



Review on alcohol fumigation on diesel engine: A viable alternative dual fuel technology for satisfactory engine performance and reduction of environment concerning emission



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ABSTRACT

Fossil fuels are the most imperative parameters to flourish the every sphere of modern civilization including industrial development, transportation, power generation and easing the accomplishment of works. The rapid increase in usage of fossil fuel has unavoidable deleterious effect on environment. The international consciousness for environment protection is growing and ever more strict emission legislations are being enacted. Simultaneously the storage of fossil fuel is depleting. Hence, the above situations promote the scientists to find alternative sustainable fuels along with their suitable using technique which will reduce the pollutant emission and will be applicable for gaining satisfactory engine performance. In these perspectives, alcohol fumigation is getting high demand as an effective measure to reduce pollutant emission from diesel engine vehicles. Alcohol fumigation is a dual fuel engine operation technique in which alcohol fuels are premixed with intake air. The aim of this paper is to identify the potential use of alcohols in fumigation mode on diesel engine. In this literature review, the effect of ethanol and methanol fumigation on engine performance and emission of diesel engine has been critically analyzed. A variety of fumigation ratios from 5% to 40% have been applied in different types of engines with various types of operational mode. It has been found that the application of alcohol fumigation technique leads to a significant reduction in the more environment concerning emissions of carbon dioxide (CO₂) up to 7.2%, oxides of nitrogen (NO_x) up to 20% and particulate matter (PM) up to 57%. However, increase in carbon monoxide (CO) and hydrocarbon (HC) emission have been found after use of alcohol fumigation. Alcohol fumigation also increases the BSFC due to having higher heat of vaporization. Brake thermal efficiency decreases at low engine load and increases at higher engine load.

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Contents

1. Introduction	740
2. Alcohol as a supplementary fuel in diesel engine	740
2.1. Renewable sources of alcohol	741
2.2. Alcohol fuel ethanol	741
2.3. Alcohol fuel methanol	741
2.4. Physicochemical properties of alcohols as fuel	741
3. Fumigation method as a dual fuel operation in CI engine	742
4. Engine performances	742
4.1. Brake-specific fuel consumption (BSFC)	742
4.1.1. Effect of alcohol fumigation on BSFC	742
4.1.2. Summary	743
4.2. Brake thermal efficiency (BTE)	743
4.2.1. Effect of alcohol fumigation on BTE	743

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4.2.2.	Summary	744
5.	Emission	744
5.1.	Oxides of nitrogen (NO _x)	744
5.1.1.	Effect of alcohol fumigation on NO _x emission	744
5.1.2.	Summary	745
5.2.	Carbon monoxide (CO ₂)	746
5.2.1.	Effect of alcohol fumigation on CO ₂ emission	746
5.2.2.	Summary	747
5.3.	Hydrocarbon (HC)	747
5.3.1.	Effect of alcohol fumigation on HC emission	747
5.3.2.	Summary	747
5.4.	Carbon dioxide (CO ₂)	747
5.4.1.	Effect of alcohol fumigation on CO ₂ emission	747
5.4.2.	Summary	748
5.5.	Smoke and particulate matter (PM)	748
5.5.1.	Effect of alcohol fumigation on smoke opacity and PM emission	748
5.5.2.	Summary	749
6.	Conclusions	749
	Acknowledgments	749
	References	749

1. Introduction

Nowadays, the global transportation sector completely relies on diesel engine vehicles for public and commercial transportation from the point of view of better efficiency and durability. However, this transportation sector is responsible for 26% of greenhouse gas emission and global warming is the corollary of the greenhouse gas [1]. Simultaneously diesel engine vehicles are the dominant sources of respirable suspended particles in air [2,3]. Primary particulate matter (PM) from diesel vehicles consists of various types of chemical components such as elemental carbon, organic carbon, inorganic ions, trace elements etc. [4–6]. These particles have extremely harmful effects on human health and environment. Numerous studies have proved that these particles cause respiratory and cardiovascular health problems [7–10] and neuro-degenerative disorders [11,12]. In urban cities, vehicular sources are responsible for around 70–75% NO_x emission. NO_x is one of the major cause of smog, ground level ozone and also a cause of acid rain [13,14]. Thus, international consciousness for environment protection is growing to reduce such emission from diesel engine vehicles [15]. To achieve that emission standard many engine manufacturing communities already have devoted significant resources to reduce emission from diesel-powered engines. In this regard, the use of alternative and sustainable biofuels such as biogas, bio alcohol and biodiesel are being considered as effective step to reduce the greenhouse gas, PM and NO_x emission from diesel engines [16–21]. In a recent study, International Energy Agency reported that biofuels could be a key alternative fuel technology to reduce the greenhouse gas from diesel-powered engines [22].

Moreover, the sources of fossil fuel are dwindling day by day. According to an estimate, the fossil fuel reserves will continue until 41 years for oil, 63 years for natural gas and 218 years for coal [23–25]. The increasing industrialization and motorization of the world has led to dearth situation in the field of energy supply. Again the price of petroleum oil is becoming higher on daily basis. These pose a challenge to availability of fossil fuel. At these circumstances, demand of alternative biofuels is increasing as a substitute of fossil fuel in transportation sector for energy security issues.

Among the biofuels such as biogas, bioalcohol and biodiesel, alcohol seems to be the most attractive and promising alternative fuels due to its storage facility, availability and handling. High

pressure is required to use biogas for automobile. Again leakage from biogas may cause problem. Biodiesel from edible vegetable oil may cause the dearth situation to supply of food for population. The use of non-edible oil as biodiesel sources requires a large-scale cultivation that may cause decrease in food crops.

Alcohol fuels can be used with diesel fuel in different duel fuel operation techniques. The most used methods are blending and fumigation. In blending method, alcohol fuels are mixed with diesel fuel before injecting inside the cylinder. To stabilize the miscibility of blending alcohol with diesel fuel extra additives are required. Hence there is a limitation on amount of alcohol which can be used for blending operation. Alcohol fumigation has been defined simply as the introduction of alcohol fuel into the intake air upstream of the manifold either by spraying, carbureting or injecting. This method of introduction has the advantage of providing a portion of the total fuel supply premixed with the intake air thus improving air utilization. This method requires minor modification of engine which is done by adding low pressure fuel injector, separate fuel tank, lines and controls [26,27] but allows a large percentage of alcohol fuels to be used in engine operation since no additives are required for stabilizing the miscibility of alcohol and diesel fuel [27,28]. As a result, the efficiency of engine will be better in fumigation mode.

In this literature review, a wide range of diesel engine sizes and types was investigated at different operation conditions. 4-cylinder naturally aspirated direct ignition diesel engine was most frequently used. Different percentages of fumigation were applied to get the optimize result. Engine efficiency and emission characteristics are discussed at different sections to get the clear scenario of the effect of alcohol fumigation on engine efficiency and emission.

The main purpose of the present study is to provide a comprehensive review of the literature related to the potential use of alcohol fumigation on diesel engine.

2. Alcohol as a supplementary fuel in diesel engine

The use of alcohol fuels in internal combustion engine is not new. These fuels have been used intermittently in internal combustion engine since their invention. The first commercial use of ethanol as fuel started when the automobile company Ford designed Henry Ford's Model T to use corn alcohol, called ethanol

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