Implementation of Multivariable Self Tuning Temperature Controller and LIW Feeder for an Extruder Machine

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***Abstract*-Polymer Extruder machine is a basic requirement of plastic product formation. So, it is very intended to maintain the desired temperatures. Polymer Extruder machine faces a many problems related to temperature control. Under manual condition it is difficult to control temperature at precise settling time and at overshoot condition. With manual control it is not possible to obtain precise temperature control due to its nonlinear behavior. Logic based intelligent concepts are used to control the temperature process. In this paper PLC based temperature controller is developed for temperature control in polymer extruder machine. This control scheme is interfaced with HMI to improve the monitoring and controlling function.**

Index Terms-Polymer Extrusion, PLC, HMI, Ladder Logic

I. INTRODUCTION

Utilization of polymer materials has increased extensively over last few decades due their adjustable and selective properties. Plastic materials can be molded into different shapes, thickness, transparency, high chemical resistance, high temperature resistance and tensile strength. This attractive property of polymer materials has resulted in an industrial application for polymer materials. All these properties can be achieved by the addition of additives/ filler agents/ catalyst with raw polymer source. This process is carried out very efficiently in an extruder machine. Extruder machine is used for the production of commodities in diverse industrial sector such as electrical wire insulation, packaging, automobile, etc. Despite of this success, it seems that effective thermal monitoring and still remains a concern.

Extrusion is a high volume manufacturing process in which raw plastic is melted and formed into a continuous profile [1]. Extrusion produces items such as pellets, sheets etc. In Extrusion process, the raw polymer (small beads often called resin) is gravity fed from a top mounted hopper into the barrel of the extruder. Additives like colorants and ultra- violet inhibitors (in either liquid or crystal form) are used and can be mixed into the resin prior to arriving at the hopper. Along with the polymer and additives, filler materials also supplied from the third feeder mechanism.

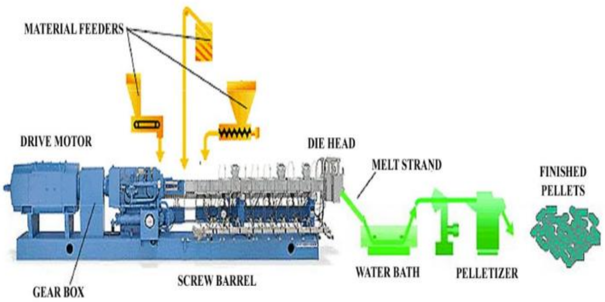

Fig- 1. Polymer Extrusion Machine

The material enters through the feed throat (an opening near the rear of the barrel) and comes into contact with the screw. The rotary screw (normally turning at up to 120 rpm) forces the mixture of polymer, additives and filler materials forward into the heated barrel. The desired extrusion temperature is rarely equal to the set temperature of the barrel due to viscous heating and the other effects. In most processes, a heating profile is set for the barrel in which three or more independent controlled heater zones gradually increase the temperature of the barrel from the rear (where mixture enters) to front. This allows the plastic beads to melt gradually as they are pushed through the barrel and lowers the risk of overheating which may cause degradation in the polymer.

As the screw rotates, forcing the plastic material to advance through the extruder cavity and is pushed through the die. After this plastic material is fed through the strand water bath, which solidifies the heated plastic material. Further these solid plastics are fed pelletizer to form small pellets and finally packed.

II. METHODOLOGY

The program is developed in the Ladder diagram mode, since it has the components or the blocks which are pictorially understood and easy for verification. PLC receives analog signals from an extruder machine. These analog signals namely from temperature sensors. All these analog inputs taken from the extruder machine are then passed to analog to digital converter [2] & [5]. From this analog to digital converter all analog signals are converted to digital signals and passed to controller. Controller is a Delta based DTC 1000 temperature controller, where it can be run in two modes i.e., ON/OFF mode and PID control mode [1]. In this work temperature controllers are programmed to run in ON/OFF mode. In PID mode the output is continuously adjusted in proportional to the input signal [1]. In ON/OFF mode, the control logic works in simple way. The temperature controller has two outputs i.e., coolant output and heating output. When the input exceeds the preset limit coolant output will turn ON and heating output will be turn OFF automatically. Hence these outputs can be used for switching the heater and blower as per the needs. This DTC 1000 controller allows the Modbus communication over RS-485 cable. So that temperature can be monitored in computer or Human Machine Interfaces. At the beginning these controllers needs to be setup for custom set points, this can be achieved with the help of RS-485.

