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International Journal Of Modern Engineering Research (IJMER)

A Review on performance of a DI Diesel Engine Fuelled with Ethanol-Diesel Emulsions

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ABSTRCT: *This paper explores the possibility of utilizing ethanol-diesel emulsion in different numeric values refer to the percentage of ethanol in DI Diesel engine.The main aim of the present review is to study the effect of performance and emissions overall of the blends can be minimized moderately, even total hydrocarbon emissions are fewer than those of emission characteristics of emulsified fuels on a DI diesel engine. The ethanol diesel emulsion decreases the brake thermal efficiency, brake torque, and brake power while increase the brake specific fuel consumption. At high loads, the emulsion minimize smoke significantly with a small penalty on CO, acetaldehyde and unburned ethanol emissions compared to diesel fuel. NOx and CO2 emissions of the blends are reduced fairly. At low loads, the emulsion have small effects on smoke reduction due to leaner mixture. With the aid of additive ignition improver, CO, unburned ethanol and acetaldehyde diesel fuel. The results indicate the performance and emission characteristics are studied and compared with the base fuel.*

Keyword: *DI (diesel) engine ,emissions, Emulsions, Ethanol*

I. INTRODUCTION

Among derived fuels, ethanol is considered to be one of the biomass potential alternative fuels for IC engine. It can be obtained from natural as well as chemical means in the laboratories. Study involving the use of biodiesel and commercial diesel emulsions had its origins in the period between industrial revolution and Second World War, driven by strong demand for fuel. Currently the insertion of biodiesel in the market is necessary not only to balance the supply/demand ratio, but also for reasons of environmental feasibility in terms of reducing the emission of pollutants and gases emitted by the road transportation modal. A result of rapid increase in the demand and prices of petroleum oil, a number of current studies have focused on the development of alternative fuels for transportation. In addition, high emissions of CO2, NOx, SO2 and particulate matter (PM) are produced during fossil fuel use, generating environmental problems. These facts have converged in the search of renewable energies, such as biofuels. The lack of conventional fossil fuels, their increasing costs and rising emissions of combustion-generated pollutants will make biobased fuels more attractive. Due to the rise in price of petroleum products, especially after the petrol crisis in 1973 and then the Gulf War in 1991, geographically reduced availability of petroleum and more rigorous governmental regulations on exhaust emissions, many researchers have studied alternative fuels and alternative solution methods.

Most of the internal combustion (IC) engines utilize petroleum fuels. The source of petroleum fuels are limited and it is to be exhausted in about 40 years. Limited energy sources warn of potential lack of energy in the future [1]. IC engines are consumed around 35% of the petroleum fuels and exhausts emitted from these engines are one of the major causes of the environmental pollution. In the last two decades of the 20th century, major advances in engine technology have occurred, leading to greater fuel economy in vehicles. The reduction of emissions from engines has become a major factor in the development of new engines and manufacturers are focusing considerable energy and resources in order to meet emissions standards specified by the US Environmental Protection Agency (EPA) and by the EU. As a result the use of non-conventional fuels as a means of meeting these requirements has generated much attention.

There are many studies on the use of alcohols in spark ignition (SI) engines. In the past little attention has been given to the utilization of alcohols in compression ignition (CI) engines. The difficulties encountered while attempting to use alcohols in CI engines, especially at high alcohol ratios, which are summarized as follows.

1.) Alcohol contains less heating value in comparison to diesel fuel therefore additional alcohol required than diesel fuel by mass and volume.

2.) Large proportion of alcohol could not mix with diesel fuel homogeneously hence use of diesel alcohol emulsions at large a ratio of alcohols is not suitable. Also the emulsions were not stable and separate in the presence of a trace amount of water.

3.) The cetane numbers of Alcohols have extremely low whereas the diesel engines are favor to high cetane umber fuels that can auto-ignite easily and give minute ignition delay.
4.) The poor auto-ignition capacity of alcohols is accountable for severe knock due to fast burning of vaporized alcohol and combustion quenching caused by high latent heat of vaporization and subsequent charge cooling.

