Effect of Preheating Temperature on Performance and Emission Behavior of a Diesel Engine

Rohit Rai[1], Nishant Vibhav Saxena[2]

[1]Research Scholar, [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Millennium Institute of Technology Bhopal, (M.P), India

Abstract

Small and medium sized industry and other manufacturing units in the India have vital contributed to the growth of our country. However, to run these units and for transportation of products more of petroleum fuels have been consumed. To replace the petroleum fuels many researches have been done and biodiesel derived from Jatropha oil has been found one of the suitable candidates. In this study fuel obtained by the pyrolysis of waste tire is blended with jatropha biodiesel and used as test fuel. The fuel B20 (80% Jatropha biodiesel+20% tire pyrolysis oil) has higher viscosity then diesel which restrict its good performance. It is well known fact that viscosity is directly proportional to temperature. In this regard test have been done with various preheating temperature to evaluate the behavior of the engine. The B20 was preheated at three temperature i.e. 50 ˚C, 60 ˚C and 70 ˚C and used as a diesel engine fuel. The test was conducted in a single cylinder diesel engine of model TAF1. The various performance and emission studies have been conducted, analyzed and presented in this research paper.

Keywords: *Alternative fuel; Diesel engine; Performance; Preheating; Emission*

1. Introduction

Worldwide, the demand for energy is increasing exponentially with the increase in the population and improvement in living standards [1]. The source of energy for almost in all the sectors including domestic, transportation etc. is still fossil fuels. The excess consumption of the fossil fuels is major cause for the global greenhouse gas (GHG) emissions which cause an adverse effect on the public health and climate change. Internal combustion (IC) engines used in transportation, power generation, and commercial sector are one of the significant contributors to the air pollution. The GHG emission noticed from different resources is illustrated in Fig.1. To reduce these emissions, we need to move towards fuel derived from other resources.

