Design for Automatic Automation for Batik Effluent Treatment System by PLC Controller Siemens Logo! 230RC

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Abstract

Automation of water treatment plant in batik industries has already been developed and widely used in Malaysia. However, the majority of the batik effluent treatment systems which is in small and medium scale batik industries are still using manual automation system. Unfortunately, by using manual automation system is time consuming especially when human supervision is required during a long cycle of batik effluent treatment. Therefore, this paper focuses on design of a system to cope with this problem by proposing a design of an automatic automation control system for batik effluent treatment embedded with Programmable Logic Controllers (PLCs) Siemens Logo! 230RC. PLC Siemens Logo! 230RC is used to communicate with input and output devices for batik effluent treatment system. The automatic automation system was designed and tested using a pilot plant which was installed at Nordin Batik and Craft, Kelantan. The results showed the overall time consumed by input and output devices (floating sensors, PH sensor, water pumps, blower and dosing pump) to treat batik effluent is t = 2 hours 25 minute per cycle. The comparison between automatic automation by using PLC to a manual technique in term of annual cost saving are analysed. As the results, RM 15101.30 is able to be saving yearly by using this automatic automation system. Hence, this system presented as an effective automatic automation system in term of reducing human supervision, time consuming and cost effective.

Keywords: automatic, PLC Siemens, batik effluent treatment

1.0 Introduction

One of the main cultural heritages associated with Terengganu and Kelantan people's way of life and economy is batik (Rashidi, Nik Sulaiman, Awanis Hashim, Che Hassan, & Davazdah Emami, 2016). Although batik production plays important role in textile industry it also as other wet textile processes, generates huge amounts of hazardous wastewater. Due to the presence of effluent in the batik production process, an efficient wastewater treatment is necessary to appropriately prepare related effluent conditions for further conventional wastewater treatment (Rashidi, Sulaiman, Hashim,

& Che Hassan, 2012). Basically, there are three key processes for treating batik effluents which are The Ventilation Process, The Neutralizing Process (the effluent solution of batik) and The Trapping Batik Effluent Process (using active carbon). However, in Kelantan's and Terengganu's batik industry, the automation system used for treating the batik effluent are based on 3 key processes which still uses manual automation control("*Garis Panduan Pelaksannan Amalan Industri Hijau bagi Industri Batik*," 2014).

Kraftangan Malaysia for example has produced a system called *Sistem Rawatan Effluen Batik* (SREB) as the treatment for large amount of waste discharge in batik industry. Based on SREB, the automation is operated manually (Bahagian Teknikal, 2014). Thus, a worker is required to operate the system. Currently the SREB has been deployed at several batik company such as Noor Arfa Batik in Terengganu, and several batik companies in Selangor (Bahagian Teknikal, 2014). The problem using manual automation system is time consuming because it is using human supervision to treat effluent batik during a long cycle, maintenance, cost and operation. Based on SREB system, it is found that manual automation can be improved by using PLC. PLC controllers can be integrated seamlessly in Industry 4.0 production environments using the service paradigm (Langmann & Rojas-Pena, 2016). PLC is also proved to be a versatile and an efficient control tool especially in industrial plant (Firoozshahi, 2010). Thus, by improvising the system from manual automation control to fully automatic control, the effectiveness of the automation can be widely used to be a model for all batik companies in Malaysia.

The aim of this study is to design an automatic automation system for the treatment of batik effluent. To achieve that, a control panel board using PLC Siemens Logo! 230RC are designed to communicate with input and output devices for batik effluent automation treatment system (Siemens, 2012).

