Journal of Techniques, ISSN: 2708-8383, Vol. 5, No. 3, 2023, Pages 101-107
DOI: https://doi.org/10.51173/jt.v5i3.1173

JOURNAL OF TECHNIQUES

Journal homepage: http://journal.mtu.edu.iq

REVIEW ARTICLE - ENGINEERING

Review of Design and Implementation of Automated Drugs Mixer

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Article Info.

Article history:

Received
09 January 2023

Accepted
10 March 2023

Publishing
30 September 2023

Abstract

Macromixing and drug control are becoming more essential in a wide range of chemical and biological applications. The efficacy of microfluidic macromixing devices, which are particularly beneficial to give an exact quantity of material at specified times, is greatly influenced by the infusion pump. The construction of a low-cost functional prototype of an infusion pump in the management of delivery rates that are variable and low in particular quantities is proposed in this study. The infusion pump may be seen working at various flow rates, proving that the device may be utilized to control the volume and rate of flow of chemical fluids in medical settings, in addition to microfluidic mixing investigations in specific and scientific studies, In general, the biomedical field.

Publisher: Middle Technical University

Keywords: Macromixing of the Drug; Pumping; Syringe Pump; Infusion Pump; Smart Pump.

1. Introduction

Smart syringe pumps are automated medicine administration systems created with the most modern breakthroughs in digital technology [1]. These devices may be utilized either independently or in a network connection with the help of the vendor's inbuilt software [2]. The software requires to decrease drug dosing inaccuracy for the stated drug dose and flow rate [3]. There must be no dosing errors that affect the patient's life [4]. Recently, a smart syringe pump has been developed with soft and hard alarm limitations for each medication, as employed in a variety of infusion pumps, including syringe and volumetric infusion pumps. Implementing control schemes allows for the adjustment of the desired medication flow rate in the MCPS framework [5]. Researchers have concentrated on a framework based on the Medical Cyber-Physical System (MCPS) by (FDA) Food and Drug Administration criteria to manage and regulate certain drug distribution [6]. This study consists of five sections, the first represents the introduction, the second contains previous work, the third represents the research methodology, the fourth represents the discussion and analysis of the results of previous work, and the fifth is a conclusion.

2. Previous Work

A publicly available open-source design for an easy-to-build and customize syringe pump was proposed by Bas Wijnen et al.[7]. in which functioning pumps have been created and tested. The design worked well when compared to significantly more expensive commercial models allowing nearly limitless customization and so should suit the requirements of a certain research activity needing a syringe pump only open-source hardware and software were chosen since they were freely available for pump design and construction, further validating the use of open-source approaches in the creation of laboratory equipment suitable for research.

I. L. Grassetti et al. [8]. have investigated the need for x-ray shielding for infusion pumps exposed to radiation; therefore, a safer and more cost-effective shielding approach is required. To lessen the risk factor, a casing material is provided with the composites. More development was required for greater efficacy and medicinal uses.

Luiz E. G. Martins et al. [9]. intended to build a low-cost insulin infusion pump for diabetes treatment because present pumps are too expensive. It had various disadvantages, such as lack of precision, unreliability, and certain parameters. It was beneficial for blood glucose and overcoming diabetes risk factors [10].

XialiHei et al. [11]. A wireless technique is considered for insulin pumps, where a pattern of infusion patients is illustrated. It identified the medication quantity, pace, and time of infusion and kept patients from being overdosed. The insulin pump is subject to a variety of threats. They are looking at two new lethal assaults that are aimed exclusively against wireless insulin pumps. A single acute overdose attack is the first

Nomenclature & Symbols			
MCPS	Medical Cyber-Physical System	EMI	Electromagnetic Interference
FDA	Food and Drug Administration	ICU	Intensive Care Unit

type of assault. The second form of attack is chronic overdose (underdose), which occurs when a small amount of medicine is administered over a lengthy period. It protects against the onslaught. They decided that the performance was satisfactory and that it might be applied to different infusion systems.

C. Luca et al. [12]. have addressed wireless approaches for reducing electromagnetic interference and carried out various trials to determine the source of equipment that disturbs diffusion pump operation and found that changes disappear when the source of disruption is removed and raised electromagnetic interference (EMI) awareness.

