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Roles of Artificial Intelligence in Diesel Engine: State of Art

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Abstract Artificial intelligence has become these days the most widely used tool because of its ease and accuracy. Therefore, artificial intelligence plays a very important role in diesel engines, where scientists and researchers carry out many experiments and research to be able to predict exhaust gases. Because of the abundance of those harmful emissions that began to negatively affect the surrounding environment, scientists turned to make a response that predicts those emissions, which can then be avoided, and also the engine performance can be improved using artificial intelligence, where it is Where the network is trained to give outputs that are close to reality, where the experiment is done more than once, and the percentage of error associated with reality is measured, and among those inputs are brake force, exhaust temperature and fuel consumption. And the outputs in this case represent emissions such as carbon dioxide and nitrogen oxides. Therefore, artificial intelligence plays a big role in diesel engines, as it can predict harmful emissions. It can also predict engine performance.

Keywords: Artificial intelligence; Neural networks; Emission; Diesel engine performance.

1 Introduction

Since artificial intelligence (AI) is a relatively new field of study, it is still in its infancy. Its definition varies depending on techniques and the objectives employed in research. It can be summed up as the science of making machines perform tasks that require intelligence from humans. One of the application of AI is artificial neural networks .In the context of power systems and in the literature, the terms "AI applications in power systems" are frequently used to describe the using of fuzzy logic and artificial neural network (ANN).

One of the Renewable Energy Applications is the Scope of Artificial Intelligence Techniques for Exhaust Emission Prediction. That predict the exhaust emission characteristics from compression ignition engines. By using technique of artificial neural Network in modelling of soot emissions and nitrate from the diesel engines and acts as an alternative for real-time experimentation which is costly and time-consuming. [1]

Artificial Neural Network Model for Emission and Performance Paradigm Prediction Diesel Biodiesel Engine Direct Injection because Pollution and the rapid depletion of fossil resources become the main reasons for the search for alternative energy sources. There is Many and edible alternatives such as Palm oil, Soya Bean and Sunflower. Non-edible alternatives such as jatropha, mahua, canola, karanja, and neem are tested successfully with or without engine modifications. The outcomes are positive. When combined with petroleum diesel, biodiesel is a green fuel that can be used to power diesel engines and reduce harmful emissions. The outcomes are positive. When combined with petroleum diesel, biodiesel is a green fuel that can be used to power diesel engines and reduce harmful emissions. Furthermore, with the help of an ANN find out the optimal blend. [2]

Performance can be predicted by ann when blending To gather data for training and testing the proposed ANN, different ratios of rapeseed oil methyl ester with diesel were used at varied loads. Input data utilized to train the network included the biodiesel specific fuel consumption mix percentage, engine load, mix percentage, exhaust gas temperature and specific fuel consumption. Output variables included exhaust pollutants and engine performance. [3]

There is various attempts for improving the performance of diesel engine following an explanation of modelling techniques, state-of-the-art metrics that describe the performance of diesel engines are limited to artificial intelligence methodologies for improving performance, with the noisy experimental scenario, imprecision robustness, and temporal variations of approximations of fitness models posing the biggest challenges. Considering that the optimization methods and diesel engine modelling still face these difficulties. [4] A turbocharged diesel engine was tested on an instrumented dynamometric test-bench to determine the impact of exhaust back pressure (EBP) on engine performance, focusing on effective power. The testing and training of all artificial intelligence (AI) solutions created in order to estimate their power. [5] Artificial intelligence techniques for simulating the movement of diesel engine injector needles. It is possible to calculate the amount value of fuel burnt in one engine cycle. The models were built using two computational intelligence methods: regression trees and genetic-fuzzy system. [6]

To predict noise, vibration, CO_2, $NO_{x,}$ and carbon monoxide (CO). Using two different artificial intelligence methods: artificial neural network (ANN) and support vector machines (SVM). when four-cylinder diesel engine fueled with canola, sunflower, and corn biodiesel mixes while H_2 injected through inlet manifold .[7]

By dealing with (ANN) modeling a diesel engine used waste cooking biodiesel fuel to predict torque, the brake power, exhaust emissions and specific fuel consumption of engine. To test the proposed ANN, four-stroke diesel engine was fuelled with diesel fuel two cylinders, and waste vegetable cooking biodiesel blends and operated at various engine speeds .These properties measured based on ASTM standards . The results of experiment provide better engine performance and improved emission characteristics [8].

