Research Article

Combustion Characteristics of Methanol Blended Diesel Fuel in CI Engine

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ABSTRACT

The consumption of diesel fuel is increasing day by day due to its wide application in agriculture and transportation sectors which is also responsible for deteriorating condition of environment due to emissions i.e., smoke, CO, HC, NOx, etc. These emissions may be reduced by adding methanol in diesel fuel. As compared to diesel, lower value of viscosity and density of methanol-diesel blends helps in easy pumping. The lower boiling point of methanol helps in reducing the ignition delay and thereby avoiding knocking. Methanol with higher oxygen content also helps in easy availability of more oxygen in the vicinity of the diesel for its quick and better combustion. To improve the working of diesel engine and control its emission level, blend diesel version definitely plays a very important role.

Keywords: Methanol, Diesel, Combustion properties.

INTRODUCTION

For the improvement in engine efficiency and reduction of environment exhaust emissions, considerable research has been carried out to improve the combustion characteristics of fuels in recent years[1]. The use of additives with diesel fuel is a potential method for improving the combustion characteristic of the diesel-additives blend. It may improve engine performance and reduce the emissions simultaneously without any structural changes[2-4].

Among all available additives, oxygenated additives have strained more attention due to better combustion properties and rich oxygen content in their molecular structure[5,6]. Oxygenated additives are renewable in character and their oxygen content support in reaction for better combustion[7-9]. Alcohols are bio-oxygenated compounds with low viscosity and high volatile characteristics which make them appropriate fuel additives for CI engines[10-12]. Alcohol compound additives (i.e., methanol, ethanol, n–butanol etc.) are fuels infused with rich oxygen content and used to improve the combustion characteristic when blended with diesel[13, 14]. The advantages of alcohols as an additives include[15]

- It can be easily injected, atomized and mixed with air due to its Low viscosity as compared to diesel fuel.
- It improves the volumetric efficiency of the engine due to its high latent heat of evaporation which results in cooler intake process.
- It may improve the thermal efficiency of engine due to its high laminar flame propagation speed which helps in completing the combustion process earlier.
- It may reduce the emissions due to its high oxygen and low sulfur content.

Among alcohols, methanol is an alternative, renewable, economic, environment friendly and one of the most promising additives for conventional fossil base fuels. The main raw material available for the production of methanol is coal. In recent years, several researchers have been used the methanol as an alternative to conventional fuels for CI engine[16-18]. Though there are so many methods to solve the difficulty of direct application of methanol in diesel engine, the fumigation of methanol seems to be a promising method that could flexibly switch from pure diesel mode to relatively high methanol substitution mode[19].

The aim of current study is to investigate the effect of methanol blended diesel fuel on combustion characteristics of diesel engine.

Preparation of Methanol-Diesel Blends

Different methanol-diesel blends on volume basis were prepared using a magnetic stirrer and glassware for blending and storage as shown in Figure 1. The methanol used was of 99.0% purity.

Figure 1: Diesel-methanol blend preparation

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Several blends of varying concentrations were prepared by varying the methanol concentration (2.5, 5, 7.5 and 10% methanol) in diesel denoted by D-M2.5, D-M5, D-M7.5 and D-M10. The comparison of properties of diesel and methanol is given in Table 1 and Figure 2.

Table 1: Properties of diesel and methanol[9, 15, 19, 20]

Property	Diesel	Methanol
Calorific value (kj/kg)	44800	20000
Cetane number	55	05
Density (kg/m^3) at 20 ˚C	829	729
Boiling point (˚C)	190	64
Latent heat (kJ/kg)	250	1178
Oxygen content (%)	00	50
Auto ignition temp. (˚C)	315	470
Viscosity (cSt) at 40 ˚C	2.45	0.54

