

Research Article

Artificial Neural Network (ANN) One of the Strong Computational Method of Determining Kerosene Adulteration in Diesel

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Abstract

In some of the developing countries of South Asia, fuel like diesel are being mixed with kerosene and this types of inferior quality of blends are used as a fuel in engine. By using this type of inferior quality fuel many pollutants are emitted like NO_x, SO_x, CO₂, CO, and particulate matter. Furthermore, because of using these types of blends as a fuel it also affect the engine life. By observing the consequences of use of these types of fuel it is required to detect how much adulteration or mixing is done. There are lots of sophisticated technologies are available to detect this type of adulteration or mixing but all these technology have their own limitations. So here in this paper one of the strong and easier computation method is being described by which one can detect the quantity of mixed or adulterated kerosene easily in twenty to thirty minutes. Only it required to give input values to designed Artificial Neural Network and it will give value of mixed or adulterated kerosene with an average error of plus or minus 0.268.

Keywords: Fuel, mixing of petroleum fractions like diesel, techniques for detection, ANN

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Introduction

In many countries especially in South Asia countries diesel is being mixed with kerosene and used as a fuel in engine. This type of inferior quality of fuel is causes of pollution and decay in engine life. So it is required to quantify how much kerosene is being mixed with fuel. The use of diesel with kerosene is done in industries to increase use of fuel working condition at low temperature. This type of mixing is favourable till it met with the given specification of manufacturers. However, mixing of low level sulphur fuel like diesel mixed with high level sulphur fuel like kerosene is causes of maximum sulphur content in fuel. PAH's and nitrogen containing PAH's in diesel exhaust arise in diesel fuel because of 'flow through' effects in fuel composition. By using kerosene as an adulterant it decreases PAH composition because it not contain PAH in high quantity. This is the benefit of use of kerosene in diesel as an adulterant. The smoke is result because of over-rich-zone. This over-rich-zone is generated due to high fuel injection ratios, dirty injectors and injection nozzle tip wear. Over-fuelling to increase power output, common phenomenon world-wide, result in higher smoke emission and lower fuel economy. During injection is common cause because for that high maintenance cost is required.(6) Because of addition of heavy oil the PAH in fuel is increase and the emission of PAH and PM is also increases.

The important step in tackling this fuel adulteration is reducing incentives for engaging in this commercial malpractice to the extent possible. The incentive depends on the relative benefit and cost. The benefit arises from differential taxation, tax evasion and differential production cost and can be reduced but not be eliminated. It is important to bear in mind that the fiscal policy has multiple objectives and reducing the fuel adulteration one among many. As such concerned about fuel adulteration, however serious, cannot and should not be the sole driver of fiscal policy. The cost depends on the ability of the regulating authorities to detect adulteration and to impose sufficiently punishing sanctions to deter recurrence of fuel adulteration. The manner in which retail fuels are distributed has an important bearing on fuel adulteration. For example, having large numbers of small, independent transport truck operators moving fuels from terminals to the point of sale creates an environment conducive to adulteration.(4) Adulteration may also be occurring with the collusion of the retail outlet operator. If government officials are involved in adulteration, establishing a good monitoring and enforcement mechanism becomes all the more difficult. One effective 'market based' approach is the practice in many, industrial countries whereby oil companies market at retail and assume responsibility throughout the supply chain to guarantee fuel quality in order to protect their public image and market share. Even in best of circumstances, taking and maintaining samples for checking fuel quality is not easy.(4) In South Asia, finding proper sample containers and not being personally harassed at retail outlets while

sampling are just two of the very real operational problems to be resolved. The CSE report describes the problem of auditing and sampling retail outlets. These problems are compounded by lack of experience in checking specifically for adulteration (6,7).