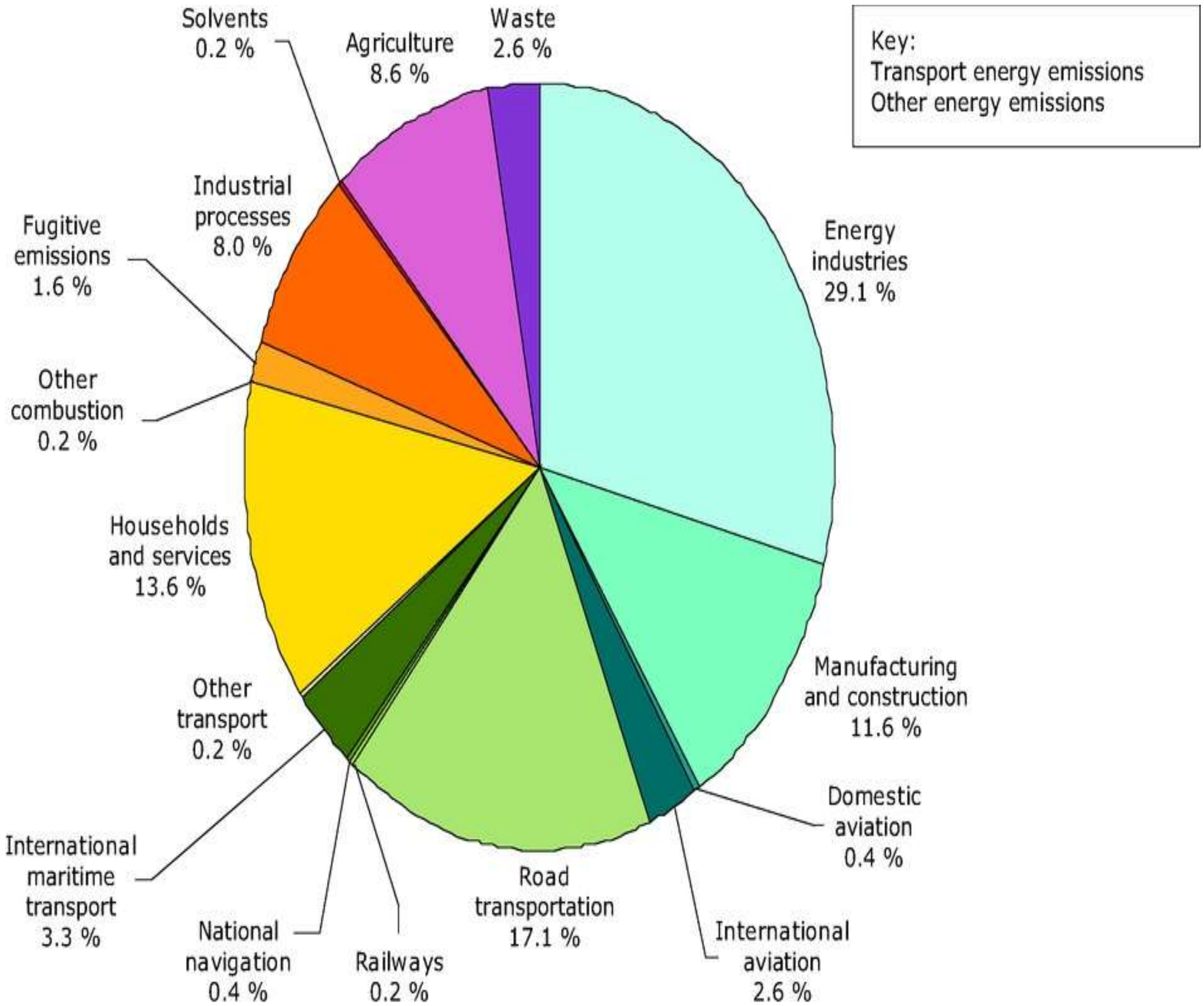

Fig. 1 Annual greenhouse gas emissions [1]

The prime research's done is related about CI engine modifications required for fruitful run of bioliquid fuels in conventional compression ignition. Almost every modern CI engines would run on biodiesel quite happily provided that the biodiesel has enough high quality, moreover biodiesel required much less engine modification but for low class engines there were some basic problems such as failure of rubber seal, cold starting, fuel injector failure due to high viscosity, poor atomization, less lubrication, etc. [2-3]. The alternative fuel can be majorly classified as first generation biofuels, second generation biofuels and third generation biofuels. The details are given in Fig. 2.