Since ethanol has used as a fuel for compression ignition (CI) engines from 19th century. Ethanol can be fermented and distilled from biomasses. Therefore, it can be considered as a renewable fuel. As a fuel for diesel engines, ethanol has a number of advantages over diesel fuel such as the reductions of soot, carbon monoxide (CO) and hydrocarbon (HC) emissions. Although ethanol has many advantages it cannot use extensively due to limitations in technology, economic and regional considerations. However, ethanol blended diesel fuels can be practically used in CI engine [2].
Ethanol has a high Octane number, and hence, it is directly used in spark ignition (SI) engines. However, compression ignition (CI) engines are preferred more than SI engines because the former gives a higher thermal efficiency and are robust in structure. But, Ethanol cannot be used directly in CI engines, because of its low Cetane number. It can be used either by fuel modification by making solution, blend or emulsion with a high Cetane fuel, or carrying out necessary engine modification such as dual fuel mode and surface ignition. Fuel modification is an easier and cheaper method in comparison with engine modification. Ethanol has some limitations such as lower flash point and lower miscibility which may cause phase separation. Ethanol is immiscible in diesel over a wide range of temperatures. It can be used without much modification in the diesel engine. . Ethanol is an oxygenated component that increases the percentage of oxygen during the combustion and reduces the smoke and particulate emissions in exhaust.
Cetane value is most important factors for the evaluation of fuel ignition ability of ethanol. The cetane value of pure ethanol is 8, which makes the cetane value of the EDBF lower than that of pure diesel. The ignition ability of ethanol-diesel blended fuel is worse than that of pure diesel and will further lead to poor combustion performance and degraded exhaust emission. In the Based on engine combustion visualization and in-cylinder temperature field analysis using the primary color method. Reported that the ignition ability is increased by using EDBF but the luminosity of the flame and total combustion duration are minimized and the peak combustion temperature is reduced. The effect of additives on the compatibility of diesel and ethanol diesel emulsion fuel has been studied.
When considering an alternative fuel for use in diesel engines, a number of issues are important. These issues include supply and distribution, integrity of the fuel being delivered to the engine, emissions and engine durability. The purpose of this review is to discuss the properties and specifications of ethanol emulsified with diesel fuel with special emphasis on the factors critical to the potential commercial use of these blends. These factors include blend properties such as stability, viscosity and lubricity, safety and materials compatibility. The effect of the fuel on engine performance, durability and emissions is also considered.

II. BLEND PROPERTIES

There are a number of fuel properties that are essential for the proper operation of a diesel engine. The addition of ethanol to diesel fuel affects certain key properties with particular reference to blend stability, viscosity and lubricity, energy content and cetane number. Materials compatibility and corrosiveness are also important factors that need to be considered.

2.1. Blend stability

Solubility of ethanol in diesel is mainly affected by two factors temperature and water content in emulsion. At below about 10 degree C the two fuels separate. Prevention of this separation can be accomplished in two ways: by adding an emulsifier which acts to suspend small droplets of ethanol within the diesel fuel, or by adding a co-solvent that acts as a bridging agent through molecular compatibility and bonding to produce a homogeneous blend (Letcher, 1983). Emulsification usually requires heating and blending steps to generate the final blend, whereas co-solvents allow fuels to be ‘‘splash-blended’’, thus simplifying the blending process [3].

