Liquid And Magma Level Control System In Sugarcane Industry Using Fuzzy PID Controller

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Abstract- *The Proportional-Integral-Derivative (PID) controller is a traditional controller for industrial process control and shows an vital part in keeping the control variable at an ideal set point by comparing the real response with predefined response of the system. The procedures in the sugar manufacturing are functioning with more number of process variables and few common constraints in maximum of the industries are temperature, pressure, level and flow. In this paper liquid level and magma level of sugarcane industry is controlled using numerous controllers. The prevailing technique for approximation of controller tuning parameter has more mathematical calculations and takes more time to settle the system. To overcome this problem the current work is enhanced the control action by investing the controller tuning process using fuzzy logic controller. Simulation is done using MATLAB software and the output shows that fuzzy logic controller yields better performance than PID controller.*

Keywords- Liquid level control, Magma level control, PID controller, Fuzzy logic controller, transfer function, Matlab

I. INTRODUCTION

Industrial process control emphases on the process monitoring and control for bring the reaction of the system at a predefined set point. This process control system contains of a controller, process, final control element and measuring device for feedback control mechanism. In a closed-loop system, the output is fed back as an input which is cast-off to manipulate the control variable to bring the system in a specific functioning condition and is also known as a feedback system. The significant parameters related with an industrial process control system are processed variable and manipulating variable. A Proportional- Integral-Derivative (PID) control is the most frequently used and efficient controller in industrial control systems and seeks the attention of many researchers since the invention of PID control. The chief purpose of this research is to estimate the performance of the liquid level and magma level control in sugarcane industrial process using optimized PID controllers.

II. OVERVIEW OF SUGAR INDUSTRY

The primary procedure in the sugar factory for sugar manufacturing is cane juice extraction by the cane crushing unit. This unit consists of cane feeder, cane carrier, chopper and leveller. The cane crushing capability of the plant has up to 4000 tons per day. The sugar cane from the truck is loaded into the cane carrier through the cane feeder uninterruptedly. Typically, a chopper is installed at the start of the inclined part of the cane carrier and it rotates in the opposite way of cane flow direction. Leveller is regularly provided on the inclined portion of the cane carrier. Leveller rotates in the same direction as the cane carrier. If the cane carrier gets moves, the cane kicker pushes the cane load within the cane carrier then cane knives break the cane into small bits. This cane cutting method is called cane preparation. The cut pieces of cane bits are then passed into the several mills for juice extraction. The extracted juice has been stowed in a raw juice tank with a storage volume of 7853 L. The filtrate that arises from the mill after juice extraction is known as Bagasse. This Bagasse will be burned in a boiler to generate steam for the boiling unit.
After juice extraction it goes to clarification state where the clean juice is eradicated from the top and seeded mud at the lowest is detached. Lastly the procedure goes to crystallization and centrifugation to achieve the crystals of sugar:

III. LIQUID LEVEL CONTROL SYSTEM

The process control industries must have an open or closed storage tank for liquid or fluid stowage. In the sugar industry, level control of the raw juice tank at the cane crushing process has taken for the research work. It is observed that a convinced quantity of juice should be stowed inside the tank for ensuring the constant flow of liquid to the consecutive process. The schematic representation of the cane crushing process and juice level control is given in figure 1. The process flow has described in **a**n overview study of the sugar industry. The objective of this process is the extraction of cane juice from sugarcane through heavy mills and stored in a large tank with height of 250 cm and a diameter of 200 cm.

