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# An Experimental and Emission Performance Analysis of Single Cylinder Diesel Engine Test with Hydraulic Loading by Using Ethanol

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**ABSTRACT :** Investigation of the possibility of dual fuelling of single cylinder diesel engine with diesel fuel and additionally with ethanol, which is injected into inlet manifold, was carried out. Due to physic-chemicals properties of ethanol, such as: poor lubrication properties, poor miscibility with diesel fuel in presence of water, corrosion and chemical degradation of engine materials neat ethanol and diesel fuel ethanol mixture cannot be used in CI engines. Investigation was carried out on one-cylinder, direct injection CI engine with modified inlet duct for injection of ethanol. Investigations showed that energy ratio of ethanol to diesel fuel up to over 25% may be applied, engine thermal efficiency increased, with the increasing load, soot emission was decreased dramatically already for small amount of injected ethanol, emission of greenhouse gas  $(CO_2)$  was decreased with increasing amount of ethanol, NO<sub>x</sub> emission was decreased for small load but for high load is kept at the same level as when the engine is fuelled only on diesel fuel. Optimization of the energy ratio of both fuels and injection timing of diesel fuel is being carried out.

KEYWORDS: ethanol, diesel fuel, thermal efficiency, emissions.

## I. INTRODUCTION

In the last years the worldwide interest in application of alternative fuels, especially these fabricated from biomass, may be observed. Such a fuel is ethyl alcohol (ethanol), which may be made from corn, sugarcane and biomass. Neither neat ethanol nor ethanol-diesel fuel mixtures cannot be applied to CI engines due to its physic-chemical properties as low cetin number, low lubricate, weak mixing with diesel fuel in the presence of water and degradation of lubricating oil. It also causes corrosion. Scandia CV AB Company experimentally fuelled its city buses with mixture of diesel fuel and ethanol, but only 5% of ethanol by volume. In this paper the possibility of application of ethyl alcohol to CI engines was undertaken. Experiments were carried out in Politechnika Radomska. Ten years ago the project on diesel engine fuelled with evaporated methyl alcohol as a main fuel and diesel fuel as a pilot ignition fuel was developed. Methanol entered to the cylinder as a gas, where was burnt, do not giving occasion to corrosion of cylinder liner. In the present work ethanol was injected to inlet port, where it evaporated (beginning of its injection had no influence on engine operation) and entered to the cylinder as a vapour The idea of such fuelling system is as follows: diesel fuel droplets after self-ignition will ignite ethanol vapour which together with them burns much more quickly than droplets in air. This will result in higher rate of heat release and – due to that – higher thermal efficiency and some emissions especially soot. The main objectives of the present work were as follows to investigate, whether the ethanol may be used as an alternative fuel for CI engines.



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#### **II. FUNDAMENTAL ASPECTS OF ALCOHOLS**

#### A) ETHANOL

Alcohols are defined by the presence of a hydroxyl group (-OH) attached to one of the carbon atoms. Ethanol, in particular, (or ethyl alcohol) is a biomass based renewable fuel (bio-ethanol), which can be produced, relatively easily and with low cost, by alcoholic fermentation of sugar from vegetable materials, such as corn, sugar cane, sugar beets, barley, and from (non-food) agricultural residues such as straw, feedstock and waste woods [6,7,14]. Ethanol is isomeric with dimethyl ether (DME) and both ethanol and DME can be expressed by the chemical formula C2H6O. Although they may have the same physical formula, the thermodynamic behavior of ethanol differs significantly from that of DME on account of its stronger molecular association via hydrogen bonds. Because of its high octane number, ethanol is considered primarily a good spark-ignition engine fuel. Nonetheless, it has been considered also a suitable fuel for compression ignition engines, mainly in the form of blends with diesel fuel, although investigations with pure ethanol (or methanol) have been conducted too. For the latter case, cetin improvers and/or glow plugs were implemented combined with an increase in the engine compression ratio to facilitate ignition, particularly during cold starting. Another successful method for using alcohols in diesel engines is fumigation. In this technique, alcohol is atomized in the engine's intake air either by carburetion or injection. Diesel fuel is directly injected into the cylinder and the combined air-alcohol/diesel mixture is auto-ignited, with diesel fuel consumption being reduced by the energy of the alcohol in the intake air. This procedure, however, requires separate fuel systems for the diesel and ethanol fuel. Additionally, the amount of alcohol used is practically limited by the amount that can be vaporized into the intake air. As a result, this approach seems more feasible as an engine retrofit, where total energy substitution is not the primary objective. The initial investigations into the use of ethanol in diesel engines, on the other hand, were initiated in South Africa in the 1970s, and continue and the US during the 1980s. Most of these works related to the use of in-farm equipment (tractors and combines) and employed an ethanol/diesel fuel blend. The main benefit from the use of ethanol during diesel engine operation is the significant reduction of PM/smoke, due to the high oxygen content of the fuel blend. Carbon monoxide emissions have been reported lower too, but NOx as well as unburned HC may increase.



