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Operation System of Washing Machine with Fuzzy Logic Control System and Construction of Detergent box

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Abstract- In this paper, a normal household washing machine, which is used very often, is modeled with the help of Fuzzy logic. Fuzzy logic uses statements instead of mathematical model for solving a given problem. This paper describes the automatic water and detergent filling for processing time (wash, rinse and spin) of washing machine with fuzzy logic control system. The design of fuzzy logic controller having three inputs and three outputs fuzzy logic variables of washing machine. The three inputs are type of clothes, amount of clothes and amount of dirtiness. The three outputs are wash time, rinse time and spin time. Fuzzy logic control system can be used to calculate the processing time of washing machine for different cloths. The aim of this system is to automatically fill the water and detergent and to get correct the processing time of washing machine. In this paper, the amount of water and detergent will automatically fill into the tub and not to refill the detergent after finishing the washing process one time because the detergent box is constructed and it can be filled full detergent powder.

***Index Terms*— Fuzzy Logic Controller, Water Level Sensor, AC Motor Driver, Construction Detergent box, MATLAB Software**

I. INTRODUCTION

Washing machine is commonly used household appliances. These machines have three important performing processes. They are washing, rinsing and spinning processes. There are mainly three types of washing machine, namely, semi-automatic, full-automatic, and washer. Semi-automatic washing machine consists of two tubes, one for washing and rinsing and other for spinning purposes. In these machines the controls are not fully automatic and manual intervention is required. Whereas the fully automatic washing machine have a single tub which serves as the washing, rinsing and spinning processes. In these machines, manual intervention is not required. Washers are single-tub machines that only wash. Since washers don't have the facility, these cost less than semi-automatic and fully automatic washing machines [1].

The problem of washing machines are selecting the amount of water and detergent, the length of wash time, rinse time and spin time based on the different clothes[2]. Moreover, the user of washing machine need to fill the detergent when once use time. Most of the people find it very difficult to decide that which cloth needs what amount of water and detergent and processing time. So, they approximate their processing time for washing machine [3].

In this paper, the detergent box is constructed and tested the water level of washing machine by using the sensor. The basic structure of fuzzy logic controller model for processing time of washing machine is described in MATLAB simulation and the microcontroller is improved to be Fuzzy Controller and designed hardware components by testing results in simulation before implementing to apply in the real world. The design of fully automatic washing machine is performed the experiments on hardware implementation by using Fuzzy IF THEN Rules in a program.

II. FUZZY CONTROL SYSTEM FOR WASHING MACHINE

The Fuzzy Logic Controller for washing machine consists of three linguistic inputs. They are-

- Type of clothes
- Amount of clothes
- Amount of dirtiness

Types of clothes are separate as thin clothes, thick clothes and jean clothes. Amount of clothes and amount of dirtiness are separating as little, normal and large.

The fuzzy controller takes three inputs, processes the information and gives three outputs. All the above LIs control the three Linguistic Outputs i.e.

- Wash time
- Rinse time
- Spin time

The basic structure of fuzzy logic controller for washing machine is shown in fig 1.

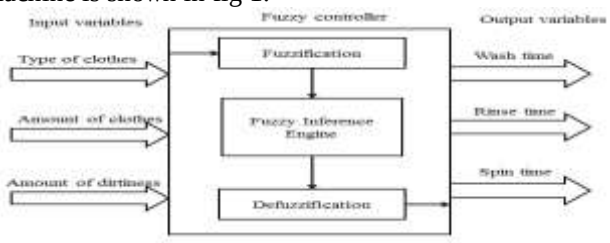

Fig1.Fuzzy Logic Control for Washing Machine

Fuzzification aims to convert a single (crisp) input value into corresponding fuzzy-set values. Inference Engine that it infers from the rules applied to it and depending upon the inputs derives the output for the desired applied input. Defuzzification is finally carried out to obtain a crisp output

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value using a very popular technique known as the "center of gravity" method [4].