Because of lots of consequences for detection of adulteration it is required to give easier and strong method which should be very fast and could be used in field. Some of the methods are available like evaporation test, distillation test, ash determination test, gas chromatography, optical fibre sensor detection method, ultrasound detection techniques etc (6, 8). An evaporation test is not a field technique and in this technique gum is being found in given sample. In density measurement technique, the densitometer is used which is very sensitive equipment in field. Likewise the gas chromatography is so much sophisticated equipment which could be used but it required experienced analyst as well as skilled interpretation of the result. There is a easier technique known as measurement of ash is also used but it is for adulteration of industrial solvents but this technique is not used for all the adulterant like kerosene etc, while the distillation test is used by taking the data for pure diesel and compared with adulterated sample but this method is not used for industrial solvents like hexane, toluene and xylene. One of technique which is very well-known in recent year is marker technique in which visible dye has been added in the diesel to produce colour and on the bases of that adulterant is detected. In South Asia this technique is used but by using this technique cost of product is increase, marker must be purchased and added, than detection equipment needs to be bought, operated and maintained. All this technique has their own limitation to detect adulteration and no any strong method available without limitation. So here in this circumstances one of the computational method described which give quickly adulteration done within twenty to thirty minutes. This method required only input values to give designed Artificial Neural Network (ANN) and automatically it give quantity of adulteration. This ANN is designed in MATLAB software.

Material and Methods

Material and equipment

The diesel sample is collected from Ashram road, Ahmedabad, Gujarat, India. Kerosene is being collected from Vadodara, Gujarat, India. MATLAB software is used in SVNIT, Surat for designing Artificial Neural Network (ANN). For designing the ANN input values are required to give to network which are properties like smoke point, diesel index, specific gravity, API gravity. All these properties are evaluated at L.D. Engineering, Ahmedabad, Gujarat, India. L. D. Engineering is co-anchor institute of petroleum refinery engineering with Dharmising Desai institute of engineering, Nadiad, Gujarat, India.

Methodology

For evaluation of properties like smoke point, specific gravity, API gravity, diesel index, different proportional blends of diesel and kerosene like pure diesel, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90, pure kerosene where prepared. And for all this blends all above mentioned properties are evaluated. The smoke point determination is done by P:31 IP 57 methodology, specific gravity is being determined by using specific gravity bottle of 25 ml capacity. API gravity and diesel index are determined by mathematical equations given bellow which are given by ASTM.

$$\text{API deg. Gravity} = \frac{131.5}{\rho} - 141.5$$

Smoke point is defined as the maximum height of flame in millimetres at which the given oil will burn without giving smoke in standard lamp mentioned in P 31 IP 57 methodology. (XIII). Sp. Gravity is the ratio of density of given oil at 15.5 deg. C to the reference liquid at 15.5 deg. C in standard specific gravity bottle as shown in Figure 1 (XIV).

All this evaluated properties are additive properties as per the readings evaluated (**Table 1**). These properties are used to design Artificial Neural Network (ANN) in MATLAB software. For that a supervised neural network is designed. The supervised neural network is that network in which input and output values are required to give neural network. Here the output value is known as target value. The input value is multiply by weight and goes to neuron. The neuron is contain an activation function and when it get required value for activation it will become activate and it will give an output value. This output value is compared with target value which we have already given. If there is an error between target value and network output value then the beck signal is goes to neuron and according to back

value the weights are adjusted. This process is called training or learning. Here at bellow one neuron is shown for giving example.



Figure 1 Smoke point (mm) determination lamp as per P 31 IP 57 methodology. (2, pp 146)



Figure 2 Specific gravity bottle of 25 ml capacity (1, pp 121)

Table 1 An input and output (Target) values for designing Artificial Neural Network (ANN)

S. No	In put			Output (Target)
	Sr. Gravity	API gravity	Smoke point (mm)	
1	0.8214	40.76	23	0%
2	0.8210	42.24	18	10%
3	0.8144	41.5	16	20%
4	0.8000	42.24	15	30%
5	0.7800	43.62	40	40%

