Design of Wireless Control Mixing System of Liquids using Raspberry Pi Device

Mortada Mohamed Abdulwahab[1*], Ahmed Babiker[2], Talal Abdulrhman[3], Mohammed Elnoor[4]

[1] Faculty of Engineering & Technology, Gezira University, Sudan

[2,3,4] Alnour College of Science and Technology, Sudan

[*]corresponding author: murtadaabdelwahab@gmail.com

Abstract – *The use of automation technology in the field of mixing liquids assists to reduce errors in this process which improved the quality of products. Liquid mixing machines often require a number of workers in order to operate the machines which increases the risk to them. This paper proposes wireless design for mixing three different liquids using raspberry pi technology. The design aims to provide lower risk rates, lower cost and high accuracy. The mechanism of mixing the three liquids and filling the tanks is done automatically using raspberry pi and ultrasonic sensors. Users must have to login with the correct IP address and password in order to access the application using a Wi-Fi connection. The system consists of three sub tanks filling the main tank in specifec ratio for each one. The programming of this implemention is accompleshed using python language. The experimental results have proven that the system works successfully and it can be applied in a real environment.*

I. Introduction

Mixing liquids is an essential operation for most industrial process as such as juices mixers. In many cases these liquids are considered very dangerous due to their effects on human health such as chemical liquids., use this document as an instruction set. Therefore, the operation of mixing hazardous liquids must be done in high accuracy rates and using advanced control technology to reduce errors and avoid any possible effects on the work force. The operation which involves of mixing two different chemical solvent together to obtain a chemical reaction is the most important operation which required to be done carefully [1]. Mixing operation classified to three categories, liquid-liquid, liquid-gas and solid-liquid [2]. The design of mixing equipment which performs the desired industrial process developed rapidly.

The operation of mixing in industrial is a critical process must produce successful product. Failure in the necessary mixing process may cause dangerous effects, for example the poor process of mixing chemical liquids in medicine industrial process probably leads to produce failure product that has different properties and this result product can caused many death cases. The associated cost to solve consequences of these problems is very expensive [3]. Programmable controller devices such as microcontrollers have a memory unit to store the execution sequences of instructions. The significant of this paper is in using modern control unit and wifi automation system. The rest of the paper is organized into four sections as the follow: related works, brief overview of raspberry pi, methodology section which discussed the circuit design and the operation concept, then results reported for three operations cases and discussed.

II. Survey of Related Works

Mixing liquids is important process in different industrials operations especially if the liquids were hazardous. Therefore, a lot of research works were published in this field. Most of the published related works were depending on either microcontroller or PLC technologies. The mechanism of the used sensor is also differed where most of those works used volume sensor or level sensor. The design in this paper presents a design of mixing three liquids using the Raspberry pi device and used ultrasonic sensor to specify the tank level. In Raphael et al [4] explained a design based on microcontroller used for mixing drinks together and filing

the glasses, the system used three microcontrollers the system used water level sensor, the paper concludes that the system can serve the cocktail in five seconds. SaWanstry [5] in his paper presented microcontroller system that used AT8951 device. In this system volume sensor was used and the paper concluded that this system based on microcontroller provides minimal percentage error. Azman[6] in his master thesis design PLC system of mixing different liquids without using wireless technology, the operation starts by determining the quantity of volume for each liquid then the mixture process done until matching the required PH. Swapnil [7] review in his paper the controlling of liquid mixing and filling the bottles using three controllers PIC microcontroller, AT8951 microcontroller and PLC device. the paper concludes that the controlling system of PLC and SCADA overcomes all the drawbacks of the other systems. May [8] presented a design of liquid mixer control system based on PIC microcontroller, the system used ultrasonic sensor to specify the level in the mixing container, the paper concluded that the system works in accuracy for the specified juice. In Mini .S [9] the automation mechanism based on PLC , the design operation is mixing and filling bottles. In Harishandra et al [10] two liquids were mixed using PLC automation system the paper concluded that the system system performance satisfied for the required operation and the advantages of the PLC will overcomes its high cost. Wang et al [11] proposed siemens S7200 PLC design of mixing liquids and used liquid level sensor, the paper concluded that the design provides accurate control requirements. Muhammad F [12] presented PLC design of distillation and tank level, it used simple level circuit sensor consisted of probe, resistor and transistor when the water reaches a specific value the probe complete the transistor circuit and come to saturation state, the paper concluded that the mechanism was free of error Pratap [13] presented PLC control design of liquid mixer and offers monitoring by using SCADA, the design used level sensor and valves the paper concludes that the system provides reliable operation and useful in many manufacturing industries such as paint,ink and etc.

