# Fuzzy Logic based Fuel Consumption System

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**Abstract- This research work describes the design and simulation of a fuel consumption control system using fuzzy rule. The rule base receives two crisp input values from speed and load sensors, divides the universe of discourse into regions with each region containing two fuzzy variables, fires the rules, and gives the output singleton values corresponding to each output variable. One defuzzifier is used to control the fuel consumption. The results obtained from the simulation were found correct according to the design model. This research can be used to enhance the performance of the system which gives its output by consuming fuel depending upon some speed and load. MATLAB-simulation is used to achieve the designed goal.**

**Index Terms: Fuel Consumption Control System, Fuzzy Logic, Fuzzy Rule.**

## I. INTRODUCTION

Fuzzy logic is used to monitor non-linear systems which are difficult to deal mathematically. The non-probabilistic uncertainties issues are monitored by fuzzy logic and fuzzy set theory. The concept of fuzzy logic to solve the problem has been reported first time by Lotfi Zedeh [1]. He also reported the concept of linguistic variables. Fuzzy logic includes different processes in itself such as fuzzification, defuzzification, membership functions, domain, linguistic variables and rules. Domain determines the range of values in which membership of fuzzy is performed. The basic part of fuzzy sets is membership function. The relation between a domain value and its degree of membership is determined by membership function. Fuzzy logic exhibits many similarities and differences with Boolean logic. Fuzzy logic operates Boolean logic results when all the fuzzy membership functions are restricted from 0 to 1. So there are infinite values between 0 and 1 in fuzzy logic. Fuzzy logic uses natural language techniques and variables which are based on the degree of truth and it is easier to understand for human beings.

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There are many applications of fuzzy logic. Household appliances like washing machines and dishwashers use fuzzy logic techniques. With the help of this, the accurate water pressure and optimal amount of soap for clothes and dishes is determined [2]. It is also implemented in the systems such as multi-channel PC, data acquisition, networking and other micro-controller based systems. The air-conditioning and elevator control systems also use the fuzzy technique. There are several benefits of fuzzy logic control system. Problems related with incomplete and imprecise data is held by fuzzy logic. It provides flexibility and simplicity to the problems. One can make any fuzzy system to match any set of input-output data [3]. Manfouf et al. [4] discussed the utilization of fuzzy control system in the medical field. Khan et al. [5] described a mixing and grinding system by using fuzzy logic control. This system is an application of fuzzy time control discrete model. The system has four elements which are controlling the system i.e. grinding motor, rotatory motor, cooling units and heating units. Matlab simulation was used to test the time control fuzzy rule. This system can be used for any industrial time control system to achieve better performance, reliability and accurate results. Abbas et al. [6] presented a traffic signal control system for over saturated intersections with right and left turns by using fuzzy rule based system. Schouten et al. [7] reported the fuzzy logic control for parallel hybrid vehicles. The parameters like speed of the motor and driving commands are used to develop a set of rules for fuzzy logic controller. A combination of electric motor and combustion engine is also used to improve fuel efficiency. Lee et al. [8] describe fuzzy logic controllers by using fuzzy technique. In the presented study construction, implementation and performance of fuzzy logic controller has been described. Fuzzification, defuzzification and matlab simulation was used to describe the results. They reported that it is a useful technique to handle many industrial control systems. Corcau et al. [9] describe the fuzzy logic controller as power system stabilizer. Baig et al. [10] describe the use and implementation of fuzzy logic control system in medical field. Huang et al. [11] presented a survey, which includes an active suspension system to make the ride more comfortable. They used fuzzy logic to perform this operation. Abbas et al. [12] used the fuzzy logic technique to describe the design, implementation and performance of an autonomous room air cooler. The

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physical variables like temperature and humidity were used to describe the working of an air cooler. In this process, fuzzy control techniques like IF-THEN rules, fuzzification and defuzzification have been used. This process can be used in modern processing systems, which depends on automatic control. Matlab simulation was used to describe the designed model. Pouramini et al. [13] presented a vehicle speed limit model by using fuzzy logic technique. A road safety model was discussed that was based on fuzzy rules.

This paper deals with the design and simulation of fuel consumption control system. Fuel is something, which is consumed to produce energy and it undergoes different nuclear and chemical reactions. The amount of fuel used per unit distance is termed as fuel consumption. Lower the value of fuel leads to the more economical vehicle. Fuel consumption is related with the vehicle performance, maintenance issues, costs and other driving patterns. Nowadays the prices of fuel are rising rapidly, so it is necessary to find a number of ways to use less fuel and to find the factors which are effecting fuel consumption. These factors can be driving styles, vehicle components, exploitation conditions, speed, load, friction, weather and traffic jams. Fuel consumption of vehicles is determined at constant speed or the speeds at which traffic congestion has no effect. Fuel consumption is controlled by the variations in speed. Lowering the maximum speed of vehicles, results in decreasing the fuel consumption. As the speed goes high the fuel consumption is increased. One of the fuel consumption affecting factors is load and it is very hard to measure. As adding more weight to vehicle will increase its fuel consumption. The fuel consumption can be decreased by decreasing the load on the vehicles. Here, we use fuzzy logic technique to describe fuel consumption.