#### Fig1: Structure of ethanol

PROPERTY	DIESEL	ETHANOL
-	FUEL	
	TOLL	
Chemical formula(n=12,32)	$C_nH_{1.8n}$	C <sub>2</sub> H <sub>5</sub> OH
Molecular weight	~170	46
Density@20 <sup>0</sup> C,kg/m <sup>3</sup>	840-880	789
Calorific value,MJ/kg	~42,5	26,8
Calorific value of stechiometric	3,66-	3,85
mixture with air, MJ/m <sup>3</sup>	3,83	

#### ble I: Comparsion of Diesel and Etha



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Heat of evaporation,kj/kg	270	840
Temperature of selfignition, K	~500	665
Stechiometric air/fuel ratio, kg air /kg fuel	14,5	9,6
Lower flammability	0,98	2,06
Higher flammability	0,19	0,30
Kinematic viscosity, mm <sup>2</sup> /s	2,97	1,4
Octane number		
motored	-	94
research	~3	111
Cetane number	45-55	8
Flame temperature ,K	-	2235

### **III. DATA ACQUISATION SYSTEM**

This is informal introduction digital data acquisition hardware. It is primarilydirected towards assisting in the selection of appropriate hardware for recording with the Acquire program.

### 1. Overview

In principle, data acquisition hardware is quite simple. An A/D converter delivers a sequence of values representing an analogy signal to an acquisition program. In practice, selecting and properly using data acquisition hardware isomer complex. This document provides an informal introduction to the topic. Many of the examples are taken from patch-clamper cording. This technique requires accurate acquisition of low-level signals (microamperes) with bandwidth in the audio range (up to10kHz).

### 2. Signal Source

The source of most signals to be digitized is a sensor, connected to an amplifier with appropriate signal conditioning. The amplifier delivers an electrical signal. This signal is then digitized using an A/D converter. For patch-clamp recording, the sensors are solution filled pipettes. The pipette is connected to a patch clamp amplifier that converts the voltage at the pipette or the current through the pipette to a high-level signal. By convention, the full-scale output range of a patch-clamp amplifier is  $\pm 10V$ , matching the range of common instrumentation quality digitizers.





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#### 3. Digitizer

A digitizer converts one or more channels of analogy signal to a sequence of corresponding digital values. The heart of a digitizer is an A/D converter, a device that samples an analogy signal and converts the sample to a digital value. For example, for recording from a single ion channel, the digitizer might determine the output of the patch clamp amplifier once every 50s and provide the resulting value to the computer.

