MODELLING AND ANALYSIS OF A COMPRESSION IGNITION ENGINE BY FUZZYLOGIC USING BIODIESEL

1.M. Durga M.E, 2.T.Vinithrabanu M.E, 3.T.Vijayaraj M.E

1.Assistant professor, mechanical, prince shri venkateshwara & padmavathy engineering college, tamilnadu, india
2.Assistant professor, mechanical, prince shri venkateshwara & padmavathy engineering college, tamilnadu, india
3.Assistant professor, mechanical, prince shri venkateshwara & padmavathy engineering college, tamilnadu, india

ABSTRACT

Intelligent control is performed with the help of Fuzzy Logic as a tool. Fuzzy Logic enables the development of rule-based behavior The performance of a diesel engine using cotton seed fuel is analyzed with the help of optimization technique. The technique is, Fuzzy Logic (FZ). In which optimized engine parameters such as brake power, torque, specific fuel consumption and heat loss to exhaust is predicted in relation with input parameters such as engine speed and bio diesel blends of the engine. To acquire data for training and testing , two cylinders, four-stroke diesel engine is fuelled with cotton seed biodiesel and diesel fuel blends and operated at different engine speeds. A Different activation functions and several rules are used to assess the percentage error between the desired and the predicted values. It is observed that the fuzzy logic can predict the engine performance and exhaust emissions quite well with correlation coefficient(R). The obtained results are compared and evaluated.

Key word: *Fuzzy Logic, FZ Elements, Biodiesel, Compression Ignition engine*

---

1. INTRODUCTION

The knowledge of an expert can be coded in the form a rule-base, and used in decision making. The main advantage of Fuzzy Logic is that it can be tuned and adapted if necessary, thus enhancing the degree of freedom of control. It is also a non-linear structure, and this is especially useful in a complex system such as an advanced power train.Bio diesel, which is defined as a mono alkyl esters of long chain fatty acids derived from biological sources like vegetable oils and animal fats, which is proposed to replace a significant percentage of petroleum diesel in this century. Moreover bio diesel produced from oil seeds, vegetable oil cannot meet realistic need and it can be used only for a small fraction of existing demand for transport fuels. Increasing energy prices, energy and environment security concerns about petroleum based fuels are drawing considerable attention among researchers to find an alternate source of fuel.

1.1 General structure of fuzzy system

The standard configuration of a fuzzy logic system is composed of three major components. That is fuzzifier, fuzzy inference engine with rule bases, and defuzzifier. The fuzzifier performs the function of fuzzification, which converts input data from an observed input space into proper linguistic values of fuzzy sets through predefined input functions. The fuzzy inference matches the output of fuzzifier with the fuzzy logic rules and performs the approximate reasoning. Finally the defuzzifier performs the function of defuzzification to yield a crisp output through a predefined output.

