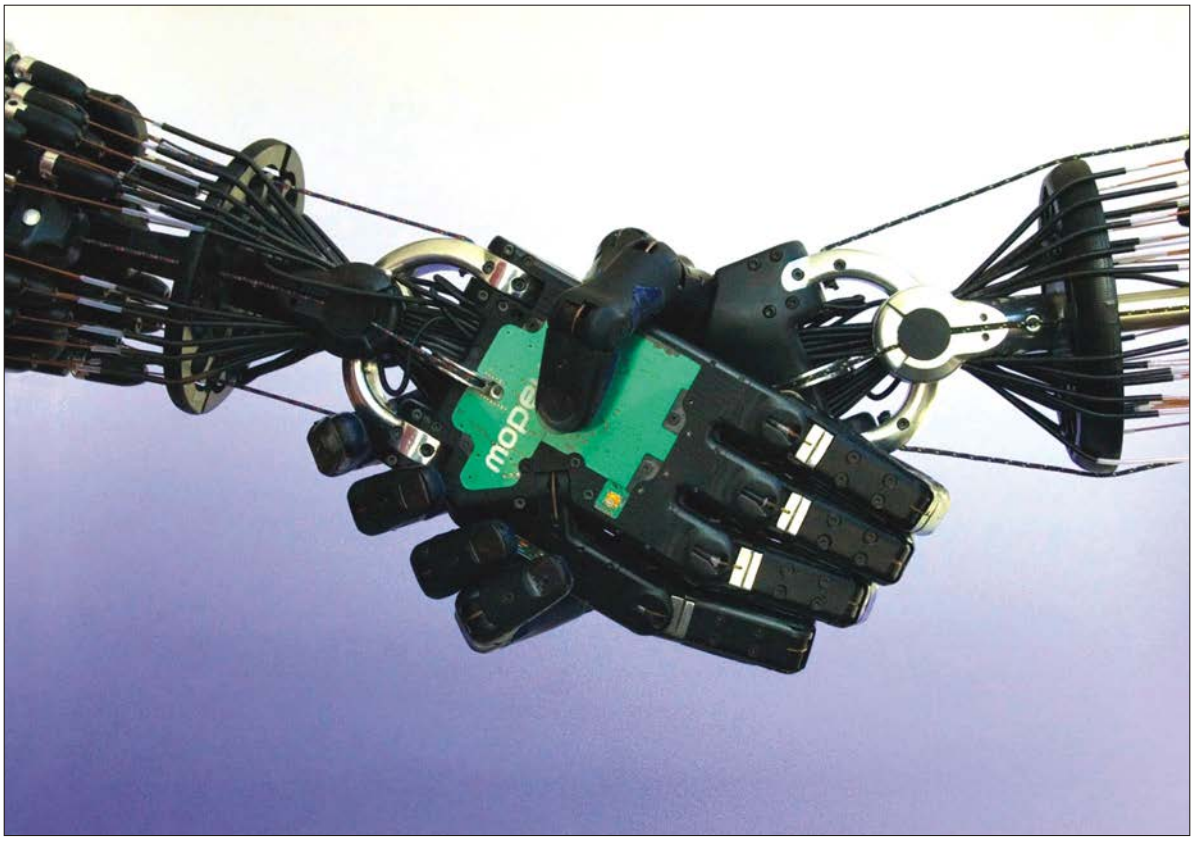

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Research Article
Development of Intelligence Technique in Shariah Compliance Washing Machine via PLC

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Abstract

Background and Objective: As in Islamic Fiqh (rule), the usage of flowing clean water is must during washing of the contaminated clothes. This study aimed to describe the integration intelligence technique of water inlet valve and optical sensor through the Programming Logic Control (PLC) in consumer washing machine. **Materials and Methods:** Washing machine that uses control technology to clean clothing is based on clothing weight factor proportionately to the amount of water used irrespective of the nature of the contaminants. **Results:** With the concept of algorithm system and integrated into the washing machine, the continuous running water was subjected during the initial wash and spin option. The light sensors used on both inlet and outlet valve ensure the contaminated solids or liquids and accordingly removed. In this study, a washing machine was modified on two major parts prototype of artificial water blend circulation which are hardwares containing modified washing machine, sensors and display, others were the software development of PLC which stand the most crucial part. Through the design of the hardware and software in this system, the water was supplied through the water inlet valve automatically when the switch is ON. The water inlet valve was also close automatically by setting embedded timer in ladder diagram in PLC software. The flow of water in and out of machine was influenced by the detection of optical sensor by execution instruction of PLC at spinning mode of washing machine, clean water flow into rotating drum that having clothes then flows out through water outlet valve. **Conclusion:** This novelty is not to deny the existing washing machine in the market but here is to introduce the best practise for complying Islamic Shariah on the flowing water technique in now-a-days washing machine. The water flow is expected to flow continuously in spin mode process which simultaneously for drying purpose.