III. Raspberry Pi Technology

The Raspberry Pi is a small computer board, the first generation of Raspberry pi invented in the United Kingdom for the purpose of teaching computer science. The first model was successful and became popular which encouraged the efforts to improve several generations. The first version of Raspberry pi was based on Linux operating system, recently many others operating systems become available to run raspberry pi such as windows [14][15].There are many advantages of Raspberry pi such as easy programming , useful for all tasks the small and large task. It has the ability to add a

camera [16]. Raspberry pi has a 32 bit processor and it has USB 2.0 which allows the possibility of communicating with network devices over LAN adapter [17]. Earlier Raspberry pi applications were limited to home and science projects but it became widely used in many monitoring and controlling applications[18].Python language is the main programming language that used widely in programming raspberry pi, due its syntax programmers enable to explain their concepts easily in short code. Python was released in 1991 by Guido van Rossum to help programmers to create code for small and large scale projects [19].

IV. Methodology

The design uses the ultrasonic sensors which are involved to measure the liquid ratio in each barrel and when the level of liquids reach a value less than the reference level then a sensor will send a signal to Raspberry pi, which sends a signal to a thermocouple that open the pump to pump the liquid into a barrel by a certain percentage as the programmer specified**.** The basic components of the system are shown in Fig.1. It mainly consists of the following:

- Ultrasonic sensors: These sensors are used to determine the tanks level by measuring the distance that echo takes to arrive. The main advantage of this sensor that its response is independent of the color and other optical properties of the object [20].

- Raspberry pi unit: The control unit is the heart of design it responsible for all control processes filling and closing the subtanks and main tank.

- Pumps**:** The pumps are used to pump liquids from subtanks to the main tank when the sensor in the main tank is take a value less than the reference value.
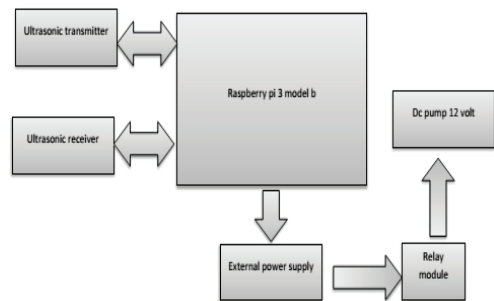

Fig. 1. Block diagram

Fig.2. shows the operation mechanism in which the system has accomplished the mixing process. The mechanism contains three pumps each one is responsible to pull the liquid from each subtank down to the main

tank with specific ratio automatically. Also there are three ultrasonic sensors to measure the levels of all the tanks continuously. Fig. 3 shows the real view of the design.
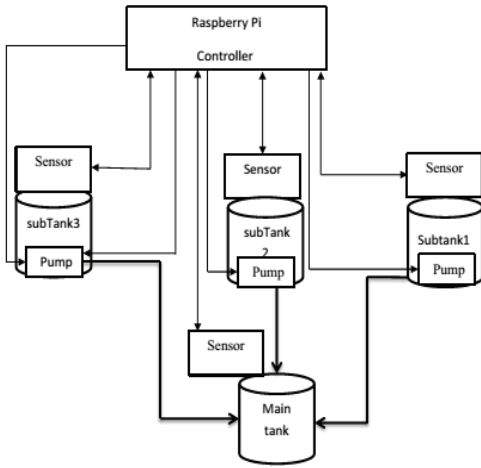

Fig. 2. Operation Mechanism

Fig. 3. Hardware Design

V. Software Implementation

The user can follow the steps that are shown in Fig.4. to access this application. The first step is to connect Raspberry pi with a wi-fi, this procedure requires login to a Raspberry pi using the appropriate IP address, the next step is to enter a user name and password to login. Finally issue the commands to run the application.
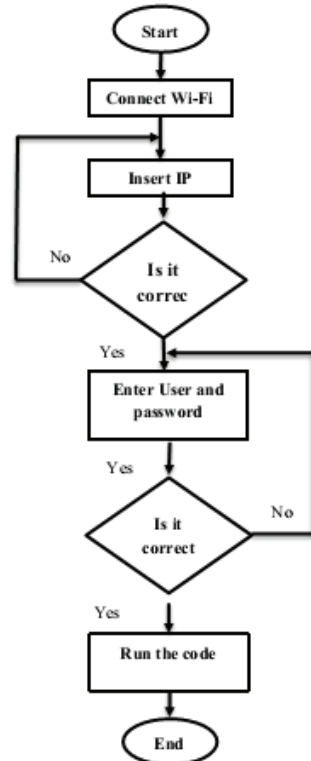

