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Technical Note

Artificial neural networks used for the prediction of the cetane number of biodiesel

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Abstract

Cetane number (CN) is one of the most significant properties to specify the ignition quality of any fuel for internal combustion engines. The CN of biodiesel varies widely in the range of 48–67 depending upon various parameters including the oil processing technology and climatic conditions where the feedstock (vegetable oil) is collected. Determination of the CN of a fuel by an experimental procedure is a tedious job for the upcoming biodiesel production industry. The fatty acid composition of base oil predominantly affects the CN of the biodiesel produced from it. This paper discusses the currently available CN estimation techniques and the necessity of accurate prediction of CN of biodiesel. Artificial Neural Network (ANN) models are developed to predict the CN of any biodiesel. The present paper deals with the application of multi-layer feed forward, radial base, generalized regression and recurrent network models for the prediction of CN. The fatty acid compositions of biodiesel and the experimental CNs are used to train the networks. The parameters that affect the development of the model are also discussed. ANN predicted CNs are found to be in agreement with the experimental CNs. Hence, the ANN models developed can be used reliably for the prediction of CN of biodiesel.
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Keywords: Cetane number; Biodiesel; Artificial neural networks

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1. Introduction

Diesel engines dominate the field of commercial transportation and agricultural machinery due to its higher fuel efficiency. The consumption of diesel fuel is several times higher than that of petrol. Due to the shortage of petroleum products and its increasing cost, researchers are trying to develop alternative fuels especially for the full or partial replacement of the diesel fuel. In this context it is significant to use the renewable fuels in diesel engines, i.e. biomass-derived fuels like biodiesel, biogas, etc.

In recent years, biodiesel has received considerable attention, both as a possible renewable alternative fuel and as an additive to the existing petroleum-based fuels. Biodiesel exhibits several merits when compared to that of the existing petroleum fuels. It has fuel properties similar to that of diesel and is produced easily and renewably from the crops or oil yielding trees. Biodiesel fuels are generally classified as fatty acid methyl esters (FAME), which are derived from the alkali-catalyzed trans-esterification of fats and oils with methanol, although other alcohols can be used. Trans-esterification of vegetable oils yields monoesters (biodiesel) and glycerin.

The experimental results of various researchers support the use of biodiesel as a viable alternative to the diesel oil for use in internal combustion engines [1–4]. The cetane number (CN) is one of the most commonly used indicators for the determination of diesel fuel quality. It measures the readiness of the fuel to autoignite when injected into the engine. It is generally dependent on the chemical composition of the fuel and can impact the engine's startability, noise level and exhaust emissions [5].

American Society for Testing and Materials (ASTM) testing procedures are used to characterize the petroleum fuel. CN is measured by matching against the blends two reference fuels namely *n*-cetane (100 CN) and hepta-methylnonane (15 CN). CN of the test fuel is the percentage in volume of cetane in a blend of *n*-cetane (100 CN) and hepta-methylnonane (15 CN) having the same ignition quality when tested in the same engine under the same test conditions (ASTM D613). It is not always possible to conduct engine tests to determine CN because of the cost of the reference fuels and the more effort required. Hence, there have been many attempts either to calculate the CN itself or to derive an alternative parameter that could provide an indication of the ignition quality. Calculated cetane index and diesel index are the other parameters, which indicate the quality of diesel fuel.

Calculated Cetane Index (CCI) gives a number, which corresponds quite closely with the actual CN of diesel. CCI is calculated on the basis of distillation curves of fuel that is the relation between the temperature at which the amount of fuel is recovered in the distillation column (ASTM D86). The method is unreliable for gas oils containing large amount of paraffin or thermally cracked components. The Planning Commission of India on biofuels reported that cetane index determined had not been given correct results with respect to the CN of biodiesel [6]. Hence, it is suggested that CCI should not be used in place of CN of the biodiesel.

Diesel index is also used for the estimation of the CN of diesel fuel. Diesel index usually gives figures slightly above the actual CN. Nevertheless, it provides a reasonable idea about the ignition quality of fuel. Diesel index is evaluated by converting aniline point into

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