Key words: Intelligence technique, PLC, water inlet valve, optical sensor, artificial water blend system, programming automation software

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Now a days, technology plays an important role in every aspect of human's life. Human needs technologies function that enable to complete their duty. One of the technology components is programming logic control or PLC. Using PLC, every work might be done automatically. Through the optical sensor, the signal was sent to the PLC to run the project[1].

Programming Logic Control (PLC) can be explained as a digital electronic device that use a programmable memory to store direction and to complete functions such as counting, logic sequencing, arithmetic and timing in order to control machines and processes. According to Selvaraj[1] and Amer *et al.*[2] the term logic was used because the programming is basically concerned with implementing logic and switching operations. The PLC used logic function or refers as programming instruction which is store in its memory via programming software to take action when the switch is ON[2,3].

Optical sensor is a device that converts light rays into electronic signals. Optical sensor need to communicate with PLC so that an automatic machine can be run. Optical sensor measured the physical quantity of light and transform into the form that can be read by the PLC. Ahuja and Parande[4] agreed that the optical sensor today are used in many research and application such as for quality and process control, metrology, remote sensing and medico technologies.

Water inlet valve or also known as solenoid valve is a valve that was controlled by the electric current through the solenoid. Solenoids can control the flow of water by compared action of the plunger along with the magnetic force that was created by the coil in the solenoid. The solenoids convert the electrical energy into the mechanical energy in order to opens or closes the valve mechanically. Razali[5] stated that automated valves are activated electrically, hydraulically or pneumatically and used to switch water on or off, flush filters, mains and laterals, sequences water from one field or segment to other. Implementation of PLC is important not only in agriculture sector, but also in the automotive machines, fisheries sector, food technologies and oil and gas industry. Malaysia which is famous in the oil palm industry, also using many automatically machineries in the production of oil palm. In order to increase the use of automatic system in the agriculture activity, the introduction of other use of PLCs in irrigation system is applied through this project.

There is insufficient capacity to produce enough food in the world in able to feed world's human population. Unfortunately, by the year 2050, the world's population would increase to 9 billion peoples. The increasing of the population with limited amount of food production, will lead human being to suffer from chronic hunger. The Food and Agriculture Organization [FAO] of the United Nations[6] stated that nearly 80% of poor farmers grow food but not enough to avoid hunger.

The FAO also pointed that it is essential to invest and create new products, technologies, processes and friendlier models to support the poor farmers, improve their resilience and enable them to produce more agriculture products in sustainable way. This is because mankind does not have enough energy and time to conduct a large scale agriculture production on theirs owns[6]. When running an agriculture farm, farmers need to ensure that their crops got enough food and water so that the production increases. Farmers have to do all the activities in the farm to protect their crops such as land preparation, weeding, irrigation, pest and diseases control and land clearing. All the activities cannot be done by farmers alone because there might be mistake or leaking somewhere when doing all the works themselves regarding their limit energy and time.

The production in agriculture sector still not highly improved in most developing countries in Malaysia because of the lack automatically systems or machines to carry out better agriculture production. Basically, in irrigation system with the huge farm, an automatic system of irrigation must to be implemented in order to increase the production of the crops. This is because water is the most important thing to a plant other than fertilizer and light. Some farm practice fertigation on their crops which is applying both water and fertilizer through the irrigation technique. The use of water in agricultural is dominates the human use of water with estimated average use is in the range of 70%[7].

So, the use of automation is important when handling a farm especially. One of the automation is PLC controller. This study focused more on the overview of how water inlet valve and optical sensor work through PLC to run the irrigation system.

Automation machineries are the most needed items in agriculture production now a days. Farmers seem comfortable to use automation systems in their farm which also include high technology systems such as GPS-based and vision-based. The technologies are included self-guided tractors and harvester. Using this tools, their work became less burden and more accurate. An automation issue arise at NAE[8], stated that one of the great achievements of agricultural machineries of the 20th century is a technology that created value in agricultural production practices through the more efficient use of labor, the timeliness of operations and more efficient input management with a focus on sustainable, high-productivity systems.