P. Pankhurst and Z. M. Abdollahi [13]. have created a portable micro-pump that addresses the shortcomings of existing pumps. It is simple to use and cheap. Its great performance, accuracy, and small erring size allowed it to be used in a wide range of medical applications. It enabled controlled pharmaceutical delivery in terms of dosage and time [14].

M.Deepalakshmi and Dr.R.Jayaparvathy[15].have presented a small-size and cost-effective integrated infusion pump system that is not currently available at a cheap cost in the Indian market. It controlled blood glucose levels within a certain range and delivered the appropriate insulin amount. They concluded that continuous monitoring was required, which may be viewed as a disadvantage of this approach.

Hasnaa ElKheshen et al. [16]. proposed an integrated system for tracking the patient's condition, as well as syringe pump recording. They were primarily concerned with patient safety. In emergency conditions, In the critical care unit, the patient's condition is not completely monitored (ICU).

The research was conducted by Erin Quattromani et al. [17]. to investigate if when compared to traditional ways, the smart pump app would be a more effective and exciting educational tool for junior nursing students. The application was assessed based on their knowledge and performance as learning infusion pump users. They labelled the app as an instructional tool since there was no difference.

Pooja Rajendra Prasad et al. [18] created a safe program for infusion pumps while keeping security in mind. It was regulated by including security into the Wireless infusion pump software architecture. When there was a lack of security, it provided information. However, the network was not secure.

Sakthivel Sankaran et al.[19]. proposed a study to describe a method for infusing the medicine consistently into the patient. Input data was virtually given and then analyzed to determine the motor's rpm according to the rpm at which the shaft rotates, which causes the medicine to be injected.

Md. Rakibul Islam et al. [20] developed a low-cost intelligent syringe pump for telemedicine applications. This syringe pump was intended largely for stationary usage at the bedside of the patient. It can be operated at various flow rates by adjusting the voltage across the armature of the dc motor using pulse width modulation. The deviation from the target flow rate was less than 5%. The device ensured continuous flow and had safety features such as all switches being locked when the pump is operating, a backup power source, and an alarm for failure alert. The GSM module is utilized for telemonitoring and telemedicine healthcare integration with cellular networks [21].

Kwan Young Hong et al. [22] developed many infusion pumps, all of which maintained satisfactory function with minor vibrations in this experimental investigation comparing the performance of several infusion pumps under clinically feasible vibrations. However, with moderate vibration, syringe pump flow rate variability rose above the known error ranges, and unintentional bolus injection occurred, although peristaltic pump flow rate accuracy was maintained. The redesigned cylinder pump demonstrated consistent pump performance and was not affected by external environmental vibration.

Hang Tran Thanh et al.[23].presented a low-delivery-rate syringe infusion pump with many channels for continuous and constant flow delivery in a microfluidic micromixer. This research was also concerned with the user's safety. The system's monitoring capability assisted users in avoiding dangers throughout the operating process. Controlling the syringe pump using a microcontroller and a functioning graphical user interface allowed for controlling many syringes at the same time or separately [24].

The researchers Ofoegbu M. C. et al. [25]. proposed the application of the IoT infusion pump, which was created and built to provide operational precision in medicine and fluid administration. The gadget was delivered with a volume dispensation of 10 ml every 5 minutes for the duration set. These delivery methods were compared using a stopwatch to determine the delivery time, and volume in time was measured using a graduated cylinder. The test observation results show that the range of set time was between 5-15 min according to the volume was 10 ml. In addition to observed time was 5.02-15.09 min and the volume is 10 to 30 ml and this indicated the system was a failure.

J. V. Alamelu et al. [5]. illustrated that implementing an automated control system is essential for reducing medication dose error, timed infusion under the threshold that assists even when there is a reduction in start-up delay in smart infusion the patient is subjected to several infusions. The work done looks to be useful for evaluating relevant control algorithms and designing an automated patient-specific medication infusion system [5]. The previous works can be summarized in the table below, as shown in Table 1 [8].

