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Implementation of Self Tuning PID Controller in Pasteurizer Machine for Food and Beverage Industry Using Siemens S7-300 PLC

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Abstract *- Temperature is an important parameter to be controlled, and when it comes to the pasteurization of food and beverages it becomes the most important parameters of all. So proper temperature controlling is needed to obtain the best taste of the products. Hence, in pasteurizer it becomes necessary to have a good temperature control. Generally the temperature is controlled by the PID blocks, and most of the PID blocks are tuned in conventional way. This leads to non-optimal temperature control most of the time. So it demands for the necessity of some self-tuning program. Here the self-tuner proves to be quite handy. It takes the parameter values based on model type with more precision and higher accuracy. A successful programming of self-tuner can lead to better PID parameters and which is much better than the conventional PID block.*

The self-tuning PID controller can not only be applied to temperature processes, but also in other process types which are controlled by PID. So, this fundamental can further be expanded into varied areas where precise control is needed, and it also reduces the human efforts as well as human errors which occur while manual tuning.

Keywords *- S7-300 PLC, PID controller, Self-tuner, Pasteurizer m/c, Temperature Control*

I INTRODUCTION

Pasteurization was developed and named after its inventor Louis Pasteur who in 1862 first successfully tested his method of heating wine to prevent further fermentation and spoiling.Pasteurization is the process where the edible items with prefixed amount of micro-organisms in it are heated so that the amount of bacteria inside the product doesn't increase than a particular limit. To pasteurize anything a proper temperature control is needed. And most of the time PID controller is used to regulate that spraying temperature[5]. PID controller is one of the most popular controllers in industrial control loop, it also occupies an important position in industrial control area. PID controller has a typical structure, it programs easily, it has smaller computing workload, its parameter has clear physical significance, it adjusts parameters conveniently, and it is easy to implement multi-loop control. At present, there are many PLC manufacturer offers PID control system function blocks. It makes industrial control easy and convenient. This paper is based on Siemens PLC S7-300 CPU-317 PN-DP. PID control system function block introduce how to realize PID parameters auto-tuning method in Pasteurizer m/c for food and beverage industries. [6]

II CONSTITUTION OF PASTEURIZER M/C FOR FOOD AND BEVERAGE INDUSTRY

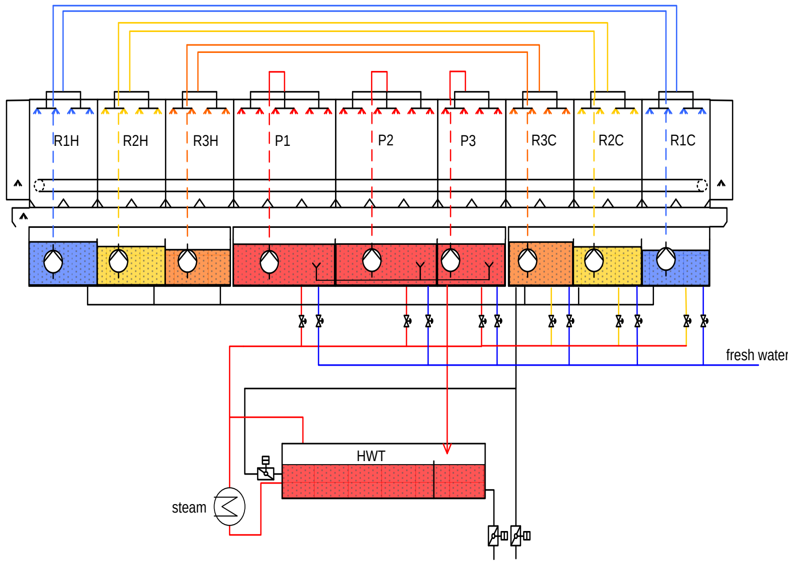

Fig1 Piping and Instrument Diagram of pasteurizer

There are total 9 zones in the standard fitting. Three zones (R1H,R2H,R3H) for initial heating, another three zones for actual pasteurization (P1,P2,P3) and last three for cooling (R1C,R2C,R3C) purpose. All heating and cooling zones are interconnected for circulation of water.[3]

A. Heating Zones

As bottles are filled at very low temperature (6-8 ‘C), it will enter to pasteurizer at the same temperature, and so to prevent the thermal shock it needs to increase the temperature gradually. Heating zones are normally increasing the temperature of bottles. All the zones have a temperature difference of 7-10 ‘C.

B. Pasteurization Zones

After bottles passes through the heating zones, it will enter to pasteurization zones where actual pasteurization of the product happens. Normally pasteurization zones are kept above 60 ‘C. and number of pasteurization zones depend upon the product. The temperature of the pasteurization zones must be kept controlled to maintain the test and the life of the product.

C. Cooling Zones

The last section of the pasteurizer is the cooling zones. After pasteurization process has been completed, it need to cool down the bottles at normal room temperature. So these zones are responsible for this.

