TESTING DETERGENT PUMP CONTROL IN RESIDENTIAL WASHING MACHINES WITH FUZZY CONTROL METHOD

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Abstract-- Currently laundry service providers are mushrooming, this is because most people are busy with office work and activities, while homework cannot be ruled out, for example washing clothes. Cleanliness of clothes is an absolute thing that must be achieved. The thing that most influences the cleanliness of laundry results is the right amount of water and the appropriate detergent capacity. If the detergent capacity is adjusted to the water capacity and number of clothes, maximum results will be obtained. To overcome this, a detergent pump with fuzzy logic was made for the control system. Fuzzy logic provides a limit on the detergent volume adjusted for the input of water volume and the capacity of the clothes to be washed. For input data taken using a flow meter sensor to measure the volume of water used and a potentiometer to provide input weight of clothes to be washed. From the input data, the fuzzy logic method will produce detergent volume according to needs, so there is no excess detergent volume that can cause damage to clothes and reduce the live time of the washing machine. With a pump using a peristaltic pump, the resulting detergent volume is expected to be more stable. With the results of three volume variable experiments namely 20ml, 40ml, and 60ml obtained a maximum error data of 4.01% of the expected volume, the deviation of the desired detergent volume is not too much, so it is expected to reduce excess expenditure on the use of detergent. As for the fuzzy logic method that is applied can provide output results that are adjusted to changes in clothing weight between 5kg - 15kg and changes in the volume of water used between 37L - 56L so that it is expected to provide optimal results during the washing process. The system is designed using a maximum voltage of 12V DC and 3A current making this device low-power only 36 watts. This tool does not consume too much electricity.
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Keywords: Laundry, Detergent, Fuzzy logic, Pump, Residential

1. INTRODUCTION

The amount of busyness that a person does, makes it difficult for that person to have time to do homework, for example washing clothes. To overcome this, someone will wash clothes at the laundry which is currently mushrooming everywhere and can be found easily.

The cleanliness of clothes from laundry is absolutely something that must be achieved, damage to clothes is also something that needs to be considered. In this case, what affects both of these things is the condition of the washing machine and the detergent used. But the most important thing is the detergent used.

Usually, each laundry place uses a different type and capacity of detergent - different, powder type detergents sometimes leave stains on clothes if the results of the laundry process are uneven, stick to clothes and cause stains on clothes, so it is not uncommon for many laundry places to change detergent ingredients from powder to liquid detergent.

After changing to liquid detergent, the problem of stains from powder detergent that stick to clothes can be resolved, but new problems arise, namely that the clothing material becomes damaged or dirty stains do not really disappear, this is because too much liquid detergent is used, the clothing material will be easily damaged and if the liquid detergent used is less than the dose, the stains will not really disappear.

In detergents, according to Bajpai [6] contains active ingredients including surfactants, builders, fillers and additives. Active ingredients have their respective functions, namely: (i) Surfakatan serves to lower the surface tension of water, so as to release dirt attached to the surface of the material. (ii) Builder serves to increase the washing efficiency of surfacatan by deactivating minerals that cause water hardness. (iii) Filler serves for detergent additives that do not have the ability to increase washing power, but add quantity. (iv) Additives serve as additional ingredients to make the product more attractive, e.g. fragrances, solvents, bleaches, colorants, etc. Not directly related to detergent washing power.

In addition to the above problems, companies sometimes spend a considerable budget to provide these detergents, because customers sometimes pour a lot of detergent, they assume that the more detergent used, the more foam produced, the cleaner the clothes will be, while the reality is not the case. So that many laundry companies have to spend more.