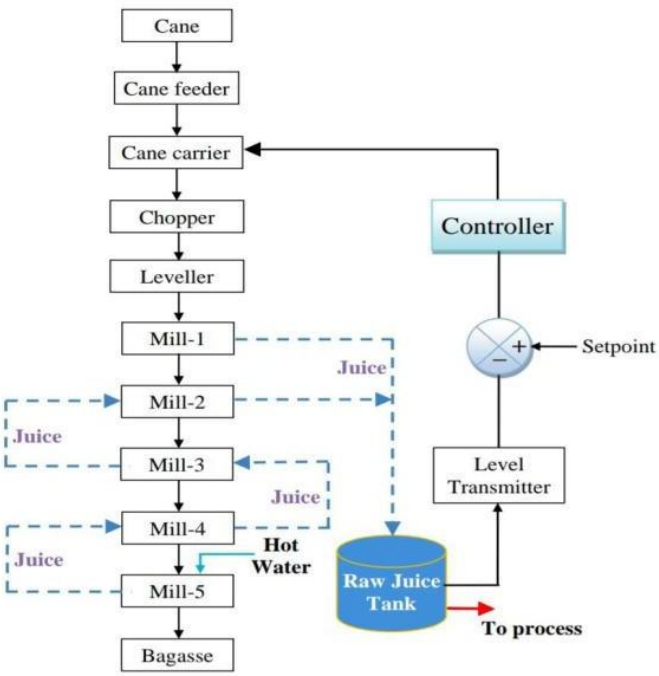

Fig.1 Schematicdiagramofliquidlevelcontrolinraw juice tank

IV. BRIX CONTROL FOR SUGAR INDUSTRY

The second study considered for thisresearch work is sugar magma Brix control using melter unit. The key objective of this procedure is to dilute the B and C sugar magma from 90 to 60 Brix. The magma is nothing but the viscosity of the substance derived from B and C massecuite. Thetemperatureofhotwaterrangesfrom65°Cto80°C. This hot water dilutes the substance and its thickness gets reduced instantaneously. Figure 2 shows the schematic block diagram of magma brix control system.

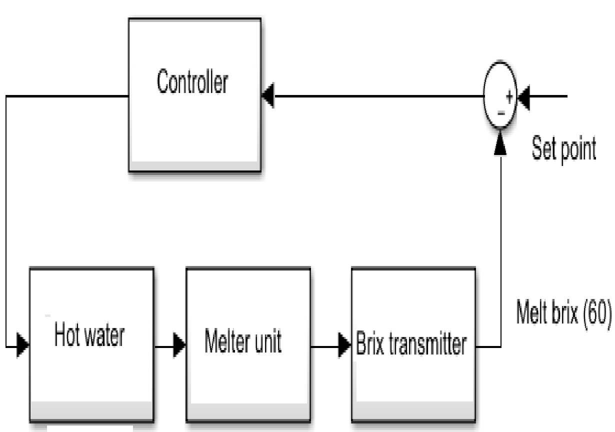

Fig.2 Schematic diagram of sugar magma brix control system

V. TRANSFER FUNCTION

The experimental data collected from the process is a source data for system identification. In raw juice tank level control process, tank level and cane carrier speed are the input and output signal. Likewise in brix control at melter unit, the input and output signal are brix and hot water flow rate respectively. Here hot water flow can be varied using globe control valve in according to the brix level at melter tank. The removed data have split up into two segments as training data and validation data for finding the suitable model of the system

The training data is used to estimate the model parameters and the identified model should be equivalent with the verification data which is not used to fix the model parameters. The experimental data composed from the real time process have been treated with all the model structures in MATLAB Simulink. The significant and noticeable thing in system identification process is to choose the best model which should have maximum fitness between the input and output signal.

VI. PID CONTROL DESIGN USING FUZZY

The PID controller is a combination of proportional, integral and derivative controller, generally used in the closed-loop industrial process control system**.** In common, the derivative and integral controller would have steady-state error and stability error respectively. It can be overcome by using the benefit of three controllers combinable that proportional controller decreases rise time, integral controller can able to exterminate the steady-state error and the derivative controller diminish the peak overshoot and settling time [3,4]. The different tuning methods for setting the PID controller constants are discussed in literature investigations and based on the observation with all the methods, the damped oscillation method has been preferred for level variable control and it does not demand generating sustained oscillations for fining controller constants because of the complexity of the system. The auto-tuning method in MATLAB with version R2015a is used to determine the controller tuning parameter for brix variable control process.

VII. RESULTS AND DISCUSSIONS

The Simulink model consists of unit step input, PID controller, transfer function and scope to view the response of the system. Figure 3 shows the simulation model of liquid level and magma brix control system. The system is simulated using Matlab.

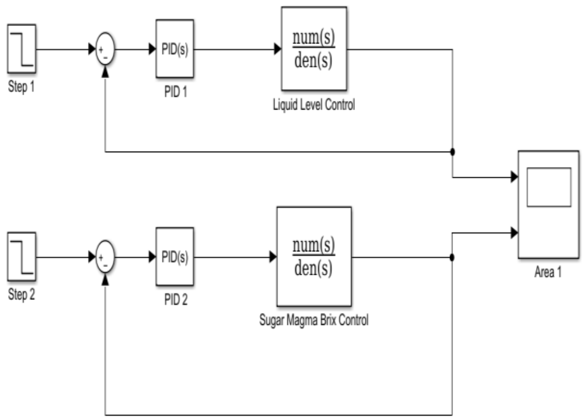

Fig. 3 Simulation model of control system

In every industrial process, response of the system can be analyzed by using the steady-state and transient response of the closed loop control system. The chief characteristics of transient response are rise time, settling time, peak time and peak overshoot. The transient response with unit step input of both processes displays peak overshoot and in particular for level control systems having damped sinusoidal response. It is clear that both of the systems are stable based on the response of the PID controller [5]. The purpose of PID controller has described for liquid level control in raw juice tank and brix control in Melter tank. The tuning parameters for PID controllers are determined using damped oscillation and auto-tuning method for level and brix process.