Compared and Studied the emission and the performance characteristics of hybrid fuel mixes of diesel with biodiesel in a naturally aspirated, multi cylinder, direct injection diesel engine to reduce hydro carbon emissions [9]sophisticated a model for the study of emission in diesel engine using methyl esters of fish oil [10]

Artificial neural networks approach is used in prediction engine systems reliability, by Traditional ways, failure data analysis requires justifications of certain assumptions and specifications of parametric failure distributions, which are at sometimes validate difficultly. [11]

The continuous reduction of sulfur in diesel fuel has resulted in engine pump failure and poor fuel lubricity, a fact which led to develop a number of methods that measure actual fuel lubricity level so ANN has been used in prediction of diesel fuel lubricity [12]

To identify a nonlinear dynamic model of the throttle body processes and the intake manifold in an automotive engine artificial neural network is used and Modeling results show that the neural-network-based model has a rather simple structure. [13]

2 EXHAUST EMISSION PREDICTION BY ANN

ANN is a powerful tool for estimating output parameters by modelling the system if certain experimental or input data is provided. ANN doesn't require formulation of the systems physical relations instead it requires only parameter values of the systems in similar context .the neural networks are trained by varying the connection values between adjoining elements called as weights. Neuron works by receiving the input signals from parameters (X_1 ,X_2 ,…) with weighing factors (W_1 ,W_2 ,…) and then combining them after adding its summation value with a constant bias value to perform a particular operation in the output as shown in equation no 1 and 2. Where the following parameters are used namely output value of summarizers (U_i) and neuron output value (Y_i). ANN system has the ability to develop the relationship between the output and input parameters without complete information about the system. Pictorial representation of neuron is shown in figure no 1.

Summarizers output value = $u_i = \sum_{j=1}^{n} \text{Wij Xj} + \text{bi}$ (1)

Neuron output value = $y_i = f(u_i)$ (2)

Training of networks can be carried out using a number of algorithms out of which most commonly used one are back propagation algorithm where regression analysis is used for determining the performance of ANN results in comparison to actual results. Main aim of network training is to obtain the optimum values of weights and bias so that the network results are close to the experimental results. Neural networks can be trained to obtain the best results only if there exists a logical relationship between the input and output data

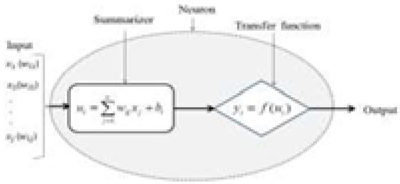

Fig. 1 Pictorial representation of neuron

ANN network is comprised of three layers named hidden, output and input layer. Experimental data was used for developing ANN model in [10], where the output layers and input layers were established as shown in figure 2. The neurons number in the hidden layers is determined based on problem complexity and availability of data. It has to be derived by using trial and error method. Results of optimization calculations carried out in neuro intelligence software shows that the 4-2-1 architecture is the best for engine emission prediction [9]. Earlier studies have shown that the accuracy of the output results will be reduced if more than one component is present in the output layer of the system architecture. Therefore for finding the output values of the nitrate emissions and soot emissions using network modelling, similar network architecture has to be used but independently.