2.0 Methodology

In this research, the pilot system is installed at Nordin Batik and Craft, Kelantan. The PLC Siemens LOGO! 230RC are used to control the input and output devices. The Ladder Logic Diagram was design to examine how it reacts to input devices, such as, Floating Sensors and PH Probe, as well as, PH Controller and output device which includes; 2 water pumps, a Blower and a Dosing Pump. The software used to transfer ladder diagram to PLC which runs the simulation is Siemens LOGO!Soft Comfort Version 8.1. Before the ladder diagram transferred to PLC, a simulation process is conducted. This is to ensure the design fulfils the specification requirements of Environmental Quality Act 1974, and the subsidiary legislation act (DOE, 1974). Figure 1 demonstrates the overall design and process for automatic automation control treatment of batik effluent. Reservoir tank is equipped with floating sensor while ventilation and neutral tank comes with PH sensor. All the sensors are installed inside the tanks. The water used in the batik pool will be pumped into the reservoir tank. All the automated system includes water pumps, blower and dosing process is controlled through one single control panel board.

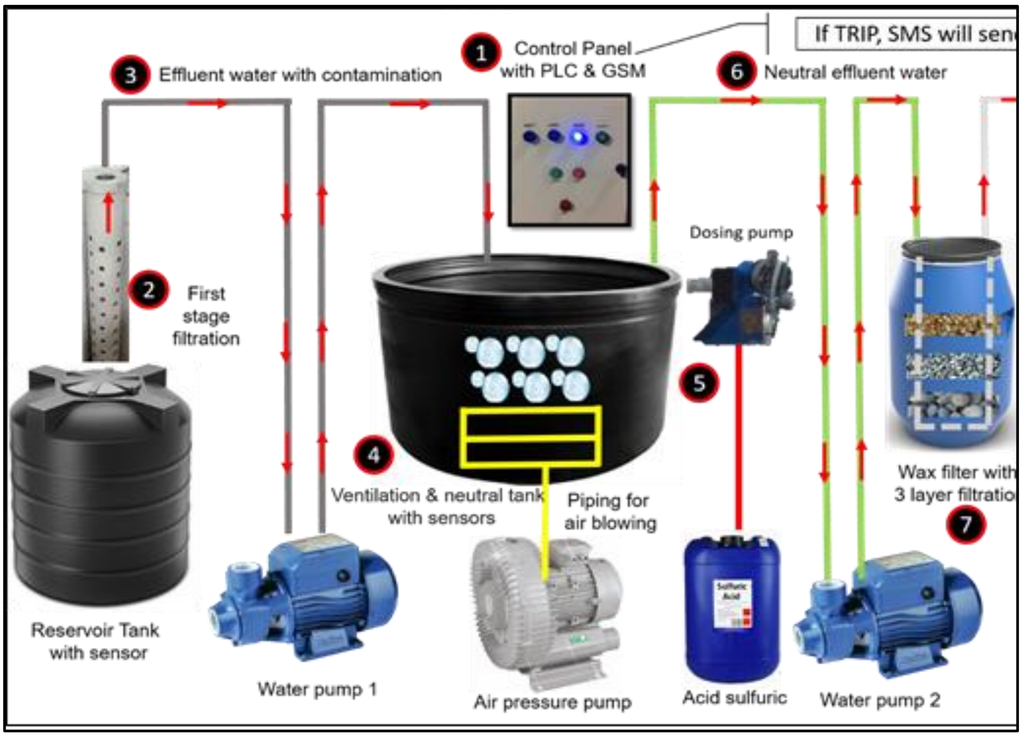

Figure 1: Overall design and process of automatic Batik Effluent treatment system

Thus, to enable the whole batik effluent automation systems, the push button START need to be ON. Then, the overall process will be operated in automatic mode. The operation times to treat batik effluent are recorded starting from the ventilation process which includes blower operation and neutralizing process which includes Dosing Pump and Water Pump 2. The purpose of recording the operation time is to ensure the consistency of the time operation of one complete cycle of automatic automation of batik effluent treatment system.

