MODELLING AND ANALYSIS OF A COMPRESSION IGNITION ENGINE BY ARTIFICIAL NUERAL NETWORK USING BIODIESEL

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ABSTRACT

The performance of a diesel engine using cotton seed fuel is analyzed with the help of optimization technique. The technique is, Artificial Neural Network (ANN). 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 the proposed ANN, a two cylinders, four-stroke diesel engine is fuelled with cotton seed biodiesel and diesel fuel blends and operated at different engine speeds. A Multilayer perception network (MLP) is used for non-linear mapping between the input and output parameters. 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 ANN can predict the engine performance and exhaust emissions quite well with correlation coefficient(R). The obtained results are compared and evaluated.

Key word: *ANN, ANN Elements, Back Propagation algorithm, Biodiesel, Compression Ignition engine*

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1. INTRODUCTION

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 [2]. High prices coupled with the paucity of petroleum reserves and environmental concerns have sparked a search for renewable engine fuels. As most of the developing nations are agricultural nations**,** producing plenty of oilseed crops and production of vegetable oils will not be a difficult task. In the present investigation blends of cotton seed oil and diesel oil have been chosen as a fuel for CI engine [2].

Feasibility of these oils,

- It can be domestically produced, offering the possibility of reducing petroleum imports

- It is biodegradable; Some alternate fuel has to take the place of these fuels in order to sustain the economic growth
- It's combustion products have reduced levels of particulates, carbon monoxide and Nitrogen oxides
- Engine wear and maintenance costs are reduced

1.1 Need for biodiesel

There exists an inherent and ever-looming problem with fossil fuels, currently the world's dominant energy source. Increasing industrialization and motorization has led to a steep rise in the demand of petroleum-based fuels. With the exception of hydroelectric power and nuclear energy the majority of world energy needs are supplied through petrochemical sources, coal and natural gas. In particular the sources of oil are finite and at current consumption rates will be probably exhausted by the end of the century. It is estimated that 995 billion barrels of crude oil remain underground which can be mined at reasonable production costs. If this assessment is taken to be true, "cheap" oil would run out by the year 2025 and a majority of oil wells would be dry by 2040. While these figures are only educated guesses, they emphasize the seriousness of the problem facing humanity.

1.2 BIOFUELS AS AN ALTERNATIVE TO PETROLEUM

In this perspective, new renewable fuels such as bio fuels are found to be a favorable option. Biodiesel is made in more than 28 countries in which Germany and France are pioneers and they are major producers in Europe. Nevertheless there are still technical problems that limit the cost of bio diesel. The United States Department Energy assesses that up to 50% of the total of diesel fuel could be potentially replaced by bio diesel. At present bio fuels are produced from edible crops (Cotton Seed, Palm Nut, Linseed, Groundnut, and Sugarcane), non-edible crops Jatropha Curcas, Algae, Eucalyptus, Orange Skin, Eruca Sativa Gars, Neem Oil), waste tyre, animal tallows and fish.

2. NEURAL NETWORK INTRODUCTION

Neural computing is an information processing paradigm inspired by biological system composed of large number of highly interconnected processing elements(neurons) working in unison to solve specific problems. A neural net is an artificial representation of the human brain that tries to simulate its learning process. An artificial neural network (ANN) is often called a neural network or simply Neural Net (NN).Traditionally, the word neural network is referred to a network of biological neurons in the nervous system that process and transmit information. Artificial neural network is an interconnected group of artificial neurons that uses a mathematical model or computational model for information processing based on a connectionist approach to computation .The artificial neural networks are made of interconnecting artificial neurons which may share some properties of biological neural networks. Artificial neural network is a network of simple processing elements (neurons) which can be exhibit complex global behavior determined by the connections between the processing elements and element parameters[1]

2.1 Structure of neural cell in human brain

The human brain consists of a large number more than a billion of neural cells that process information. Each cell works like a simple processor. The massive interaction between all cells and their parallel processing only makes the brains abilities possible.