1.2 How to generate fuzzy rules?

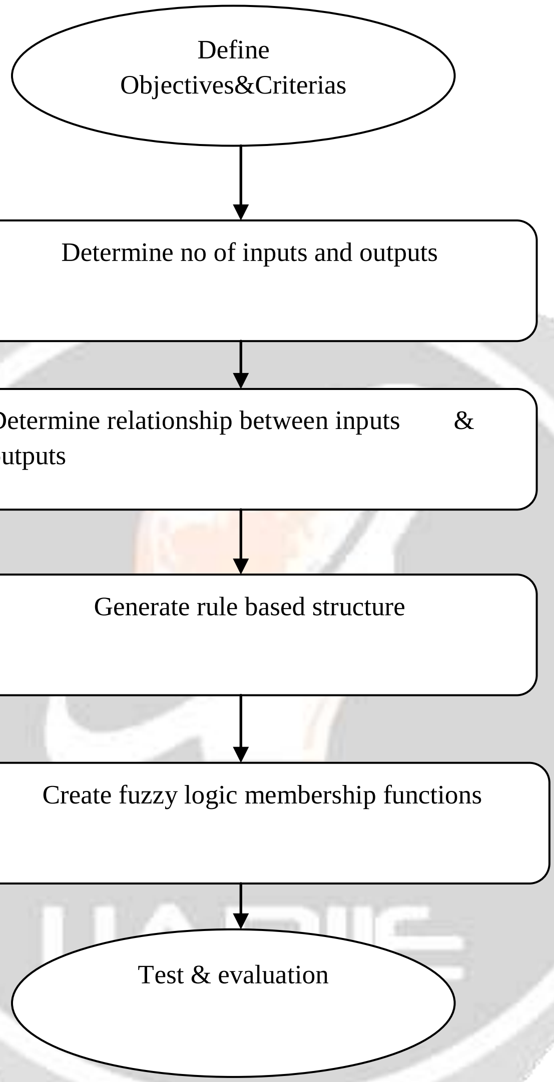


Fig-1 Flow chart for fuzzy rule list

1.3 Rule list table

Table-1 Fuzzy rule list

Speed	1600,1800,2000,2200(1,2,3,4)	2200,2400,2600,3000(5,6,7,8)
Biodiesel blends	0,20(1,2)	40,60(3,4)
Power	1312.5,1562.5,1843.81968.8 (1,2,3,4)	2125,2218.8,2250,2250 (5,6,7,8)
Torque	8,8.625,8.9375,8.875(1,2,3,4)	8.667,8.25,7.5,6.8334(5,6,7,8)
Fuel consumption	662.5,600,562.5,525(1,2,3,4)	512.5,550,587.5,650(5,6,7,8)
Heat loss	15,14.375,15.625,18.125(1,2,3,4)	22.5,24.375,26.25,26.875(1,2,3,4)

2. PURPOSE OF FUZZY SYSTEM

- It is inherently robust since it does not require precise, noise-free inputs and can be programmed to fail safely if a feedback sensor quits or is destroyed. The output control is a smooth control function despite a wide range of input variations.
- Since the FL controller processes user-defined rules governing the target control system, it can be modified and tweaked easily to improve or drastically alter system performance. New sensors can easily be incorporated into the system simply by generating appropriate governing rules.
- FL is not limited to a few feedback inputs and one or two control outputs, nor is it necessary to measure or compute rate-of-change parameters in order for it to be implemented. Any sensor data that provides some indication of a system's actions and reactions is sufficient. This allows the sensors to be inexpensive and imprecise thus keeping the overall system cost and complexity low.
- Because of the rule-based operation, any reasonable number of inputs can be processed (1-8 or more) and numerous outputs (1-4 or more) generated, although defining the rulebase quickly becomes complex if too many inputs and outputs are chosen for a single implementation since rules defining their interrelations must also be defined. It would be better to break the control system into smaller chunks and use several smaller FL controllers distributed on the system, each with more limited responsibilities

2.1 Neuro fuzzy system

These networks are low-level computational structures that perform well when dealing with raw data although neural networks can learn,they are opaque to the user. Fuzzy Systems fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. Fuzzy systems lack the ability to learn and cannot adjust themselves to a new environment. Integrated Neuro-fuzzy systems can combine the parallel computation and learning abilities of neural networks with the humanlike knowledge representation and explanation abilities of fuzzy systems. As a result, neural networks become more transparent, while fuzzy systems become capable of learning.

2.2 FIS structure and Parameters

A network-type structure similar to that of a neural network, which maps inputs through input membership functions and associated parameters, and then through output membership functions and associated parameters to outputs, can be used to interpret the input/output map. The parameters associated with the membership functions changes through the learning process. The computation of these parameters (or their adjustment) is facilitated by a gradient vector. This gradient vector provides a measure of how well the fuzzy inference system is modeling the input/output data for a given set of parameters. When the gradient vector is obtained, any of several optimization routines can be applied in order to adjust the parameters to reduce some error measure. This error measure is usually defined by the sum of the squared difference between actual and desired outputs. Anfis uses either back propagation or a combination of least squares estimation and back propagation for membership function parameter estimation.

3. DIESEL ENGINE

Diesel engine (compression ignition engine) is used widely as the power source of the ship and the automobile. As the principle of this engine, the air is entered in the cylinder, and it is compressed adiabatically to a high temperature at the first. When the mists of the fuel are jetted into the high temperature cylinder, it combusts automatically, and the engine obtains the output power. It can get the higher efficiency than that of the gasoline engine for a high compression ratio. Also this engine has economical advantage because it can use inexpensive light oil and heavy oil as the fuel. However it may have the problems such as large vibrations and noises, and increase of the engine weight for the high pressure in the cylinder

3.1 Performance and Analysis

Testing modified engines under all possible operating conditions and fuel cases is considered to be both time consuming and expensive. We have investigated the prospects of using artificial neural networks (ANN) to alleviate the burden of extensive experimental testing. The structure and function of the ANN tend to simulate a biological neuron network, which receives inputs from many sources, combines these inputs in some way, performs a generally non-linear operation on the result, and then outputs the final result.

The network usually consists of three groups of layers: an input layer, a number of hidden layers, and an output layer. Each layer has number of neurons. The number of neurons in the input and output layers depends on the input and output experimental data, while the features of the hidden layer are generally regarded as adjustable.

The hidden layers are generally tuned until the prediction has the minimum mean square error. All neurons are connected with other neurons in previous and subsequent layers.