In the washing machine, the amounts of clothes that fill into the tub depend on the washing machine tub. Therefore, there is various size tubs for washing machine but this system considers depend on the 6.5kg size. This size of tub can be washed maximum 20 clothes for thinness, maximum 15 clothes for thickness and maximum 8 clothes for jean. The amount of water can be fill maximum 50 liters. Input variables are separated as depend on the above factors and output variables are separated as depend on the real work. Every Linguistic inputs and outputs has a set of membership functions (MF). The MF used for all LIs and LOs is triangular MF. The parameter is used to define MF are shown in TABLE I to TABLE V.

TABLE I
AMOUNT OF CLOTHES

Membership function	Range(no. of clothes)		
	Thin Clothes	Thick Clothes	Jean Clothes
Little	1 to 6	1 to 5	1 to 3
Normal	5 to 15	4 to 10	2 to 6
Large	14 to 20	9 to 15	5 to 8

TABLE II
AMOUNT OF DIRTINESS

Amount of dirtiness	
Membership function	Range (%)
Little	0 to 40
Medium	30 to 80
Large	70 to 100

TABLE III
WASH TIME

Membership function	Range(sec)		
	Thin clothes	Thick clothes	Jean clothes
Short	0 to 300	0 to 360	0 to 480
Normal	240 to 600	300 to 840	420 to 1140
Long	540 to 900	780 to 1200	1080 to1500

TABLE IV
RINSE TIME

Membership function	Range(sec)		
	Thin clothes	Thick clothes	Jean clothes
Short	1 to 100	1 to 180	1 to 240
Normal	90 to 200	120 to 300	180 to 420
Long	190 to 300	240 to 420	360 to 600

TABLE V
SPIN TIME

Membership function	Range(sec)		
	Thin clothes	Thick clothes	Jean clothes
Short	1 to 60	1 to 100	1 to 180
Normal	50 to 120	80 to 200	120 to 300
Long	110 to 180	180 to 300	240 to 420

The Fuzzy Logic Controller inference engine is designed using 27 rules. The rules formed in this research are derived from the common sense and purely based on experience from a typical home use. The decision which the fuzzy controller makes is derived from the rules which are stored in the database [5].

TABLE VI
INPUT AND OUTPUT RULES

No.	Input variables			Output variables		
	TC	AC	AD	W	R	S
1	H	LT	LT	S	S	S
2	H	LT	N	S	N	S
3	H	LT	LR	N	N	S
4	H	N	LT	S	N	N
5	H	N	N	N	N	N
6	H	N	LR	L	L	N
7	H	LR	LT	N	N	L
8	H	LR	N	L	N	L
9	H	LR	LR	L	L	L
10	K	LT	LT	S	S	S
11	K	LT	N	S	N	S
12	K	LT	LR	N	N	S
13	K	N	LT	S	N	N
14	K	N	N	N	N	N
15	K	N	LR	L	L	N
16	K	LR	LT	N	N	L
17	K	LR	N	L	N	L
18	K	LR	LR	L	L	L
19	J	LT	LT	S	S	S
20	J	LT	N	S	N	S
21	J	LT	LR	N	N	S
22	J	N	LT	S	N	N
23	J	N	N	N	N	N
24	J	N	LR	L	L	N
25	J	LR	LT	N	N	L
26	J	LR	N	L	N	L
27	J	LR	LR	L	L	L

TC=Type of clothes, AC=Amount of clothes, AD=Amount of dirtiness, W=Wash time, R=Rinse time, S=Spin time, H=Thin, K=Thick, J=Jean, LT=Little, LR=Large, S = short, N = normal, L= long

III. SIMULATION RESUIT IN MATLAB

In this research, amount of clothes and amount of detergent are considered the normal conditions. The amount of clothes is 13 for thin clothes, 8 for thick clothes and 5 clothes for jean clothes and amount of dirtiness is 50% for

each type of clothes are calculated. After all of the output values had been calculated based on the fuzzy logic rules in MATLAB simulation, this value are taken and used into the hardware setup. Rule viewers for Inputs and Outputs of thin, thick and jean clothes are shown in figs 2 to 4. Figs 5 to 7 are shown the surface viewers of outputs variables.