- **Dendrites** are branching fibers that extends from cell body or soma
- **Soma** of a neuron contains the nucleus and other structures support, chemical processing and production of neurotransmitters
- **Axon** is a singular fiber carries information away from the soma to the synaptic sites of other neurons, muscles,
- **Axon hillock** is the site of summation for incoming information. At any moment, the collective influence of all neurons that conduct impulses to a given neuron will determine whether or not an action potential will be initiated at the axon hillock and propagated along the axon [3]
- **Myelin sheath** consists of fat- containing cells that insulate the axon from electrical activity. This insulation acts to increase the rate of transmission of signals. A gab exists between each myelin sheath

cell along the axon. Since fat inhibits the propagation of electricity, the signals jump from one gap to the next

- **Nodes of ranvier** are the gaps (about 1 µm)between myelin sheath cells along axons are since fat serves as a good insulator, the myelin sheaths speed the rate of transmission of an electrical impulse along the axon
- **Synapse** is the point of connection between two neurons or a neuron and a muscle. Electro chemical communication between neurons takes place at these junctions.
- **Terminal buttons** of a neuron are the small knobs at the end of an axon that release chemicals called neurotransmitters[4]

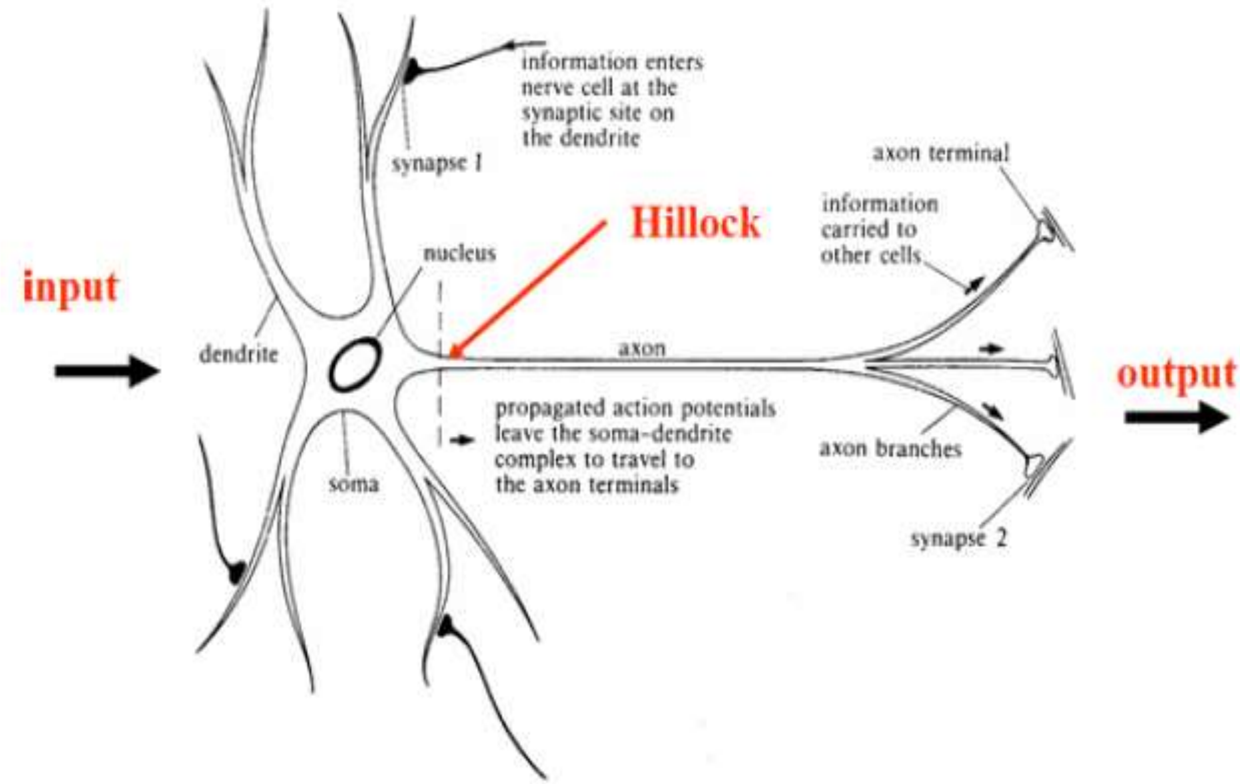

Fig-1 Structure of neural cell in the human brain

2.2 Information flow in the neural cell

- Dendrites receive activation from other neurons
- Soma processes the incoming activations and converts them into output activations
- Axons act as transmission lines to send activation to other neurons
- Synopses the junctions allow signal transmission between axons and denrites
- The process of transmission is by diffusion of chemicals called neuro-transmitters

2. ARTIFICIAL NEURON MODEL

An artificial neuron is a mathematical function conceived as a simple model of a real (biological) neuron. It is a simplified model of real neurons known as threshold logic unit in which a set of input connections brings in activations from other neurons[2]. A processing unit sums the inputs and then applies a nonlinear activation function. An output line transmits the result to other neurons[4]

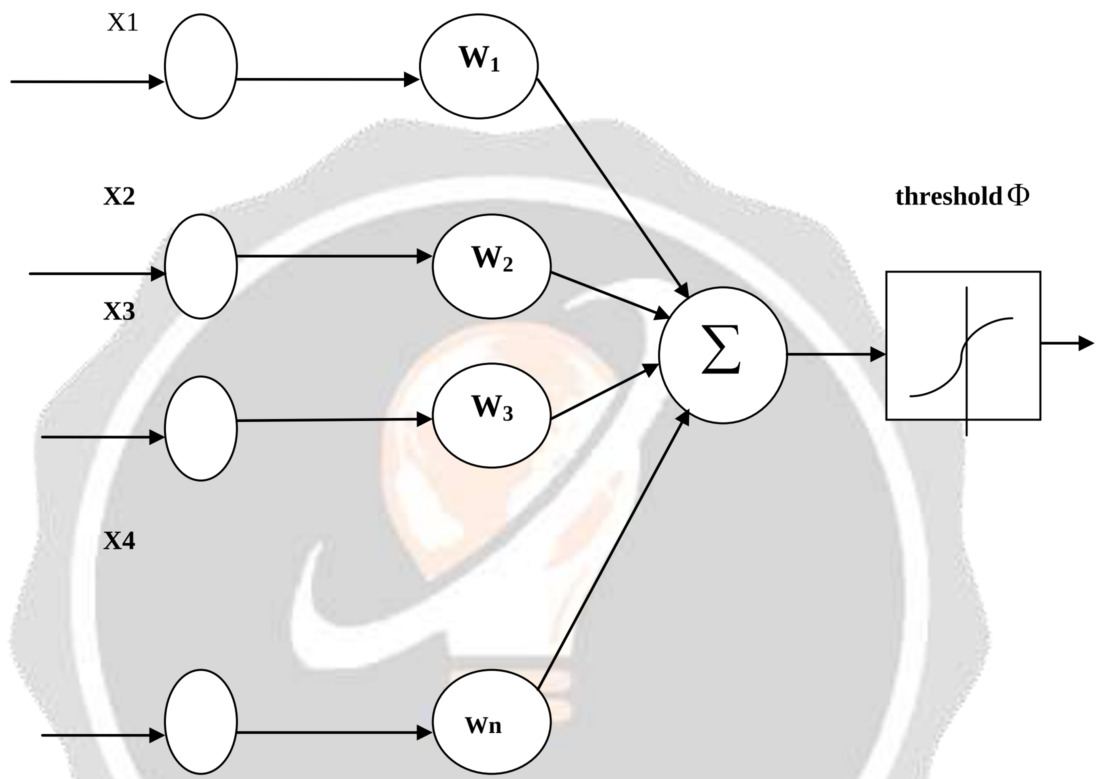

Fig-2 Neuron model

In this process,

-the input to a neuron arrives in the form of signals

-the signals buildup in the cell

-finally the cell discharges through

-the cell can start building up signals again

Where Φ is the neuron activation threshold

$$\text{Output} = \text{sgn}\left(\sum_{i=1}^{n} \text{Input i} - \Phi\right)$$

$$\text{If} \quad \sum_{i=1}^{n} \text{input i} \geq \Phi \text{ then output} = 1$$