## II. DESIGN OF FUZZY LOGIC BASED FUEL CONSUMPTION CONTROL SYSTEM

### *A. Design Algorithm*

The fuel consumption system is designed for two input variables like speed and load. The membership function of two input variables speed and load are shown in Table I. The ranges of input variables are also given.

TABLE I
MEMBERSHIP FUNCTION OF INPUT VARIABLES LIKE SPEED AND LOAD

| Membership Function | V small | small | medium | large | V large |
|---|---|---|---|---|---|
| Speed (kmph) | 0-10 | 0-20 | 10-30 | 20-40 | 30-40 |
| Load (kg) | 0-25 | 0-50 | 25-75 | 50-100 | 75-100 |

The plots of membership function for input speed is shown in Fig. 1.

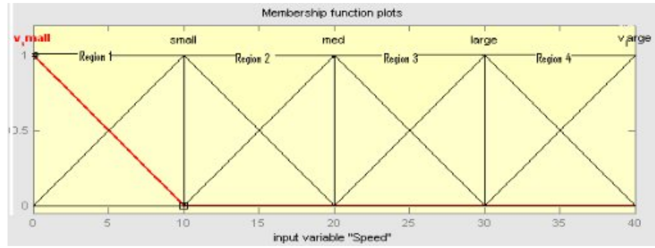


Fig.1. Membership functions for input fuzzy variable-speed.

The five membership functions (very small, small, medium, large and very large) are used to show various ranges of input fuzzy variable like speed. The plot consists of four regions.

The plot of membership functions for input load is shown in Fig. 2.

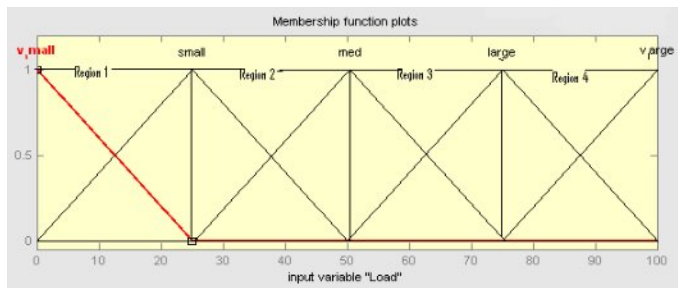


Fig.2. Plot of membership function for input fuzzy-Load.

The five membership functions (very small, small, medium, large and very large) are used to show the various ranges of input fuzzy variable-load. The plot consists of four regions. There is one output variable. The plot of membership functions for output is shown in Table II.

TABLE II
OUTPUT MEMBERSHIP FUNCTION

| Membership Function | Normal | High | V high |
|---|---|---|---|
| Fuel (ltrs) | 0-30 | 30-60 | 60-100 |

The plot for output variable of fuel system is shown in the Fig.3.

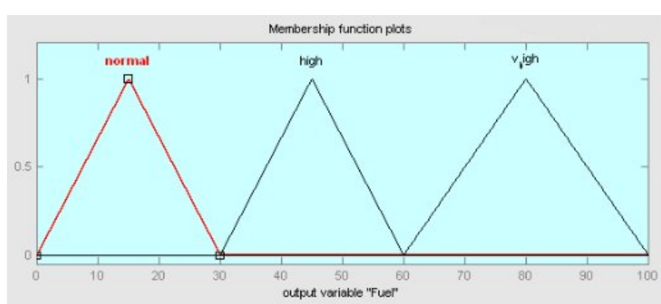


Fig.3. Plot of membership function of output variable-fuel.

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### *B. Fuzzi fication*

The proposed fuzzy logic fuel consumption control system consists of two input variables like speed and load. The linguistic values the mapping values of input fuzzy variables and their membership function occupied in the regions. The mapping of input fuzzy variables with functions in four regions is listed in Table III and mapping rules for regions occupied is shown in Table IV.