Starting from the problems above, a tool is made that is used to make it easier for operators, cut excessive use of detergents which have an impact on the budget that swells, damage to clothes and washing machines if the detergent is too much and the foam is too much. From these problems, a detergent pump is made with a fuzzy logic control method, where fuzzy logic consists of three logic blocks, namely Fuzzification, fuzzy Inference, and Defuzzification. Where Fuzzification is the first step in taking input in the fuzzy inference process. It involves domain transformation where crisp inputs are transformed into fuzzy inputs. Crisp Inputs are initial inputs that can be measured by sensors and forwarded to the control system for processing, such as temperature, pressure, and others [10]. Fuzzy Interference Engine, its function is to evaluate rules simultaneously to produce conclusions and the order of rules can be randomized. Therefore, all rules must be defined first before building a Fuzzy Interference Engine [7].

2. METHOD

2.1 Research Location

The research was conducted at the Swiss German University Tangerang Workshop. Precisely at Prominence Office Tower.

2.2 Flow Chart

In this research, the first thing to do is to gather information about the problems that occur. Then do the design of the concept of solving existing problems. The design process is assisted using mechanical design software and electrical design software.

This research focuses on the efficiency of detergent use in residential washing machines. Making this concept refers to the flow chart which can be seen in **Figure 1.**

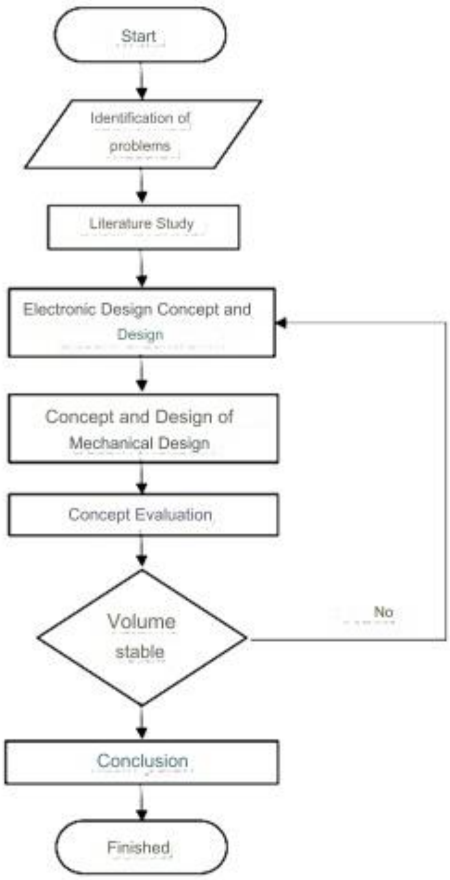


Figure 1. Flow Chart

2.3 Material and Methods

The tools used include an electronic circuit that functions as a tool to control the detergent liquid that will be used to wash clothes with a certain weight and volume of water. Scales serve to measure the weight of detergent. Measuring cup that serves to measure the volume of detergent flowed. So that the specific gravity of the detergent used is obtained.

In this study, the specific gravity of the detergent used was checked, checking the specific gravity of the detergent using a measuring cup and scales. To get the specific gravity using the following formula:

$$\rho = {}^{m}/_{V} \quad (1)$$

Where,

ρ = Density (Kg/m^3)
m = Mass (Kg)
V = Volume (m^3)

After obtaining the density of detergent, the calculation of the time required to pump the detergent to the desired volume is carried out. To get the maximum discharge from the pump, an experiment was conducted by taking 10 data by pumping detergent for 60 seconds and then taking the average discharge generated, from this data it can be calculated how long it takes to get the required volume. To get how long it takes to use the following formula:

$$Q = V/t \quad (2)$$

Where,
- Q = Capacity (l/min)
- t = Time (Sec)
- V = Volume (m^3)

In the last stage, testing was carried out on the flow meter used. Testing is done by measuring the frequency issued by the flow meter using an oscilloscope. Testing was carried out 9 times a trial with the amount of water discharge flowed different every 3 times the test. So that the data obtained can be compared with the data sheet provided by the flow meter so that it can be ascertained that the flow meter used is in accordance with the data sheet provided.