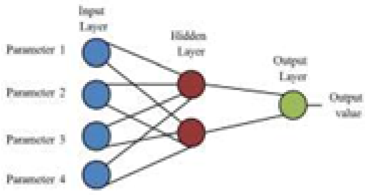

Fig. 2 Simple ANN network model 4-2-1 architecture

Various algorithms can be used for building the relationship network output and actual output, out of which back propagation algorithm is most common where the network performance is evaluated by regression analysis. The error determined by regression analysis can be reduced by adjusting the weights of network and the optimum values can be determined by carrying out iterations. Once the optimum values of the network weights are determined, this network can be used for forecasting the characteristic of emission at different input values. Absolute values of the input parameters has to be normalized using equation no.3 before introducing it to the network since large differences in the values will complicate the learning process of the network model [10]. The input parameter values has to be normalized to the range of [$v_l = .001$, $v_h = 1.00$]Mean square error of the output values are calculated to evaluate the performance of the system using equation no 4.

$$normalized = \frac{va - vmin}{vmax - vmin} \times (vh - v1) \qquad (3)$$

$$MSE\ \frac{1}{n} \sum_p \sum_k (t_{pk} - f_{pk})^2 \qquad (4)$$

Most of the studies carried out to determine the scope of artificial intelligence techniques in prediction of exhaust emission showed that the network results achieved are close to the experimental results. Application of ANN in exhaust emission prediction was tested and validated in the case of single cylinder diesel engine with rapeseed biodiesel as fuel in [9]. The investigation results showed that the regression coefficient value was close to unity and it was less than 5% relative error in the test data obtained. smoke opacity and Nitrate emissions was modelled by using ANN methods in [14], by considering parameters like valve position, fuel injection pressure and speed in the input layer of network. Results of the analysis proved that the nitrate levels can be predicted by ANN methods but there were higher error values in smoke levels since its formation is complex to be defined with limited parameters. Various algorithms can be used for building the relationship between network output and actual output in ANN modelling. Nitrate emissions from power plant boilers were reduced by applying ANN methods where optimized operation parameters were obtained by Ant Colonial Optimization (ACO) algorithm combined with regression modelling. Genetic Algorithm can also be combined with the ANN models for prediction of emission characteristics [15].

3 Performance prediction by ANN

3.1 Materials and Methods.

Crude rapeseed oil; sodium hydroxide; methanol as catalyst are required for transesterification process; concentrated hydrochloric acid and anhydrous sodium sulphate; Transesterification process was carried out for the preparation of rapeseed oil methyl ester.

A water cooled, stationary single cylinder, four stroke, direct injection diesel engine is used for the present the study. The load on the engine is varied with the help of the controller provided with electrical, record and capture the engine parameters flow of Fuel rates are measured by using an electronic weighing.

AVL-5 gas analyzer is used for measurement of exhaust emissions. Exhaust gas temperature is measured by using the thermocouples, Short term performance tests were carried out on the engine with i diesel to generate the base line data, subsequently B10R (90% diesel by the volume +10% rapeseed oil methyl ester), B20R (20% rapeseed oil methyl ester and 80% diesel by volume), B30R (70% diesel by volume +30% rapeseed oil methyl ester) and B40R (60% diesel by volume +40% rapeseed oil methyl ester) was used to assess if it may be suitable as fuel. All fuels' qualities were established in accordance with ASTM standards. To assess the behavior of the diesel engine, different blend and load percentages were used, along with engine performance metrics including brake-specific fuel consumption, exhaust gas temperature, and emissions like CO and NO. Before the measurements were collected, the engine was driven for a short while at its rated speed of 1500 rpm to achieve steady state. Measurements of performance and emission were averaged after repeating the trials. [16]

3.2 ANN Modelling

Training a network is a technique for altering the weight in the connections between network layers in order to produce the desired results. Learning is the term used to describe the internal process that occurs when a network is trained. The user of a neural network does not need to be aware of any specific details about how the system works because it behaves like a "black box" model. The network is trained using a variety of techniques. The most well-known of them is the online back propagation method, which has several variations. A regression analysis between the network outputs and the real outputs is used to assess the performance of the network outputs. The correlation coefficients and mean relative error are the parameters used to gauge network performance. The correlation coefficient assesses the strength of the relation between the experimental and the predicted results and its ranges between+1 and -1. R values close to 1 indicate a positive relationship.