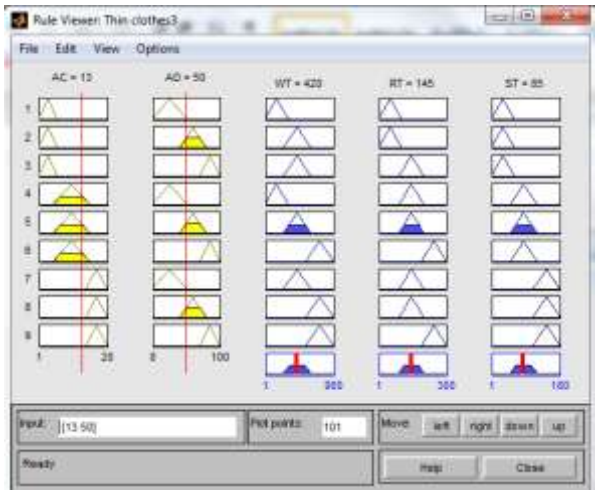

Fig2. Rule View for Thin Clothes

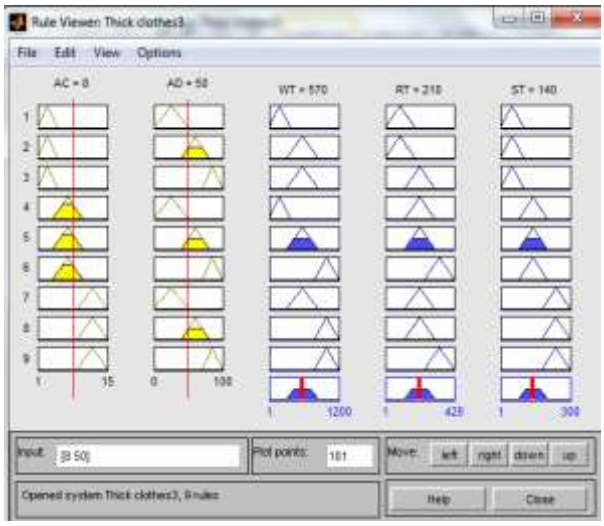

Fig3. Rule View for Thick Clothes

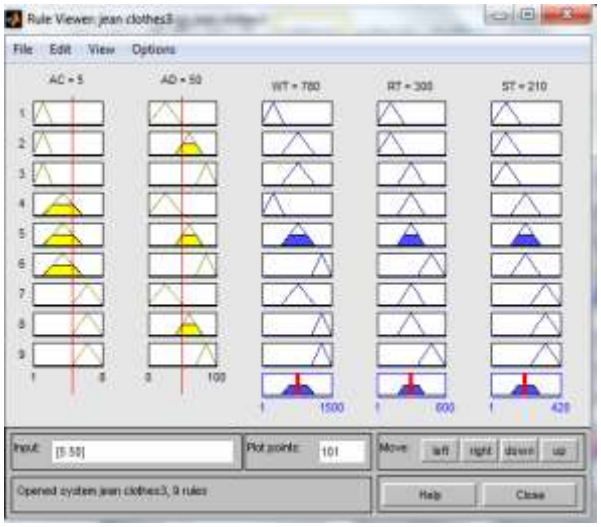

Fig4. Rule View for Jean Clothes

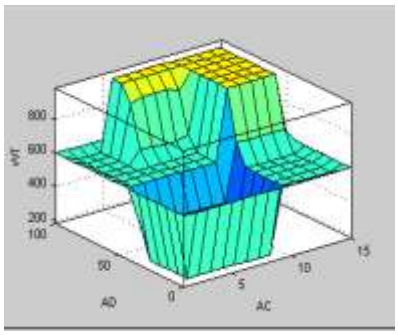

Fig5. Surface View of wash time

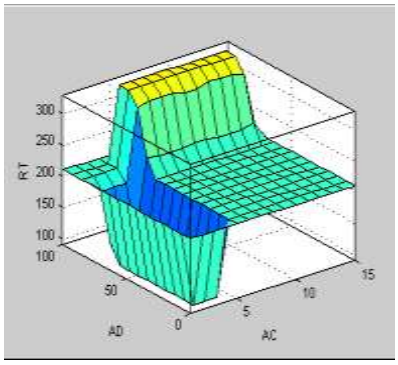

Fig6. Surface View of rinse times

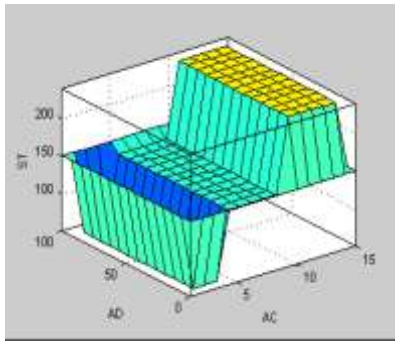

Fig7. Surface View of spin time

IV. HARDWARE IMPLEMENTATION

In this paper, three main parts are constructed. These parts are AC Motor Driver Circuit, Water Level sensor and construction of Detergent box. AC Motor Driver Circuit is constructed to rotate the AC Motor, Water Level Sensor is constructed to automatically fill the water and Detergent box is constructed to automatically fill the detergent into the tub depend on the user choosing.Fig8 is shown the block diagram of the system.

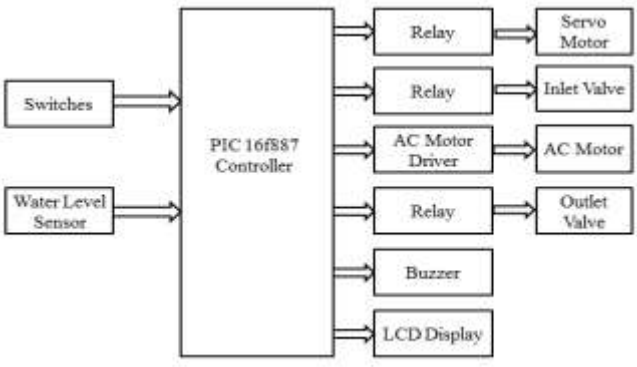

Fig 8. Block Diagram of the System

A. AC Motor Driver Circuit