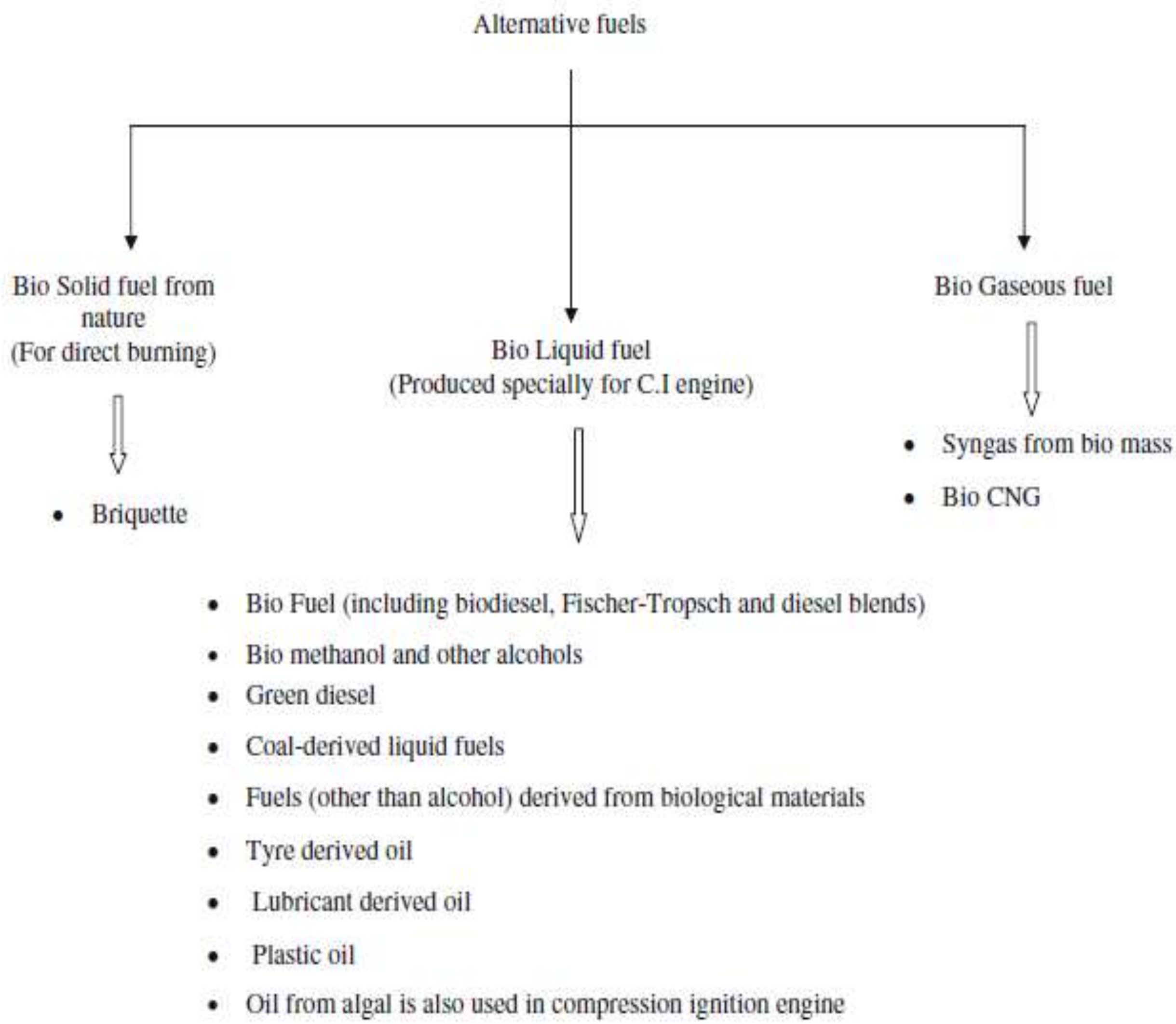

Fig. 2 Major alternative fuels for energy production

Based on the literature it was noticed that many studies have been done on the usage of TPO but due to higher viscosity and moisture content the performance was not up to mark [4-5]. In this study fuel obtained by the pyrolysis of waste tire is blended with jatropha biodiesel and used as test fuel. The fuel B20 (80% Jatropha biodiesel+20% tire pyrolysis oil) has higher viscosity then diesel which restrict its good performance. It is well known fact that viscosity is directly proportional to temperature. In this regard test have been done with various preheating temperature to evaluate the behavior of the engine. The B20 was preheated at three temperature i.e. 50 ˚C, 60 ˚C and 70 ˚C and used as a diesel engine fuel. The test was conducted in a single cylinder diesel engine of model TAF1. The various performance and emission studies have been conducted, analyzed and presented in this research paper.

2 Experimentation

The test was conducted in a diesel engine which gives power out put of 4.4 kW at rated rpm of 1500 rpm. The schematic diagram of the set up is given in the figure 3. The important parameters such as brake thermal efficiency, nitric oxide emission, hydrocarbon emission, smoke opacity etc. were recorded and analyzed and compared with diesel operation.