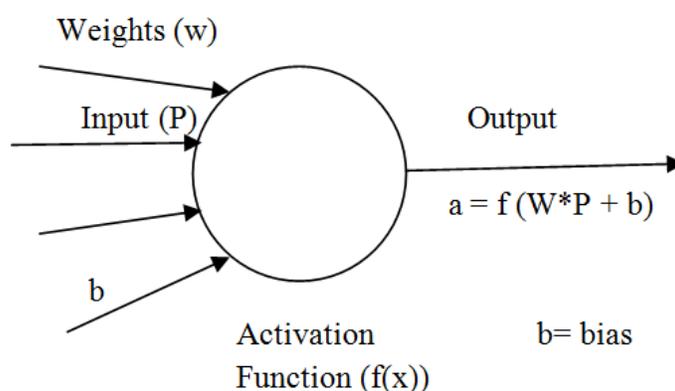


Figure 3 An example of Artificial Neuron

The calculation of weights for one neuron is very simple but that for more than one neuron it will become complicated so for this type of neural network which contain more than one neuron weight is being adjusted by algorithms. The activated function is also required to select as per data selected for input. Here in this case the data for 10 to 100% adulteration are available. As these data are properties evaluated above and all this properties are additive so they could converted in data for 1% change in Excel software. When these output and input data are ready they are taken in MATLAB software's workplace for giving input and output values to Artificial Neural Network which we want to design. One test file is also required to prepare for simulation purposes. This workplaces of output, input and test file are taken on desktop. By giving the $f(x) \ll nntool$ function to MATLAB the ANN space is being open. The input, output and test file is being imported from destalk to ANN space. Then for giving the data to network, take the data inside input and target cell. Then generate neural network by click the "new" button of ANN space. Then it is required to select number of neurons, algorithm (trainLM) and activated function (logsigmoidal) then the neural network can be generated. Now for simulation double click on the generated neural network. One simulation screen will be displayed. For simulate the neural network give input and target file to network then click on trasin. The network will be trained. Then output will be taken from the network by simulating the trained network for which it is required to give the input value to simulate. Then output will be come on the screen of ANN. Here this output is called the predicted values from network which is compared with experimental values.

All the screenshot of MATLAB software are given bellow which shows the procedure of designing of Artificial Neural Network.

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	CA	CB	CC	CD	CE
1	34	34.3	35	35.5	36	36.3	37	37.3	38	38.5	39	39.5	40		
2	34.6	34.59	34.5	34.45	34.4	34.35	34.2	34.25	34.2	34.15	34.1	34.05	34		
3	0.702	0.798	0.75	0.789	0.789	0.793	0.796	0.78	0.794	0.793	0.781	0.783	0.78		
4	41.792	42.861	42.91	42.995	43.062	43.137	43.206	43.275	43.344	43.413	43.482	43.551	43.62		
5															
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12															
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Figure 4 Preparation of input and output data in Excel software