The *filled beer bottles or cans* move through the pasteurizer slowly on conveyor belt. The tunnel is divided into many temperature zones to slowly bring the product up to temperature, keep them at a specified holding temperature and then bring them back down to room temperature. Modern tunnel pasteurizers contain sophisticated control systems to manage the temperatures.

The pasteurizer machine is working on the very specific control scheme of control system is the Ration control. Ratio control is control strategy commonly used in the process industries. It is used when the flow rates of two or more streams must be held in proportion to each other. In this machine ,see fig3 ,blue pipe line is of normal water and red pipe line is of hot water coming from heat exchanger . Then Both, the pipe lines are combined and then spreyed on the bottles into the tunnel. Temperature sensor(RTD) is continuesly sensing the temperature of the sprey water and according to the temperature hot water line valve is been controlled by PID controller.

Water is normally recirculated to improve energy efficiency; water is preheated by spraying onto hot bottles within the cooling zones , then the water is heated externally and sprayed onto the bottles within the pasteurizing zones, before being cooled by spraying onto the cold bottles in pre heating zones. A run through the pasteurizer takes between 20-50 minutes at temperatures from 60°C to 90°C. Due to the length of time the bottles must be heated, tunnel pasteurizers can be extremely large. [3]

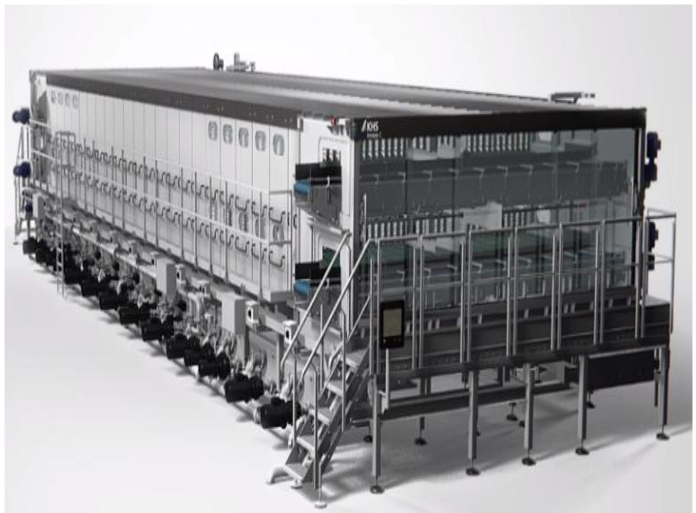

Fig 2 Tunnel Pasteurizer m/c

III WORKING OF BASIC PID CONTROLLER

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Simply put, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, a damper, or the power supplied to a heating element.

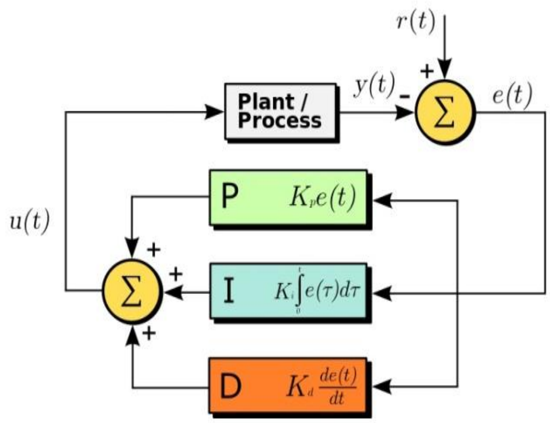

Fig 3 Block Diagram of Close Loop Process

By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point, and the degree of system oscillation.

Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

Mathematical Description:

The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining u(t) as the controller output, the final form of the PID algorithm is:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

Where,

K_p: Proportional gain, a tuning parameter

K_i: Integral gain, a tuning parameter

K_d: Derivative gain, a tuning parameter

e: Error =set point - process variable

t: Time or instantaneous time (the present)

τ: Variable of integration; takes on values from time 0 to the present.

IV THE CONCEPT OF PID CONTROL IN SIEMENS PLC

The function blocks (FBs) of the PID Control package consist of controller blocks for continuous control (CONT_C).The controller blocks implement a purely software controller with the block providing the entire functionality of the controller The data required for cyclic calculation is stored in data blocks assigned to the FB. This allows the FBs to be called as often as necessary. [9]

V APPLICATION

A controller implemented with the two controller blocks is not restricted to any particular application. The performance of the controller and its processing speed is only dependent on the performance of the CPU being used. With any given CPU, a compromise must be made between the number of controllers and the frequency at which the individual controllers are processed. The speed at which the control loops must be processed, in other words, the more often the manipulated variables must be calculated per unit of time, determines the number of controllers that can be installed (faster loops mean less controllers).

There are no restrictions in terms of the type of process that can be controlled. Both slow processes (temperatures, tank levels etc.) and very fast processes (flow rate, motor speed etc.) can be controlled.

