LIQUID LEVEL CONTROLLING BY FUZZY LOGIC TECHNIQUE

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ABSTRACT: The liquid level controlling is useful and important phenomena in industrial, domestic and many other applications. We designed a system to control the liquid level of a container/boiler or any other type of tank. There are many techniques use to control the level of particular tank like PID and PI. We used fuzzy logic technique for liquid controller. Our FLC consist of two input parameters liquid level in the tank and the consumption of the liquid from the tank. To control these two input parameters one output parameter valve is used. The technique used by us involve the FIS with define rules.

KEYWORDS: Proportional integral derivative(PID), Proportional integral(PI), Fuzzy logic controller(FLC), Fuzzy inference system(FIS).
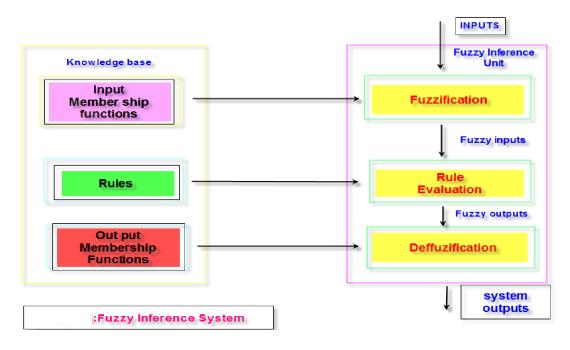
1 INTRODUCTION

Liquid level controlling is now a days much important in many applications. If proper check and balance of the level of any fluid is not maintained there will be very hard and dangerous consequences in industry. To maintain the arrangement of proper controlling of the level of the fluid many controlling techniques or many controllers are used. Our system is fuzzy logic system. The fuzzy logic technique is much important and useful it solutions faster and most efficient way than conventional control techniques to control the level of the fluid through valve as an output function.We under go Matlab simulated values for output and check out these results by comparing with the software simulated values with Mamdani model mathematical calculations and reveal the percentage difference for output parameter. We focused on the level controlling technique of the tank or container to design the controller. Such type of controller has many industrial, domestic applications. These type of controllers have specific applications for boilers .To control the liquid level we involve two input parameters and valve as output parameter.

Fuzzy Logic is a design methodology, useful for both linear and non linear systems. With the help of fuzzy logic, designers can realize smallest development costs, and better performance [1]. In this paper etl mehmood in 2013 stated the application of Fuzzy Logic Controller (FLC) used to control the liquid level in the second tank of two cascaded coupled containers. System modeling involves to develop mathematical model. Software simulated studies are conducted which are based on the developed Matlab model or a simulink[2]. Fuzzy logic system(FLS) is used to tackle non linear systems which are hard to deal mathematically. The fuzzy Logic concept to solve the problems ist time reported by Lotfi Zedeh [3]. Fuzzy logic technique is used in modeling solutions for non linear control models with multi parameters for a control strategy. Such system delivers solutions efficiently and in precise way then other design techniques for control. Fuzzy logic technique based temperature control system is established in this paper. The system consists of operational amplifiers, temperature sensors, Analogue to Digital Converter, microcontroller based display interfaced circuit. This technique successfully introduces controller design to control the temperature [4]. Berthold et al. at 2006 stated a designed room air cooling system from fuzzy logic technique .The two input variables temperature and humidity and the output variables are, cooler fan, water pump and exhaust fan [5]. Akyildiz et al. at 2008 proposed his work on cognitive radio. He worked on spectrum sensing for cognitive radio. He presented main issues for cognitive radio like spectrum sharing , spectrum sensing and spectrum mobility[6].

2   METHODOLOGY

We use fuzzy logic tool in a Matlab to design a liquid or fluid level controller. There are two main models in a fuzzy logic tool Mamdani model and Sugeno model But we focused on Mamdani model. The basic difference between Sugeno and Mamdani model is that the sugeno output member ship functions are linear and constant, but Mamdani model deals with member ship functions which are non linear. Another important difference between these models is In sugeno weighted average method use to generate the specific output but in Mamdani the Defuzzification process use to generate crisp output [7].
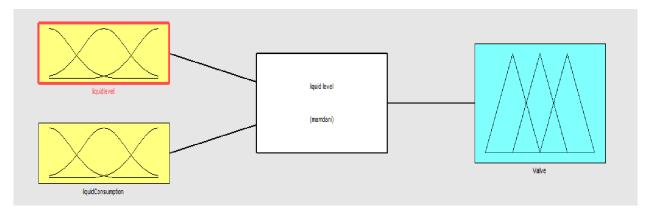
Fuzzy logic is a form of logic which deals with approximate values for the reasoning in spite of the fixed or exact values. The variables involve in fuzzy logic having a range between 0 and 1. In order to implement the fuzzy logic on the system it is necessary to have input data firstly then this data goes to fuzzification process in a fuzzifier the third stage is the analysis which is based on the rules defined in the rule editor and analyze with the conditions in the inference engine and then goes to Defuzzification system and at the end decision takes place. Here is the diagram which shows this implementation.