### **IV. PROJECT DESCRIPTION**

The engine was operated with ethanol $\pm$  diesel blends having 5, 10, 15 and 20% ethanol on volume basis as well as on fumigated ethanol $\pm$  diesel fuel. For the fumigation operation, the ethanol from a separate tank was supplied to the engine through a variable jet carburettor. Tests on diesel fuel alone were also conducted as a basis for comparison. The engine was run on the no load condition and its speed was adjusted to 1500+20 rpm by adjusting the screw provided with the fuel injector pump rack. The engine was run to attain uniform speed, then it. The engine was operated with ethanol $\pm$  diesel blends having 5, 10, 15 and 20% ethanol on volume basis as well as on fumigated ethanol $\pm$  diesel fuel. For the fumigation operation, the ethanol from a separate tank was supplied to the engine through a variable jet carburettor. Tests on diesel fuel alone were also conducted as a basis for comparison. The engine was run on the no load condition and its speed was adjusted to 1500+20 rpm by adjusting the screw provided ethanol $\pm$  diesel fuel. For the fumigation operation, the ethanol from a separate tank was supplied to the engine through a variable jet carburettor. Tests on diesel fuel alone were also conducted as a basis for comparison. The engine was run on the no load condition and its speed was adjusted to 1500+20 rpm by adjusting the screw provided with the fuel injector pump rack. The engine was run to attain uniform speed, then it The thermal balance of the engine operating on diesel, ethanol $\pm$  diesel blends, and fumigated ethanol was established at different loading conditions of the engine. The thermal balance was Energy Conversion & Management 41 (2000) 1533 $\pm$ 1541 1537in respect of useful work, heat lost to cooling water, heat lost through the exhaust, heat carried away by the lubricating oil and other losses (i.e., radiation, vapour in the exhaust, unaccounted for losses). The relationships between engine thermal balance and percentage load for the various fuels used are presented in figs.





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It can be seen from the gores that as the load on the engine increased, the percentage of useful work increased, while the other losses decreased. At the initial stage, the increase was more pronounced than at the latter stages of the loading conditions. This trend is due to the fact that the engine attains optimum operation at the latter stages of loading conditions, and as such, the differences in useful work are minimal.

### **V.WORKING PRINCIPLE**

The engine used for this study was a single cylinder, four stroke, direct injection, variable compression ratio, diesel engine with a swept volume of 582 cm3. The engine is naturally aspirated and water cooled. The engine was coupled to an electrical generator through which load was applied by increasing the held voltage. A red 208 injection timing and 18 compression ratio were used throughout the experiments. Indicators on the test bed show the following quantities which are measured electrically: engine speed, brake power and various temperatures shows a schematic of the ethanol fumigation system. Ethanol was fumigated into the intake air charge and introduced in the engine as a vapor or mist, dependent on the degree of vaporization which occurred.

A simple fumigation system was used, consisting of a single hole, direct opening conjuration spraying nozzle. It was selected to achieve ethanol delivery at relatively low pressure. The nozzle has a diameter of about 0.25 mm. Since the obtained nozzle flow rate was relatively high, the produced ethanol jet was allowed to hit a partition in order to get ethanolmist which is directly mixed with air before entering the engine. An electrically driven air compressor was used to supply ethanol to the nozzle. The nozzle was positioned approximately 50 cm ahead of the inlet manifold. This allowed the ethanol to be mixed with the intake air for a scent period, providing uniform mixing. Indicators on the test bed show the following quantities which are measured electrically: engine speed, brake power and various temperatures shows a schematic of the ethanol fumigation system The intake manifold was provided with a transparent window for optical inspection of the ethanol $\pm$  air mixture. Particulate exhaust emissions were drawn using a special sampling probe. Particulates were collected on Teflon-coated glass . The manufactured by Pal flex Products Corporation (Type TX40 HI20-WW), measured 25 mm in diameter and were held in a 25 mm holder which is connected to the diffuser end by a copper elbow. An electrically driven air compressor was used to make a vacuum such that exhaust particulates can be extracted continuously from the main exhaust flow and collected on the later. The flow through let it was maintained nearly constant by using an at the outlet of the sampler.





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1. Flywneel	5. Digital air flow meter
2. Dynamometer	6. Air filter
3. R.P.M.Measuring device	7. Ceramic heater
4. Air stabilizing tank	8. Injector

### A) EXHAUST EMISSIONS

As an opening argument for the exhaust emissions discussion that follows, it can be stated that irrespective of the biofuel tested, spray properties may be altered with respect to normal diesel operation owing to differences in the physical and chemical properties such as molecular structure, cetane number, latent heat of vaporization, viscosity, surface tension, bulk modulus of elasticity, and boiling point. All these, in turn, affect the injection timing, the ignition delay, as well as the balance between premixed and diffusion combustion, shifting the emission pattern to lower or higher emission values depending on other specific conditions (blending percentage, injection system and engine technology in general, transient schedule, exhaust gas after-treatment).