TABLE III
LINGUISTIC VALUES OF FUZZIFIERS OUTPUT IN ALL REGIONS

| Input Variables | Linguistic Fuzzifier Outputs | Region 1 | Region 2 | Region 3 | Region 4 |
|---|---|---|---|---|---|
| Speed | F1 | F1[1] | F1[2] | F1[3] | F1[4] |
| | F2 | F1[2] | F1[3] | F1[4] | F1[5] |
| Load | F3 | F2[1] | F2[2] | F2[3] | F2[4] |
| | F4 | F2[2] | F2[3] | F2[4] | F2[5] |

TABLE IV
RULE MAPPING FOR REGIONS OCCUPIED

| Sr No | Regions Occupied | | Rules Fn[m]=Membership Value, Where n=No of input variables ,m=No of membership functions |
|---|---|---|---|
| | Speed Input Variable 1 | Load Input Variable 2 | |
| 1 | 1 | 1 | R1=F1^F3= F1[1]^F2[1]<br>R2=F1^F4= F1[1]^F2[2]<br>R3=F2^F3= F1[2]^F2[1]<br>R4=F2^F4= F1[2]^F2[2] |
| 2 | 1 | 2 | R1=F1^F3= F1[1]^F2[2]<br>R2=F1^F4= F1[1]^F2[3]<br>R3=F2^F3= F1[2]^F2[2]<br>R4=F2^F4= F1[2]^F2[3] |
| 3 | 1 | 3 | R1=F1^F3= F1[1]^F2[3]<br>R2=F1^F4= F1[1]^F2[4]<br>R3=F2^F3= F1[2]^F2[3]<br>R4=F2^F4= F1[2]^F2[4] |
| 4 | 1 | 4 | R1=F1^F3= F1[1]^F2[4]<br>R2=F1^F4= F1[1]^F2[5]<br>R3=F2^F3= F1[2]^F2[4]<br>R4=F2^F4= F1[2]^F2[5] |
| 5 | 2 | 1 | R1=F1^F3= F1[2]^F2[1]<br>R2=F1^F4= F1[2]^F2[2]<br>R3=F2^F3= F1[3]^F3[1]<br>R4=F2^F4= F1[3]^F2[2] |
| 6 | 2 | 2 | R1=F1^F3= F1[2]^F2[2]<br>R2=F2^F4= F1[2]^F2[3]<br>R3=F1^F3= F1[3]^F2[2]<br>R4=F2^F4= F1[3]^F2[3] |
| 7 | 2 | 3 | R1=F1^F3= F1[2]^F2[3]<br>R2=F1^F4= F1[2]^F2[4]<br>R3=F2^F3= F1[3]^F2[3]<br>R4=F2^F4= F1[3]^F2[4] |
| 8 | 2 | 4 | R1=F1^F3= F1[2]^F2[4]<br>R2=F1^F4= F1[2]^F2[5]<br>R3=F2^F3= F1[3]^F2[4]<br>R4=F2^F4= F1[3]^F2[5] |
| 9 | 3 | 1 | R1=F1^F3= F1[3]^F2[1]<br>R2=F2^F4= F1[3]^F2[2]<br>R3=F2^F3= F1[4]^F2[1]<br>R4=F2^F4= F1[4]^F2[2] |
| 10 | 3 | 2 | R1=F1^F3= F1[3]^F2[2]<br>R2=F1^F4= F1[3]^F2[3]<br>R3=F2^F3= F1[4]^F2[2]<br>R4=F2^F4= F1[4]^F2[3] |
| 11 | 3 | 3 | R1=F1^F3= F1[3]^F2[3]<br>R2=F1^F4= F1[3]^F2[4]<br>R2=F2^F3= F1[4]^F2[3]<br>R4=F2^F4= F1[4]^F2[4] |
| 12 | 3 | 4 | R1=F1^F3= F1[3]^F2[4]<br>R2=F1^F4= F1[3]^F2[5]<br>R3=F2^F3= F1[4]^F2[4]<br>R4=F2^F4= F1[4]^F2[5] |
| 13 | 4 | 1 | R1=F1^F3= F1[4]^F2[1]<br>R2=F1^F4= F1[4]^F2[2]<br>R3=F2^F3= F1[5]^F2[1]<br>R4=F2^F4= F1[5]^F2[2] |
| 14 | 4 | 2 | R1=F1^F3= F1[4]^F2[2]<br>R2=F1^F4= F1[4]^F2[3]<br>R3=F2^F3= F1[5]^F2[2]<br>R4=F2^F4= F1[5]^F2[3] |
| 15 | 4 | 3 | R1=F1^F3= F1[4]^F2[3]<br>R2=F1^F4= F1[4]^F2[4]<br>R3=F2^F3= F1[5]^F2[3]<br>R4=F2^F4= F1[5]^F2[4] |
| 16 | 4 | 4 | R1=F1^F3= F1[4]^F2[4]<br>R2=F1^F4= F1[4]^F2[5]<br>R3=F2^F3= F1[5]^F2[4]<br>R4=F2^F4= F1[5]^F2[5] |

As we are working with two input variables therefore, four linguistic values are given in the Fig. 4. Fuzzifier converts input crisp values into linguistic values.