The fuzzy logic system is one of the eminent and successful soft computing techniques that would be applying for process automation in industries as well as home appliances. The controller setting parameters are tuned mathematically which is not opted at abnormal or any variations happened in the procedure.

The schematic diagram of the closed-loop fuzzy tuned PID controller is shown in Figure 4**.**

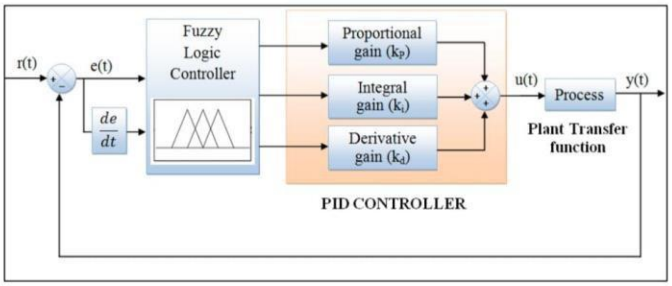

Figure 4 Closed loop fuzzy tuned PID controller

The closed-loop controller design consists of a fuzzy logic system coupled with a real-time process and a measurement device.

The closed-loop system has r(t) as a reference input and e(t) is an error signal. It is a deviation between reference signal r(t) and a feedback signal y(t). The output of the PID controller is quoted as u(t) and y(t) is the measured signal or output from the real-time process [1,2]. The two main inputs of the fuzzy logic system are error signal e(t) and the rate of change in error de(t)/dt. The authentic elements of the fuzzy logic system are Fuzzification, Fuzzy inference system, Defuzzification, Fuzzy rule base and fuzzy knowledge base. The measured signal using sensors from the real-time process should be converted into a defined label for framing the fuzzy rules.

As per the requirements from input and output of the fuzzy logic system seven fuzzy sets have been considered for both level and brix process. The fuzzy logic system is one of the best soft computing techniques applying in many of the automated control systems [6,7]. The asset of a fuzzy logic system is a knowledge base and database of the system which requires auto-tuning and control. The fuzzy logic system is applied here for PID tuning with two different processes in the sugar industry like cane crushing and melter process having controlled variable with level (cm) and viscosity of magma (brix) respectively. Simulation results are shown below.

Figure 5 and 6 shows the simulation results of liquid level and magma level control system using PID controller.

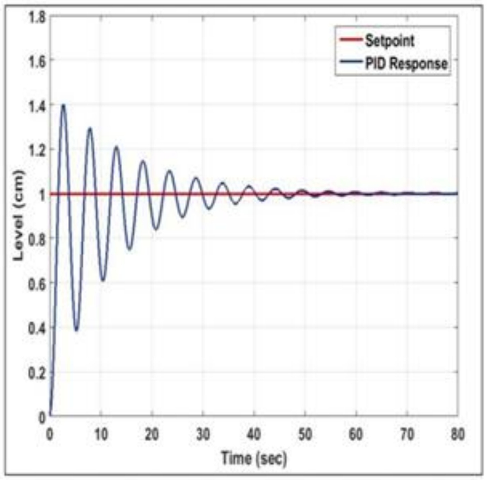

Figure 5 Simulation result of liquid level control using PID

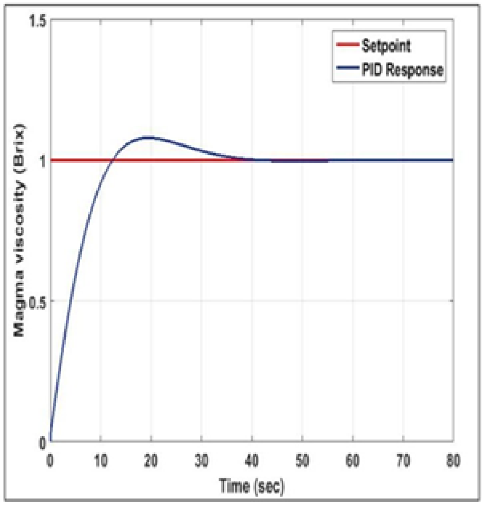

Figure 6 Simulation result of magma level control using PID

In every industrial process, response of the system can be analyzed by using the steady-state and transient response of the closed loop control system. The main characteristics of transient response are rise time, settling time, peak time and peak overshoot**.**

Rise time is the time required to attain the 0 to 100% of the Set point for under damped system. It is varied for over damped and critically damped system as 10% to 90% and 5% to 95% of the desired set point respectively.