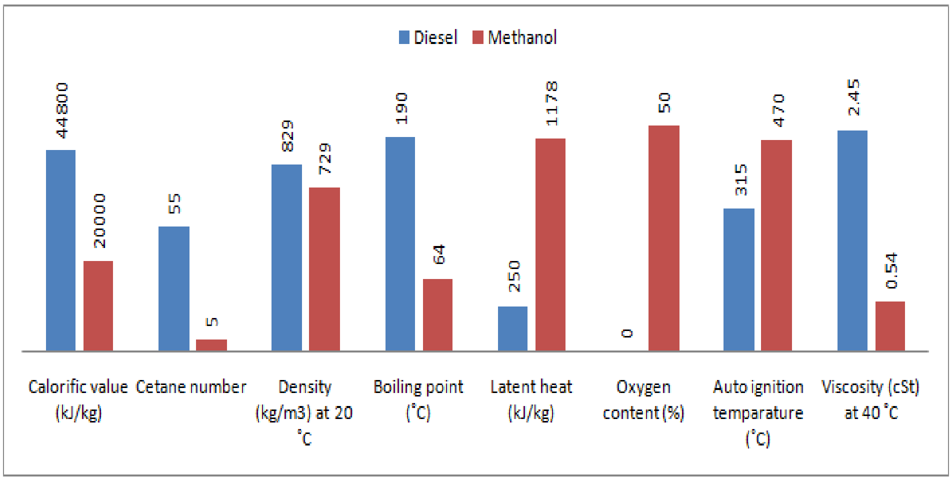

Figure 2: Comparison of diesel and methanol properties

Calculation of Properties of Diesel-Methanol Blends

The properties parameters for diesel–methanol blends were obtained analytically by using Eqs. (1-3). The formula presented in Eq. (1) was used to calculate the calorific value of blend. Formulae presented in Eqs. (2) and (3) were used to calculate cetane no. of blend and density of blend respectively. Table 2 shows the calculated calorific value, cetane number and density of different diesel-methanol blends.

$$Calorific\ value\ of\ blends\ (CV)(kJ/kg) = \left\{\left(\frac{v_m}{v} \times \rho_m \times CV_m\right) + \left(\frac{v_d}{v} \times \rho_d \times CV_d\right)\right\} / \left\{\left(\frac{v_m}{v} \times \rho_m\right) + \left(\frac{v_d}{v} \times \rho_d\right)\right\} \quad (1)$$

$$Cetane\ No.of\ blends\ (CN) = \left(\frac{v_m}{v} \times CN_m\right) + \left(\frac{v_d}{v} \times CN_d\right) \quad (2)$$

$$Density\ of\ blends\ (\rho_b) = (X_m \times \rho_m) + (X_d \times \rho_d) \quad (3)$$

where

CV= Calorific value of blend (kJ/kg), CV_m, and CV_d=Calorific value of methanol and diesel,

V_m and V_d = Volume percentage of methanol and diesel,

ρ_m and ρ_d = Density of methanol and diesel,

T = Brake torque (i.e. load) (Nm), N= r.p.m., m_f = mass of fuel consumption (kg/h),

CN_m and CN_d = Cetane number of methanol and diesel,

X_m and X_d=Mass fraction of methanol and diesel.

RESULTS AND DISCUSSION

The experiments were performed on single cylinder, water cooled, four stroke CI engine at standard parameters (i.e. CR= 17.5, Injection timing=23° btdc and Injection pressure= 210bar) with different blend ratio of diesel-methanol (D-M). The engine performance in term of brake thermal efficiency (BTE) for different blends and diesel are shown in Figure 3.

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Table 2: Composition of diesel-methanol blends and its properties

Blend	Pure diesel	D-M2.5	D-M5	D-M7.5	D-M10
% of Diesel	100	97.5	95	92.5	90
% of Methanol	0	2.5	5	7.5	10
Calorific value (kJ/kg)	44800	44180	43560	42940	42320
Cetane number	55	53.75	52.50	51.25	50
Density(kg/m^3)	829	826.5	824	821.5	819

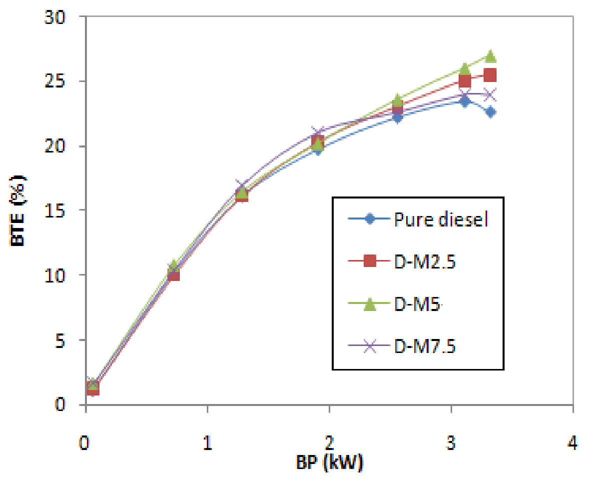

Figure 3: Variation in BTE with BP for pure diesel and D–M blends

The best engine performance (BTE) and reduced emission (Smoke NOx, CO, HC) results were found with D-M5 blend among all blends and diesel.

With D-M5 blend, increment in BTE (17.39%) and reduction in emissions (Smoke= 25.54%, NOx= 8.22%, CO= 12.24%, HC=10.34%) was observed as compared to pure diesel at full load condition.

Better physico-chemical properties of D-M blends may be responsible for these obtained results. With respect to diesel, the lower value of boiling point of methanol helps in reducing the ignition delay and thereby avoiding knocking. Higher auto–ignition temperature of methanol also helps in avoiding knocking in diesel engine.

Methanol with higher oxygen content helps in easy availability of more oxygen in the vicinity of the diesel for its quick and better combustion. As compared to diesel, lower value of viscosity and density of methanol-diesel blends helps in pumping.