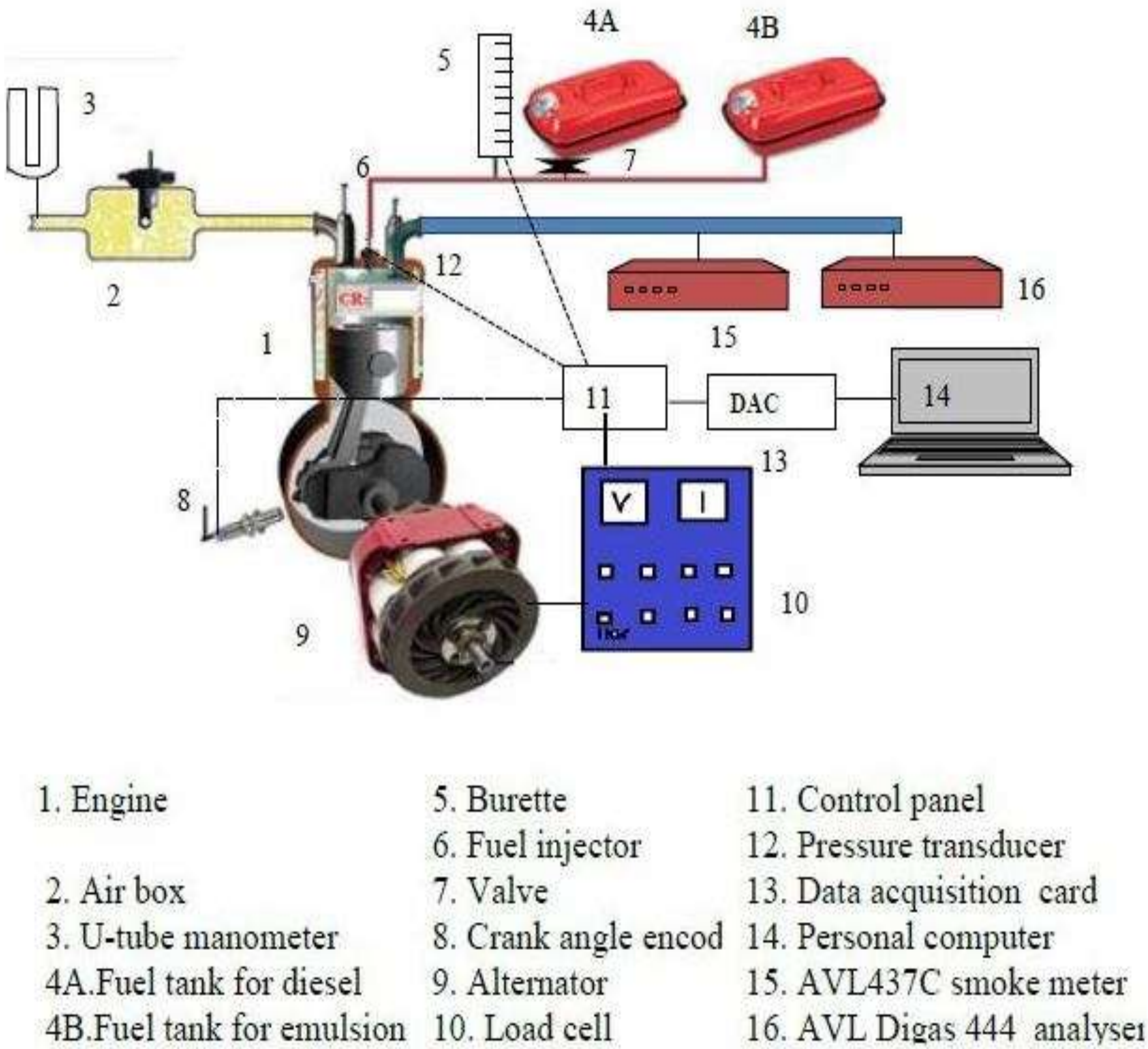

Fig.3 Schematic diagram of the set up

3. Brake Thermal Efficiency (BTE)

Brake thermal efficiency is an important efficiency for CI engine, it means how much thermal energy of fuel input was converted into shaft output [6]. Figure 4 shows the comparison of BTE for CI engine without preheating and with preheating for B20 fuel in a unmodified engine. Generally, 29-30 % efficiency is reported on full load condition and after preheating become 31 %, hence, there is an increment of 2 % of the efficiency [7]. Although, at less temperature also efficiency was increasing order. A better BTE with high viscous fuel is possible due to preheating. Better swirling of air in combustion chamber leads to better combustion of alternative fuel and results increased in brake thermal efficiency [8]. The findings and trends are supported by literature available data