Fig. 4. User Flow Chart

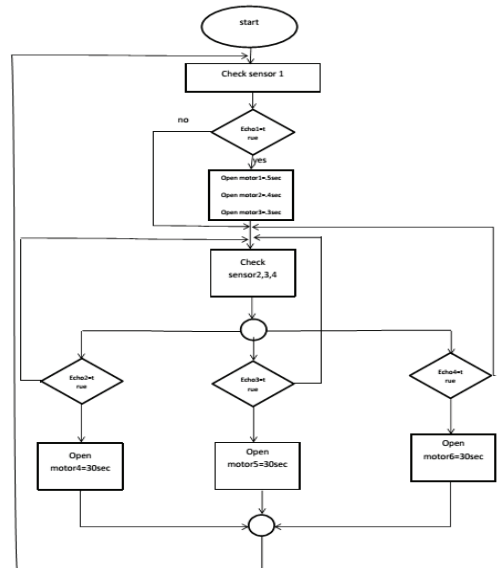Fig.5 Illustration of the operation algorithm of the system.

Fig. 5. Flow chart

When the program starts, it sends a signal to read the first sensor and test it. For a level less than the required value (reference level) the first motor will start working for specific time, the second and the third works for different times adjusted by the design operator as the process needs. The process continue to check the rest of sensors, at any time that it was the level less than the required level for each tank sensor then it will start it's motor, after this circle is closed and finish then it will start again from the beginning. The operation principle of the sensor is given by the following simple formula:

$$Distance = V \times T \qquad (1)$$

Where:

V : is the speed of sound
T : is the arriving time of the reflected wave from the target

The ultrasonic sensor has transmitter which transmits an ultrasonic wave in the air and the receiver unite receives the reflected back wave from the object.

VI. Results and Discussions

The experiment was done to investigate the behavior of the design in all the possible cases of operation. The first experiment case occurred when the level of the main tank was less than the reference value thus in this case all the pumps were opened, and each one operated for a specific time which can be adjusted by the design operator regarded to the requirements of the process. The measured level refers to the remain distance in the tank. In this case the Raspberry pi screen shows the message that shown in Fig.6.
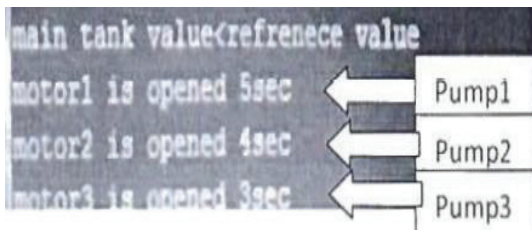

Fig. 6. Empty Tank

The second operation case when the level of the main tank reaches a value greater than the reference level. Therefore in this situation all the pumps were stopped automatically. In this case the Raspberry pi display unit shows the following massage as shown in Fig. 7.
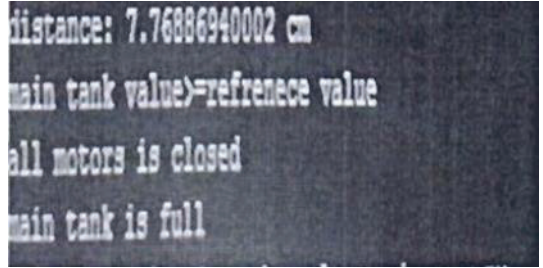

Fig. 7. Filled Tank

When the value of the main tank becomes closer to the reference level the raspberry pi sent the following warning massage in its display unit as shown in Fig,8.
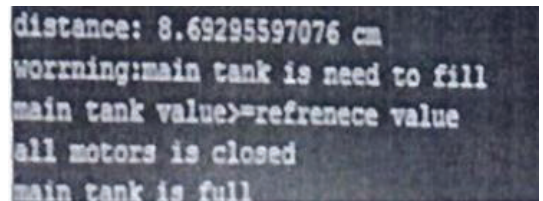

Fig. 8. Third case

The operating functions of this system are shown in Table I. The overall results show that the design works successfully in all operation stages.in the filling case all the pumps works in a specific time as the operator required, when the tank closed to fill a warning massage is shown and at the end of operation all the pumps were closed.