CONCLUSIONS

To improve the working of diesel engine and control its emission level, methanol-diesel blend version definitely plays a very important role. Although bending diesel with methanol results in comparatively low calorific value of the blend but oxygen content in methanol helps in completing combustion of diesel thereby compensating for low calorific value. However high specific fuel consumption may lead to higher input cost, but due to better combustion of fuel blend, this cost may be negligible.

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REFERENCES

1. Yao C, Hu J, Geng P, Shi J, Zhang D, Ju Y, Effects of injection pressure on ignition and combustion characteristics of diesel in a premixed methanol/air mixture atmosphere in a constant volume combustion chamber. Fuel, 206, 2017, 593–602.

2. Curran H J, Fisher E M, Glaude P A, Marinov N M, Pitz W J, Westbrook C K, et al., Detailed chemical kinetic modeling of diesel combustion with oxygenated fuels. SAE Trans. 2001–01–0653, 2001.

3. Moghaddam M S, Moghaddam A Z, Chemical engineering research and design performance and exhaust emission characteristics of a CI engine fueled with diesel-nitrogenated additives. Chemical Engineering Research and Design, 92(4), 2014, 720–726. doi:10.1016/j.cherd.2014.01.009.

4. Rahman M M, Stevanovic S, Brown R J, Ristovski Z, Influence of different alternative fuels on particle emission from a turbocharged common–rail Diesel engine. Procedia Eng, 56, 2013, 381–6. doi:10.1016/j.proeng.2013.03.136.

5. Rajasekar E, Murugesan A, Subramanian R, Nedunchezhian N, Review of NOx reduction technologies in CI engines fuelled with oxygenated biomass fuels. Renew Sustain Energy Rev, 14, 2010, 2113–21.

   doi:10.1016/j.rser.2010.03.005.

6. Kumar C, Rana K B, Tripathi B, Performance and Emission Characteristic of VCR Diesel Engine Using Diesel–Nitromethane blend, International Journal of Engineering Technology Science and Research, 4 (6), 2017, 375-380.

7. Kumar C, Bafna M, Nayyar A, Parkash V, Goyal N, Experimental investigation of the performance of VCR diesel engine fuelled by NM–diesel blend, International Journal of Emerging Technology and Advanced Engineering, 4, 2014, 122–125.

8. Goyal N, Nayyar A, Kumar C, Experimental investigation of the performance of VCR diesel engine fuelled by n-butanol

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diesel blend. nternational Journal of Research in Engineering and Technology, 4(2), 2015, 444-50.

9. Padwa R S, Gupta S, Singh V, Kumar C, Experimental Investigation on the Performance of VCR Diesel Engine Fuelled by E-NM2-Diesel blend International Journal of Innovative Research in Science, Engineering and Technology, 5(5), 2016, 6794-8.

10. Desjardins P P, Pitsch H, Malhotra R, Kirby S R, Boehman A L, Structural group analysis for soot reduction tendency of oxygenated fuels. Combust Flame 154, 2008, 191–205.

11. Leclerc F B, Detailed chemical kinetic models for the low–temperature combustion of hydrocarbons with application to gasoline and diesel fuel surrogates. Prog Energy Combust Sci 34, 2008, 440–98.

12. Nabi M N, Hustad J E, Experimental investigation of engine emissions with marine gas oil–oxygenate blends. Sci Total Environ, 408, 2010, 3231–9.

13. Datta A, Mandal B K, Impact of alcohol addition to diesel on the performance combustion and emissions of a compression ignition engine. Appl Therm Eng, 98, 2016, 670–82. doi:10.1016/j.applthermaleng.2015.12.047.

14. Fayyazbakhsh A, Pirouzfar V, Comprehensive overview on diesel additives to reduce emissions, enhance fuel properties and improve engine performance. Renew Sustain Energy Rev 74, 2017, 891–901.

15. Sayin C, Engine performance and exhaust gas emissions of methanol and ethanol–diesel blends. Fuel 89, 2010, 3410–5. doi:10.1016/j.fuel.2010.02.017.

16. Yao C, Cheung C S, Cheng C, Wang Y, Chan T L, Lee S C, Effect of Diesel/methanol compound combustion on Diesel engine combustion and emissions. Energy Convers Manag, 49, 2008, 1696–704.

17. Yao C, Cheung C S, Cheng C, Wang Y, Reduction of smoke and NOx from diesel engines using a diesel/methanol compound combustion system. Energy and Fuels, 21, 2007, 686–91. doi:10.1021/ef0602731.

18. Zhen X, Wang Y, An overview of methanol as an internal combustion engine fuel. Renew Sustain Energy Rev, 52, 2015, 477–93.

19. Kumar C, Rana K B, Tripathi B, Nayyar A, A comparative study of oxygenated additives for diesel in compression ignition engine, Int. J. Renewable Energy Technology, 9, 2018, 16–27.

20. Kumar C, Nayyar A, Bafna M, Agarwal A, Parkash V, Analysis of emission characteristic of NM–diesel blend on VCR diesel engine, International Journal of Recent Advances in Mechanical Engineering, 4, 2015, 115–124.

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