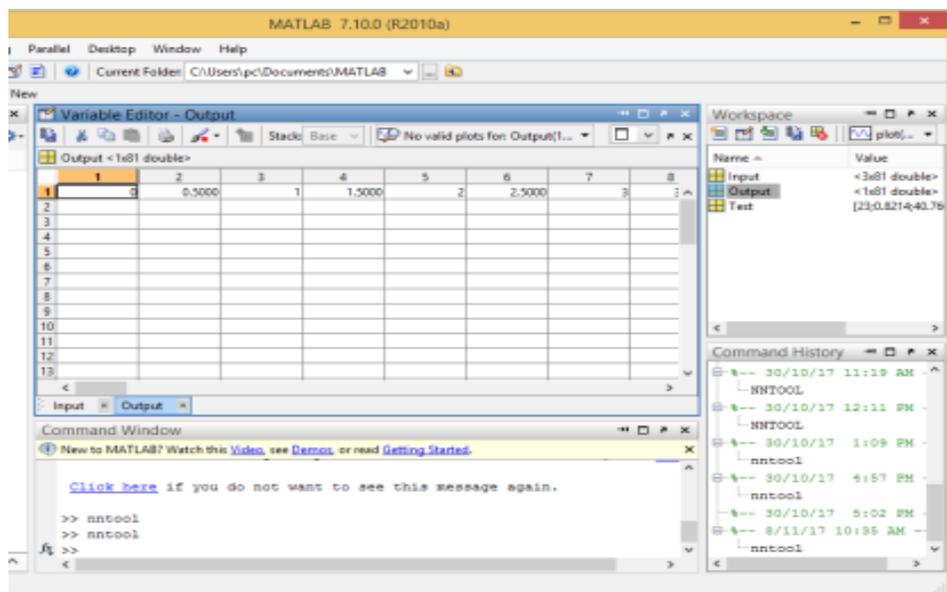


Figure 5 Preparation of input data in workspace of MATLAB software

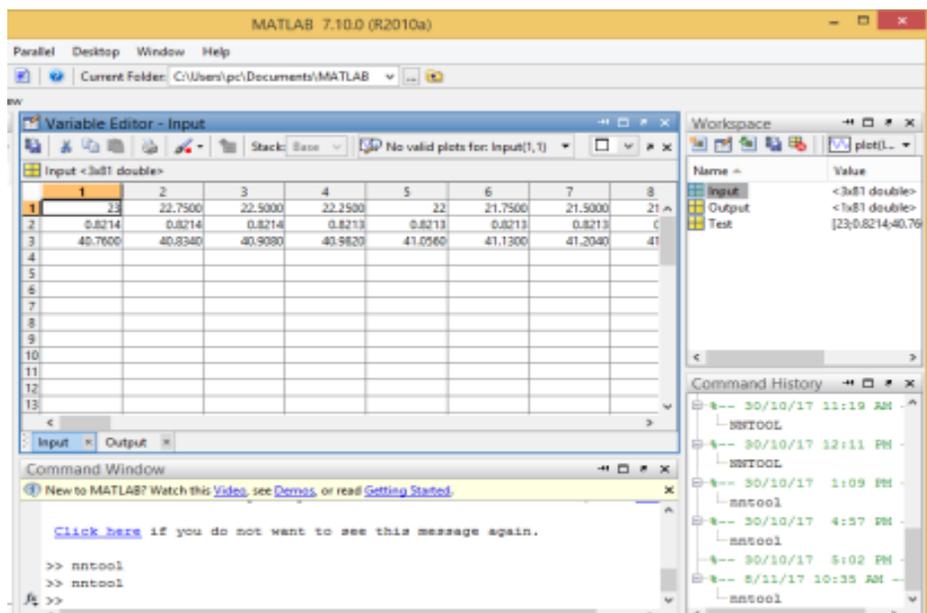


Figure 6 Preparation of output data in workspace of MATLAB software

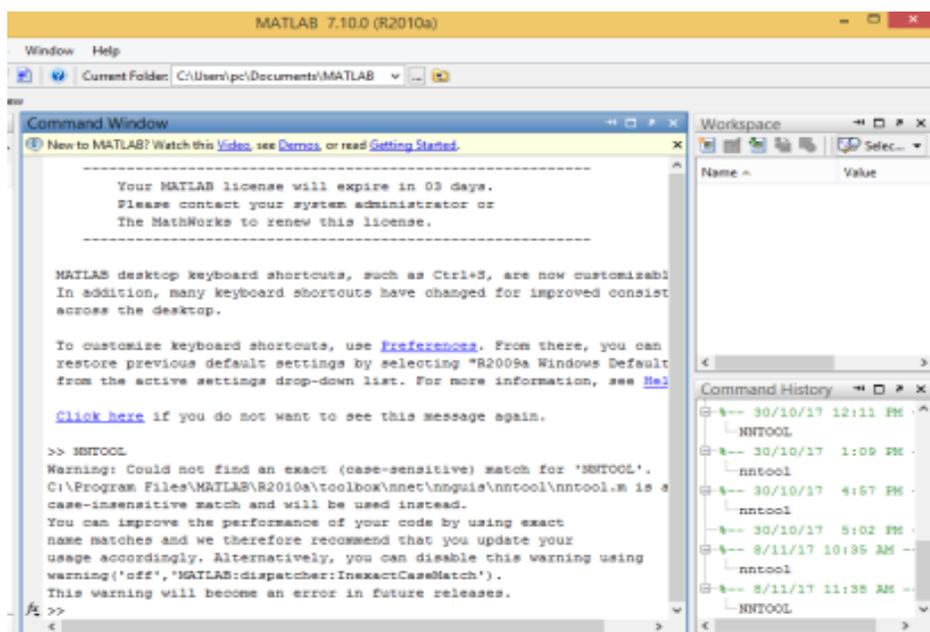


Figure 7 Opening of ANN in MATLAB by giving “nntool” command

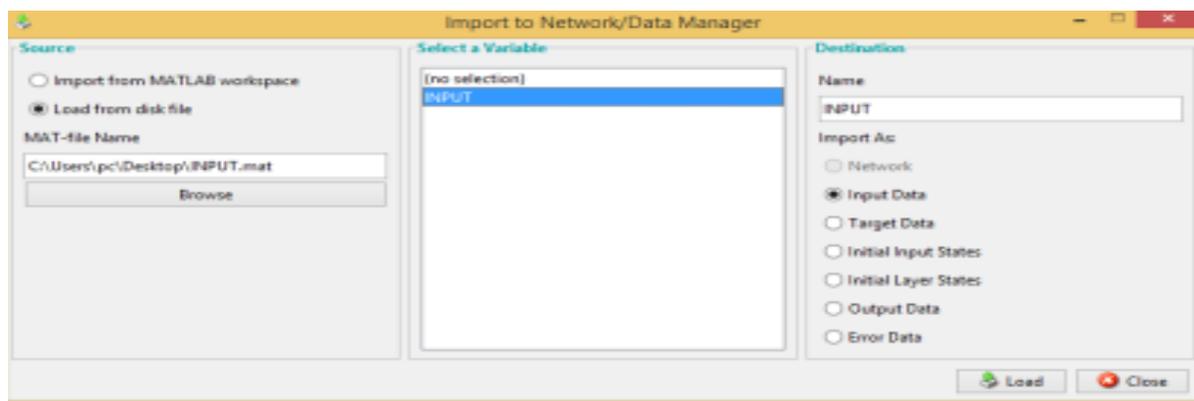


Figure 8 Import of input and output (or target) data in ANN

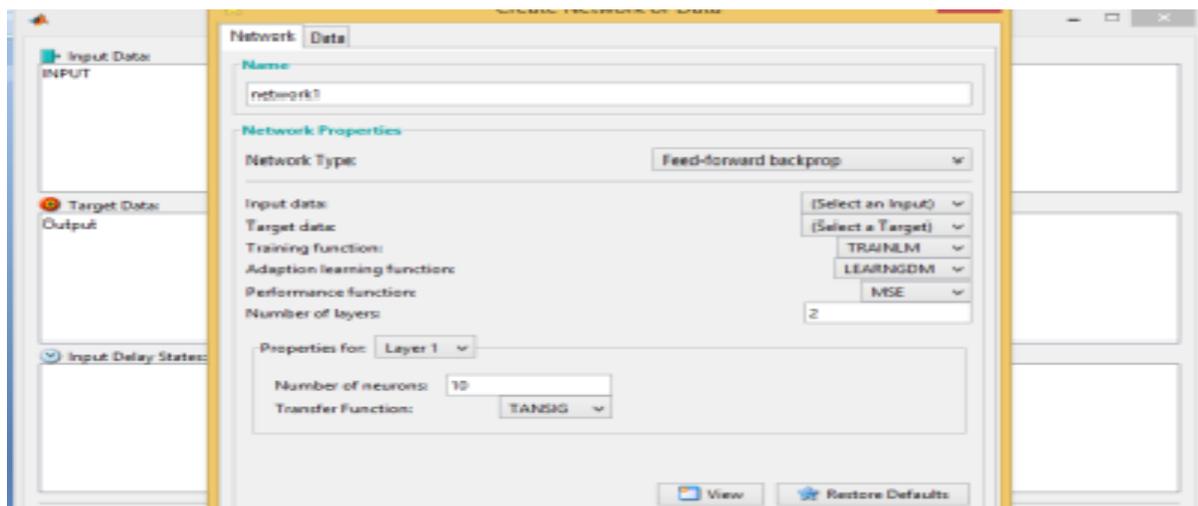


Figure 9 Designing of Artificial Neural Network

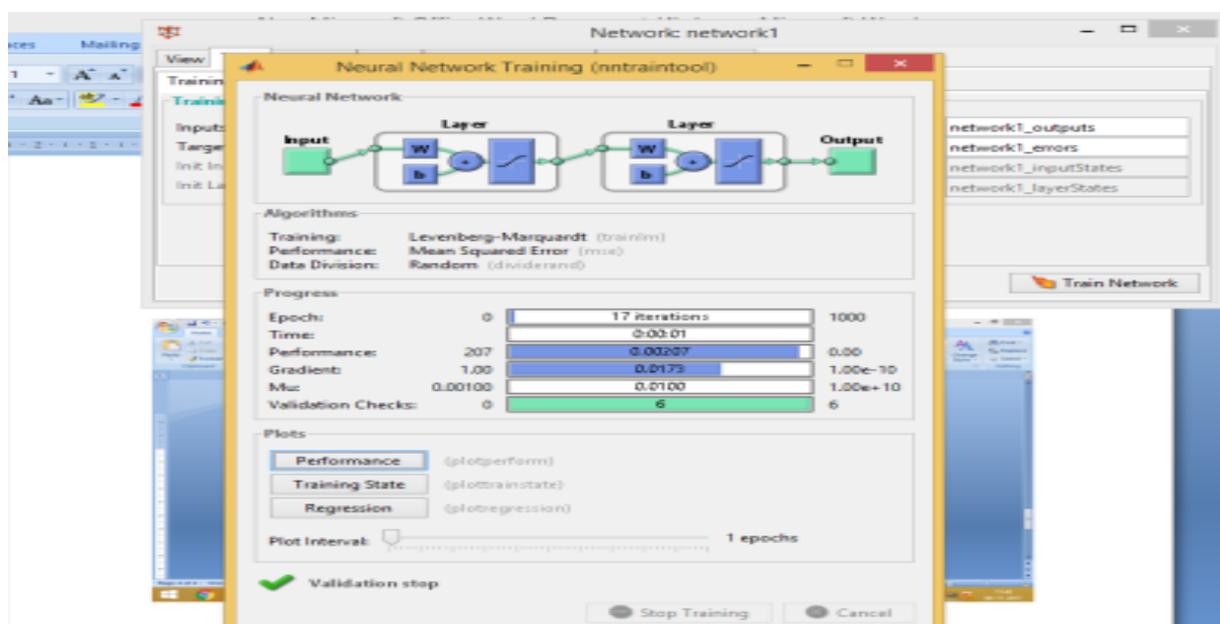


Figure 10 Training of generated network

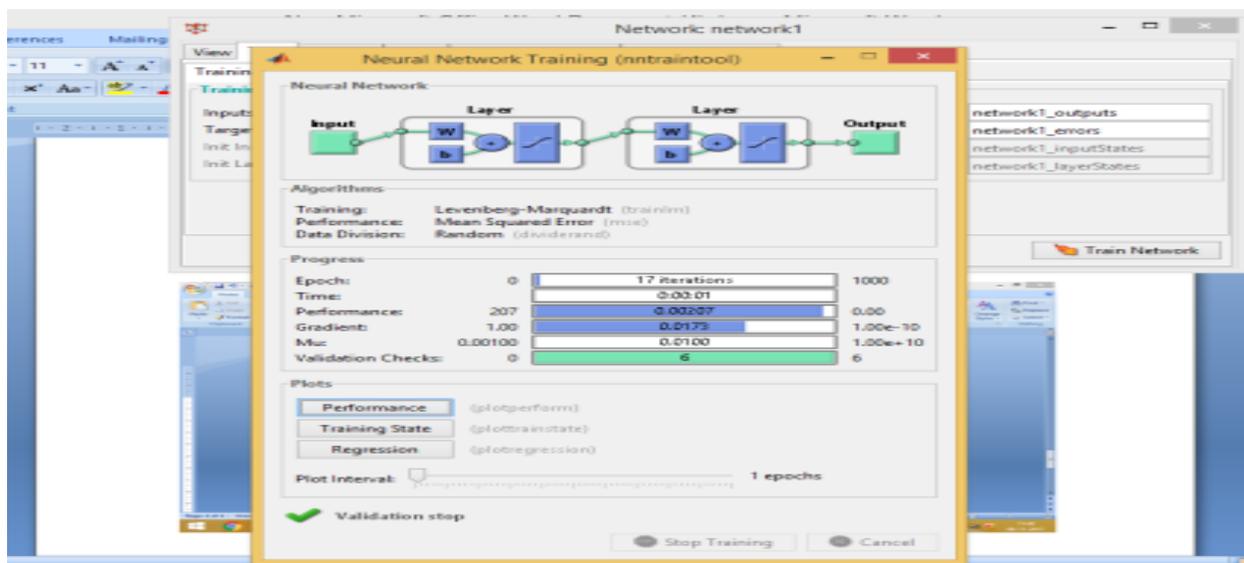


Figure 11 Trained ANN

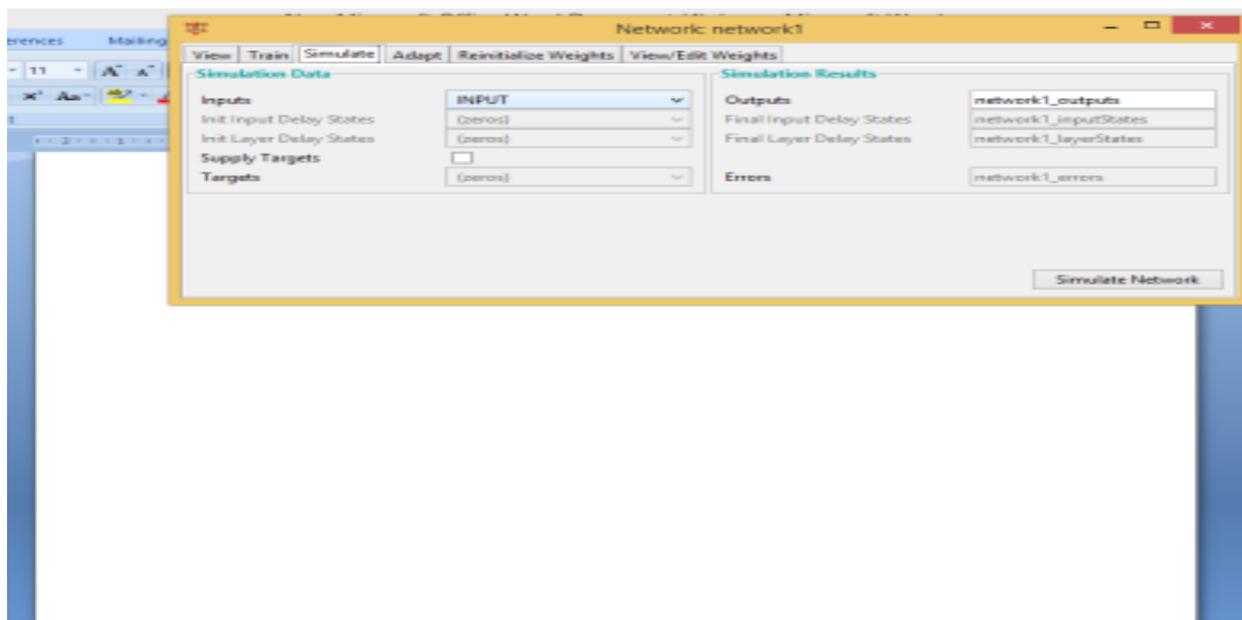


Figure 12 Simulation of trained network

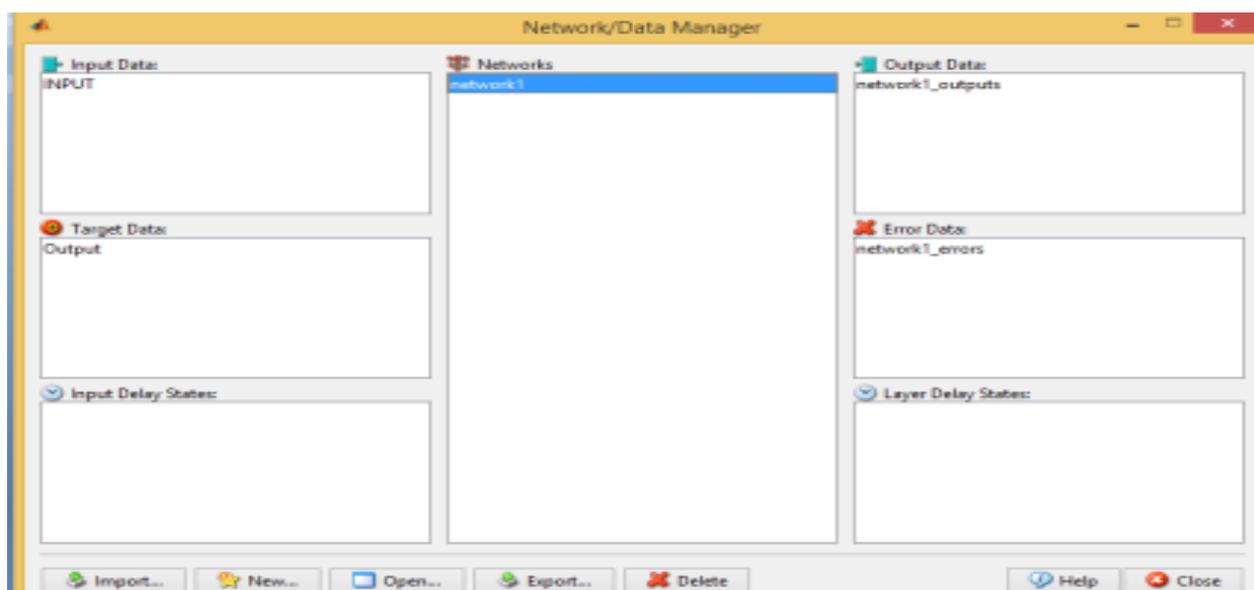


Figure 13 Output of simulated artificial neural network

Result and Discussion