$$\text{If} \quad \sum_{i=1}^{n} \text{input i} < \Phi \text{ then output} = 0$$

3.1 Parameter analysis using ANN

Neuron consists of three basic components -weights, thresholds, and a single activation function.The values W_1, W_2,… Wn are weights to determine the strength of input vector X=[X_1,X_2,….Xn]. Each input is multiplied by the associated weight of the neuron connection XTW. The +ve weight excites and the –ve weight inhibits the node output.$I=X^TW=X_1W_1+X_2W_2+$………..+ XnWn = $\sum_{i=1}^{n} x_i w_i$

The node's internal threshold Φ is the magnitude offset. It affects the activation of the node output Y as: Y=f(I)=f{ $\sum_{i=1}^{n} x_i w_i - \Phi k$ }.To generate the final output Y ,the sum is passed on to a nonlinear filter f called activation function or transfer function or squash function which releases the output Y

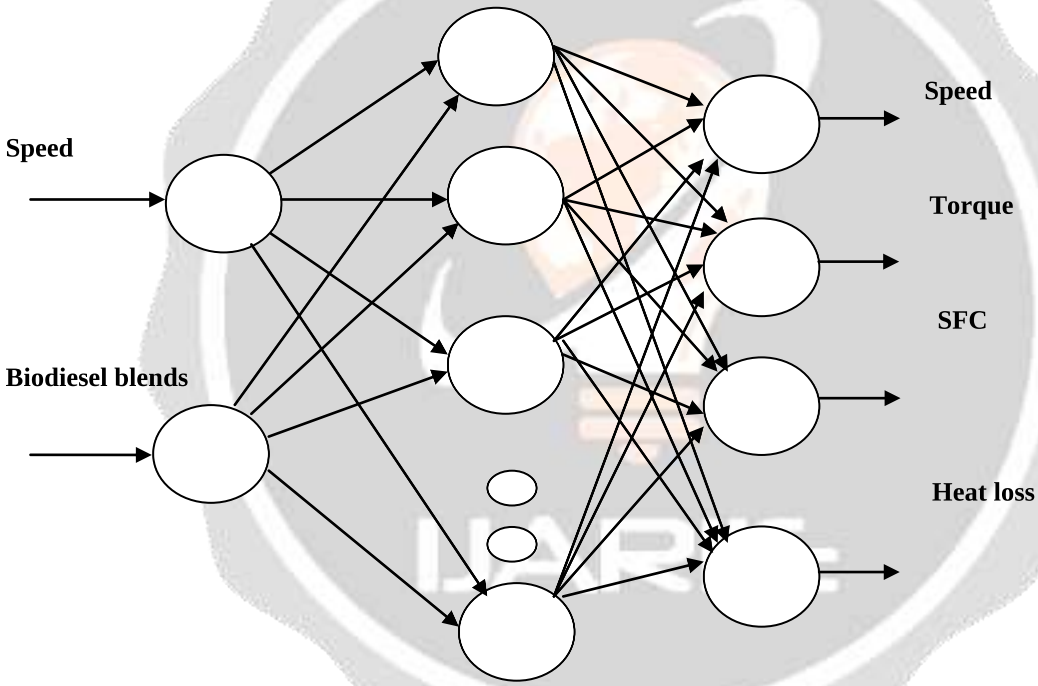

Fig-3 System analysis using ANN

4. NEURAL NETWORK ARCHITECHTURES

An artificial neural network is a data processing system, consisting large number of simple highly interconnected processing elements as artificial neuron in a network structure. It can be represented as a set of vertices and a set of edges[2] .The vertices may represent neurons (input/output).The edges may represent synaptic links labeled by the weights attached. It is classified into three types. They are single layer feed forward netwok, Multilayer feed forward network and Recurrent network.