Table 1. Comparison of previous work

Researcher	Objective	application	Advantage\ Disadvantage	Results
Bas Wijnen et al.[2014][7]	creating and producing high-quality scientific equipment	Development of laboratory equipment.	Regulated of dose\individual syringe pump.	A publicly available open-source design for an easy-to-build and customize syringe pump has been supplied, and functioning pumps have been created and tested.
Isabella L. Grassetti et al.[2015][8]	studied infusion pumps	Clinical settings Diabetes.		

Luiz E. G. Martins et al.[2015][9]	They studied the syringe pump.	Wireless insulin pump.	Safety from radiation\regulated doesn't mention.	The findings of this investigation support the notion that there are X-ray shielding alternatives to lead.
XialiHei et al.[2015] [11]	Secure from harmful attack.		Adjustment of the insulin injection\not for all drugs.	Developing a prototype of a low-cost insulin regulator, which is in the testing stage.
C. Luca et al.[2016][12]	Security on medical devices.	Laboratory	Safety from electromagnetic field\x ray protects don't mention.	The result is secure by using an access control scheme.
P. Pankhurst and Z. M. Abdollahi[2016][13]	Design micro-pump.	Chemotherapy, Insulin delivery. Diabetics.	Safety from electromagnetic field\x ray protects don't mention.	The effect of the electromagnet disappears when the source of the equipment disruption.
M.Deepalakshmi and Dr.R. Jayaparvathy [2016] [15]	Design infusion pump.		Regulator the dose of insulin.	Dose error less than ±1%.
Hasnaa ElKheshen et al[2018][16]	Design of syringe pump.	Administration of drugs. Mobile app.	Monitoring, insulin delivery\individual infusion pump.	The glucose level in the body after insulin infusion. After insulin administration, it reduced progressively dependent on the system delivering what was expected and what was observed.
Erin Quattromani et al.[2018] [17]	Study smart pump.	Infusion pump.	Monitoring, drug delivery\ Safety from radiation.	The limitation of work was a delay in appearing in the monitor signal and solved by using a microcontroller (Arduino).
Pooja Rajendra Prasad et al[2018][18]	research on security concerns.	Infusion pump.	Adjustment of drugs\they cannot calculate the time.	The use of the smart pump mobile app for teaching smart pump infusions was a good alternative to traditional methods. This research on beginner smart infusion pump users used confidence and simulation performance metrics.
Sakthivel Sankaran et al.[2019][19]	Solving the bubble and amount of dose in the syringe.	Telemedicine.	Safety programming errors\didn’t study the amount of dose.	Development attack scenario.
Md. Rakibul Islam et al.[2019] [20]	Adjustment of the dose of drugs with the cellar network.	syringe pump.	Adjustment of the drugs and bubble detect\ individual syringe pump.	The accurate amount of dose with a specific time.
Kwan Young Hong et al.[2021][22]	experimental study.	Biomedical application.	Regulator the dose\ individual syringe pump.	The dose error is ±5%.
Hang Tran Thanh et al/[2021] [23]	Design a Triple Syringe Infusion Pump.	Clinical setting.	The effect of vibration on syringe pump\dose regulation didn't mention.	Apply a new-generation cylinder pump.
Ofoegbu M. C. et al.[2021][25]	Design drug delivery monitor by IoT.	medical applications	Macromixing of drugs\monitoring of the patient didn't indicate.	This study's technique will help in the creation of a new generation of intelligent syringe infusion pumps.
J. V. Alamelu et al.[2022] [5]	Design smart infusion pump.		To adjustment of drugs in IoT\individual pump. Regulator the time and dose of dopamine\X ray protect don't mention.	According to the Food and Drug Administration, infusion pump failure has been reported across numerous manufacturers and device types. By using automatic control to control the less dose error.

3. Research Methodology

In this study, sixteen related studies are reviewed in terms of comparison, as in Table 1. The research strategy entails analyzing (objectively and subjectively) the various factors in each criterion to demonstrate their convergence and divergence in dealing with accreditation standards. From that end, a block diagram of the proposed method is introduced according to the related studies, as in Fig. 1.