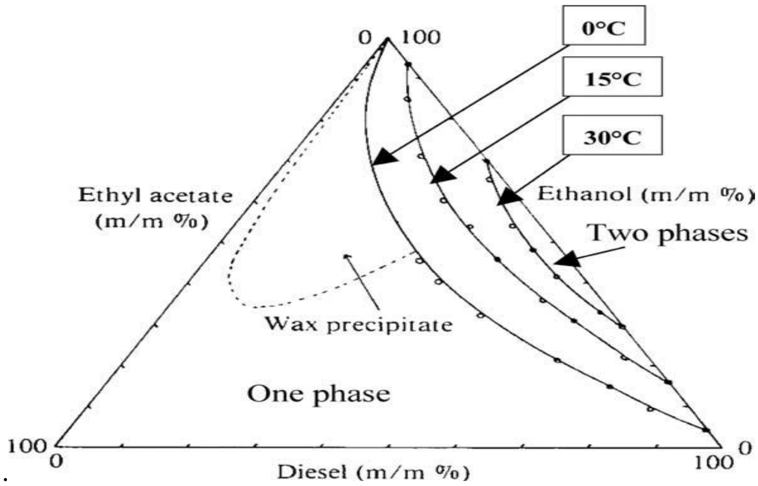

Fig. 2.1 Liquid–liquid ternary phase diagram for diesel fuel, ethyl acetate and dry ethanol mixtures

2.2. Viscosity and lubricity

Fuel viscosity and lubricity play significant roles in the lubrication of fuel injection systems, particularly those incorporating rotary distributor injection pumps that rely fully on the fuel for lubrication within the high pressure pumping mechanism. The addition of ethanol to diesel lowers fuel viscosity and lubricity. Wrage and Goering (1980) investigated the variation of kinematic viscosity with percentage of ethanol present and generated the graph shown in Fig.1.2

2.3. Energy content

The energy content of a fuel has a direct influence on the power output of the engine. Wrage and Goering (1980) stated that it would be desirable for ethanol– diesel blends to have gross energy contents at least 90–95% of that for No. 2 diesel to permit existing engines to deliver adequate power for the loads for which the vehicle is designed. The energy content of ethanol–diesel blends decreases by approximately 2% for each 5% of ethanol added, by volume, assuming that any additive included in the blend has the same energy content [4].

2.4. Cetane number

The minimum cetane number specified by ASTM Standard D 975-02 for No. 2 diesel is 40. Typical No. 2 diesel fuels have cetane numbers of 45–50. With the inverse relationship of octane number and cetane number, ethanol exhibits a low cetane rating. Hence, increasing concentrations of ethanol in diesel lower the cetane number proportionately. Hardenberg and Ehnert (1981) stated that using cetane numbers to describe the ignition characteristics of ethanol–diesel blends was unreliable, because of discrepancies in the determination of cetane numbers below 30.

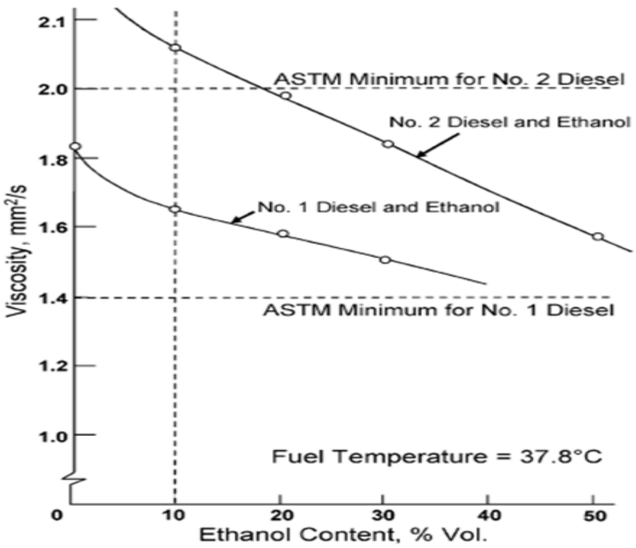

Fig 2.2. Effect of ethanol content on fuel viscosity

Comparisons of engine performance between ethanol– diesel blends or emulsions and standard diesel in unmodified engines generally show reductions in power that are approximately the same as the reductions in energy content of the blends relative to diesel fuel [5]. In his studies, Hansen et al. (2000) measured a 7– 10% decrease in power at rated speed with a 15% dry ethanol, 2.35% PEC additive and 82.65% No. 2 diesel fuel blend run in a Cummins 5.9 L engine. Kass et al. (2001) checked the torque output from the same model engine with two blends containing 10% and 15% dry ethanol, respectively, and 2% GE Betz additive, and reported an approximate 8% reduction for both fuel blends.