4.1 Single layer feed forward network

Single layer feed forward network consists of a single layer of weights where the inputs are directly connected to the outputs, via a series of outputs. The synaptic links carrying weights connect every input to every output, but not other way. This way it is considered a network of feed forward type. The sum of the products of weights and the inputs is calculated in each neuron node, and if the value is above some threshold (typically 0) the neuron fires and takes the activated value (typically 1) ; otherwise it takes the deactivated value(typically -1)

4.2. Multilayer feed forward network

The architecture of this class of network , besides having the input and the output layers also have one or more intermediary layers called hidden layers. The computational units of hidden layer are known as hidden neurons. The hidden layer does intermediate computation before directing the input to output layer. The input layer neurons are linked to the hidden layer neurons. The weights on these links are referred to as input-hidden layer weights. A multilayer feed forward network with l input neurons m1 neurons in the first hidden layers, m2 neurons in the second hidden layers and n output neurons in the output layers is written as (l-m1-m2-n)

4.3 Recurrent network

The recurrent networks differ from feed forward architecture. A recurrent network has at least one feedback loop. There could be neurons with selffeed back links.

5. APPLICATIONS OF NEURAL NETWORK

5.1 Clustering

A clustering algorithm explores the similarity between patterns and places similar patterns in cluster. Best known applications include data compression and data mining[3]

5.2 Pattern recognition

The task of pattern recognition is to assign an input to one of many classes. This category includes algorithmic implementations such as associative memory.

5.3 Function approximation

The Tasks of function approximation is to find an estimate of the unknown function subject to noise . Various engineering and scientific disciplines requires function approximation

6. 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 ANN 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 ANN 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.