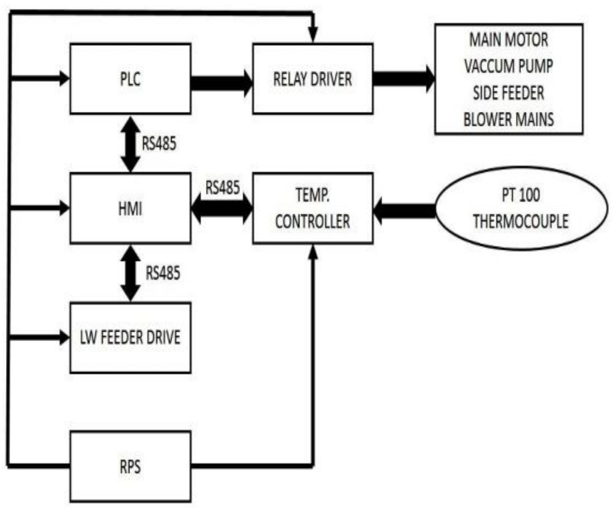

Fig- 2: Block diagram of proposed control scheme

A. *ON/OFF Control*

An ON/OFF control method is the basic type of temperature control method. There are two settings for this controller. It can be either ON or OFF as shown in Fig-3. If the actual or present temperature is below the preset limit, the output will be ON for heating control. In cooling it is on when the actual temperature is above the preset limit. This is just like a typical heating and cooling thermostat. ON/OFF control method is the simplest way of temperature control.

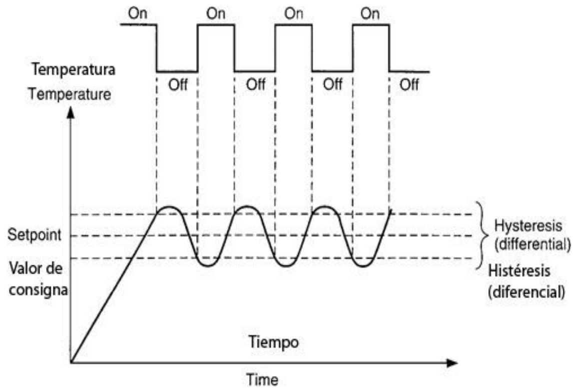

Fig- 3: ON/OFF Control

B. *Loss In Weight Feeder*

Loss in weight feeder is used to reduce man power and feeding rate error. This Loss in weight feeder has twin screw feeder with interchangeable feeding tools mounted on an inbuilt weighing scale. The weigh bridge is stainless steel and the scale housing is completely enclosed. All parts in contact with the material being fed are stainless steel. Feeder screw moves the materials in forward direction with specified rate. Feeder screws are easily interchangeable. Each feeder has its own control module. Connection between feeder, operator interface and smart I/O is via Industrial Network. Loss in Weight feeder keeps feeding rate constant by measuring the current weight and motor RPM [4].

All values are communicated to HMI through RS-485 cable. These values are taken and apply different operation algorithm like temperature control by switching the heater and blower supply, main motor, side feeder and vacuum pump control operation. By applying these different algorithm produces output for every operation. These outputs are relay type signals used to control the motors pumps, heaters and blowers according to selected algorithm. In all these steps power supply is given to the every block of control system. In this manner whole control system for polymer extruder machine is developed. The PLC monitors and controls all the input/output devices through HMI.