The washing machine motor needs to rotate the forward and reverse direction to perform washing, rinsing and spinning processes [6]. In the AC Motor driver circuit, two types of Triacs are used to perform these processes. Triacs BTA16 and MOC 3023 are used. This driver circuit will be control from the microcontroller (PIC 16F887). In this research had different time of washing, rinsing and spinning processes depend on the user choosing [7]. Fig 9 is shown structure of AC motor driver circuit.

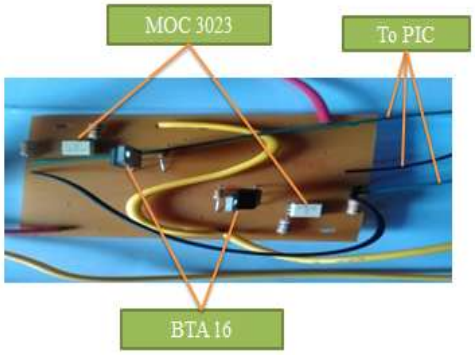

Fig9. Structure of AC Motor Driver Circuit

B. Water Level Control System

The system need to automatically fill the water into the tub and the amount of water that it fill into the tub will be change depend on the user choosing. Water level sensor is used to perform above condition. Washing Machine of water level sensor is the inductor type. This sensor needs to change the inductance to frequency because the system needs to control from the controller. Inverse oscillator circuit is used to change the inductance to frequency. This circuit includes two NAND gates, four capacitor (10uF) and variable resistor (10nF) [8]. Fig8 is shown block diagram of inlet valve construction and fig8 is shown measuring of inductance to frequency circuit by using the microcontroller (PIC 16F887).