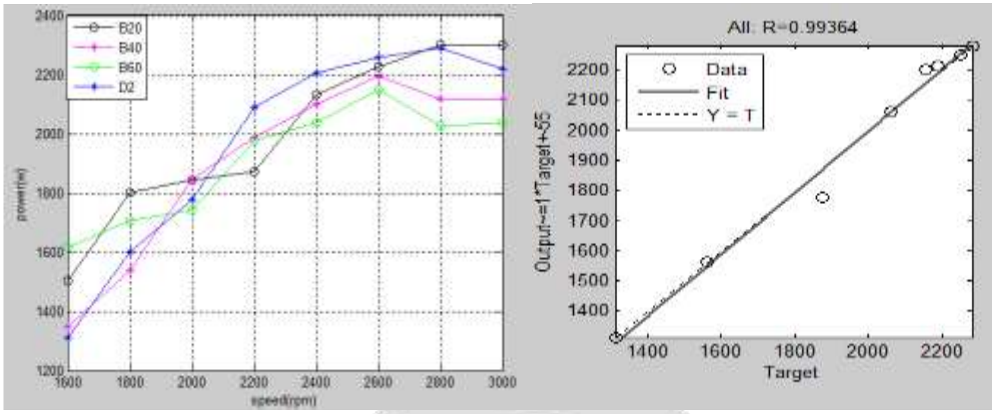

Chart-1 Speed Vs Power

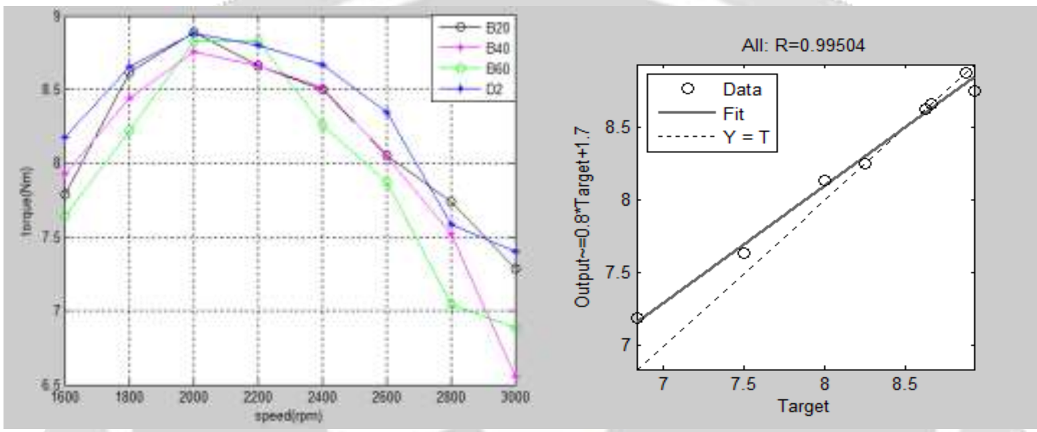

Chart-2 Speed Vs Torque

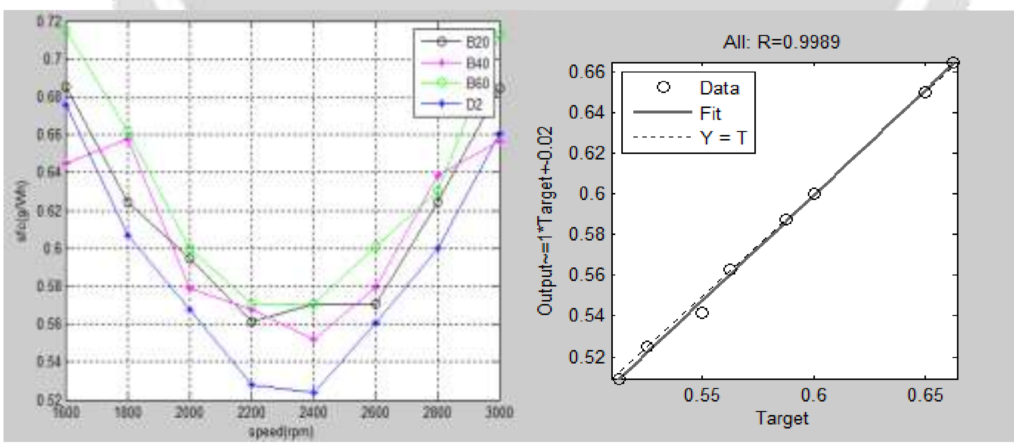

Chart-3 Speed Vs SFC

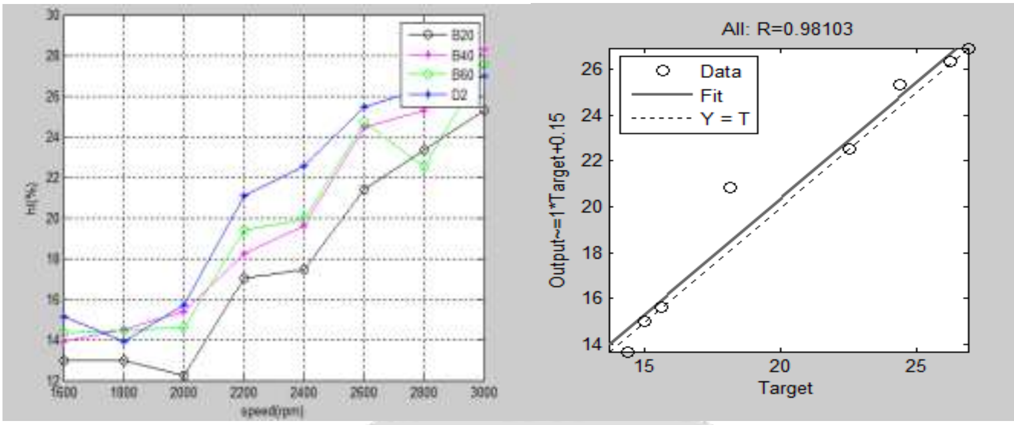

Chart-4 Speed and Heat loss

ANN PROGRAM FOR POWER

```
close all;
clear all;
constt=257.6;
%generation of training data
%initialize speed
n=[1600 1800 2000 2200 2400 2600 2800 3000 ];
t=(constt.*n)/1400;
%disp(t);
%p=(2.*22.7.*n.*t)/60;
p1=[1312.5 1562.5 1843.8 1968.8 2125 2218.8 2250 2250];
disp('Experimental value of power for B20');
disp(p1);
inp=p1-10;
net1=newff(inp,p1,5,{'logsig','purelin'});
net1= train(net1,inp,p1);
w1=net1.IW{1,1};
b1=net1.b{1};
w2=net1.IW{2,1};
b2=net1.b{2};
Y1 = sim(net1,p1);
disp('Simulated value of power for B20');
disp(Y1);
p2=[1281.3 1531.3 1843.8 1968.8 2093.8 2187.5 2125 2125];
disp('Experimental value of power for B40');
disp(p2);
inp=p2-10;
net2=newff(inp,p2,5,{'logsig','purelin'});
net2 = train(net2,inp,p2);
w3=net2.IW{1,1};
b3=net2.b{1};
w4=net2.IW{2,1};
b4=net2.b{2};
Y2 = sim(net2,p2);
disp('Simulated value of power for B40');
disp(Y2);
p3=[1250 1500 1812.5 1968.8 2062.5 2125 2050 2062.5];
```

```
disp('Experimental value of power for B60');
disp(p3);
inp=p3-10;
net3=newff(inp,p3,5,{'logsig','purelin'});
net3= train(net3,inp,p3);
w5=net3.IW{1,1};
b5=net3.b{1};
w6=net3.IW{2,1};
b6=net3.b{2};