The output of the designed Artificial Neural Network is being compared with the experimental values. Following table shows the comparison of experimental value of adulteration with artificial neural network output. The result shows that the output of designed ANN is giving good result. So this is a simple and easier method for which only it required to evaluate some properties and designed the ANN.

Here **Table 2** shows the output of ANN. But design of ANN is proper or not that can be evaluated by giving the input to which it gives the experimental adulteration that is being evaluated from ANN. Here the inputs are smoke point, API gravity and specific gravity. Comparison of experimental API gravity, specific gravity and smoke point with network values for evaluation of designed ANN is shown below.

By observing the above Table 1 and 2 it could be say that the designed Artificial Neural Network is proper and this computational method could be used as an adulteration detection technique for mixture of diesel and kerosene with proof of evaluation of detection technique (ANN).

Table 2 Comparison of experimental input values with network values

S. No.	In put						Output
	Sp. gravity (Experimental value)	Sp. gravity (Network Value)	API gravity (Experimental Value)	API gravity (Network Value)	Smoke Point (Experimental Value)	Smoke Point (Network Value)	
1	0.8214	0.8213	40.76	40.74	23	22.8	0%
2	0.821	0.8211	42.24	42.21	18	17.89	10%
3	0.8144	0.8142	41.5	41.6	16	15.9	20%
4	0.8	0.79	42.24	42.17	15	14.9	30%
5	0.78	0.769	43.62	43.52	14	13.9	40%

Table 3 Comparison of experimental value (% adulteration) and ANN output (% adulteration)

S. No.	Experimental value (% adulteration)	Predicted values from ANN (% adulteration)
1	1	1.4
2	2	1.7
3	3	2.2
4	4	2.8
5	5	3.47
6	6	4.29
7	7	5.28
8	8	6.45
9	9	7.8
10	10	8.59
11	11	10.28
12	12	11.55
13	13	12.27
14	14	13.02
15	15	13.79
16	16	14.57
17	17	15.38
18	18	16.20
19	19	17.04
20	20	17.89
21	21	18.74
22	22	19.79
23	23	21.02
24	24	22.25
25	25	24.05
26	26	25.22
27	27	26.35
28	28	27.49
29	29	28.47
30	30	29.46
