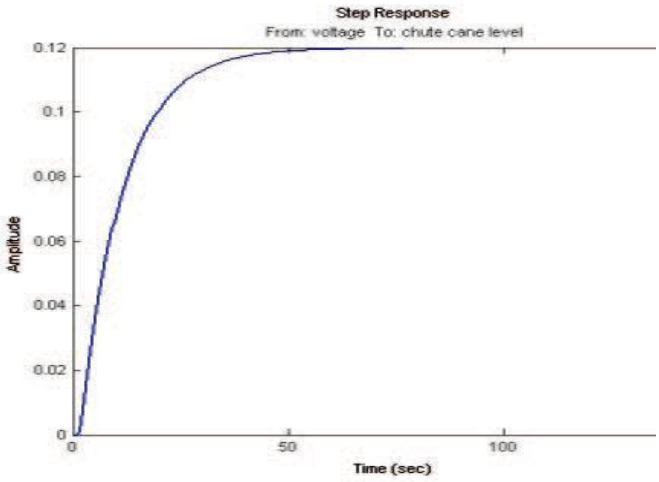
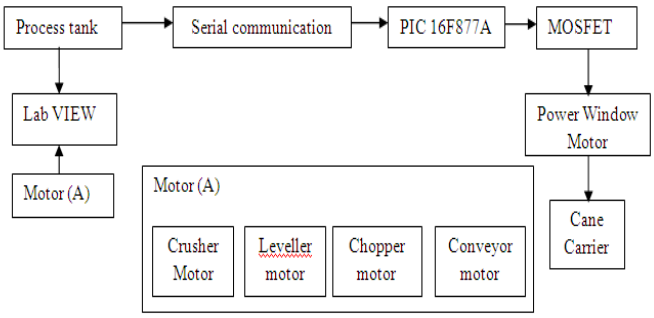


Fig.2: Open loop step response of crushing



III. BLOCK DIAGRAM

A. Power-requirement

Rated power is the motor parameter always specified when motors are selected for a belt conveyor—motor slip is usually ignored. The power-requirement for a belt conveyor is a function of five components: 1) the power required to run the empty belt, 2) the power required to horizontally move the load, 3) the power required for vertical lift, 4) the power required for friction from additional equipment such as skirting or side-travel rollers, and 5) the power required for acceleration. The sum of the first four components is the power required to run the conveyor. The acceleration component is only required during starting.

If the power requirement for the conveyor has been determined correctly and if the power available is inadequate, the stretch-to-slip ratio is too high—probably the result of an inadvertent selection of high-efficiency motors with low slip and poor starting characteristics. With these motors, mechanical devices that introduce slip are required if the conveyor is to operate near design capacity. A preferable solution is to avoid the problem by using directly coupled high-slip motors to improve load sharing and increase starting torque.

B. Sugarcane transportation process

Belt conveyor is a machine transporting material in a continuous way by friction drive. It is mainly composed by rack, conveyor belt, belt roll, tensioning device and gearing. It can form a material delivery process between the initial feeding point and the final discharging point of jaw crusher . It can transport not only granular material, but also work piece. Besides the pure material transporting, it can also form a rhythmic flow transport line complying with the requirements of various industrial production processes. The belt conveyor can be used for horizontal transportation or inclined transportation in a convenient way, and widely used in modern industrial enterprises, such as: mine tunnel, mine surface transportation system, open-pit and concentrator.

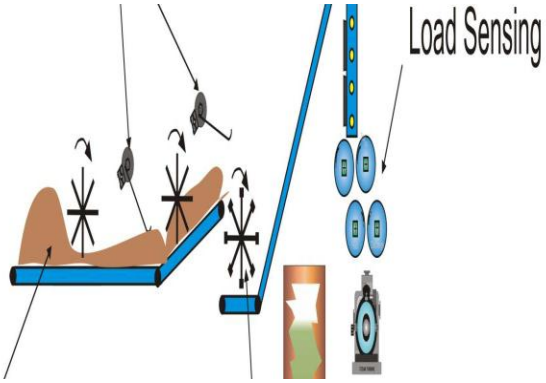


Fig.3 General conveyor setup

Fig.4 Mechanical setup

C. MOSFET driver

The speed of conveyor motor is controlled by MOSFET driver circuit which consists of four mosfet switches and an opto-coupler unit. MOSFETdriver provides a simple and effective solution to drive single, dual, triple or quad N-Channel or P-Channel FETs. Key features include wide input range of operation, extended temperature range of operation, powerful gate drive and short circuit protection.

D. Phototransistor Optocoupler

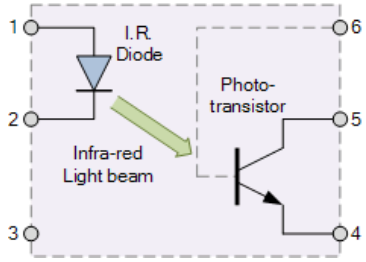


Fig 5. Phototransistor optocoupler circuit

The basic design of an optocoupler consists of an LED that produces infra-red light and a semiconductor photo-sensitive device that is used to detect the emitted infra-red light.Current from the source signal passes through the input LED which emits an infra-red light whose intensity is proportional to the electrical signal.