Y3= sim(net3,p3);
disp('Simulated value of power for B60');
disp(Y3);
p4=[1312.5 1562.5 1875 2062.5 2156.3 2250 2281.3 2187.5];
disp('Experimental value of power for D2');
disp(p4);
inp=p4-10;
net4=newff(inp,p4,5,{'logsig','purelin'});
net4 = train(net4,inp,p4);
w7=net4.IW{1,1};
b7=net4.b{1};
w8=net4.IW{2,1};
b8=net4.b{2};
Y4= sim(net4,p4);
disp('Simulated value of power for D2');
disp(Y4);
figure,
plot(n,Y1,'o-k',n,Y2,'*-m',n,Y3,'o-g',n,Y4,'*-b')
grid on;
Hold on;
xlabel('speed(rpm)');
ylabel('power(w)');
legend('B20','B40','B60','D2');
```

RESULTS

Experimental value of power for B20

1.0e+003 *

1.3125 1.5625 1.8438 1.9688 2.1250 2.2188 2.2500 2.2500

Simulated value of power for B20

1.2813 1.5313 1.8438 1.9688 2.0938 2.1875 2.1250 2.1250

Simulated value of power for B40

1.0e+003 *

1.3478 1.5402 1.8480 1.9873 2.0984 2.1960 2.1186 2.1186

Experimental value of power for B60

1.0e+003 *

1.2500 1.5000 1.8125 1.9688 2.0625 2.1250 2.0500 2.0625

Simulated value of power for B60

1.0e+003 *

1.6144 1.7057 1.7422 1.9766 2.0380 2.1482 2.0254 2.0380

Experimental value of power for D2

1.0e+003 *

1.3125 1.5625 1.8750 2.0625 2.1563 2.2500 2.2813 2.1875

Simulated value of power for D2

1.0e+003 *

1.3099 1.6003 1.7763 2.0898 2.2057 2.2587 2.2891 2.2185

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8. REFERENCES

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