AUTOMATIC COLOR MIXING PLANT

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Abstract - Colors plays an important role in our regular lives. There are multiple shades of a single color which varies their basic concentration. The mixing process of liquid is the most significant and demanded process in any industry. The main objective of industries is to improve the efficiency, increase the productivity rate, reduce errors and eliminate human efforts. In past, industries used to change the combination of color by changing their concentration manually. Minor adjustment in color combination can change the entire shades of color which causes complications in an industrial sectors. To overcome this problem, we have designed a prototype that will automate the mixing process. In this technologically advanced era, technology is playing a vital role in the development of various industries in which there is no need of human assistance to perform any task. Various type of mixing can be done, it can be either color mixing or any other liquid mixing. Color mixing is the process of developing new colors by using the combination of primary colors. It is either done manually or performed on machine with a lot of human effort. We have initiated a programmable logic control PLC based system that gives the desire color by mixing the primary colors with their specific ratios. A user friendly HMI has been designed to make the system more convenient and can be easily operated by a non-technical person. Availability of input colors are mentioned in our system. User can create any color combination with his own ratio of the three basic colors that need to be selected on HMI or user can select pre-defined output colors. To achieve the required concentration, our system is comprised in close loop that monitor the flow of basic color and the output is verified by industrial color detector sensor. This system can be implemented in many industries such as food industries, textile industries and paint industries etc. This process has vast applications in different areas of industrial sectors.

Index Terms - Color sensor, HMI, Industrial automation, PLC.

I. INTRODUCTION

In today's world, the necessity of greater efficiency, high quality and automated machines has been boost up in the industrial zone of different plants. Many industries needs continuous inspection and monitoring at regular basis. There are high possibilities of errors that can be occur at various stages if machines are being operated manually by human workers. The mixing process of liquid is the most significant and demanded process in any industry. This process has vast applications in different areas of industrial sectors. Various type of mixing can be done, it can be either color mixing or any other liquid mixing. Color mixing is the process of developing new colors by using the combination of primary colors. It is either done manually or performed on machine with a lot of human effort. To automate a color plant and reduce the human effort and intervention, we developed a ladder logic design in programmable logic controller PLC. PLC is a device which is widely used in industry to control the system. It has multiple input and output terminals which operates to receive and transmit the given/desired signal. There many ways to understand the desired task to PLC [12]. Among them ladder logic programming language is the easiest to understand as well as easy to develop the logic [4]. It is based on relay logic that is why most of the relay circuit are placed by PLC along with capability to work with analog inputs and outputs. Proportional integral derivative (PID) can be performed to achieve high precision and accuracy and PLC also communicate with different protocol. Using ladder logic, we designed a mechanism of mixing three colors autonomously. To monitor the required proportion of color to form the desired color we use solenoid valves and flow meters. The primary colors that are used in this proposed system are blue, red and yellow RYB. The main reason of choosing these colors is because RYB are primary colors and more number of output colors are possible with these combination. We have developed 3 colors that are purple, orange and green as an output of the system. At the point, the specific amount of red and blue joins, the developed color is purple. When red and yellow join, the consequence is orange. When blue and yellow consolidate, the outcome is green. Other colors are made by adjusting the ratios and percentage of primary colors. Input command has been sent using human machine interface HMI. A color sensor is interfaced with PLC to detect the final generated color. This system is in close loop, Color sensor detects and verify the concentration of color and send the feedback to the flow meter. The flow of basic colors is monitored and controlled by using flow meter and calculations in PLC. This color mixing plant can be useful and implemented at many industries, mainly in food industries, textile industries and paint industries etc.

II. LITERATURE REVIEW

The demand and worth of greater efficiency, high accuracy and quality for mixing liquid color is increasing day by day in this globalized world.