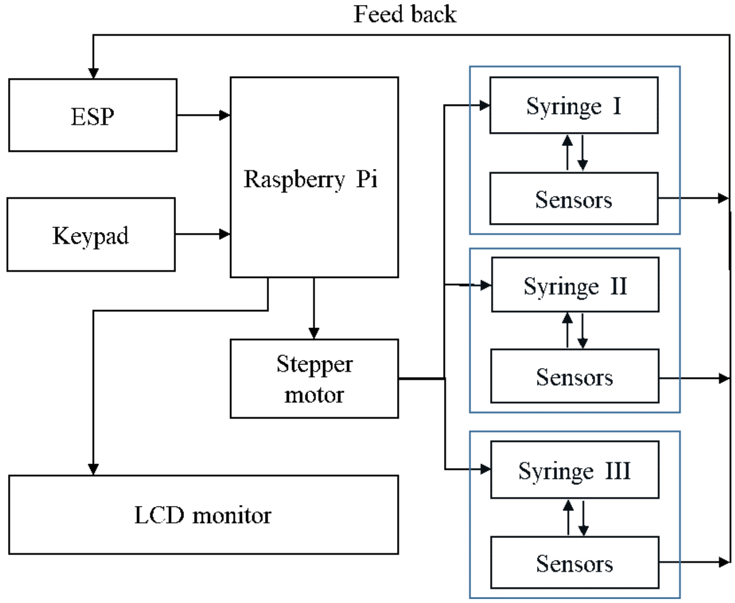


Fig. 1. proposed method

4. Results and Discussion

By discussing the previous research that was approved in the related work and the most important problems that were found to be solved in the design of the syringe infusion pump device, for example [19] the knowledge of the presence of bubbles and the level of treatment in the syringe was overcome by placing a bubble sensor and an IR sensor with the help of connecting the Arduino with the LabVIEW as showed in Fig. 2.

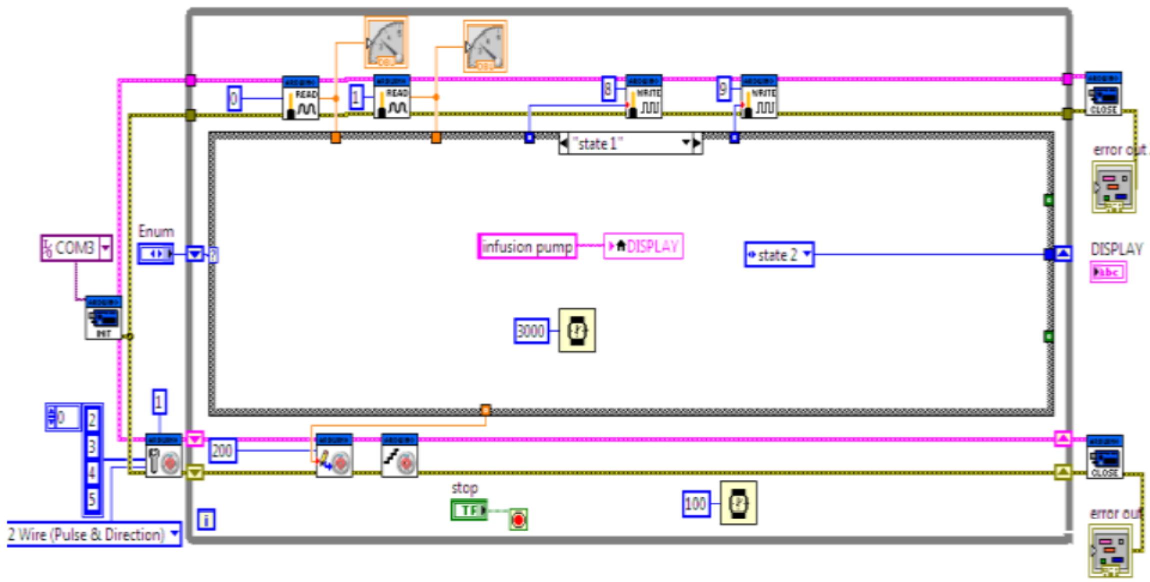


Fig. 2. Design of Lab VIEW circuit

In terms of security, to secure the syringe infusion pump device, and as was done in [11,12][18], multiple methods were used to protect against malicious attacks, for example in [12], the effect of electromagnetic field was studied, and they built testing protocol. Before the study checked the medical device in the lab, as shown in Figure 3, they studied seven devices from common sources, and they noticed the effect of the electromagnetic field, which disappeared. This effectively removes the source of the equipment disruption.