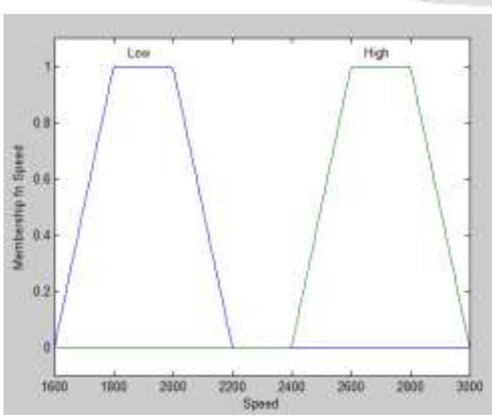
3.2 Parameters used

Table-2 Inputs and Outputs

Input Parameters	**Output Parameters**
Speed Bio-diesel blends	Power Torque Specific fuel consumption Heat loss to exhaust

4. CONCLUSION

From the predicted results operating a diesel engine on dual fuel bio-diesel, gives more power and torque with lower fuel consumption. It is found that the training algorithm of back propagation is sufficient for predicting engine power, torque, specific fuel consumption and exhaust temperature for different engine speeds and fuel mixers. Analysis of the experimental data by the FZ revealed that there is good correlation between the simulated results and experimental results. But It is shown that the predicted results are very close to the experimental data by FZ approach. This new approach could be considered as an alternative and practical technique to evaluate the engine parameters. This is widely used in various application areas such as pattern recognition, system identification, dynamic control, thermal system and so on