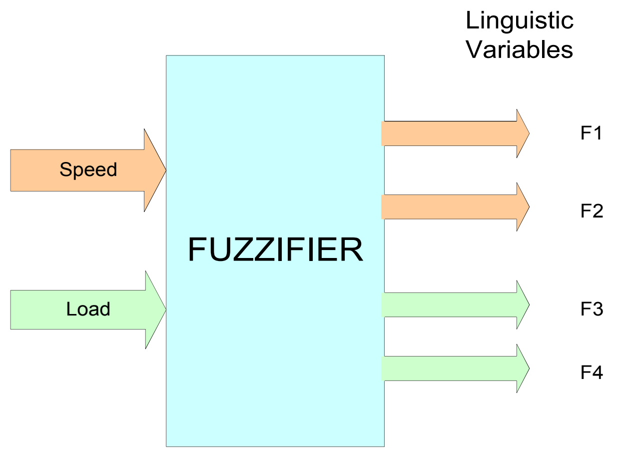


Fig.4. Fuzzifier showing two input crisp values and four output linguistic variables

Each fuzzifier consists of a multiplier that converts the input voltage range 0-5 V into crisp value ranging from 0-40 for speed by multiplying the input with 10 and for load crisp value 0-100 by multiplying with 25. Comparators are used to decide the region occupied by the input variable value. Subtractors find the difference of crisp values from end value of each region. Multiplexer multiplexes the four proposed values of four regions by using the address information from region selection and inputs from subtractors. Divider divides the difference values in each selected region by 10 to find mapping value of membership function of speed and by 25 for load.

Second fuzzy set subtractor finds the active value of second fuzzy set by subtracting the first active set from 1. The general internal structure of fuzzifier for four regions is shown in Fig. 5 and Fig. 6.

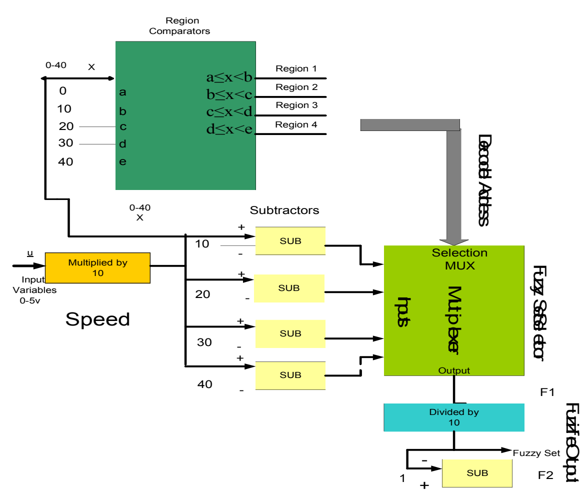


Fig.5. Internal structure scheme for four regions of speed

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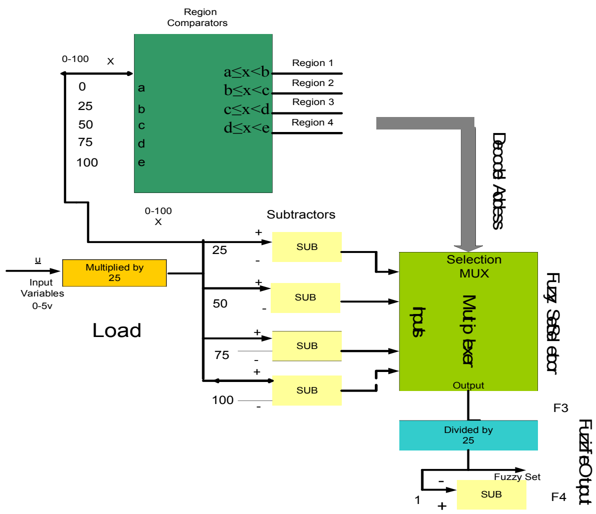


Fig.6. Internal structure scheme for four regions of load

### C. Inference Engine (IE)

The inference engine consists of four AND operators, unlike logic AND operators these operators select minimum input values for the output. The IE takes four inputs from fuzzifier and produces the output R values according to min-max composition. This min-max inference method uses min-AND operation between our inputs. Fig.7. shows this inference process.