Meanwhile, the advancement in sensor technology and control system in agriculture contributed to optimum resources and integrated pest and disease management which is increasing the production of crops and at the same time reducing the human and environmental factor errors. Human errors can be like the wastage of water or the laziness of the human and the environmental errors such as heavy rains, flood and storm. Matthew and Susan[9] agreed with statement that they are various types of sensor and communication technologies are being used in order to provide data and perform analysis necessary to increase the productivity of water and to reduce the requirement in irrigation systems.

Unfortunately, according to Kamruddin[10], the level of input of engineering technologies into agriculture is generally still low in Malaysia. But, with this project on control of water movement through PLC, in future there will be more irrigation system based on PLC automation can be implement in agriculture industry in Malaysia. So, the production of crops can always increase in order to supply the food for the world population. The program was stored in a backed up battery's and in non-volatile memory. According to Amer *et al.*[2], in order to automate a process or machine, a PLC monitors inputs, makes decisions based on its program and controls outputs. The PLC consists of two major components which is hardware and software. Hardware is a main body of a PLC which controls the output from the PLC to other output devices such as solenoid, relay indicators, motors, coils device and so on. Meanwhile, software is a function program that was wrote in the computer PC and excreted to the PLC main body to perform the instruction. Kaldate and Kulkarni[11], stated that PLC system based on 3 different units which is PC, the software to configure the hardware, the PLC which contain input and output and last is the other devices that to be controlled by the PLC system. In this study, the software that was used to write the function program into the PLC hardware is CX-one programmer software which is available in the form of CD if purchasing both PLC controller. The function sequences were wrote in the PC and put into the PLC hardware using an adapter. The PLC then excreted the function in order to run the machine. The logic sequences were wrote using the ladder logic format which can be easily learned without further training.

The name derived from the form of the logic resembles a ladder. Lei *et al.*[12], stated that a ladder logic diagram consists of a vertical line on the left hand side, known as the hot rail and a vertical line on the right hand side, known as the neutral rail. The hot rails refer to the power or energized conductor while the neutral rail refers to the output or instruction. The rails were connected by lines or commonly known as rungs or network with several different symbols represents input and output. Based on the Amer *et al.*[2], the ladder logic diagrams were read from left to right, top to bottom.

In this study, an intelligence technique of developed washing machine was modified on an artificial water blend circulation which are hardware and software. The hardware part containing modified washing machine of sensors while the software part was the development of PLC. Through the design of the hardware and software for fulfilling Syariah Compliance concept in washing machine system, the water was supplied through the water inlet valve automatically. The water inlet valve also closed automatically that triggered by PLC software. The flow of water in and out of machine was influenced by the detection of optical sensor at spinning mode of operation, clean water flows into rotating drum then flow out through water outlet valve. By modified such mentioned hardware and software, the usage of flowing clean water is applied during washing machine operation.

MATERIALS AND METHODS

Materials: The materials used in this study were hardware and software which were as follows: PLC microcontroller (CP1E- N30DR-D), CX-one PLC programmer (software), E3X-HD11 omron fiber optic sensor, E32-DC200E fiber wire cutter, OMRON S8VK-G12024 power supply, OMRON MY2 24VDC relay, connecting wire, water inlet valve, wire cutter and water blend machine.

The hardware design of PLC included the input and output devices. For the input, the ability of PLC which can easily read the signal from various types of automated sensing or manually input field devices. In this study, the PLC was used to read the input from the optical sensor. Using the Central Processing Unit (CPU) which containing the microprocessor, the CPU interprets the input signal from the sensor and control the action based on the program installed through the software, this was supported by Kaldate and Kulkarni[11]. Meanwhile, output devices or commonly called as a controlled devices usually included relay indicator, power supply, solenoid valve and so on. The PLC will be able to excreted the instruction wrote by the software to the output devices and effect on the system performance. In this study, the output device was the water inlet valve which is to control the flow of water in and out.