The syringe infusion pump device is used to calculate the percentage of dose error, on which the accuracy depends, so [13] reached better results than [20] by ±1% and ±5% for what they reached in [20], as shown in Fig. 4.

In the end, the syringe infusion pump device is not immune from vibration. According to [22], one of the phenomena affecting the syringe infusion pump and in cases of emergency transport of patients was studied by applying the new-generation cylinder pump theory, and this technique worked to convert linear motion into rotational motion, as explained in Fig. 5.

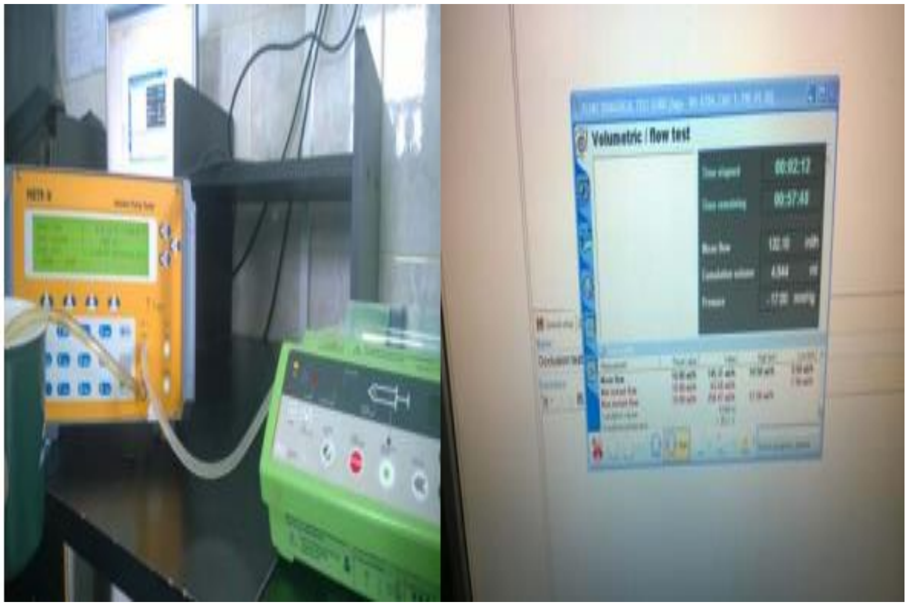


Fig. 3. Practical results in the lab

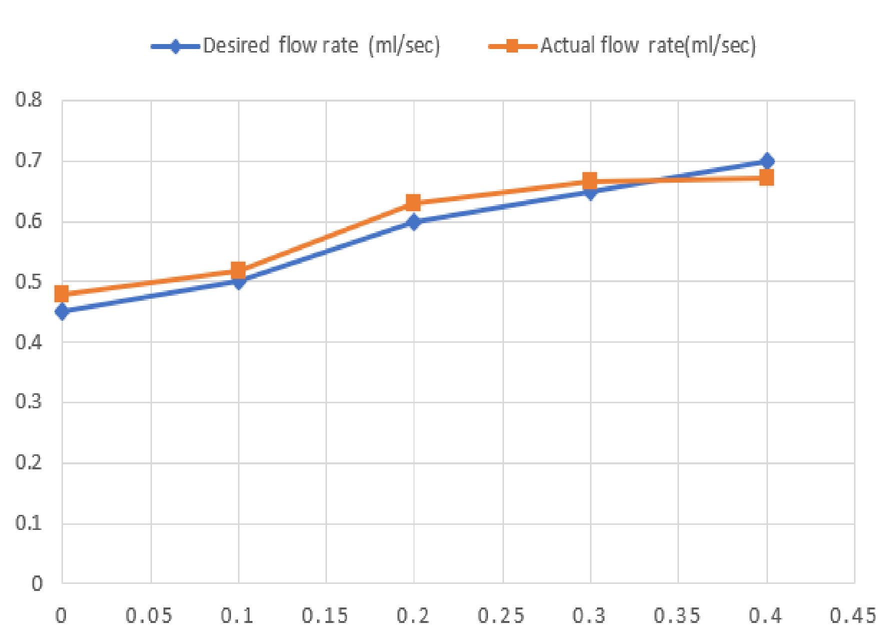
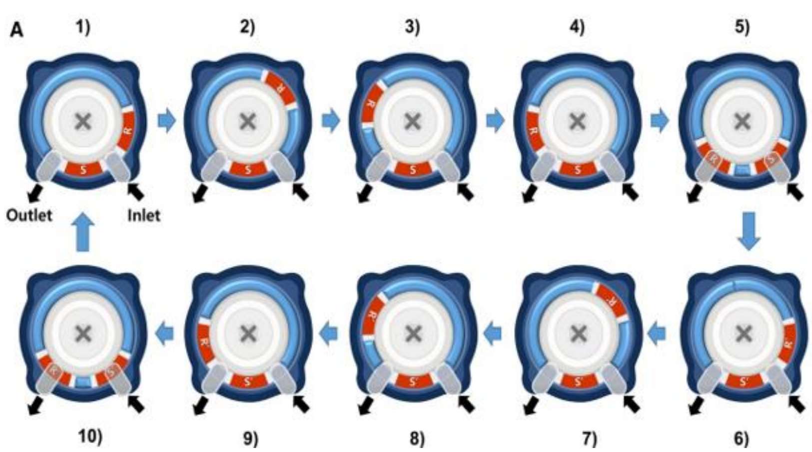


Fig. 4. The result of [9] the relation between the desired flow and actual rate



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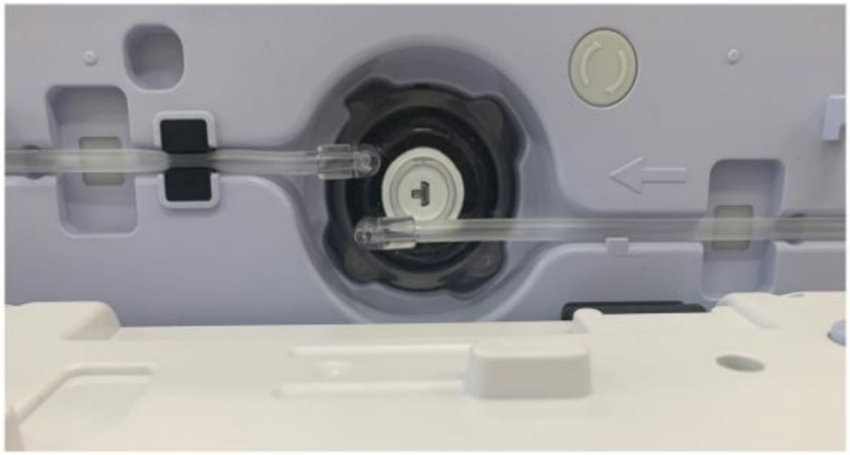

Fig. 5. a) New-generation cylinder pump's core technology, b) Illustration of a specialized cylinder cartridge

5. Conclusion

This study was prepared to review several types of research in the field of mixing and infusion therapy techniques for minimizing dose error and controlling the drugs and organization in the required time and the specified quantity to facilitate work on the medical staff through the medical syringe pumping device.

This study discussed the research reviewed above for the years 2014 to 2022. In the future, we can create smart gadgets to regulate medications to the patients and with specific time as adjustment for the staff with a multichannel low-delivery-rate syringe infusion pump with a microfluidic micromixer for continuous and stable flow distribution is presented for treatment and the biomedical area.

Acknowledgment

Thanks, and gratitude to Middle Technical University with the president and teaching staff. Thanks are extended to the Electrical Technical College, represented by the dean and professor, and to the Journal of Techniques staff.

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