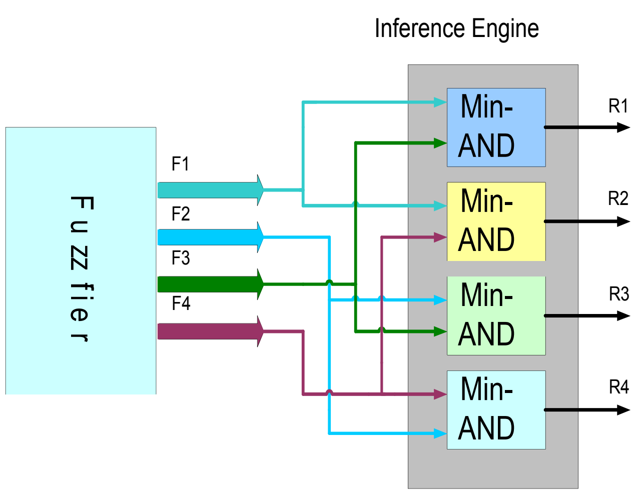


Fig.7. Block diagram of inference process

No of active rules=$m^n$, Here m = max no of overlapped fuzzy sets, and n = no of inputs, for our design, m = 5 and n-2 so the number of active rules are $m^n$ = 25. Thus 35 rules are required, which are shown in the Table V.

TABLE V
TOTAL NO OF RULES

| INPUTS | | OUTPUT |
|---|---|---|
| Speed (kmph) | Load (kgs) | Fuel (ltr) |
| V small | V small | Normal |
| V small | Small | Normal |
| V small | Medium | normal |
| V small | Large | High |
| V small | V large | V high |
| Small | V small | Normal |
| Small | Small | Normal |
| Small | Medium | Normal |
| Small | Large | High |
| Small | V large | V high |
| Medium | V small | Normal |
| Medium | Small | Normal |
| Medium | Medium | High |
| medium | Large | High |
| Medium | V large | V high |
| Large | V small | High |
| Large | Small | High |
| Large | Medium | High |
| Large | Large | V high |
| Large | V large | V high |
| V large | V small | High |
| V large | Small | High |
| V large | Medium | High |
| V large | Large | V high |
| V large | V large | V high |

In our case, only four rules are required for the particular values of two variables in a region corresponding to mapping of two functions. For our case, we made two calculation arrangements, for first arrangement the corresponding mapping values are F1[1], F1[2], F2[3], F2[4] and for second arrangement corresponding values are F1[2], F1[3], F2[3], F2[4] used.

### D. Rule Selector

The selector takes two crisp values for this system like speed and load. Rule selector gives singleton values of output function on the basis of rules. For two variables, four rules are needed to find the corresponding singleton values S1, S2, S3 and S4. For each variable the rules according to first arrangement and second arrangement are given in Table VI and Table VII.

TABLE VI
RULES APPLIED MODEL FOR FIRST ARRANGEMENT

| Rule no | Inputs | | Singleton values of output | Singleton values |
|---|---|---|---|---|
| | Speed | Load | Fuel | |
| 1 | V Small | Medium | Normal =0.15 | S1 |
| 2 | V Small | Medium | High =0.45 | S2 |
| 3 | Small | Large | Normal =0.15 | S3 |
| 4 | Small | Large | High =0.45 | S4 |

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TABLE VII
RULES APPLIED MODEL FOR SECOND ARRANGEMENT

| Rule no | Inputs | | Singleton values of output | Singleton values |
|---|---|---|---|---|
| | Speed | Load | Fuel | |
| 1 | Small | Medium | Normal =0.15 | S1 |
| 2 | Small | Large | High =0.45 | S2 |
| 3 | Medium | Medium | High =0.45 | S3 |
| 4 | Medium | Large | High =0.45 | S4 |

The rule base takes two inputs crisp values, distributes the universe of discourse into the regions with each region containing two fuzzy variables and apply these rules and gives the output singleton values corresponding to each output. Fig. 8 shows block diagram of rule base.

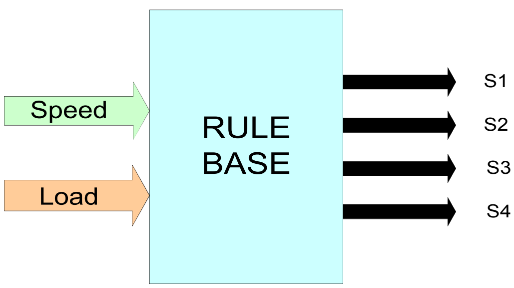


Fig.8. Rule base block

### E. Defuzzifier

The defuzzification produces the crisp values of output after examining inputs. In our system 8 inputs are given to the defuzzifier. Four values of R1, R2, R3 and R4 from the output of IE and S1, S2, S3 and S4 from rule selector. Defuzzifier examines the crisp values output according to centroid of area method which has a mathematical expression and given below.

$$\sum Si*Ri \,/\, \sum Ri \qquad (1)$$

Here, I =1 to 4.
The diffuser block is shown in Fig. 9.