Diverse studies and research concerning about automatic color mixing using different methods can be found in this literature review. The initial stage of this project is aims to pass the input of color mixing using various components. Using the mixing barrels, all input colors are passing through solenoid valves that will be mixed in the required proportion for the output [2]. In another research [3], DC motor mix the input colors and making variety of colors in output which is to be used for industry of food beverage. [4] Different type of controller and their usage has been explained in this research. This research is mainly focused on programmable logic controllers PLC and languages that can be used in PLC. They have explained about the ladder logic language, how to read the program, advantages and disadvantages, functional diagrams, counters and timers. [5] In this paper, they initiated a color mixing machine in which three basic colors are used as an input. Sensors are fitted in hydraulic line which consist of solenoid valve. SCADA is used to monitor the process and system for the internal storage of instructions for timing, logic, sequencing and countering of the logic design. [8] A conversion of a system from manually operated system to an automatic color making system. Six colors taken as an input. SCADA and PLC are used to monitor and control the system. They have also control the speed of motor and calculate the level of color in the system. [9] A coffee roaster machine has been initiated for reversible and economic reasons, they have used 2 PLCs as a main and extended PLC. Function block diagram FBD is used as a main programming for this proposed project in PLC. Pt-100 and Thermostat sensors are implemented in the system which are used to sense and detect the temperature at roaster cylinder. Painting in different color with various illumination conditions using end effector robot and a camera has been performed. They have used automatic spray gun that use to perform the painting task and related operation. The proposed system will start painting on a small sticker that is pasted on the object, the system will start painting when the desired color is detect by color detector sensor. An Arduino is communicated with PLC to make it a close loop. This proposed system is working automatically and specially designed as a cost effective [10].

III. METHODS

Several methods can be implemented for liquid mixing using the same logic. This system consists 3 chambers of basic colors (Red, Blue and Yellow) and output will prepared in another chamber. Variety of input and output color combinations are shown in figure 1. User can choose pre-defined colors or user can create any color combination with his own ratio of the three main colors that need to be selected on HMI shown on the HMI figure 5. Sample of different output color concentration is shown in figure 2.

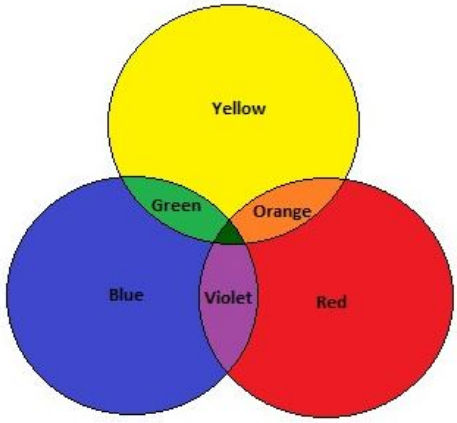


Figure 1. RYB color model.

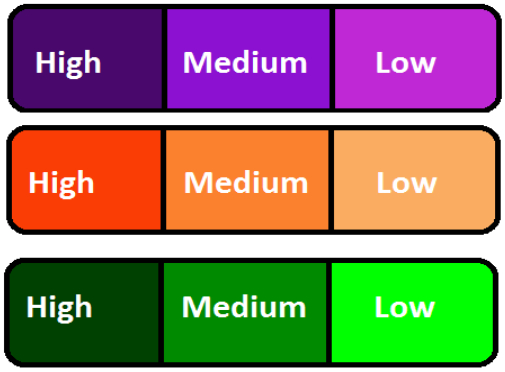


Figure 2. Output colors concentration

This system includes the electronics parts as well as the mechanical parts that are used to make this prototype. Our system consist of 3x 24 dc volt solenoid valves with flow meter. Solenoid valves and flow meters are the major component of this system. These valves are connected in parallel. Valves are used to control the flow of color. The magnetic field is generated in solenoid by passing the electric current, however that magnetic field operates the mechanism of the valve to control the liquid flow. The solenoid valves require small amount of voltage to work. The current rating it requires to work exceed from the PLC supply. PLC internal power supply is not able to provide that amount of current rating. Relay circuit were designed to resolve this problem and switched them by external power supply. The control of solenoid valve is based on calculation of required output color. The calculated amount of color is transferred by a close loop circuit based of flow meter connected with PLC to observe the flow of color. Flow meter is an instrument that use to measure the volumetric flow rate of any liquid. Separate flow meters are used for each chamber. DC Motor of 12v is used to mix the combined colors at the output chamber after the accurate ratio passes from solenoid valves. A manual valve is also attached at the output chamber to drain out the final color. EMX Color max sensor (Model: CM1000-4FLEX-4)

[11] is used to detect and identify the final generated color. It is a programmable sensor, specially use for industrial purpose. This sensor provides digital outputs for predefined colors. This sensor model can provide analog (voltage) and percentage of serial outputs of primary color present in detected color. The digital outputs configured by using provided software by EMX as shown in figure 3. We configured 3 predefined colors to enable different digital output of sensor connected with PLC. We can configure digital outputs as normally high or low. Whereas sensor can provide analog signal on regular basis or requested basis in voltage form, connected to PLC to detect the parameter of current color and these values is used to achieve customized colors.