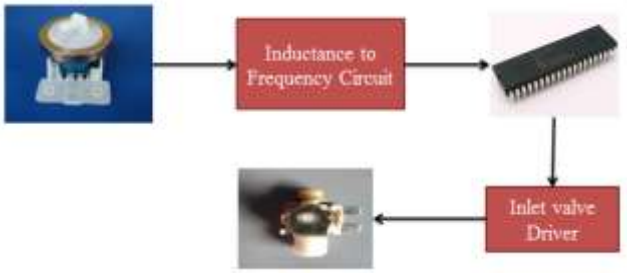

Fig 10. Block Diagram of inlet valve construction

Fig11. Measuring frequency data by using controller depend on the water level into the tub

TABLE VII
FREQUENCY DATA USING CONTROLLER

Amount of water(Liter)	Frequency(Hz)
0 Liter	19.849 kHz
6 Liter	19.369 kHz
12 Liter	18.802 kHz
18 Liter	18.284 kHz
24 Liter	17.796 kHz
30 Liter	17.319 kHz
36 Liter	16.931 kHz
42 Liter	16.551 kHz
48 Liter	16.218 kHz

C. Construction of Detergent Box

The detergent box is constructed and the amount of water and detergent will automatically fill into the tub and not to refill the detergent after finish processing one time because the detergent box can be filled full detergent powder.

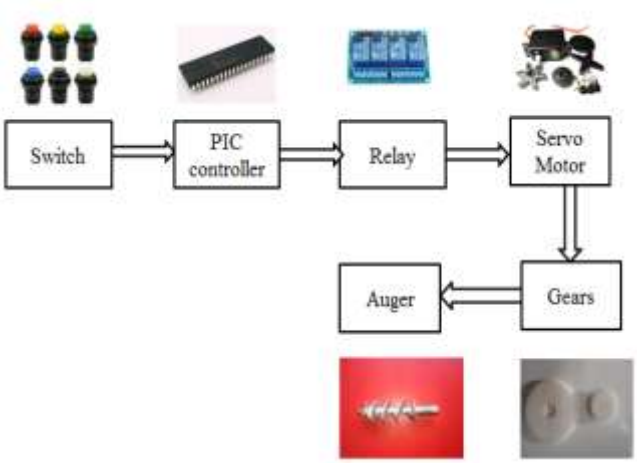

Fig12. Block diagram of detergent box working

Construction of detergent box depends on auger working. This auger is put into the pipe that it has 3 inches length and width is 1.5inches. These pipe is made two holes; one hole is made the upper layer of pipe onto the right edge and another hole is made is below layer of pipe onto the left edge. The upper hole of the pipe is connected the funnel shape box that inside these box has detergents. The below hole of the pipe is connected the small pipe that it has on the tub to fill the detergent into these washing machine tub. Gears are used to connect the shaft and motor. In this system, driver gears have 22 and driven gears have 44; gear ratio is 1/2. These gears are used to well the torque. Servo motor is used to drive these gears. Motor will be rotate 360 degree and clockwise direction. Depend on the motor rotation the amount of detergent that it fills into the tub. Fig10 is shown the block diagram of detergent box construction. Fig11 is shown

construction and testing of Detergent Box for Washing Machine.

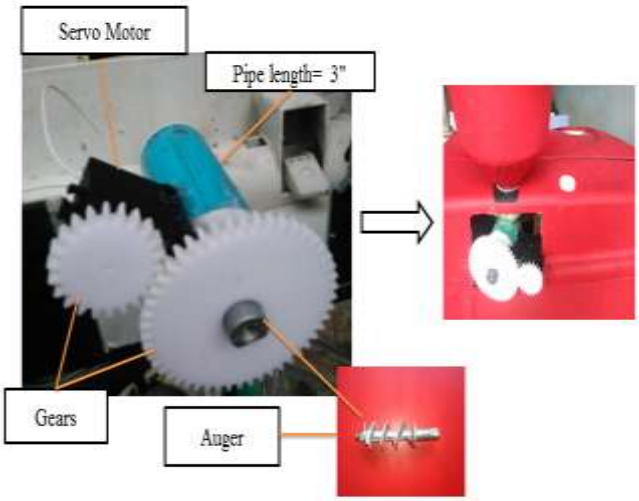

Fig13. Block diagram of detergent box construction

Fig14. Testing the detergent box construction

TABLE VIII
AMOUNT OF DETERGENT DEPEND ON TIMER

Timer for Detergent Valve Opening	Amount of Detergent(Gram)
10 sec	20g
20 sec	40g
30 sec	60g