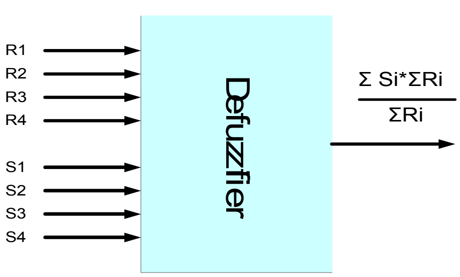


Fig.9. Defuzzifier block

Designed defuzzifier is shown in Fig. 10 which consists of one adder for ∑Ri, four multipliers for product Si*Ri one adder for ∑Si*Ri and one divider for ∑Si*Ri/∑Ri. Finally we get examined crisp output value.

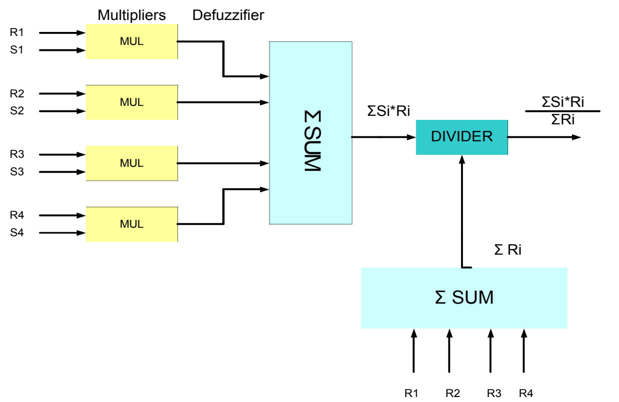


Fig.10. Defuzzifier design

## III. RESULTS AND DISCUSSION

For the system of fuel consumption control and regulation, we used two fuzzifiers and one defuzzifier to generate the results. The results have been determined for two arrangements of the input parameter values. Results of both calculating arrangements will be shown separately. The linguistic values from two fuzzifiers are fed to inference engine which use these values and apply four inference rules: R1, R2, R3 and R4. Rule base determines the singleton values by firing the rules. These values of R1, R2, R3, R4 and S1, S2, S3, S4 are applied to a defuzzifier which gives crisp value outputs. The defuzzifier uses center of average method for this purpose. After calculating the results, the rules are put into the MATLAB to find simulated results. These results are rule viewer of MATLABs fuzzy logic toolbox. The plot between input values and output is also drawn for both arrangements mapped by simulation results of MATLAB Rule Viewer.

### A. Calculation for first Arrangement

These results are found for Speed = 8 and load = 65. Table VIII shows Si*Ri for first arrangement.

TABLE VIII
RESULTS FOR FIRST ARRANGEMENT

R1= F1[1]^F2[3] =0.2^0.4=0.2
R2= F1[1]^F2[4]=0.2^0.6=0.2
R3= F1[2]^F2[3]=0.8^0.4=0.4
R4= F1[2]^F2[4]=0.8^0.6=0.6
∑Ri=1.4

| Sr no | Si | Ri | Si*Ri |
|---|---|---|---|
| 1 | 0.15 | 0.2 | 0.03 |
| 2 | 0.45 | 0.2 | 0.09 |
| 3 | 0.15 | 0.4 | 0.06 |
| 4 | 0.45 | 0.6 | 0.27 |

∑Si*Ri=0.45
∑Si*Ri/∑Ri=0.3214
0.3214*100=32.1

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### *B. Simulation Results*

Simulation results have been obtained from MATLAB rule viewer and are shown in the Fig. 11.

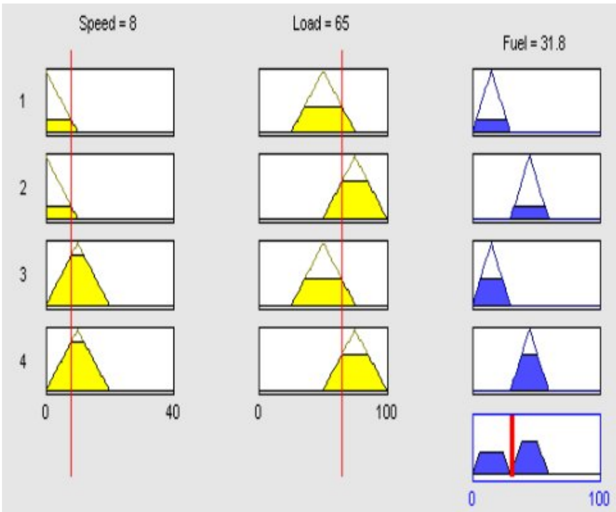


Fig.11. Simulated results of first arrangement

Simulation results of fuzzy logic (speed, load, fuel) using rule viewer for fuel consumption control system fi\or first arrangement is shown in Fig. 12.