The PLC controller that was used in this study was OMRON PLC model CP1E-N30DR-D which is suitable to control the switching on and off the inlet water valve through the optical sensor detection as shown in the Fig. 1. The

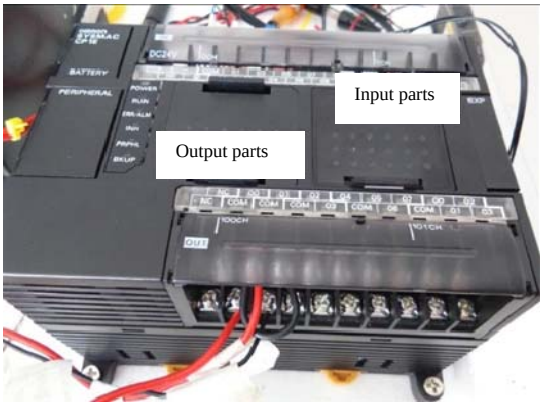

Fig. 1: OMRON PLC

Fig. 2: OMRON optical sensor

advantages of this PLC are it is a rugged and designed to withstand vibrations, temperatures, humidity and noise, it also already had interfacing for inputs and outputs inside and it is easily programmed and understood the programming language. Besides, this PLC also respond to the input and output faster with easily troubleshoot any problems occurs.

Optical sensor: Optical sensor is a device that converts light rays into electronic signals which is it measure the physical quantity of light and translate into a form that can be read by the instrument[4]. Optical sensor was used widely in numerous research and commercial application now a days such as process control, imaging, remote sensing, medico technologies and so on. The advantages of using this sensor are it has greater sensitivity, wide dynamic range, freedom from electromagnetic interference, multiplexing capabilities and have both points and distributed configuration. In this study, the E32-DC200E optical sensor from OMRON was used

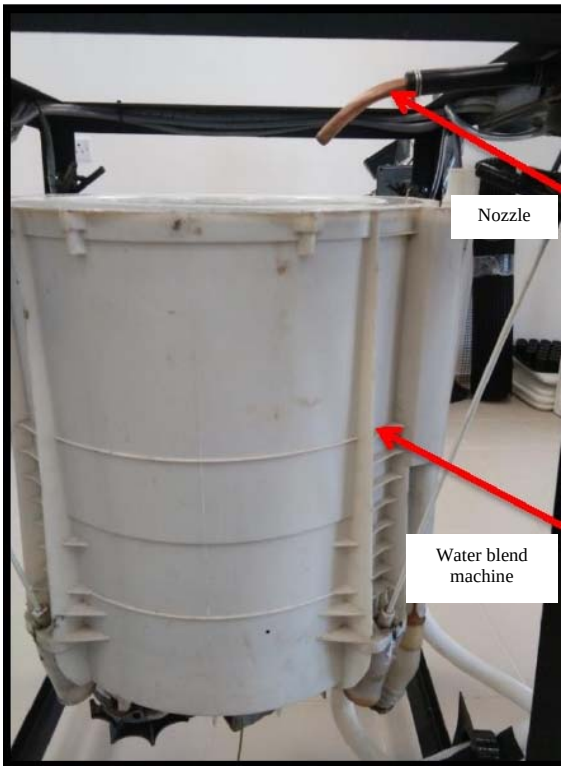

Fig. 3: Developed washing machine with nozzle

with the diffuse sensing method as shown in Fig. 2. The sensor was used to detect and diffuse the spin program and sent a signal to the PLC.

Water inlet valve: The water inlet valve was connected to one of the relays in the PLC system to automatically control the opening and closing of the valve. The valve controls the flow of water through a pipe line by the compared action of the plunger along with the magnetic force that was created by the coil and converts the electrical energy into mechanical energy which was related to the opens or closes the valve. The inlet valve had an electrical current that controlled the action of the valve[13].

Water inlet valve was connected to a nozzle in order to let the water flow into the tub of the water blend machine when spinning program detected. Water blend machine was a model to run this project completely. According to Yahaya *et al.*[14], using the concept of algorithm system and integrated into the washing machine, during the initial wash and spin option, the continuous running water will be subjected. So, the light sensor was used to ensure the contaminated solids or liquids were removed. The water blend machine which is used as an irrigation model in this experiment is shown in the Fig. 3.

RESULTS

Construction of model: The PLC controller was connected to the computer using an adapter wire. The CX-one programmer as a software program was run in the computer and the logic sequences for the experiment were wrote as in Fig. 4.

Software development: Software that used to write the logic function was CX-one programmer and the logic was wrote in the ladder form. The form that can be read easily by the PLC controller.

The ladder logic program show the complete result of the logic function that was executed into the PLC to operate the project described in Fig. 5. CX-one programmer software was used to construct the instruction using the ST language because it can be read easily by the PLC controller and can detect the error easily if there is any fault in the system.