V. TESTS AND RESULT

The most important component of this washing machine control system is PIC 16F887 microcontroller. It is called the heart of this system. It almost controls the entire components those used in this system. PIC16F887 microcontroller is used to control the various function and micro switches are used for choosing the input variables. After choosing the input variables the user needs to press the Ok switch then the amount of detergent and the inlet valve will automatically open to fill the water and detergent into the tub. If the amount of detergent and the water level reaches the limit level, the detergent valve and the inlet valve will close and then perform the washing process. After performing the washing process, the outlet valve will automatically open to release waste water. When the time of outlet valve opening is time up, the system automatically close the outlet valve and then open the inlet valve to perform the rinsing process. After rinsing process, the outlet valve will also automatically open to release waste water. Then the system will perform the spinning process. After performing this process, the system will stop and give alarm. Fig15 is shown overall circuit diagram of the system and fig16 is shown experimental result of the system.

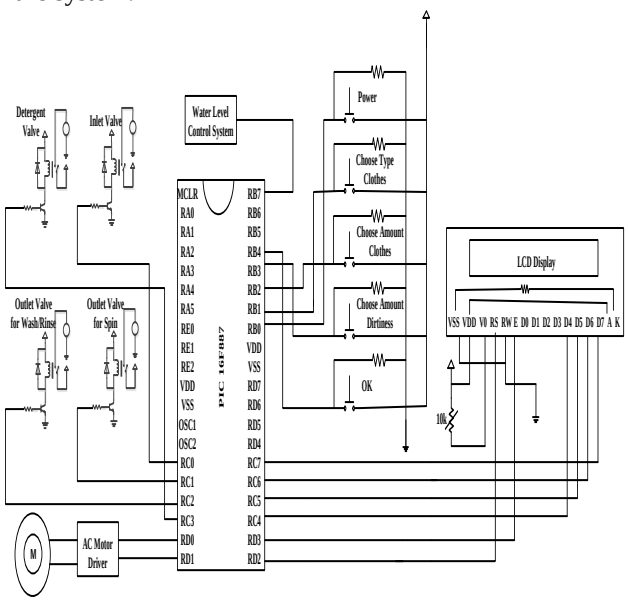

Fig.15. Overall Circuit diagram of the system

Fig.16. Testing of the system

Fig17. Top Viwe of the Washing Machine

Fig18. Side View of the Washing Machine

Depending on the hardware and software simulation, the result will get the data that it show the TABLE IX to XI. In this research, the system considers the normal condition for inputs variables.

TABLE IX
EXPERIMENTAL RESULT OF NORMAL CONDITION FOR THIN CLOTHES

Input variables			Output variables				
TC	AC	AW	AD	ADE	WT	RT	ST
H	N	N	24L	29g	420	145	85

Fig19. Experimental Result for Thin Clothes

TABLE X.
EXPERIMENTAL RESULT OF NORMAL CONDITION FOR THICK CLOTHES

Input variables			Output variables				
TC	AC	AW	AD	ADE	WT	RT	ST
K	N	N	24L	29g	570	210	140

Fig20. Experimental Result for Thick Clothes

TABLE XI
EXPERIMENTAL RESULT OF NORMAL CONDITION FOR JEAN CLOTHES

Input variables			Output variables				
TC	AC	AW	AD	ADE	WT	RT	ST
J	N	N	24L	29g	780	300	210

Fig21. Experimental Result for Jean Clothes

VI. CONCLUSION

In this paper, the system has the constant condition that the number of rinse period is twice and opening of outlet valve time is 60 sec. The result is demonstrated not only in MATLAB simulation but also Proteus for hardware implementation. After calculating the fuzzy logic controller depend on the real working of washing machine by using MATLAB simulation, the system get the simulated values dealing with the research. Then, these simulated values are used in Hardware implementation. Amount of water and processing time of washing machine will change depend on the difference clothes. Therefore, this research will get correct processing time of washing machine and automatically fill the water and detergent.

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