- Settling time is the time required to reach the steady-state.
- Peak time is the time at which the maximum level reached beyond the desired value.
- Peak overshoot is the percentage of maximum peak overshoot occurs with respect to the desired value

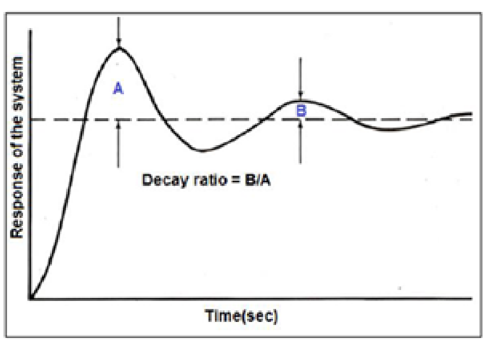

Figure 7 Tuning using damped oscillation method

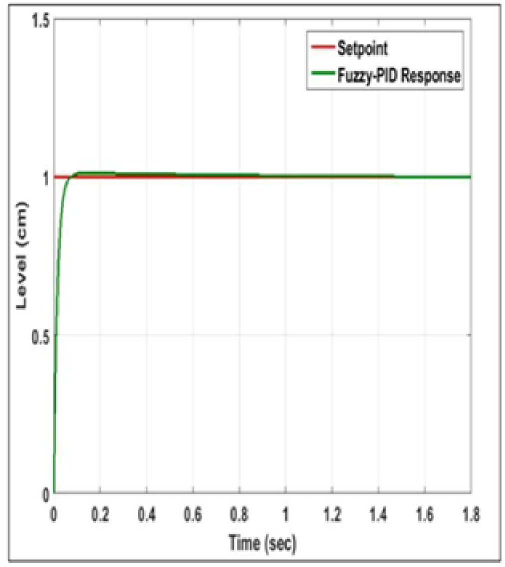

Figure 8 Simulation result of liquid level control using fuzzy PID

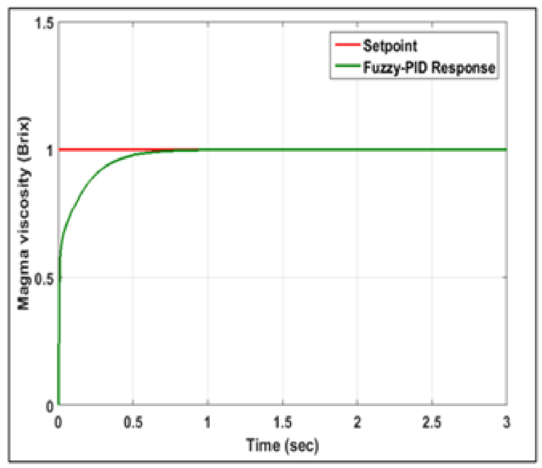

Figure 9 Simulation result of magma level control using fuzzy PID

Figure 8 and 9 shows the simulation results of liquid and magma level control using fuzzy PID controller. There are no sustained oscillations in obtained response and a fuzzy tuned PID controller has the best transient response than the conventional PID controller. This response shows that the proposed controller has more efficient than the conventional one. From the response curve, it is clear that a knowledge-based controller has highly opted for this system.

VIII. CONCLUSION

- In this research work, to analyze the performance of industrial process control, soft computing and optimization based controller tuning are carried out. Sugar industries have been taken as a case study for analyzing the performance of industrial process control system.

- The obtained simulation response proves that the fuzzy tuned controller provides better response in reducing overshoots as well as settling time get minimized. The performance indices of fuzzy based controller have minimum error which reflects the quality of controller response.

REFERENCES

[1] Ahmad Ali & Somnath maji, “PID Controller tuning fotr Integrating Processes” ISA Transactions, Vol.49, no. 1, pp.70-78
[2] Ahmad Wedyan, Jacqueline Whalley & Ajit Narayanan 2017, 'Hydrological Cycle Algorithm for Continuous Optimization Problems', Journal of Optimization, vol. 2017, pp 1-25
[3] Ali Sadollah, Hadi Eskandar & Joong Hoon Kim 2015, 'Water cycle algorithm for solving constrained multi-objective optimization problems' Applied Soft Computing, vol. 27, pp. 279-298
[4] Anastasios I. Dounis, Panagiotis Kofinas, Constantine Alafodimos & Dimitrios Tseles 2013, 'Adaptive fuzzy gain scheduling PID controller for maximum power point tracking of photovoltaic system', Renewable Energy, vol. 60, pp. 202-214.
[5] Asim Ali Khan & Nishkam Rapal 2006, 'Fuzzy PID Controller: Design, Tuning and Comparison with Conventional PID Controller', Proceedings of the IEEE International Conference on Engineering of Intelligent Systems, pp. 1-6
[6] Astrom, KJ & Hagglund, T 2001, 'The future of PID control', Control Engineering Practice, vol. 9, no. 11, pp. 1163-1175
[7] Aydogan Savran & Gokalp Kahraman 2014, 'A fuzzy model based adaptive PID controller design for nonlinear and uncertain processes', ISA Transactions, vol. 53, pp. 280-288.