This emitted light falls upon the base of the photo-transistor, causing it to switch-ON and conduct in a similar way to a normal bipolar transistor.The base connection of the photo-transistor can be left open (unconnected) for maximum sensitivity to the LEDs infrared light energy or connected to ground via a suitable external high value resistor to control the switching sensitivity making it more stable and resistant to false triggering by external electrical noise or voltage transients.

When the current flowing through the LED is interrupted, the infrared emitted light is cut-off, causing the photo-transistor to cease conducting. The photo-transistor can be used to switch current in the output circuit. The spectral response of the LED and the photo-sensitive device are closely matched being separated by a transparent medium such as glass, plastic or air.

Since there is no direct electrical connection between the input and output of an optocoupler, electrical isolation up to 10kV is achieved.Optocouplers are available in four general types, each one having an infra-red LED source but with different photo-sensitive devices.

IV . SOFTWARE SUPPORT

A. LabVIEW:

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation often imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help you troubleshoot the code you write.

There are two windows: the front panel window and the block diagram.

B. Output screen

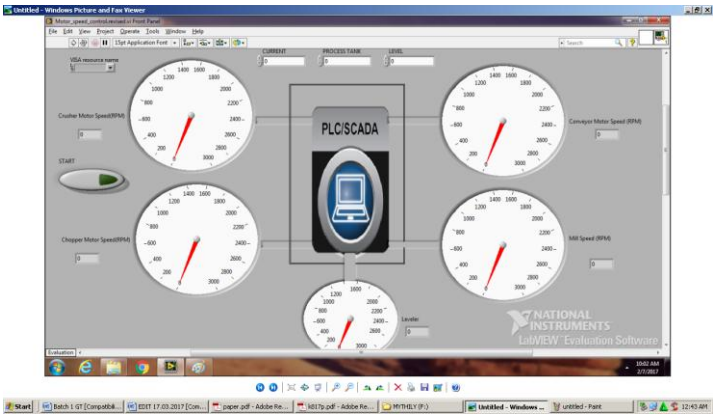


Fig 6.Front Panel

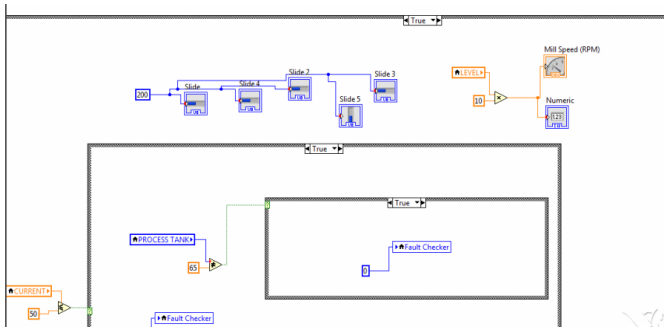


Fig 7.Block diagram(i)

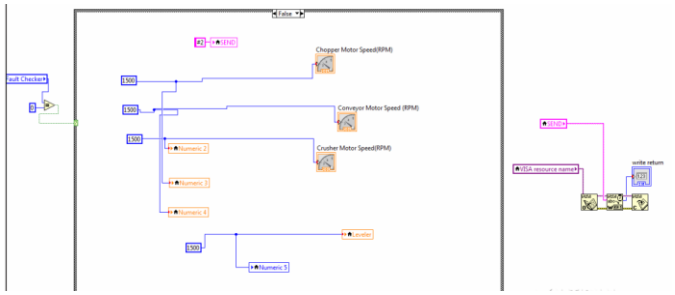


Fig 8. Block diagram (ii)

The overload of the motor is balanced by reducing the speed of the motor itself and also the other motors included in the motor(A)section.

The level of Donnelley chute level is measured and its maintained within its limit. when the level increases the speed of all the motors in the motor(A) section is reduced.

This is done to prevent the choking and jamming in the milling section. The level of fluid in the process tank is maintained in certain limit, when it overflows the milling speed is reduced

V. CONCLUSION

The automatic control of motors speed and cane feeding provides lot of advantages which includes,increased milling with the same equipment due to:continuous and un-interrupted feeding reduces downtime and increase throughput elimination of choking at preparatory devices, mills, chutes or carriers maintained juice to imbibition water ratio increases evaporation efficiency optimum mill speeds with respect to loads and levels ensure good milling results at all times effective water saving and cutting off water flow when crushing is stopped. Constant juice flow for process ensures even loading in the boiling house and stabilizes and reduces the steam consumption which means higher boiling house efficiency and Bagasse saving. Stable Juice Flow also helps in better Juice pH Control which in turn ensures better Juice and Sugar Colour which means better Sugar Price. Constant Process Flow ensures better Boiling House Efficiency.

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