Fig 1. Fuzzy Inference System

3   MATLAB SIMULATION

In our Matlab simulation we have Mamdani liquid level controller having two input parameters first one is the liquid level in the container/tank and second one is the liquid consumption from the tank. Output parameter valve the only function to control two input parameters. The position of the valve satisfies the level of the tank.

Fig 2. FIS editor for the FLC

Here is the first input parameter liquid level for our controller. It involves five different membership functions starting from the dead level then low, normal, high and full. The region 1 included from the peak point of dead level to the peak point of the low level. Second region consist of the peak point of low level to normal level peak point same as third region and fourth region having ranges involving the peak points.FIG 3 showing the membership functions for the input liquid level.
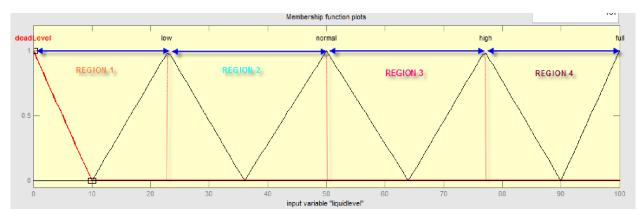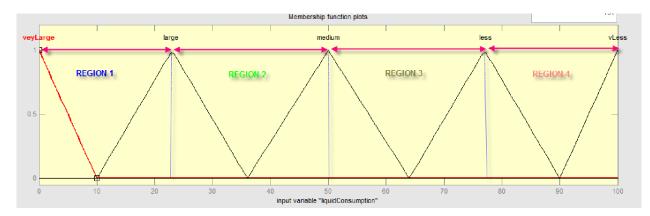

Fig 3. Input liquid level membership function ranges

Second input parameter for our controller is the liquid consumption from the tank. This second input also consist of four regions with five membership function. liquid consumption involving very large consumption from the tank second membership function is large third membership function is normal and last two are less consumption and very less consumption of the liquid from the tank. Four specific regions involving the peak to peak points from one membership function to the next membership function. Fig 4 shows the input parameter membership function ranges.

Fig 4. Liquid consumption membership functions with ranges and regions

Output parameter valve also having five membership function with specific ranges. Membership function Quick open having ranges from 0 to 20, same for slow open having ranges from 20 to 40 and no change from 40 to 60,for slow close ranges from 60 to 80 and the final membership function quick close having ranges from 80 to 100.
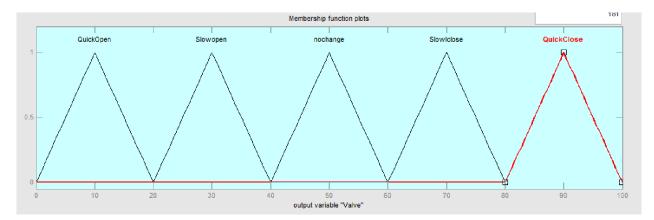

Fig 5. Membership functions for output variable valve with ranges

In a fuzzification process the crisp input values converted into its specific linguistic variables. The table no 1 which shows the relationship between the two input variables and four linguistic variables, each input variable has its own specific effect on output.

fn[m]. Here n= number of input, m= number of member ship function.

Table I   Linguistic value of fuzzifier output

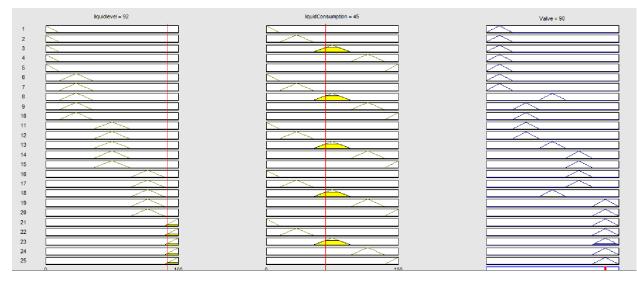| INPUT	Linguistic fuzzifier output	Region 1	Region 2	Region 3	Region 4
Liquid	f1	f1[1]	f1[2]	f1[3]	f1[4]
Level	f2	f1[2]	f1[3]	f1[4]	f1[5]
Liquid	f3	f2[1]	f2[2]	f2[3]	f2[4]
Consumption	f4	f2[2]	f2[3]	f2[4]	f2[5]

The Fuzzy Logic Rules used in the fuzzy controller are considered by the formula= $m^{n.}$. n=number of inputs and m=number of membership functions for each input .Total fuzzy rules are 5^2=25 rules.

Fig 6. Fuzzy Rules Editor

These rules are defined to get the desired response from the controller on a specific condition. fuzzy rules are same like if and then condition. These rules are much near to natural human language. Rules are specified in the FIS and according to these rules the linguistic values are defuzzified to get the crisp output value.

The rule editor use to specify the Matlab simulated values for inputs and outputs.