The inputs to the ANN are blend percentage. Brake specific fuel consumption (BSFC), exhaust gas temperature and Brake power (BP). The output parameters from the ANN are emissions which include oxides of nitrogen (NO_x), brake thermal efficiency (BTE) and carbon dioxide (CO_2) Schematic representation of the network the output and input for brake thermal efficiency are shown in Figure 3.

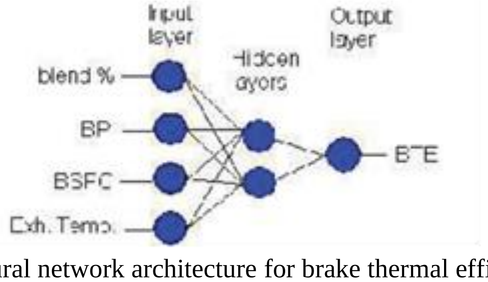

Fig.3 neural network architecture for brake thermal efficiency

The number of the neurons within each layer and hidden layer was designed by the complexity of the problem and data set. The model's inputs were pre-processed and scaled into a common numeric range (-1, 1) in order to guarantee that each input contributes equally to the ANN. Neuro intelligence evaluation software uses an optimization tool to determine the best network architecture for the current issue. The best model for predicting engine performance and emission characteristics is determined to have a 4-2-1 architecture. According to brake thermal efficiency and exhaust emissions such oxides of carbon dioxide and nitrogen, it has 105 neurons in the input layer, two neurons in the hidden layer, and one neuron in the output layer. The momentum coefficient utilized is 0.1, and the optimized learning rate is 0.1. The optimization tool box in the software is used to achieve the ideal values of learning rate and momentum coefficient. The network was trained using the online back propagation approach using input vectors and the associated target vectors from the training set. Every presentation involved comparing the network's output to the desired output and computing the error. This error was then returned to the network, where it was utilized to modify the weights so that the error was reduced with each iteration. Training will end when the performance objective is reached or the validation error is greater than the training error

A function between the input and output variables has been roughly approximated by the training process once training has ended, and this network can be used to forecast data that has not yet been observed. The particulars of the used architecture are given in Table 3.

Table. 3 Details of architecture used and results

Parameters.	**BTE.**	**NO_X**	**CO_2**
Network configuration.	4-2-1	4-2-1	4-2-1
No. of iterations.	500.0	500.0	500.0
Absolute error for training.	00.8910	24.90	0.1980
Absolute error for validation.	00.9184	26.830	00.1730
Training speed, Ite/sec,	834.990	834.990	834.990
Training algorithm.	Online back propagation.		
Learning rate.	00.1	00.1	0.1
Momentum.	00.1	00.1	0.1
$R^{2.}$	00.9481	00.9855	0.9739

4 Conclusion

OANNs could come highly suggested. There must be a logical linear relationship or a nonlinear logical relationship between the outputs and inputs in order to train a neural network. that the trained network has been subjected to the test. Moreover, the target values of ANN and the experimental output values are closer to each other, and thus artificial neural networks can be used effectively, and then artificial intelligence began to be relied heavily on diesel engines as it is used to predict exhaust gases and predict engine performance and then improve it. There are roles others are carried out by artificial intelligence, including knowing the appropriate mixture of bio-fuel alternatives, which can be used when fossil fuels are depleted, and artificial intelligence is used to calculate the amount of fuel that burned in an existing engine cycle and then predict the vibration and noise. Moreover, Engine performance metrics and exhaust emissions may be accurately modelled using artificial neural networks. A model has been developed to study emissions in the diesel engine using methyl esters from the fish oil. And artificial intelligence has evolved to predict diesel fuel lubricity and engine systems reliability

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