3. RESULT AND DISCUSSION

3.1 Function Structur

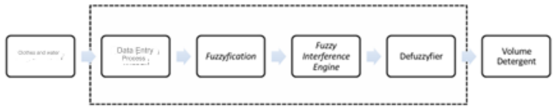


Figure 2. Function Structure on the pump

As seen above, how the process flow occurs from the start of the data entered is the weight of the clothes and the volume of water used to wash the clothes, then using a fuzzy logic system to process all the incoming data and until it outputs the volume of detergent needed for the washing process in the washing machine.

3.2 Electrical Concept and Design

After identifying the existing problems, the required information has been fulfilled, next is how to conceptualize the electronic design. In this electronic design concept, it is determined what components are needed for the Detergent Pump circuit.

The total input voltage used in the circuit is 24V DC and 12V DC, 24V DC for the input voltage on the peristaltic motor while 12V DC is the input voltage on the Microcontroller, so a fixed LM7812 regulator is needed which functions to reduce the voltage from 24V DC to 12V DC. To assist in the electronic circuit, Fritzing software is used which is currently open source software.

.**Figure 3.** Software Fritzing

Then for making the program or coding language, the author uses Arduino software which is also an Open source software.

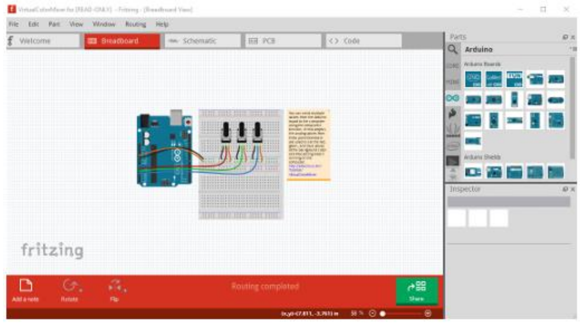


Figure 4. Software Arduino IDE

The Fuzzy Logic concept used is as follows:

Table 1. concept Fuzzy Logic

Variable	Water Volume 34 L < 41 L	Water Volume 41L < 49 L	detergent volume 49 L < 56 L
clothes weight < 5 kg	detergent volume 20 ml	detergent volume 30 ml	detergent volume 40 ml
clothes weight 5 < 10 kg	detergent volume 30 ml	detergent volume 40 ml	detergent volume 50 ml
clothes weight 10 < 15 kg	detergent volume 40 ml	detergent volume 50 ml	detergent volume 60 ml

3.3 Mechanical Concept and Design

In the concept and mechanical design, not too many things are considered, because it only follows from the electrical components used so that they can be arranged neatly and strongly.

In the concept and mechanical design, using solidworks software to assist in the design and concept. The results of the mechanical design obtained the following results.

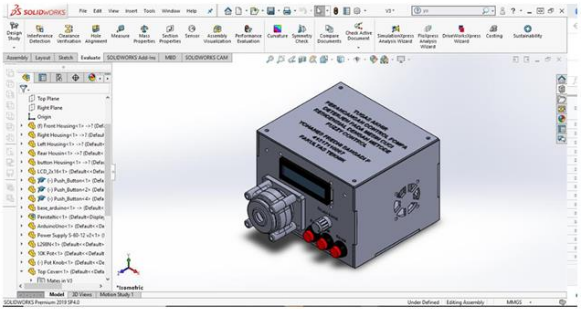
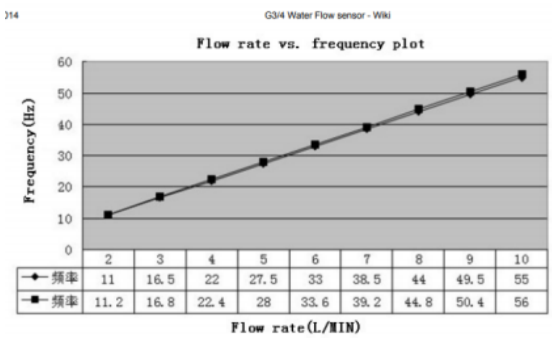


Figure 5. Detergent Pump Design



From the results of calculations and experiments that have been carried out, it shows that the density of the detergent used is approximately the same as water. As for the maximum discharge that the pump can produce tends to be slow compared to if the fluid flowed is water. This is because the viscosity of detergent tends to be more concentrated compared to the viscosity of water.