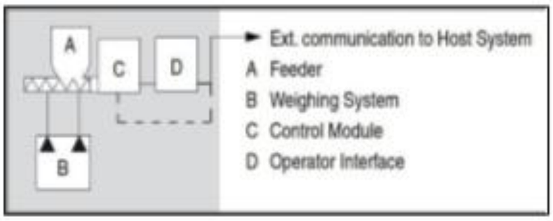

Fig- 4; Block Diagram of LIW feeder

III. DESIGNING HMI INTERFACE

The DOP Series Human Machine Interface (HMI) provides various touch screens with multiple dimensions and colors. It also offers fast and convenient control functions for industrial automation machines. In addition, Delta Windows-based and user-friendly DOP Soft Screen Editor and Programming Software configures the whole DOP Series. With DOP Soft, users can quickly edit images and graphs and easily set suitable communication protocol. More applications can be created, edited, downloaded and uploaded. This software allows the online simulation and off-line simulation methods to check the logics. It has wide range of graphical symbols suitable for the processing industry and any other fields. Online Simulation allows the user to test and monitor the process status through HMI.

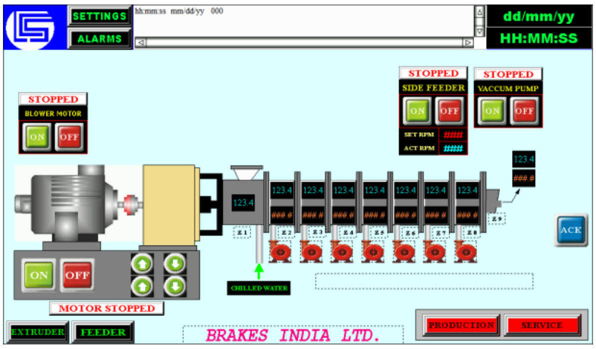

Fig- 5: HMI interface screen of Extruder machine

Fig- 6: HMI interface screen of LIW Feeder

IV. RESULTS

The development of PLC based temperature controller and LIW feeder is logical from the fact that which reduces man power by automating the entire system. Operating the extruder machine in manual control have been confusing and difficult. The automated approach adopted results reduction in human errors and increase in the quality of the output. In this paper we present an algorithm to implement multivariable self-tuning temperature controller using PLC and LIW feeder for an Extruder machine. The Fig-7 shows the polymer extruder machine which now successfully working under automatic control and LIW is feeding system.

Fig- 7: Polymer Extruder Machine

The Fig-4.2 shows the human machine interface installed near the old control panel. HMI user interface window is designed using DOP Soft. Software. RS485 communication is established between this HMI device and the PLC and LIW feeder.

Fig- 8: Installed HMI

Fig- 9 shows the old control panel which is reused for this work. Sensor outputs are brought to this control panel and connected to temperature controller. Further RS485 communication cable is used to communicate between the temperature controller and PLC. All motor control is achieved by the contactor and relay drive circuits. Contactors are energized by the 230V relay driver board and this relay driver board are actuated by 24V output of the PLC.

Fig- 11 shows the loss in weight feeder system installed near the polymer extrusion plant for efficient and accurate feeding of materials for the maintaining the continuous polymer profile and to maintain quality.

Fig- 9: Old control panel cabinet is used for our work

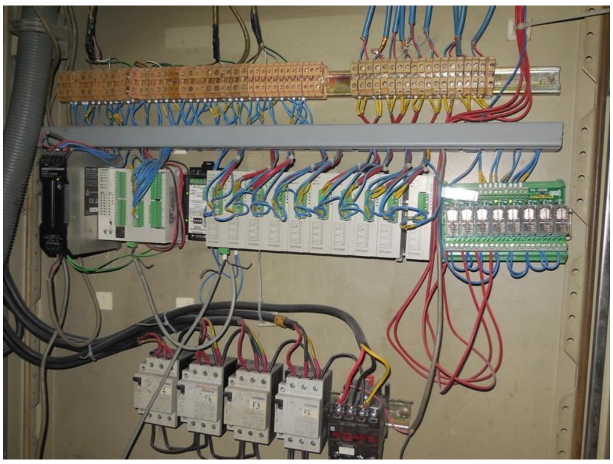

Fig- 10: PLC and Temperature Controllers

Fig- 11: LIW Feeder system installed near the plant

V. CONCLUSION

In the summary we conclude that the multi variable self-tuning temperature controlling and loss in weight feeding were the optimum, non-conflicting issues and they together can control the plant efficiently. This control model can be used for any plant following the manual feeding and manual temperature control. Hence this work can be taken as an initiative to ascertain that industrial automation with LIW feeder is possible. Supervisory Control data acquisition for complete automation of plant and supervision could be developed in future to simplify the process further.–

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