The batik water-washing residue in the reservoir tank will be pumped automatically to the ventilation tank. Candle particles contained in batik sewage water will be caught by the wax trap mechanism installed in the ventilation tank. When the ventilation tank is full, the blower is turned on automatically and the blower process will be operated for 2 hours 15 minutes to lower the level of Biological Oxygen Demand (BOD) and the Chemical Oxygen Demand (COD). The level of BOD and COD need to be lower to ensure the sludge and particles can be decompose (Wang, Gao, Zhang, Wang, & Gao, 2016). Once the BOD and COD levels are lowered, the dosing pump automatically turns on to titrate Sulphuric Acid. Sulphuric acid will be titrated into the water of effluent batik to reduce the value of PH to the permissible level between PH 6 to 9 (DOE, 1974). Once the PH value drops to the neutral and permissible level, the water will be pumped out automatically using Water Pump 2 to the tank containing activated carbon for filtering the colour before it goes to public drainage. Figure 2 shows the basic block diagram of the automatic automation for the batik effluent treatment system.

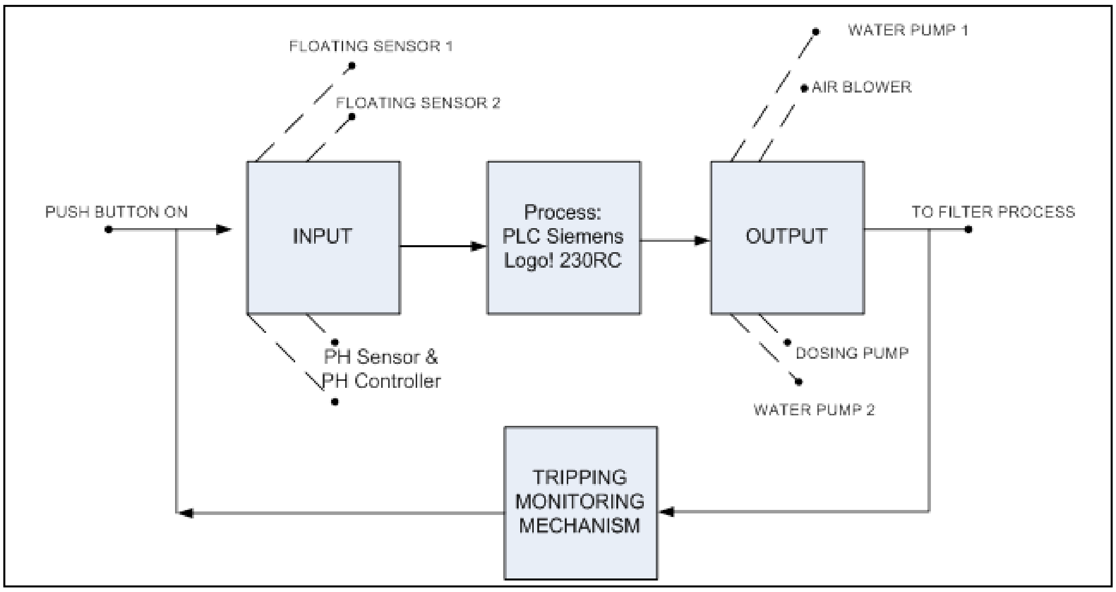

Figure 2: Basic block diagram of PLC Siemens 230 RC Logo! automation system

The model of this block diagram follows I – P controller model by Kotzapetros, Paraskevas, & Stasinakis, (2015) and Stephen and Horsley (2012). Basically, there are 3 main elements of this system. The elements are input, process and output. The input part consists of push button of the system, two floating sensor and PH sensor, and its controller. Push Button start is located in the front panel of the control board. Floating sensor 1 is located at the reservoir tank, PH Sensor are controlled by the PH Controller which is located inside the ventilation tank along with Floating Sensor 2.

This process is governed by the PLC function to process the input and give the response through output. Meanwhile the output part consists of water pumps, dosing pump and an air blower which will only operate when triggered by a signal from the PLC before functioning. The sequences of output devices function are stored in PLC by using Ladder Logic Diagram. It is designed by using platform Siemens LOGO! SoftComfort Ver 8.0. Apart from that, a precaution mechanism (tripping monitoring mechanism) for the main power supply trip or failure for the process is designed by using GSM module embedded with Arduino Uno Board to ensure user get immediate information of the failure. The Tripping monitoring mechanism will provide the information using Short Messaging System (SMS) to the user for immediate response or action. Figure 3 shows basic cabling route and electrical installation of automation part for batik effluent treatment system. The heart of the automation system is PLC Siemens Logo! 230RC. The automation system will automatically control the input devices and output devices with an operating voltage of 230 V AC, 50Hz. At the output, four contactors are used to trigger two water pumps, one air blower and one dosing pump to operate.