III. ENGINE DURABILITY

Limited tests were previously carried out for engine durability in early studies, tests with blends containing approximately 10% and 15% dry ethanol indicated no abnormal wear in engines correctly adjusted for injection timing (Hansen et al., 1982; Hashimoto et al., 1982; Meiring et al., 1983a). Some engines included in these tests were more sensitive to a lowering of the cetane number and accordingly an increased ignition delay causing piston erosion from severe localized temperatures and pressures. However, a small retardation of injection timing was recommended so as to reduce rates of pressure rise. In the durability tests conducted by Meiring et al. (1983b) no abnormal deterioration of the engine or fuel injection system was detected after 1000 h of operation on a blend containing 30% dry ethanol, small amounts of octyl nitrate ignition improver and ethyl acetate phase separation inhibitor, and the remainder diesel fuel.

IV. EMISSIONS

Early studies of the effect of ethanol–diesel blends on engine performance included measurements of soot output in the exhaust with a smoke-meter (Wrage and Goering, 1980; Meiring et al., 1983a). Substantial reductions in particulate matter (PM) were observed in these tests. Recent studies have shown that the improvement in exhaust emissions provided by oxygenate fuels depended almost entirely on the oxygen content of the fuels, regardless of the oxygenate to diesel fuel blend ratios or the type of oxygenate (Miyamoto et al., 1998). Emissions tests conducted specifically on ethanol– diesel blends confirm the effect of substantially reducing PM (Spreen, 1999; Schaus et al., 2000; Kass et al., 2001; Satg_e de Caro et al., 2001). The effect on carbon monoxide (CO), total hydrocarbon (THC) and oxides of nitrogen (NOx) are less clear [6]. In addition, comparative emissions data are influenced by anumber of factors that may have caused greater differences than those brought about by the fuel (Sinor and Bailey, 1993).
A summary of the emissions tests performed by Spreen (1999), Schaus et al. (2000) and Kass et al. (2001) is provided in Table 2. The test engines, test procedures and base fuels varied considerably. The results of Spreen (1999) and Kass et al. (2001) showed a consistent reduction in PM of 20–27% and 30–41% for 10% and 15% ethanol blends respectively. Reductions in NOx varied from zero to 4–5%. Both decreases and increases in CO emissions occurred, while Total hydro carbon increased substantially, but both were still well below the regulated emissions limit. The measurements eported by Schaus et al. (2000) vary considerably for both PM and NOx with both decreases and increases in emissions being dependent on speed and load of the engine. Both Schaus et al. (2000) and Kass et al. (2001) emphasize the potential to optimize injection characteristics, so as to minimize emissions over the complete performance map of the engine. The major variations in emissions measured by Schaus et al. (2000) are an indication of the reductions in emissions that could be obtained with ethanol–diesel blends [7]. Further factors that need to be considered are the influence of ethanol–diesel blends on exhaust gas recirculation systems (EGR). Kass et al. (2001) stated that the higher CO and THC emissions suggested that fuel blends might Kass et al. (2001) concluded from their tests that ethanol–diesel blends could be applicable as low emission fuels for current and older model vehicles that are not required to meet future EPA emission standards. However, extensive testing of these fuel types in older and late model diesel engines, need to be performed in order to accurately assess performance.

V. CONCLUSIONS

The ethanol–diesel blends properties have a significant effect on engine performance, durability, safety, and emissions. The addition of 4% ethanol to diesel fuel increases the brake thermal efficiency, brake torque, and brake power while decreasing brake specific fuel consumption . For 3% ethanol-diesel blends the engine performance was similar as diesel fuel. It was observed that ethanol-diesel blended fuels at high load conditions have stronger effects on smoke NOx, acetaldehyde emissions and unburned ethanol emissions. At low loads, the blends have slight effect on smoke reduction. With ethanol of 10% or less in emulsion has no significant effect on the performance of engine with that of using pure diesel as fuel. From literature survey it has been found that maximum cylinder pressure using ethanol-diesel emulsion is higher than diesel fuel. It is found that the considerable amount of reduction occur in PM with the use pf ethanol diesel emulsions.

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