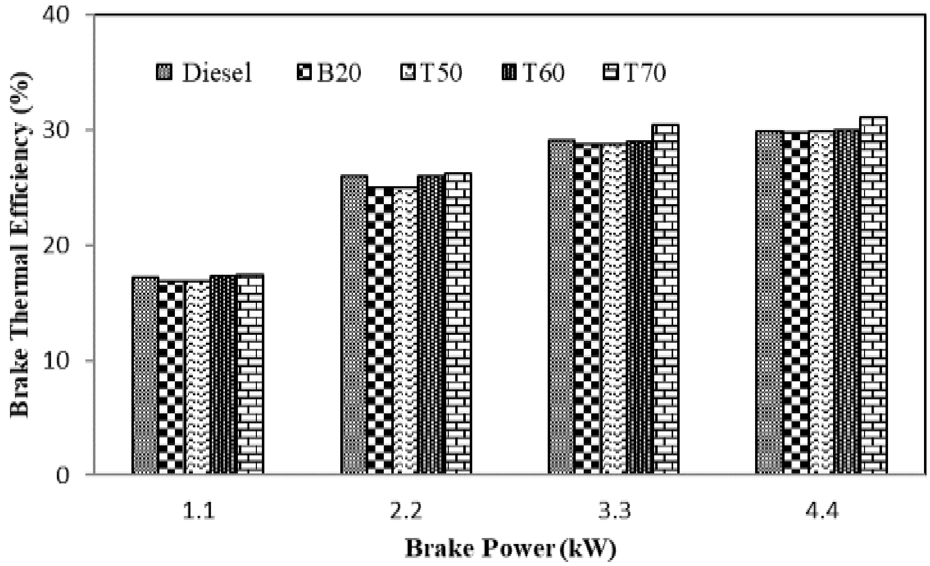

Fig. 4 Load Vs BTE

4 Nitric Oxide (NO)

Automobiles significantly contaminate the environment by emissions of pollutants like carbon monoxide (CO), carbon dioxide (CO_2), nitric oxides (NOx), sulphur dioxide (SO_2), unburnt or partially burnt hydrocarbons, and particulates [9]. We can see that with the increase in preheating temperature NO emission increases due to rise in combustion temperature. These findings are supported by some researchers [10-12]. It should also be noted that most vegetable oils contain small quantities of nitrogen containing proteins. This small amount of nitrogen in addition to atmospheric nitrogen releases extra NOx emissions through combustion. This might be a contributing factor for vegetable oils to have higher NO emissions than diesel fuel.

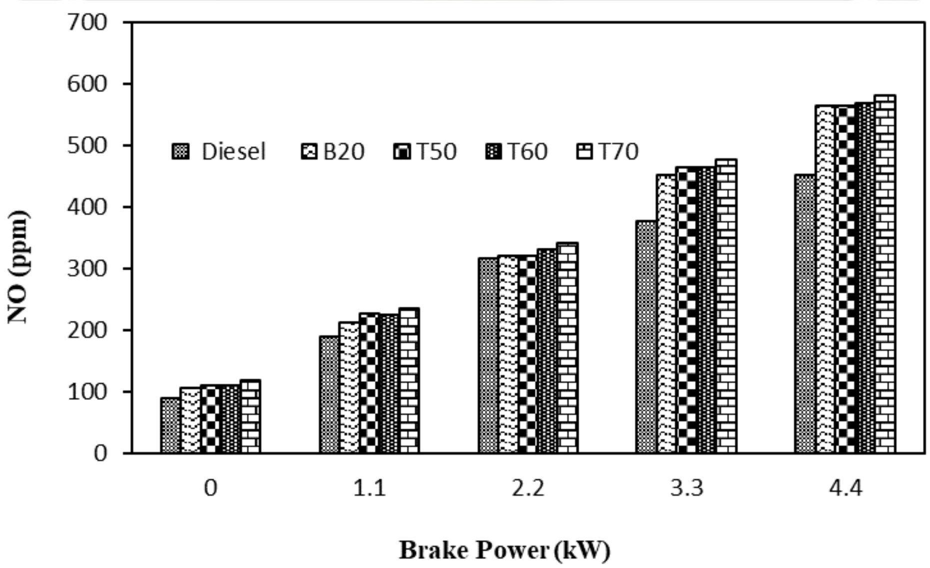

Fig. 5 Load Vs NO

5. Hydrocarbon Emission (HC)

Unburned hydrocarbon is produced due to the incomplete combustion in the combustion phase because it is the unburned part of fuel which was exhausted in atmosphere during exhaust stroke of CI engine [13]. The unburnt hydrocarbon emissions for the B20 blend was lower as due to complete combustion happed in preheating condition. The HC emissions were reduced from no load to full load with modification of preheating the B20biodiesel.