The above results show that the fuel consumption during third region of our load input variable varies corresponding to the load and is this is not highly dependent on the speed as speed is very little in the first region of speed variable.

The comparison between designed and simulated results of the first arrangement is shown in Table IX.

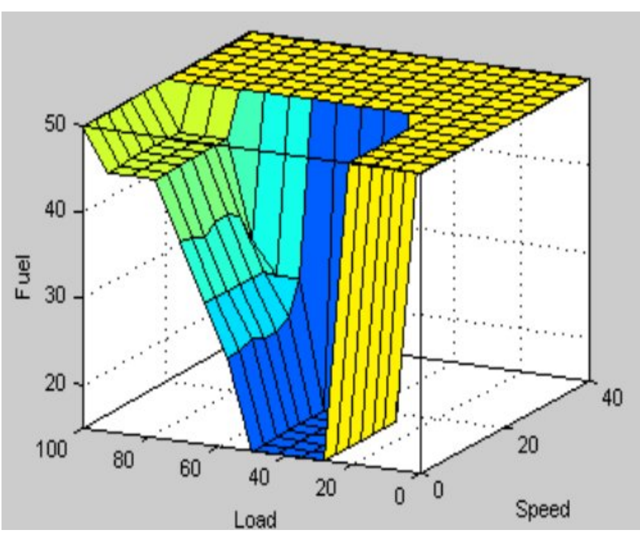


Fig.12. 3D plot for speed, load and fuel

TABLE IX
COMPARISON BETWEEN DESIGNED AND SIMULATED RESULTS FOR FIRST ARRANGEMENT

| RESULTS | FUEL CONSUMPTION |
|---|---|
| DESIGNED | 32.1 |
| SIMULATED | 31.8 |

### *C. Calculation for Second Arrangement*

The calculated results have been obtained for values of Speed = 18 and Load = 68. The results for second arrangement of Si*Ri is shown in Table X.

TABLE X
RESULTS FOR SECOND ARRANGEMENT

$R1 = F1[2] \wedge F2[3] = 0.2 \wedge 0.3 = 0.2$

$R2 = F1[2] \wedge F2[4] = 0.2 \wedge 0.7 = 0.2$

$R3 = F1[3] \wedge F2[3] = 0.8 \wedge 0.3 = 0.3$

$R4 = F1[3] \wedge F2[4] = 0.8 \wedge 0.7 = 0.7$

$\sum Ri = 1.4$

| Sr no | Si | Ri | Si*Ri |
|---|---|---|---|
| 1 | 0.15 | 0.2 | 0.03 |
| 2 | 0.45 | 0.2 | 0.09 |
| 3 | 0.45 | 0.3 | 0.135 |
| 4 | 0.45 | 0.7 | 0.315 |

$\sum Si*Ri = 0.57$

$\sum Si*Ri / \sum Ri = 0.407$

$0.407*100 = 40.7$

### *D. Simulation Results*

For second arrangement, the simulation results have been obtained from MATLAB rule viewer. These results are shown in the Fig. 13.

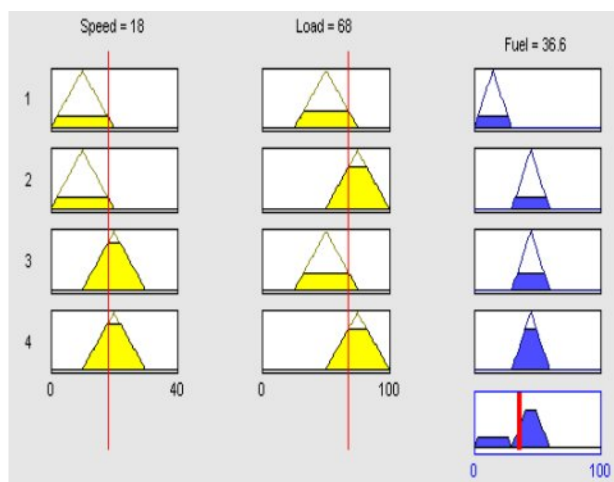


Fig.13. Simulated results of second arrangement

Simulation results of fuzzy logic (speed, load, fuel) using rule viewer for fuel consumption control system for second arrangement is shown in Fig. 14.

The above results show that the fuel consumption sensitively changes corresponding to speed and load from region 2 to 3 of speed and from region 3 to 4 of load.

The comparison between designed and simulated results for second arrangement is shown in Table XI.