The CX-one programmer is a type of software from OMRON industrial company that can be used to build, configure and program networks, motion control systems, PLCs, sensors temperature controllers and drives. After a construction of a logic program using a ladder logic program in the software, the logic was simulated online to ensure that the ladder is perform well followed the hot rail and neutral rail. The logic was transferred into the PLC controller and the result of the logic can be read easily by the PLC controller, this means that the logic program was wrote successfully. Output window can show an error occurred during the compiling, show the results of screening for contacts/coils in the list form and also show the detail of the error while loading a project file. Meanwhile, the information window is a display of small window to show basic shortcut keys in the software. Status bar is a segment that showed the whole information in the window and symbol bar can display the name, address or value and a comment of the symbol.

The CX-one programmer is an upgrade system from the embedded machine software that improved with many advantages. One of the advantages is easy project

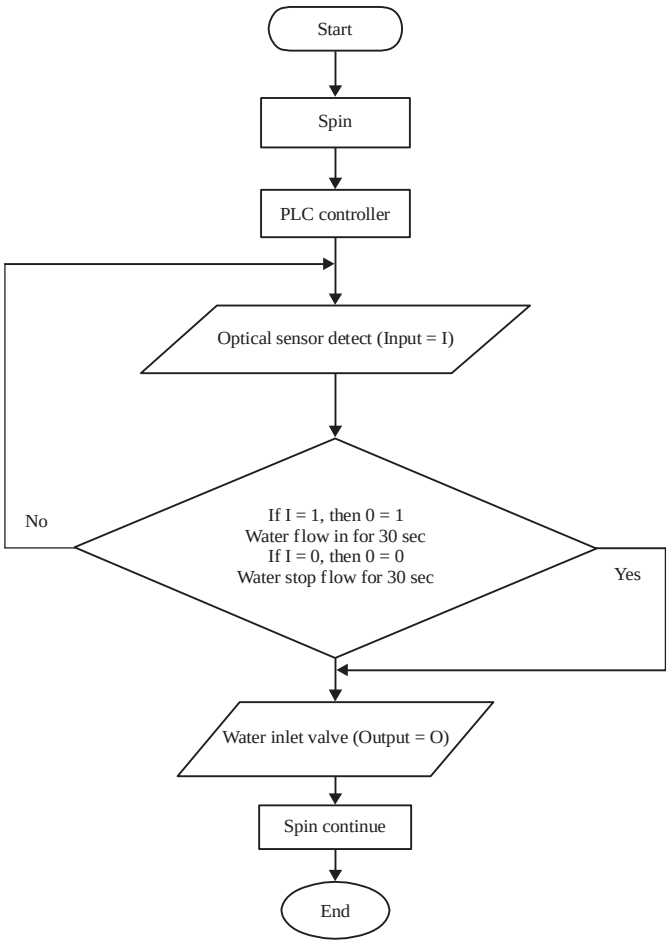

Fig. 4: Flow of construction model

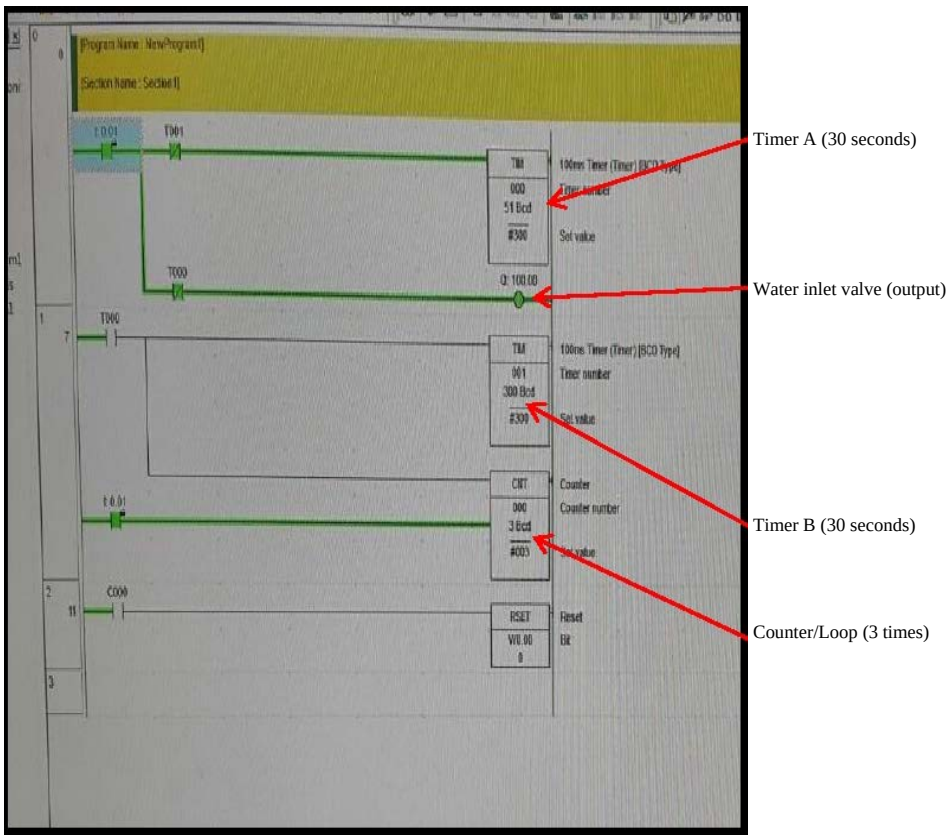

Fig. 5: Complete software system in CX-one programmer

management. This means that the logic program that was wrote using this software is automatically saved in a file in the PC and easily created a backup program even with different devices. Besides, this software is easy to use because it used the same general appearance of the software (menu, function, etc.) which can be reduces a training time. Moreover, this software is a package with the other devices which means after installing this software, the other devices like PLC, I/O special unit or CPU bus unit can be installed too.