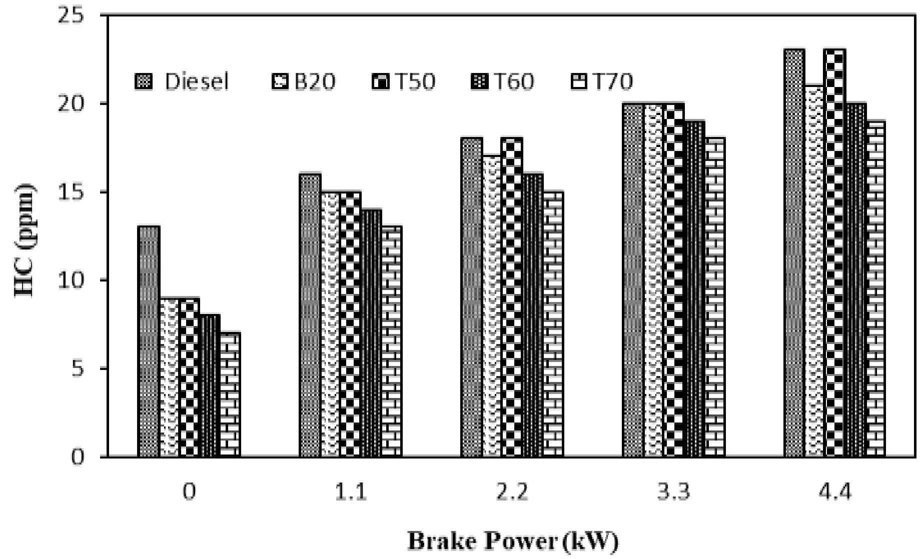

Fig.6 Load Vs HC

7. Smoke Opacity

The graph between smoke emission with power output is shown in Fig. 7. With B20 blend smoke emission is decreased particularly at higher loads due to better atomization of the fuel [14-15]. Smoke level at the maximum power output of 3:7 kW is 51% in case of pure JB and 65% in case of B20 blend. The smoke level with diesel is at maximum power. However, there is a drastic reduction of smoke emission in dual fuel operation with methanol induction. The smoke emission was 52% at peak power output in the B20 fuel operation with T70. This is due to combustion of B20 blend in better way. The increese of temperature reduces the quantity of injected fuel and lowers the smoke emission.