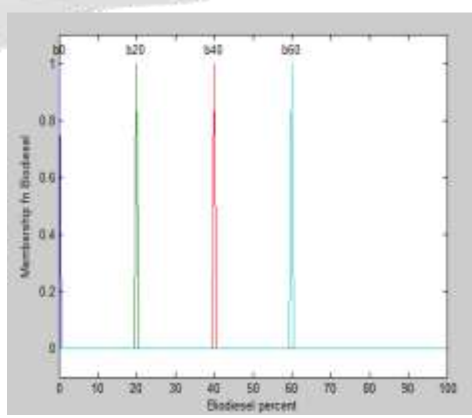


Chart-1 MF for Speed and Biodiesel blends

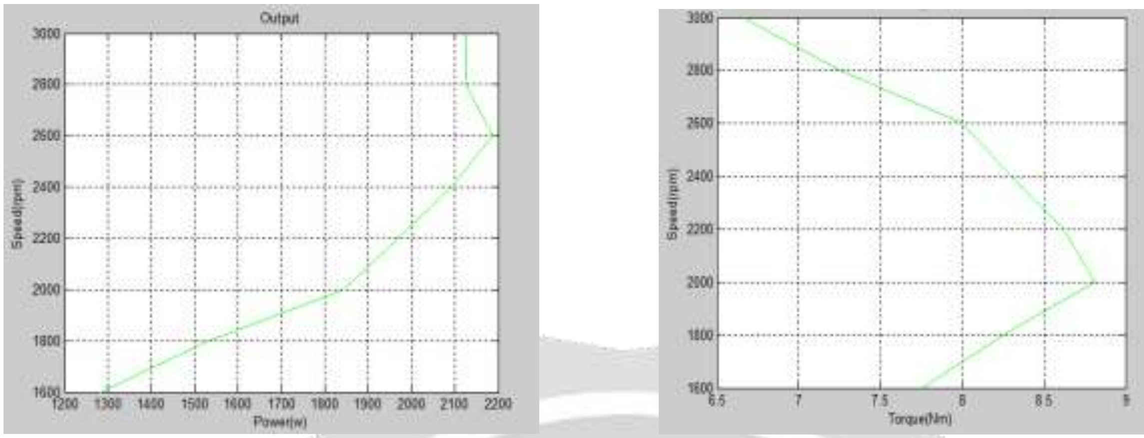


Chart-2 .Power and Torque output

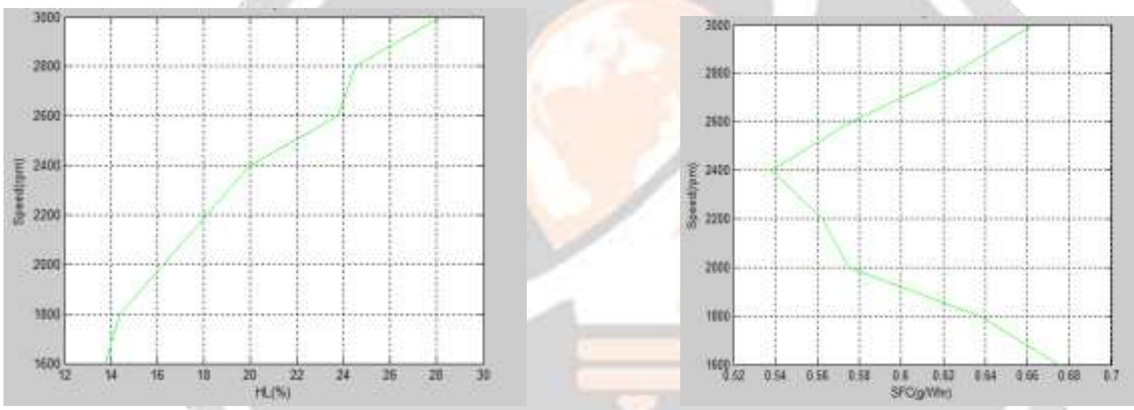


Chart-3.Heat Loss and Fuel Consumption output

FUZZY LOGIC PROGRAM

```
allti1=newfis('Power');
allti1=addvar(allti1,'input','Speed',[1600,3000]);
allti1=addmf(allti1,'input',1,'Low ','trapmf',[1600,1800,2000,2200]);
allti1=addmf(allti1,'input',1,'High ','trapmf',[2400,2600,2800,3000]);
plotmf(allti1,'input',1);
ylabel('Membership fn Speed');
allti1=addvar(allti1,'input','Biodiesel percent',[0,100]);
allti1=addmf(allti1,'input',2,'b0','trapmf',[0,0,0,0]);
allti1=addmf(allti1,'input',2,'b20','trapmf',[20,20,20,20]);
allti1=addmf(allti1,'input',2,'b40','trapmf',[40,40,40,40]);
allti1=addmf(allti1,'input',2,'b60','trapmf',[60,60,60,60]);
figure;
plotmf(allti1,'input',2);
ylabel('Membership fn Biodiesel');
allti1=addvar(allti1,'output','Power',[1000,3000]);
allti1=addmf(allti1,'output',1,'Low 0','trapmf',[1312.5,1562.5,1843.8,1968.8]);
```

```
allti1=addmf(allti1,'output',1,'High 0','trapmf',[2125,2218.8,2250,2250]);
figure;
plotmf(allti1,'output',1);
ylabel('Membership fn Power');
ruleList=[
   1 1 1 1 1
   1 1 2 1 1
   2 1 1 1 1
   2 1 2 1 1];
allti1 = addrule(allti1,ruleList);
result = evalfis([1600 0
              1800 0
              2000 0
              2200 0
              2400 0
              2600 0
              2800 0
              3000 0],allti1);
disp(result);
Speed=[1600,1800,2000,2200,2400,2600,2800,3000];
Biodiesel=[0,0,0,0,0,0,0,0];
Power =[1312.5,1562.5,1843.8,1968.8,2125,2218.8,2250,2250];
figure;
plot(Power,Speed,'-b');
title('Output')
xlabel('Power(w)');
ylabel('Speed(rpm)');
grid on;
```

5. ACKNOWLEDGEMENT

I thank God almighty from the depth of my heart for granting me the strength, time and resource to complete this project first face despite innumerable obstacles.

I sincerely thank our honored Vice Chancellor Dr. Raja Ram Ph.D. and express my profound respect to Mr.K. Karuppuswamy M.E., Head of the department for their support.

I would like to express my deep gratitude to my guide, Mr.P. Arul franco M.E.,Asst Professor, Department of Mechanical Engineering for his well-timed support and guidance and I thank all the faculties of mechanical department for their support, motivation and inspiration for pursuing the project.

6. REFERENCES

[1] Soteris A. Kalogirou *,2000, ‘Applications of artificial neural-networks for energy systems’ Applied Energy 67 ,17±35

[2] Tolga Topgu¨ l, Hu¨ seyin Serdar Yu¨ cesu, Can C- inar_, Atilla Koca,2006, ‘The effects of ethanol–unleaded gasoline blends and ignition timing on engine performance and exhaust emissions,’ Renewable Energy 31,2534–2542

[3] Mohamed M. El-Awad and Talal F Yusaf,2004, ‘Performance and Exhaust Emission of Diesel Engine Using Crude Palm Oil as Fuel Extender’ Journal of Energy & Environment 3, 61-68

[4] Gholamhassan NAJAFI, Barat GHOBADIAN, Talal F YUSAF and Hadi RAHIMI,2007,‘Combustion Analysis of a CI Engine Performance Using Waste Cooking Biodiesel Fuelwith an Artificial Neural Network Aid’, American Journal of Applied Sciences 4 (10), 756-764.