Hardware development: All the development of the hardware and software were completed in this laboratory in order to avoid any error during this study. The full set of hardware systems, be functioned together after the connection using the connecting wires is shown in Fig. 6. It also showed a complete hardware system using the water blend machine as a model. Through this machine, all the hardware and software were attached to each other in order to run the simulation of an irrigation process.

Hardware: Hardware is the physical aspect of computers, telecommunications or other devices that was referred as a "box", electronic circuitry and a component of a computer that can be functioned when the software was installed into them. Hardware used in this project is including PLC controller, relay, power supply, optical sensor, water inlet valve and water blend machine. The most important hardware is PLC because it stored the logic program of the machine to control it automatically. Meanwhile optical sensor is used to detect the favourable condition of the project according to the logic program. Relay and power supply is a side hardware that have their own function to connect all of the hardware and run the machine. Water blend machine is a model to simulate this project based on the irrigation requirement.

The PLC has four basic stages of operations during the process that are repeated many times per second. Figure 7 shows firstly, PLC checking errors on its own hardware and software, if there is no errors occurs, PLC copying all the input from software and copy the values into memory which is called as input scan and this is the second stage. Thirdly, in the logic scan, the ladder logic program was solved using the memory copy of the inputs. The output values were changed in temporary memory during the solving. For the last stage, in the output scan, the outputs were updated using the