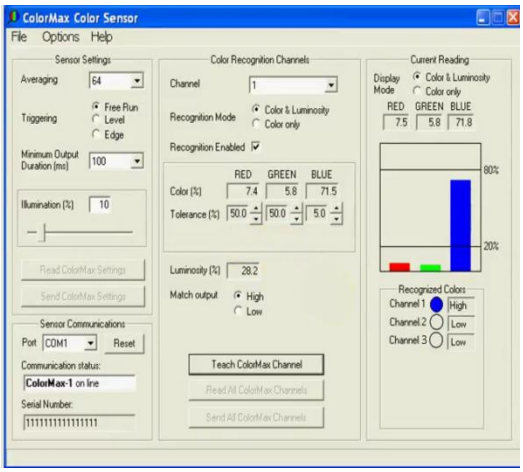


Figure 3. ColorMax color sensor configuration.

IV. WORKING PROCESS

Our plant is close looped system which consists of 3 chambers with 3 basic colors. 3 solenoid valves are connect from each input. Solenoid are electromechanical valves which control the flow of liquid when command in high. 3 flow meters are connected at every input chamber. All input's flow is controlled a closed loop using flow meters to measure flow of input and solenoid valves. The whole process is defined in flow diagram as given in figure 4.

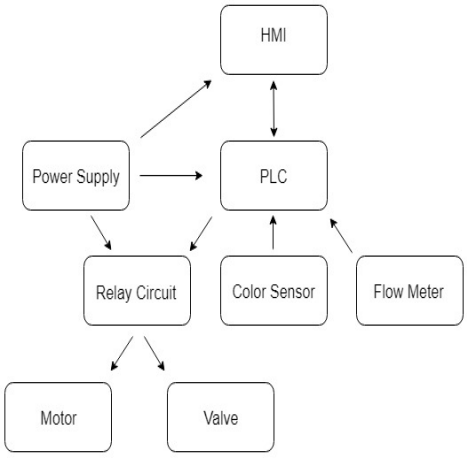


Figure 4. Flow diagram of system

When the user selects its desired color of predefined RYB ratio or inserts the desired ratio of RYB on HMI, the solenoid valves controlling the flow of primary colors will start flow of the required colors into the chamber with its predetermined ratio of each color. The ratio is controlled with the flow meters connected to the PLC to measure the flow of input liquids. User will have to write the percentage of colors on HMI in order to get specific color as shown in ratio table 1.

TABLE 1. OUTPUT PERCENTAGE CONCENTRATION (IDEAL CONCENTRATION)

Output Colors		Input Color (Percentage)			
Purple	High Purple	Red	60	Blue	40
	Medium Purple		50		50
	Low Purple (Fixed Color)		40		60
Orange	High Orange	Red	75	Yellow	25
	Medium Orange (Fixed Color)		50		40
	Low Orange		35		65
Green	High Green	Yellow	40	Blue	60
	Medium Green (Fixed Color)		50		50
	Low Green		60		40

We have used DC motor of 12 volts that will start mixing for the specific amount of time. It mixes flow of colors to have desired color is generated. At the output chamber we have attached a color detector sensor that will detect the final color and let the user know that your final color is made. Color detector sensor is connected with PLC.

This sensor can provide digital output for initially configured color and analog and serial output for value of ratio of primary color. Each color has specific range of wavelength with 400nm to 700nm in visible spectrum. It detects the color on the basis of its wavelength. It will check that either the desired color is developed or not. If input percentage command doesn't match to the detected output command, the system will indicate about required primary color based on the internal calculations of PLC and changes will be made accordingly. Errors in

output are calculated by comparing the differences from the ideal concentration to the practical concentration which is shown in table 2. There is a main switch which controls the whole system. The process will immediately stop if the main switch is turned off in case of emergency. The system is also kept dependent on the primary colors. It will not work if the primary colors are not available. Otherwise the system could not start its operation.