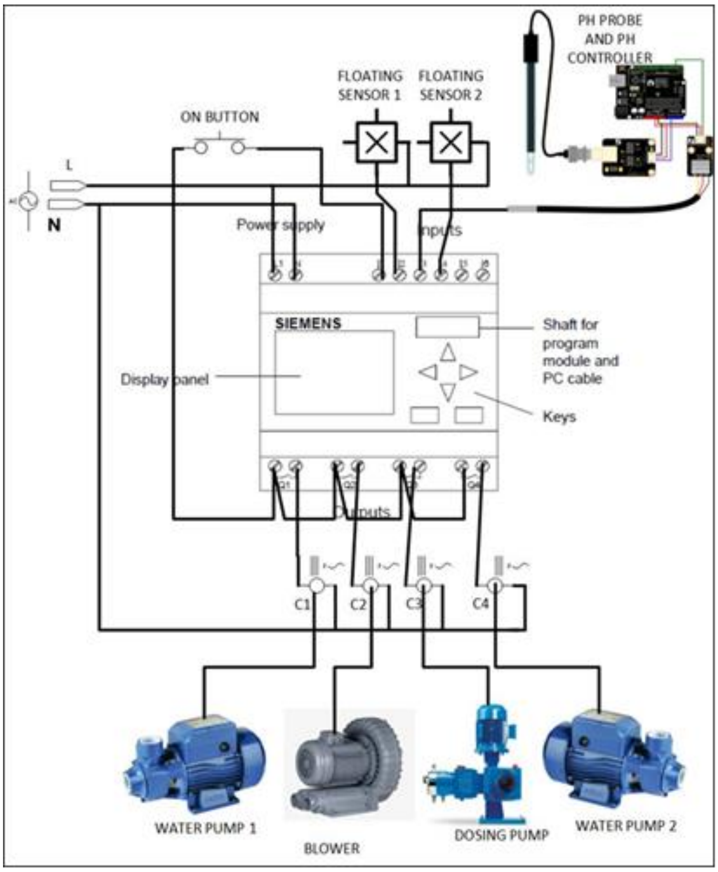

Figure 3: Overall cabling route and electrical installation

3.0 Result and Discussion

Figure 4 illustrates the assembly of accessories such as five contactors, Pilot Lamp, GSM module and protection device such as Overload, Main Switch, Residual Current Circuit Breaker (RCCB) and Miniature Circuit Breaker (MCB). This control panel board are installed to communicate with input and output devices for batik effluent automation treatment system.