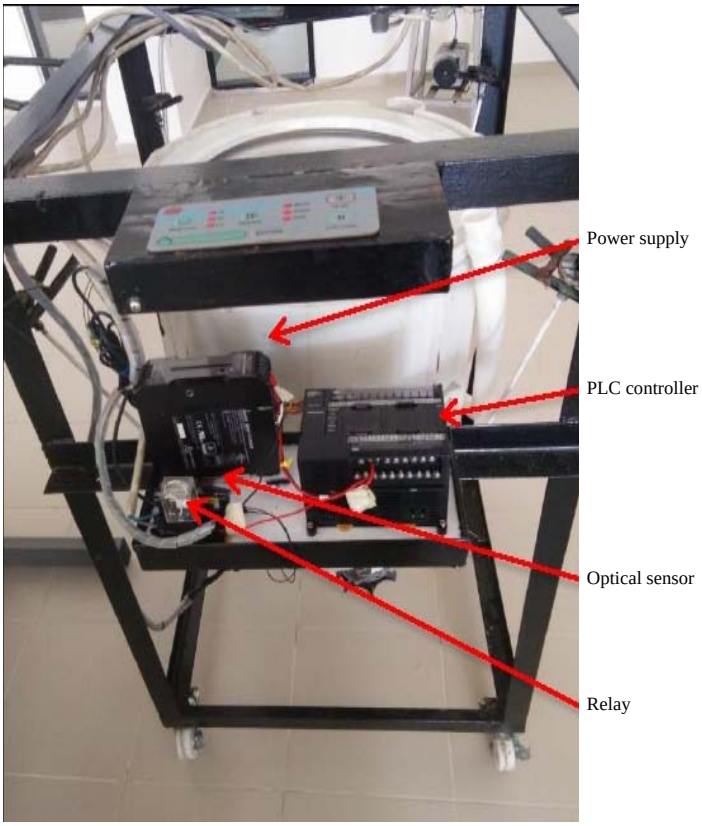

Fig. 6: Complete hardware system in water blend machine

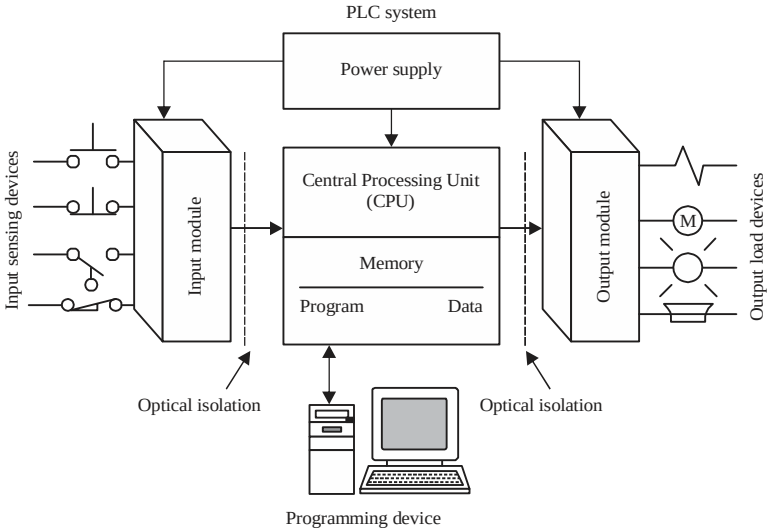

Fig. 7: A complete diagram of PLC system

temporary values in memory after the ladder scan was done. The PLC was restarted the process by starting a self-check for faults and the process was repeated 10-100 times per second.

The complete function of the optical sensor in this developed washing machine system is shown in Fig. 8. When the power is ON, the TUNE button automatically sets the emitter power and set values. The out indicator turns ON when the output is ON. The L/D indicator was used to indicate the setting status: Light-ON (L) or Dark-ON (D). The DPC indicator turns ON when dynamic power control is effective. Meanwhile, the ST indicator turns ON when smart

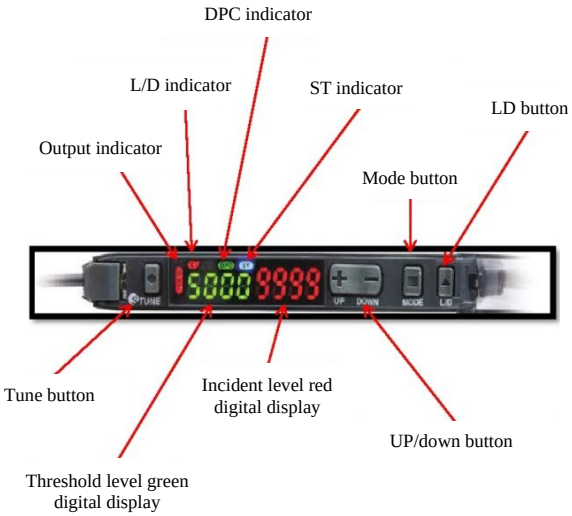

Fig. 8: E3X-HD11 OMRON optical sensor

tuning is in progress. The L/D button use to switch between Light-ON (L) and Dark-ON (D). To adjust the mode, the MODE button was used to switch between detection mode and setting mode. The UP/DOWN button used to fine-tune the threshold or change set value.

Water inlet valve used in this project is to regulate the flow of water by opening or closing the valve electrically. When there is a signal from PLC, the water inlet valve was electrically energized and the valve was open to let the flow of water. But, if there is no signal, the valve was de-energized and no flow of water. This is because, when energized, a magnetic field builds up and pulls a plunger against the action of a spring and when de-energized, the plunger was returned to its normal position.