From the experiments conducted to obtain the maximum pump discharge with a maximum pump voltage of 12V and a detergent pumping time of 60 seconds, the resulting data can be seen in Table 2.

Table 2. Maximum pump discharge experiment data

No	voltage	Weight *m* (gr)	Capacity *Q (ml/min)*
1		152.5	153.27
2		154.3	155.08
3		150.3	151.06
4		151.1	151.86
5		153.1	153.87
6	12	152	152.76
7		152.1	152.86
8		150.8	151.56
9		150.3	151.06
10		150.9	151.66
Average		151.74	150.979

To facilitate the measurement of time, measurements are taken using a system that is controlled using Arduino.

From the data obtained in Table 2. Then it can be calculated the length of time needed to get the required volume of detergent. For the next experiment, 3 volume variables were determined, namely for 20 ml, 40ml, and 60ml. The calculation of the length of time needed to achieve the three volume variables can be seen in Table 3.

Table 3. Data on the length of time to reach the desired volume

No	Volume (ml)	Average pump discharge (ml/min)	Time (detik)
1	20		7.869
2	40	152.5	15.738
3	60		23.607

From the data in Table 3. The time value is entered in the system and the average volume obtained can be seen in Table 4..

Table 4. Actual volume data generated

No	Target Volume (ml)	Lowest Vol (ml)	Highest vol. (ml)	% Error
1	20	20.101	20.905	4.53%
2	40	39.889	40.603	1.51%
3	60	59.779	60.503	0.84%

Table 4. Shows the percentage error is low enough so that the efficiency of detergent usage can be achieved.

The last experiment conducted was on the flow meter used. Testing is done by measuring the frequency released by the flow meter using an oscilloscope. The data obtained is compared with the data sheet provided by the flow meter.

This is done to calibrate the flow meter whether the measurement results of the flowed water discharge are in accordance with the act. The graph of the results of the flow meter frequency test can be seen in Figure 6

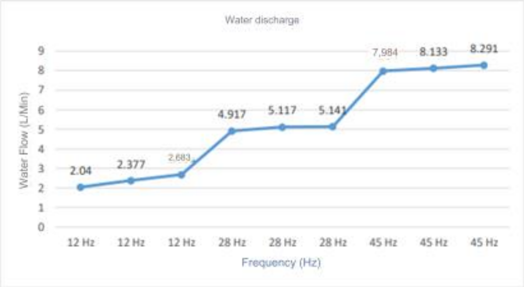


Figure 6. Graph of experimental results of flow meter frequency readings

From the graph above, it is then compared with the graph from the flow meter data sheet used. The flow meter graph used can be seen in **Figure 7.**

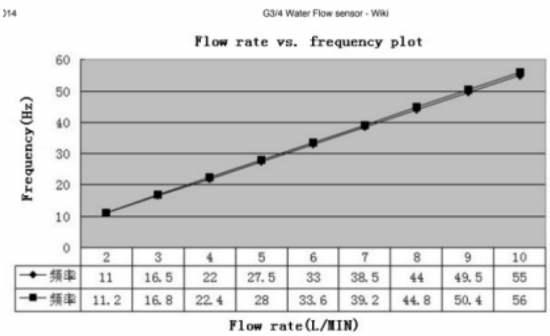


Figure 7. Data sheet graph of the flow meter used

4. CONCLUSION

Based on the experimental results of designing a residential washing machine detergent pump using the fuzzy logic method, it can be concluded that:

1. The use of peristaltic pumps in the application of detergent pumps makes the volume of detergent flowed quite stable, can be seen in **Table 3**. Up to **Table 4**. by showing a percentage error of 3-5% of the desired detergent volume target, so that the target to make more efficient use of detergent can be achieved.
2. The use of a fuzzy logic control system can be arranged flexibly because fuzzy logic can adapt to changes and uncertainties in the weight of clothes and the volume of water used.

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