#### 1. Particulate matter and smoke

Diesel particulates consist mainly of combustion generated carbonaceous material (soot) on which some organic (arisen mainly from unburned fuel and lubricating oil) or inorganic compounds have been absorbed. Particulate material is distributed over a wide size range, typically from 20 nm to 10 µm, thus being reparable.

#### 2. Nitrogen oxides

Nitrogen oxides, together with particulate matter, are the most critical pollutants produced by diesel engines. Nitrogen oxides consist mostly of nitric oxide NO and nitrogen dioxide NO2, and are referred to collectively as NOx. Nitrogen oxides production is strongly dependent on temperature, local concentration of oxygen and duration of combustion; other notable factors are injection timing and fuel properties. Nitrogen oxides are highly active ozone precursors playing an important role in the smog chemistry.

#### 3. Carbon monoxide and hydrocarbons

With the exception of the post-DOC measurements reported by Frank et al. LöfvenbergandArmas et al. (the former two during transient cycles, the latter during a cold starting event), CO emissions seem to follow in general the trend of their PM/smoke counterparts (see the results in Tables 2 and 3). This fact can be collectively attributed to the same physical and chemical mechanisms affecting almost in the same way, at least qualitatively, the net formation of these two pollutants. More precisely, it is the excess oxygen in the fuel blend that aids the in-cylinder oxidation of CO to CO2 that is most probably responsible for this behaviour.

#### 4. Non-regulated emissions

Non-regulated emissions from diesel engines correspond to organic and air-toxic pollutants such as Carbonyl compounds, formed by aldehydes (formaldehyde, acetaldehyde, acrolein, propionaldehyde, etc) and ketones. Carbonyls account for most of the ozone-forming potential of organic gases benzene, which is a colorless, flammable, carcinogenic aromatic hydrocarbon of the type C6H6 naphthalene, which is a volatile, crystalline, aromatic, white, solid hydrocarbon of the type C10H8, comprising of two benzene rings sharing a pair of carbon atoms organic compounds with a hydroxyl group (-OH) bound to a carbon atom of an alkyl or substituted alkyl group, having the general type CnH2n+1OH.



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### B) GRAPH



Fig.5 50 ml Ethanol +950ml Diesel



Fig.6 100ml Ethanol+ 900ml Diesel



Fig.7 150 ml Ethanol+850ml Diesel



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#### V. RESULT

From above process clears decreasing PM/smoke trend is established when ethanol or n-butane is added in the fuel blend relative to the neat diesel fuel operation. For the rest of the regulated pollutants, however, no such unique trend can be identified, except for the consistent, and usually significant, increase of HC. Contradicting results hold for CO2; the few studies that measured carbon dioxide emissions concluded that these may increase or decrease, usually by a small percentage, relative to the reference operation. For NOx on the other hand, as has also been the case with biodiesel blends, the alcohol/diesel blend data are scattered and controversial, indicating that there are many other critical parameters apart from the oxygen content that are responsible for the overall emission behaviour; hence no statistically significant correlation can be established (R2=0.02). The same holds true, in general, for CO and HC. However, there seems to be a notable exception as regards the engine-out, heavy-duty, engine-dynamometer measurements of CO, which present a promising value of R2=0.76 or even 0.87 if only the FTP (hot-started runs) are taken into account, although the dataset is very small to suggest an unequivocal trend.

#### VI. CONCLUSION

The authors of the work are trying to carry out an experimental investigation on 4-stroke, single cylinder, ceramic hot surface ignition CI engine with alcohol fuels by adding certain additives such as Ethyl nitrate, Butyl nitrate, Diisipropylether and Dimethylether. In this regard the authors carried out a research on previous works and make certain concussions on the concerned work.

It has been observed from the above studies that alcohols can be used successfully in combination with diesel by adding certain additives .the authors are trying to perform experiments on 4-stroke single cylinder CI engine in order to estimate the performance using alcohol as a fuel alone along with the above mentioned additives. Further it can be observed that this work is too worthy of its kind after reviewing the precious works.

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