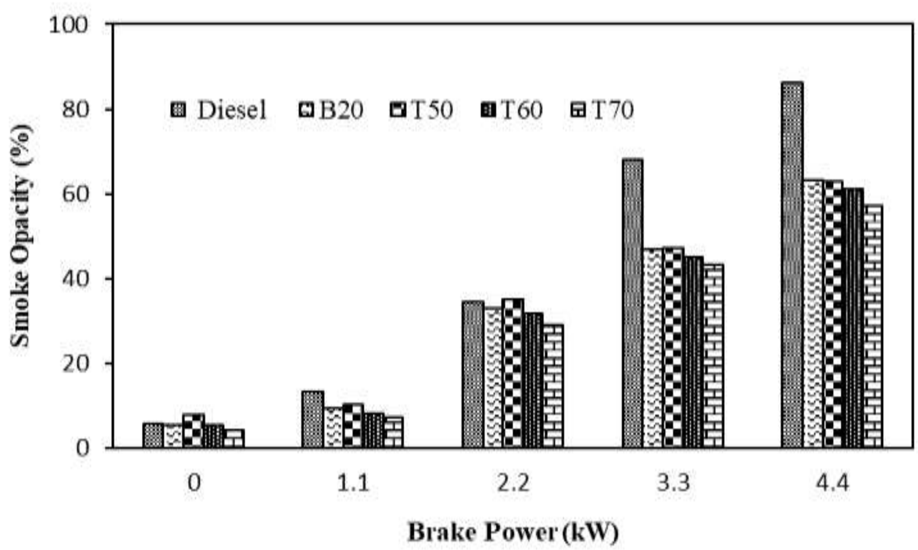

Fig. 7 Load Vs Smoke Opacity

8. Conclusion

From the above fuel modification, it is concluded that the use of B20 at different preheating temperature will be helping parameters for the increase in performance. The alternative fuel or its blends with petrol diesel in modified CI engine can create a good impact on the efficiencies and emissions of the CI engines. It is very useful in developing countries like India because India has great potential for alternative fuels. The compression-ignition engines easily adopt the characteristics of alternative fuels like higher flash point, kinematic viscosity, API density, and lower calorific value due to these modifications. Stationary slow speed compression-ignition engines were suitable for fuelled with straight vegetable oil and their blends without much environmental impact and these types of modifications were very good for stationary engines for increasing their brake thermal efficiency. Modification like fuel preheat intake in a combustion chamber through the preheating set up is very helpful for proper air–fuel mixing and proper combustion due to increase in volumetric efficiency and turbulent nature of intake air. Alternative fuel preheating through exhaust gasses was also an optional solution to reduce the kinematic viscosity of liquid alternative fuel because it created the major problems like failure of rubber seals, injector coking, cold shut in wintertime, etc.

References

[1] International Energy Agency. Energy and Air Pollution. 2018. doi:10.1021/ac00256a010.

[2] BP Energy Outlook - 2018 edition. 2019.

[3] Prakash R, Singh RK, Murugan S. Experimental investigation on a diesel engine fueled with bio-oil derived from waste wood–biodiesel emulsions. Energy. 2013 Jun 15; 55:610-8.

[4] Imtenan S, Masjuki HH, Varman M, Kalam MA, Arbab MI, Sajjad H, Rahman SA. Impact of oxygenated additives to palm and jatropha biodiesel blends in the context of performance and emissions characteristics of a light-duty diesel engine. Energy Conversion and Management. 2014 Jul 31; 83:149-58.

[5] Sanjid A, Masjuki HH, Kalam MA, Rahman SA, Abedin MJ, Reza MI, Sajjad H. Experimental investigation of palm-jatropha combined blend properties, performance, exhaust emission and noise in an unmodified diesel engine. Procedia Engineering. 2014 Dec 31; 90:397-402.

[6] Sanjid A, Masjuki HH, Kalam MA, Rahman SA, Abedin MJ, Palash SM. Production of palm and jatropha based biodiesel and investigation of palm-jatropha combined blend properties, performance, exhaust emission and noise in an unmodified diesel engine. Journal of Cleaner Production. 2014 Feb 15; 65:295-303.

[7] Imtenan S, Masjuki HH, Varman M, Fattah IR, Sajjad H, Arbab MI. Effect of n-butanol and diethyl ether as oxygenated additives on combustion–emission-performance characteristics of a multiple cylinder diesel engine fuelled with diesel–jatropha biodiesel blend. Energy Conversion and Management. 2015 Apr 30; 94:84-94.

[8] Senthilkumar P, Sankaranarayanan G. Effect of Jatropha methyl ester on waste plastic oil fueled DI diesel engine. Journal of the Energy Institute. 2015 Sep 3.

[9] Nalgundwar A, Paul B, Sharma SK. Comparison of performance and emissions characteristics of DI CI engine fueled with dual biodiesel blends of palm and jatropha. Fuel. 2016 Jun 1; 173:172-9.

[10] Murugan S, Ramaswamy MC, Nagarajan G. The use of tyre pyrolysis oil in diesel engines. Waste Management. 2008 Dec 31; 28(12):2743-9.

[11] Murugan S, Ramaswamy MC, Nagarajan G. Assessment of pyrolysis oil as an energy source for diesel engines. Fuel Processing Technology. 2009 Jan 31; 90(1):67-74.

[12] Doğan O, Çelik MB, Özdalyan B. The effect of tire derived fuel/diesel fuel blends utilization on diesel engine performance and emissions. Fuel. 2012 May 31; 95:340-6.

[13] Frigo S, Seggiani M, Puccini M, Vitolo S. Liquid fuel production from waste tyre pyrolysis and its utilisation in a Diesel engine. Fuel. 2014 Jan 15; 116:399-408.

[14] Martínez JD, Rodríguez-Fernández J, Sánchez-Valdepeñas J, Murillo R, García T. Performance and emissions of an automotive diesel engine using a tire pyrolysis liquid blend. Fuel.2014 Jan 31; 115:490-9.

[15] Sharma A, Murugan S. Investigation on the behaviour of a DI diesel engine fueled with Jatropha Methyl Ester (JME) and Tyre Pyrolysis Oil (TPO) blends. Fuel. 2013 Jun 1; 108:699-708.