31	31	30.39
32	32	31.55
33	33	32.6
34	34	33.55
35	35	34.40
36	36	35.82
37	37	36.40
38	38	36.9
39	39	37.35
40	40	37.73

Conclusion

There are lots of techniques available which could be used for determining the adulteration of kerosene in diesel. Some of the techniques are so much sophisticated that it could give the testing result very nearer to experimental values in lower range in lower range like gas chromatography. Furthermore some of the techniques are also available which gives good results like density measurement, evaporation techniques available, optical fibre method, ultrasound techniques, marker techniques. All this methods are very sophisticated that they could not used in field and though their results are good but they all have some of the drawbacks.

The adulteration quantity which is recorded till present is about 10% to 30% for mixer of diesel and kerosene, and for that this types of sophisticated equipments are not required because these could be used only by experienced analyst and skilled person for interpretation of result also.

Here in this paper designed Artificial Neural Network (ANN) could be used with an average error of plus or minus 0.268. For designing this network it required only 20 to 30 minutes. And designed network's predicted values give good result with experimental result.

In refinery all the separated fractions are blended with each other whenever it required, like straight run gasoline is blended with polymerized gasoline or SAE W10 lube oil is prepared by blending with two oils. So when the given error in designed Artificial Neural Network is permissible then this network could also be designed which gives two mixers quantity for blending. So by designing this type of network one can avoid the lengthy method of evaluation of equilibrium constant and composition of fractions from lots of equations. Only it required to give input values.

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