DISCUSSION

The PLC controller for this project was connected to the computer using an adapter wire. The CX-one programmer as a software program was run in the computer and the logic sequences for the experiment were wrote also that can be used to build, configure and program networks, motion control systems, PLCs, sensors temperature controllers and drives. After a construction of a logic program using a ladder logic program in the software, the logic was simulated online to ensure that the ladder is perform well followed the hot rail and neutral rail. Yahaya *et al.*[14] suggested on his conceptual design that the added value for modifying an existing washing machine in the market is to not disturbing current control system as in washing , spin mode etc. The logic sequences; the water was flow in through the nozzle for 30 sec when the optical sensor detected the spinning program. Similar function claimed that the PLC controller was sent the signal of the detection to the water inlet valve and valve open to let the water flow[1,2,5]. After 30 sec, the water inlet valve was automatically closed to stop the flow of water for another 30 sec and the optical sensor stop the detection of the spin. This program was loop for three times in order to test the efficiency of the flow of water by the water inlet valve with the signal detection from the optical sensor through the PLC instructions[15]. Next, the spinning program was continued until stop after the three times looping.

The output device that was used to execute the logic function is water inlet valve or known also as solenoid valve. Based on Bhawarkar *et al.*[16], a solenoid valve is a two port valve that was used to turn on and off condition automatically. The PLC was used in this project because it have so many advantages which is PLC can reduce the use of hard wiring that was associated with the conventional relay and power supply control circuits. The PLC also can increased reliability because once the logic program has been written and tested, it can be executed immediately into the PLC[17]. Using PLC also can reduce the cost because PLC was created to replace the relay control logic system. Besides, PLC also can response to any process immediately and can easily troubleshoot any problems because it has resident diagnostic and override function to trace problems and correct the problems.

Optical sensor used in this experiment is E3X-HD11 OMRON optical sensor which is a smart fiber amplifier unit with long term stable detection. This sensor was equipped with a smart tuning system with a press of a single button, it can automatically configures the setting to their optimum values. Besides, this sensor also is a new circuit design with GIGA RAY II element that can reduce power consumption by 25% over conventional models. So, this model can support energy saving and power in the equipment with no restriction to sensing distance and response time. The incident level and the light intensity will automatically compensate after the detection of dirt, vibration and LED deterioration. With the lighting element GIGA RAY II, this sensor can detect workpieces compensation without concern for colour and size because this lighting with the highest level stably detects large workpieces and low-reflective workpieces. So, this optical sensor was detected the vibration on the water blend machine model when the spinning program inserted and sent the signal to the PLC.

Software means that a data, a program or an instruction from a computer which can be stored electronically. Software used in this project to write an instruction or logic is CX-One programmer. The PLC, sensor and water inlet valve are a device that was used in most of this automation machine. The correlation of all the devices can automate the machine

successfully. Otherwise as recommendation, using a wireless error detector to detect any errors on the system and sent the signal to the owner via SMS or other social networks will be useful. Automatic adjustment of the threshold level green digital display and incident level red digital display on the optical sensor amplifiers based on the machines requirement. Using PIC microcontroller to conduct the machine more easily because it is a compact microcomputer design that are relatively cheap and can be bought as kits which can easily assembled by the user. Using intensity-based vibration sensors to detect the vibration without any errors. According to the Steffi *et al.*[15], the core part of the automation device are battery, sensors, PLC, solenoid valve and etc, where it controls the electromagnetic valve with low-power technologies to open by using electronic circuits. Maheshwari and Sindha[13] also stated that an automation system with PLC have many advantages that is it is very flexible as only one single PLC can easily control many machines. In this project, the water flow is expected to flow continuously in spin mode process which simultaneously for drying purpose.

CONCLUSION

It is concluded that this project is successfully functioned after the simulation of this program on the machine model was done. This project which differentiate into two major parts need to interface with each other to run the system without any failure. The PLC controller can be referred as the brain of this project because it controls the whole process. The PLC was controlled the water flow from inlet valve which was triggered by optic sensor that purposely to detect the speed of rotating drum of washing machine. The technique used on continuous flowing of water in the development of washing machine and introduces best complying Islamic Shariah on flowing water techniques.

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SIGNIFICANCE STATEMENT

The PLC is an important device in the automation industries which can control any machines because it is a digital computer and was designed for multiple input and output arrangement. In this project PLC worked with the software which is called as a programmable logic sequences to control an additional programme of water inlet valve in this modified washing machine. The technique on continuous water flow is used in this development of Shariah compliance washing machine. This novelty is agreed by Islamic scholar that follow Islamic Shariah law in washing machine.

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