Fig 7. Fuzzy logic Rule viewer

The surface viewer graph is present which shows us the three dimensional view of the input liquid level ,liquid consumption with respect to its output Valve. This graph shows us the non linear behavior when the liquid is at its dead level and liquid consumption is also very less then valve is at the position according to the requirement. as the liquid consumption increases valve will quick open, another condition which lead to quick open when liquid is at its dead level. Same when tank is at its full level and liquid consumption is also very less the valve will goes to quick close.
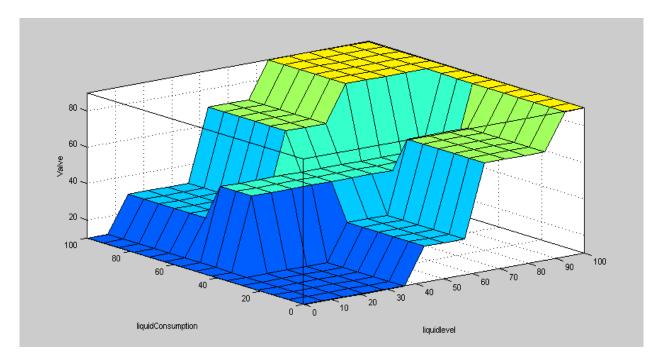
Fig 8. Surface Viewer graph between liquid level, liquid consumption and Valve

4 DESIGN ALGORITHM

The values of inputs and outputs are in percentage.

Liquid level = 92, Liquid consumption = 45 and output valve = 90.These values are software simulated values.

Liquid level

The first input parameter for the fuzzy logic controller is liquid level as the input value from the Matlab oriented result is 92.This value is placed in region 4.We have to find out the linguistic variable values .The first input having two linguistic variables.f1 and f2.
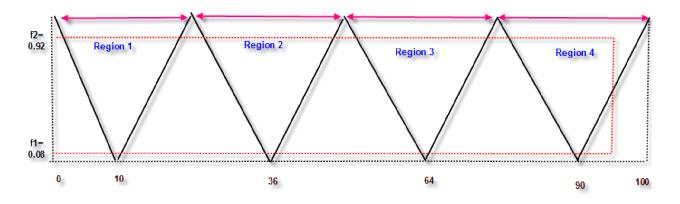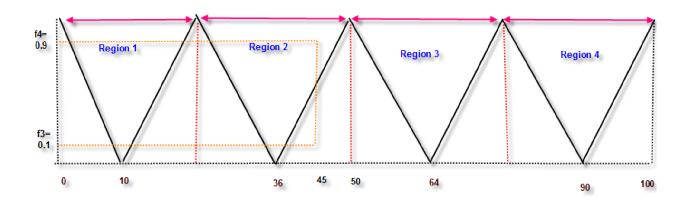
f1=100-92/100=0.08

f2=1-0.08=0.92.

Fig 9. Ranges in different regions

Liquid Consumption

The second input parameter for the fuzzy logic controller is liquid consumption as the input value from the Matlab oriented result is 45 which is in region 2.We have to find out the linguistic variable values .The first input having two linguistic variables.f3 and f4.

f3=50-45/50=0.1

f4=1-0.1=0.9

Composite rules values finding.

The most common rules among the twenty five rules are as below.

Table II   Composite rules finding

Rules	Membership functions
R0	f1^f3=0.08^0.1=0.08
R1	f1^f4=0.08^0.9=0.08
R2	f2^f3=0.92^0.1=0.1
R3	f2^f4=0.92^0.9=0.9

Table III Singleton values for Valve (output)

Rule No	Liquid level	Liquid Consumption	Output Valve value	Singleton values
R0	High	Large	Slow close	0.7
R1	High	Medium	No change	0.5
R2	Full	Large	Quick close	0.9
R3	Full	Medium	Quick close	0.9

Table IV Summition of Values

R0=0.08	S0=0.7	R0*S0=0.58
R1=0.08	S1=0.5	R1*S1=0.40
R2=0.1	S2=0.9	R2*S2=0.09
R3=0.9	S3=0.9	R3*S3=0.819
∑Ri=1.16		∑Ri*Si=1

The Mamdani model used to calculate crisp values for fuzzy logic controller. The formula for Mamdani model is as follows:

∑Ri = R0+R1+R2+R3.

∑Ri * Si = R0*S0+R1*S1+R2*S2+R3*S3.

after putting values =[1/1.16]*100=86.25

Matlab simulated value=90

% Error = [difference /Simulated Value] *100

Difference =90-86.25=3.75

Percentage Error=[3.75/90]*100=4.1%

Comparison

The comparison between design and simulated values is shown in table below.

Table V   Comparison between designed and simulated value

Results	Output Valve
Matlab Simulated Value	90
Designed Value	86.25
% Error	4.1

5   CONCLUSION

Design of level controller to control the level of the tank/container is presented. This controller consists of two input levels like the level of the tank and the consumption of the liquid from the tank. The simulated values from the Matlab having output valve value is 90 but the designed value is 86.25. The percentage error difference between software oriented value and mathematically calculated value is 4.1%.

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