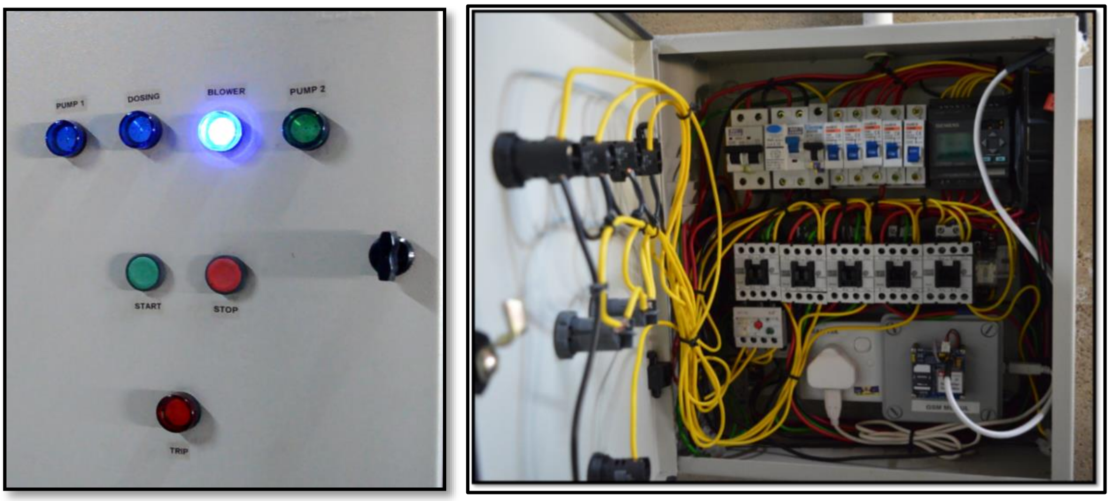

Figure 4: Automatic Automation Control Panel Board

It is clearly shown in Figure 4 the contactor drives, water pumps, blower and dosing pump. The pilot lamp is indicating the current process of the system. START and STOP button are used to on and stop the overall system. If there is trip in the system, GSM module automatically send a SMS to the supervisor and TRIP lamp is ON simultaneously.

3.1 Input and Output Devices Operation in Reservoir Tank

Table 1: Truth Table for Floating Sensor 1, 2 and Water Pump1

FLOATING SENSOR 1	FLOATING SENSOR 2	TIMING	WATER PUMP 1
OFF	OFF	-	OFF
ON	**OFF**	**T=10 min**	**ON**
ON	ON	-	OFF
OFF	ON	-	OFF

Table 1 shows the truth table of floating sensor 1, 2 and Water Pump 1. Floating Sensor 1 deployed in reservoir tank, Floating Sensor 2 deployed at Ventilation and Neutralize tank. When floating sensor 1 detects water (ON state) in reservoir tank, water pump 1 is ON. Then, batik effluents from reservoir tank are pump into ventilation and neutralize tank. When floating sensor 2 detects water at set level, floating sensor 2 is ON and Water Pump 1 stop pumping. Water Pump 1 only operates when Floating Sensor 1 is ON state and floating sensor 2 are in OFF state. The time to reach set level in Ventilation and Neutralizing Tank is T= 10 minutes in average.

3.2 Input and Output Devices Operation in Ventilation and Neutralize Tank

Table 2 shows the reading of PH Sensor, Dosing Pump and Blower state of operation. In Ventilation and Neutralize Tank, blower is turn on automatically when Floating Sensor 2 are ON state.

Table 2: Truth Table for Floating Sensor 1 ,2, Ph Sensor, Water Pump1, Blower and Dosing Pump

FLOATING SENSOR 1	FLOATING SENSOR 2	PH SENSOR	BLOWER TIMER	WATER PUMP 1	BLOWER	DOSING PUMP
OFF	OFF	PH >9.0	OFF	OFF	OFF	OFF
ON	OFF	PH >9.0	OFF	OFF	OFF	OFF
ON	**ON**	**PH >9.0**	**ON T=2h15m**	**OFF**	**ON**	**ON**
OFF	**ON**	**PH >9.0**		**OFF**	**ON**	**ON**

Blower process operated for T= 2 hours 15 minutes to lower the level of BOD and COD. Once the BOD and COD levels are lowered, the dosing pump automatically turns on to titrate Sulphuric Acid if PH > 9.0. Based on

(Khalik et al., 2015) most of PH value in batik water is in high value. This is aligning with finding in this research.

3.3 Neutralizing the Effluent Solution of Batik Process

Sulphuric acid will be titrated into the water of effluent batik to reduce the value of PH to the permissible level between PH 6 to 9. Table 3 shows that when PH value drops to the neutral and permissible level (7.0 >PH <9.0), Water Pump 2 automatically ON and treat water will be pumped out to the tank containing activated carbon.