TABLE I
SUMMARY OF RESULTS

Case	Tank	Reference Level	Operation
First	Empty	≥10cm	Open Pump1 Open pump2
Second	Filled	≥7cm	Close all pumps
Third	Close to fill	10cm< level<7cm	warning massage

VII. Conclusion

This paper proposed an advance design of mixing three types of liquids. This design can be used for many industrial applications. The design consists of four tanks three of them are subtanks that used to fill fourth tank (main tank). Raspberry pi controller used to accomplish the control process automatically. The design offers remote control by using wi-fi technology. The programming language of the implementation is python. The design was successfully checked and gives reliable and reasonable results.

References

[1] Online. Sandip B., Mixing Liquids, accessed 1 De. 2019, <https://www.academia.edu/30390023/Mixing_of_fluids>.

[2] Raza.A,Abdul.A.A.Rahman Shaliza.I Saeid.B, " Liquid-liquid mixing in stirred vessels: A review",Faculty of engineering, university of Malaya,(2013).

[3] Edward L. Paul, Victorok A. Atiemo-Obeng, Suzanne M. Kresta," Handbook Of Industrial Mixing Science And Practice" , John Wiley & Sons, Inc,(2004).

[4] Raphael M, Ryan D. Danuel V. Luisito R. tomelden J.R.'' An automated microcontroller-based cocktail mixer and dispenser" engineering e-journal .vol. 1 no. 1, march 2007, pp. 111-125.

[5] A.S.C.S.Sastry, K.N.H.Srinivas, Ch V S R G. Krishna, ch.sesha kirankumar"an automated microcontroller based liquid mixing system", (ijcse) international journal on computer science and engineering. Vol. 02, No. 08, Pages:2648-2651. 2010.

[6] Azman. " Liquid Mixure Control System Using PLC",Master thesis submitted to faculty of electrical engineering , University of Tun Hussein onn Malysia,(2011).

[7] Swapnil R. k, Akshay S. kulkarni, Mahesh V, Soham S. Mundada,"Automatic liquid mixing and bottle filling - a review" International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering,Vol. 4, issue 1, ISSN: 2321-2004, January 2016.

[8] May H P, Nu .N W' 'Design of liquid mixer control system",international journal of scientific engineering and technology research(IJSETR),ISSN:2319-885. vol.03, issue.21,september-2014, Pages:4249-4255.

[9] Mini .S ,Shilpa.C ," PLC based automated liquid mixing and bottle filling system ", IEEE first International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES),Delhi,2016.

[10] Harishandra.M, Nikhil.P, Swapnil.D, Vaibhav.T,Kavita .P,"Liquid mixing and filling with PLC based on automation",international journal for scientific research& development, vol4,issue03,(2016) ,ISSN:2321-0613.

[11] Wan.Z,Wu.X,Zhang .D,Lin .F,"Design of Automatic Liquid Mixing Device based on PLC",Scholars journal of engineering and Technollogy,vol(4),no(3),pp:137-141,(2016).

[12] Muhammad Farrukh, Irfan Ahmed Halepoto, Bhawani Shankar Chowdhry, Hameedullah Kazi, Bharat Lal, "Design and Implementation of PLC based Automatic Liquid Distillation System", Indian Journal of Science and Technology, vol. 10, pp. 1, 2017.

[13] Pratap B, Ashish M, Ashish R, Subhashree S.B," Automated High Speed Color Mixing and Bottle Filling Process using PLC & SCADA", International Journal of Engineering Science and Computing, (IJESC),PP:10603-10605,Vol(7) No(4) April 2017.

[14] Online. Raspberry Pi, accessed 1 De. 2019, <https://en.wikipedia.org/wiki/Raspberry_Pi>.

[15] Maksimovi, Mirjana, et al. "Raspberry Pi as Internet of things hardware: performances and constraints.",*Design issues*, 3 (2014): 8.

[16] P. Green, J. Hughes, R. Mullins and R. Mullins, "Raspberry Pi- A Small, Powerful, Cost Effective and Efficient Form actor Computer: A Review," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 5, no. 12, p. 18, December 2015.

[17] Kortas, Nawel, et al. "Communication within Cloudlet using the Raspberry.",*Procedia Computer Science*, 73(2015): 193-198.

[18] Online. Raspberry Pi, accessed 1 Dec. 2019, <https://en.M.wikipeda.org>wiki>Raspb>.

[19] Guzdial, Mark J., and Barbara Ericson., "Introduction to computing andprogrammingin Python, a multimedia approach.",*Prentice Hall Press*, 2009

[20] Online. Electro Schematics, accessed 1 Dec 2019, <http://www.electroschematics.com>.