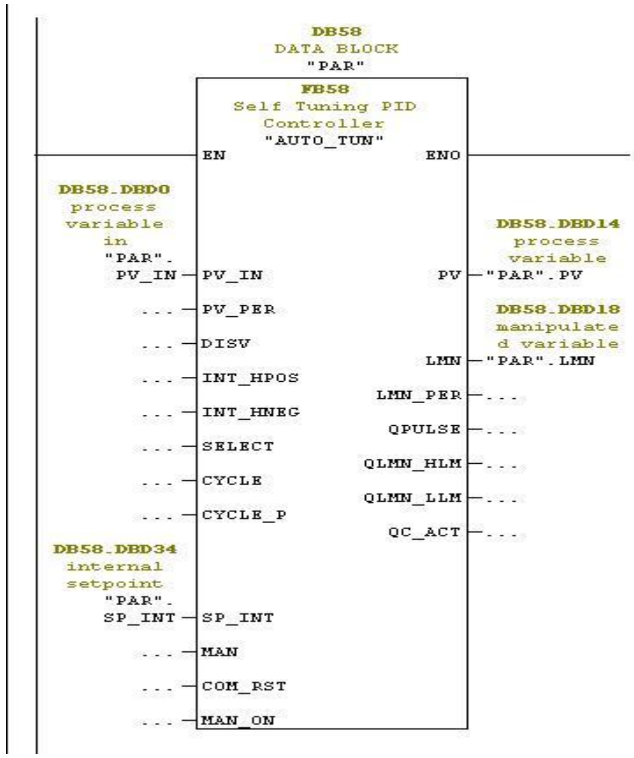

Fig 4 Self Tuning PID Controller Block

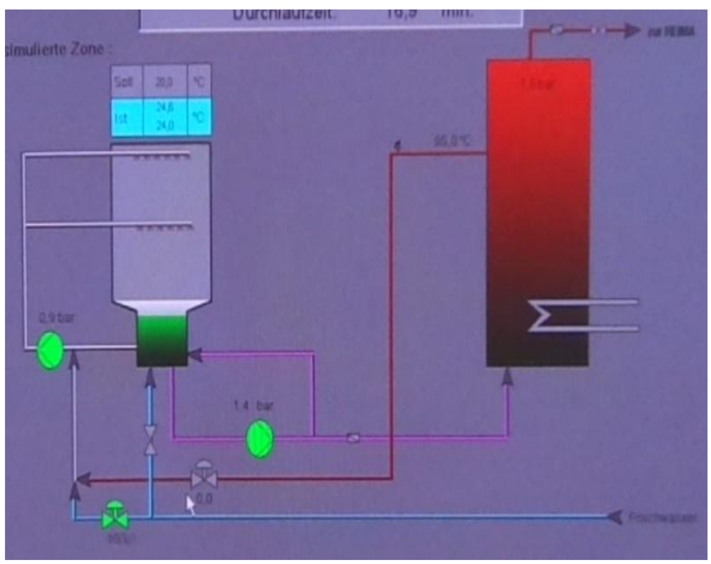

Fig5 One of the Zone of Pasteurizer m/c

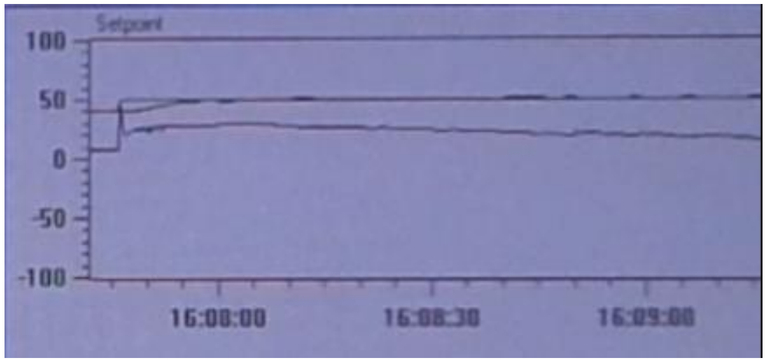

Fig.6 Result of Self Tuning PID Controller in Simatic manager

Fig7 Result of Self Tuning PID Controller on HMI

VI DISCUSSION

In the fig.7 , red colored line indicates the set point value , green colored line indicates the process variable value and the blue colored line indicates the manipulating value that is controlling the hot water line valve.

After setting all the parameters in self tuner , it enters into automatic operation mode, it can be seen from the fig 6&7 that the set value and the feedback value has overlapped very quickly.

VII CONCLUSION

According to S7-300 PLC PID parameter self-setting function and PID closed-loop control analog quantities and its principle, Combined with PID temperature adjustment control module, it gives the S7-300 PLC PID auto-tuning method and procedure. After using self tuning PID controller the system will be more stable quickly, System suitability is very good, Adjusting speed is ideal and the errors adjust in time.

VIII FUTURE SCOPE

In this project, Self tuning PID controller is used for temperature control loops of pasteurizer machine, but this same phenomenon can also be implemented for any temperature loop for any machine. Not just the temperature loops, it can be used wherever there is a PID controller for process control. It has to just replace the older PID program with new self-tuner PID and can obtain much better results than before. Further it can also be programmed with automatic set point change, so that even the efforts to change the set point can be removed.

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