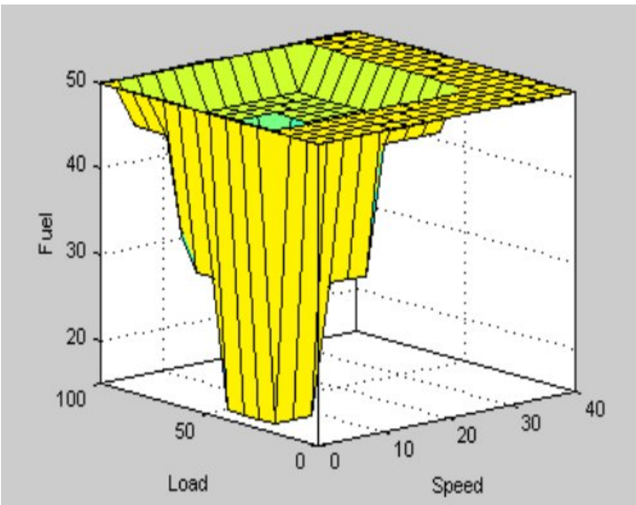


Fig.14. 3D plot between speed, load and fuel

TABLE XI
COMPARISON BETWEEN DESIGNED AND SIMULATED RESULTS FOR SECOND ARRANGEMENT

| RESULTS | FUEL CONSUMPTION |
|---|---|
| DESIGNED | 40.7 |
| SIMULATED | 36.6 |

## IV. CONCLUSION AND FUTURE WORK

This paper presents the fuzzy logic based fuel consumption control system. From the results, it is very clear that the designed and simulated findings are very close agreement. Hence, the extensions and further diversities can be made by rearranging the input parameter values or number of inputs. It has been observed from the designed system that fuel consumption depend upon the speed and load applied to the system. The consumption can be regulated and minimized corresponding to the input parameters and it can be made more sensitive and dependent on speed and load and cannot be consumed in any other way.

In future, paths are open to enhance reliability and make the system more precise. Many extensions and diversities can be made by adding some other input parameters which can affect the fuel consumption for a range of different systems depending upon the nature of the system. FPGA technique can be used to implement the model system. The hardware scheme can be designed for all the system, as simulated results satisfy the designed and calculated findings.

## REFERENCES

[1] L. A. Zadeh "Fuzzy Sets and Applications", Selected papers, ed R.R Yarger et al (John Wiley, New York,1987).

[2] Brule, James. "Fuzzy Systems", http://life.csu.edu.au/complex/tutorials/fuzzy.html

[3] SURPRIZE 96, Fuzzy Logic and its uses, Article 2: Daniel Mcniel and Paul Freiberger "Fuzzy Logic", http://www.ortech-engr.com/Fuzzy/reserviour.html

[4] M. Mahfouf, M. F.Abbod, D. A. Linkens. "A survey of fuzzy logic monitoring and control utilization in medicine," Department of Automatic control and System Engineering, University of Sheffield, August 2000.

[5] M. S. Khan, K. Benkrid, "A proposed grinding and mixing system using fuzzy time control discrete event model for industrial applications," Proceedings of the International Multi-Conference of Engineers and Computer Scientists ( IMECS 2009), 2009 Vol II, pp.18-20, 2009, Hong Kong.

[6] S. A. Abbas, S. M. Sheraz, H. Noor, "Fuzzy rule based traffic signal control system for oversaturated intersections," Department of Computer and Information Systems NED University of Engineering and Technology, Karachi Pakistan.

[7] N. J. Schouten, M. A. Salman and N. A. Kheir, "Fuzzy logic control for parallel hybrid vehicles," IEEE Transactions on Control Systems Technology, Vol 10, No. 3, 2002.

[8] C. C. Lee, "Fuzzy logic controller-part 1," IEEE Transactions on Systems, Man and Cybernetics, Vol. 20, No. 2, 1990.

[9] J. I. Corcau,and Eleonor, "Fuzzy logic controller as a power system stabilizer," International Journal of Circuits, Systems and Signal Processing.

[10] F. Baig. "Design model of fuzzy logic medical diagnosis control system," International Journal on Computer Science and Engineering (IJCSE).

[11] SJ. Huang and HC. Chao, "Fuzzy logic controller for a vehicle active suspension system," Department of Mechanical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan.

[12] M. Abbas, M. S. Khan, F. Zafar, "Autonomous room air cooler using fuzzy logic control system," International Journal of Scientific & Engineering Research, Vol. 2, Issue 5, 2011.

[13] J. Pouramini and A. Saeedi, "Fuzzy model identification for intelligent control of a vehicle speed limit," Journal of Mathematics and Computer Science, Vol.. 2, pp. 337-347, 2011.


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