TABLE 2. OUTPUT PERCENTAGE CONCENTRATION (PRACTICAL CONCENTRATION)

Output Colors		Input Color Ratio (Percentage)			
Purple	High Purple	Red	58	Blue	38
Orange	High Orange	Red	70	Yellow	30
Green	High Green	Yellow	40	Blue	60

V. RESULTS

Our system is implemented on Siemens S7-1200 PLC. Including every PLC, this PLC also has integrated HMI screen. HMI is an electronic device that connects the operator to the machine. It is designed to make this project user friendly and easy to access. HMI is used to control and monitor the operation of automatic color mixing plant. Every input command is sent using HMI.

The whole system is started by selecting the main switch on, it is an emergency button that can stop the whole process by turning that main switch off from HMI. The indication of 3 primary color is also added in the HMI to indicate the availability of primary color. If any of the primary color required for the desired output is not available then this indication will set to be low and the formation process could not be started. Options for output colors are kept in HMI. User can select from 2 options, first option is for pre-configured output colors (Orange, Purple and Green). User will easily select the 3 pre-configured desired colors by just clicking on the screen after click on “Fixed Color” option as shown in HMI screen figure 5.

The second option is to enter desired RYB ratio. User can insert the percentage of desired RYB for output mixture and click “Go” to start the process. The flashing motor on HMI screen shows that the color mixing in the main chamber is under process. Motor will automatic start when the color start flowing in the main chamber for 10 seconds for proper mixing. Whenever the output color is detected by the color sensor at the hardware section. It will send the command to PLC. HMI will show the current ratio that the selected color is formed along with continuous monitoring of output color RYB ratio, which is used to achieve desired output.

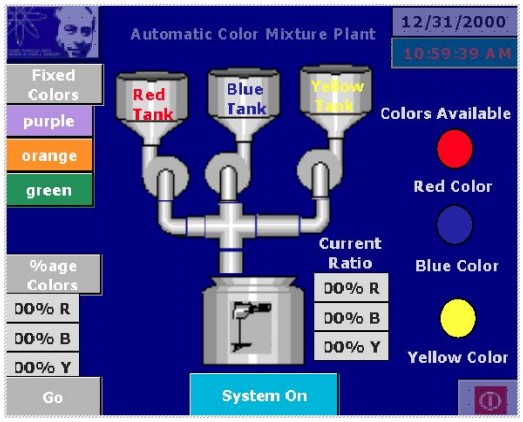


Figure 5. Human Machine Interfaces HMI screen

VI. EDITORIAL POLICY

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Authors of rejected papers may revise and resubmit them to the journal again.

VII. FUTURE WORK

Our proposed system is limited to few output colors and limited calculations; however it can be more effective by changing or adding up more combination of input colors every time when we need variety of colors on output. This system could be upgraded to many input chambers having variety of colors and there could be multiple output chamber for every combination. Furthermore, a washing mechanism can also be added to wash up the output chamber after every batch product and taking care of density of water that also can make it more efficient and effective. In future, we can also control the drain automatically and add different user selectable amount of the required color. Moreover precision can be occurred using PID that can be implemented to auto adjust the ratio and make the rare final color with 100% accuracy.

CONCLUSION

In any industry the main objective is to improve the efficiency, reduce errors, reduce costs and eliminate human efforts. Be in food industry, pharmaceutical industry or paint and coating industry etc. Mixing of liquid plays a vital role and has a wide range of application in an industrial as well as commercial purpose. However with the advancement in technology, many industries are updating themselves towards the use of these machines such as dyeing industries, painting industries, food and molding industries. To automate the process, the most important part is PLC. It can control the system

efficiently and effectively. The programmable logic is developed to generate a basic concept of mixing possible in any industry. It has 3 chambers having the primary colors RYB. After selecting the required color on Human machine interface HMI. It will take specific amount of colors from input to make the required color automatically. Solenoid valves are used to open up the path for the input color towards the output chamber with the accurate ratio of colors for the specific amount using calculation and monitored by using flow meters. Dc motor at the output chamber will start mixing for the final color for short time being. A color detector sensor will indicate the result of final color. It will check that either the desired color is generated or not. If not then the system will make the changes accordingly. Furthermore the system is not fully automated. System requires human efforts as well. It has manual liquid draining process which could be improved in future work.

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