Table 3: PH Sensor achieve 7.0 >PH <9.0

FLOATING SENSOR 1	FLOATING SENSOR 2	PH SENSOR	BLOWER TIMER	WATER PUMP 1	BLOWER	DOSING PUMP	WATER PUMP 2
OFF	OFF	7.0 >PH <9.0	OFF	OFF	OFF	OFF	OFF
OFF	ON	7.0 >PH <9.0	OFF	OFF	OFF	OFF	OFF
ON	**ON**	**7.0 >PH <9.0**	**OFF**	**OFF**	**OFF**	**OFF**	**ON**
OFF	**ON**	**7.0 >PH <9.0**		**OFF**	**OFF**	**OFF**	**ON**

The batik wastewater contained high value in all parameters especially COD concentration. This is align with Şahinkaya (2013) and Khalik et al., (2015) who reported that most of the textile wastewater has high salinity, high COD and pH as well as strong color. Thus, all the process aim of this system need to reduce PH and stabilize the value of BOD and COD to the valid value due to Environmental Quality Act 1974.

3.3 Manual Automation Compare to Automatic Automation Using PLC

Table 4 shows blower operation and dosing pump operation time recorded. Based on manual automation, it is found that the time consume to treat batik effluent is T= 4 hours per cycle. Time consume to treat batik effluent using Automatic automation is only T= 3 hours per cycle. Therefore, it can be concluded that the time consumed to treat batik effluent using automatic automation is faster compared to manual automation. In terms of power usage, by using automatic automation is more cost effective; RM 306.46 per year compared to RM 407.76 per year by using manual automation. In addition, by using manual automation, there is worker wage commitment need to pay. A total of RM 18K is needed to pay salary per year compared using automatic automation system, that only require RM 3K for the installation of the control panel board. Comparing overall annually cost, the company can save RM 15 101.30 per year by using automatic automation for batik effluent treatment system. Thus, from the finding, the effectiveness using automatic automation using PLC are align with previous study such as (Lira, Da Rocha Neto, Barros, & Van Haandel, 2003), (Jamil, Jamil, Jamil, Jinquan, & and Abdus Samee, 2013) and (Battistoni, Fatone, Pavan, Beltritti, & Raviola, 2008).

Table 4: Comparison between Manual Automation and Automatic Automation Using PLC

Item	Conversional Method (Manual Automation)	Automatic Automation Using (PLC)
Operation	*Blower Operation = 2 hours *Dosing Pumps Operation= 2 hours Total Hours = 4hours/Cycle Electrical Tariff(Industrial) (1-200KWH = RM 0.38 sen/KWH) <u>Power Usage:</u> 1. Blower : 746 W Total = 746 W x 2 hours = 1492 WH = 1.49 KWH x 0.38sen x 30 days = **RM 16.99 / months** 2. Dosing Pumps: 746 W Total = 746 W x 2 hours = 1492 WH = 1.49 KWH x 0.38sen x 30 days = **RM 16.99 / months** Total per month **= RM 33.98** **Total per year = RM 407.76**	*Blower Operation = 2.5 hours *Dosing Pumps Operation= 0.5 hours Total Hours = 3 hours/Cycle Electrical Tariff(Industrial) (1-200KWH = RM 0.38 sen/KWH) <u>Power Usage:</u> 1. Blower : 746 W Total = 746 W x 2.5 hours = 1865 WH = 1.87 KWH x 0.38sen x 30 days = **RM 21.32 / months** 2. Dosing Pumps: 746 W Total = 746 W x 0.5 hour = 373 WH = 0.37 KWH x 0.38sen x 30 days = **RM 4.22 / months** Total per month **= RM 25.54** **Total per year = RM 306.46**
System	**Worker:** Wage = RM 50 / day x 30 working days Total = RM 1500 / month **= RM 18000 / year**	**Control Panel Board:** **Total = RM 3000/ year**
Overall Cost per year	**RM 18 407.76 / year**	**RM 3306.46**
ANNUALLY COST SAVING	**RM 15 101.30**	

4.0 Conclusion

This paper presents an extension and an improved method from manual automation system to automatic automation for batik effluent treatment system. The control panel board are develop and Siemens LOGO! 230 RC PLC are proven can be communicate automatically with input and output devices for batik effluent automation treatment system. The results of comparison between manually automation control and automatic automation using PLC has been presented and has also been addressed. In conclusion, this research opens up a new avenue for the use of automatic automation control for batik effluent treatment system especially in medium and small scale batik industries in Malaysia.

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