The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 5 ||Pages|| 66-69||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Comparison of Biodiesel and Petrodiesel Particulate Emission

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---ABSTRACT---

Petrodiesel is non renewable fuel and causing air pollution. It must be replaced by biodiesel that can be made from waste frying oil (WFO). Combustion of biodiesel in a boiler burner emits particulates and gases which should be lower than those of petrodiesel.The particulates are collected using a trap then analyzed gravimetrically and compared to emission of petrodiesel combustion. At composition up to B10, particulatesemission is lower than petrodiesel emission with reduction almost 30%. +

Keywords: *WFO, biodiesel, petrodiesel, particulate, emission*

Date Of Submission: 02 May 2013 Date Of Publication: 20,May.2013

I. INTRODUCTION

Several types of fuel are derived from crude oil that originally from fossil, namely: LPG, gasoline, kerosene, and diesel. Among these fuels, most vehicles use gasoline and diesel. Meanwhile, industries tend to consume diesel for machinery fuel. Diesel fuel that originated from fossil is also known as petrodiesel [1] [2].Emission of petrodiesel combustion has caused air pollution that harmful to human health [3] [4]. Inhaling polluted air may cause severe health damage [5]. Combustion mechanism in machinery produces a black smoke. The black smoke contains particulates and harmful gases because of imperfect combustion. Normally, a perfect combustion of petrodiesel with adequate amount of oxygen producing carbon dioxide and water in form of gas. Meanwhile, imperfect combustion of fuel also producing carbon monoxide gas, unburned hydrocarbon, and soot as particulate matter, PM [6].

Besides causing air pollution and environmental problem, petrodiesel is also a non renewable fuel. It is not in accordance with sustainable development. Therefore, it should be replaced by a new generation of fuel that more environmentally friendly and renewable [3]. This type of fuel is originated from plants and known as biodiesel.Biodiesel is created by reacting oils or fats which contain fatty acids with methanol. The reaction producing fatty acid methyl ester (FAME) that has physical and chemical properties similar to petrodiesel and known as biodiesel. This reaction also producing glycerol as byproduct [7] [8].Biodiesel can be used to replace petrodiesel without machinery alteration. Usually, both fuels are combusted either by direct combustion or by injected into an internal combustion engine [9]. Naturally, combustion is carried out to generate energy and heat with gases and particulates as by products. In this research, particulate emission of biodiesel and petrodiesel mixture that combusted in a boiler burner was analyzed.Particulate is very small solid particle with diameter less than 10 nm. According to the diameter, particulates are classified into three categories. Ultrafine particulate (UFP) has diameter less 0,1 μm (<100nm), fine particulate diameter is between 0,1to 2,5 nm that usually marked as $P_{2,5}$, and the largest particulate has diameter from 2,5 up to 10 nm that marked as P_{10}. [10].Because of their tiny size it can pollute air and harmful to human health. Particulates can be formed naturally from dust, plants, volcano, etc. Human activities such as industries and vehicles can also create particulates [11].

II. METHODS

Biodiesel used in this experiment was made from waste frying oil (WFO) that originated from palm oil. WFO was reacted with methanol as second reactant and potassium hydroxide (KOH) as catalyst. Meanwhile, petrodiesel was bought from local Pertamina fuel station [12].Physical properties of both fuels were analyzed. Density was analyzed using densitometer KEM Kyoto Electronic DA-100. Flash point was analyzed using Koehler K-16270. Viscosity was analyzed using Visco Kinematic: Koehler CFR 200 and CFR 350 in accordance with ASTM D446. Gas chromatography of Hewlett Packard (HP) 5890 with OV packed column and FID as detector was used to analyze the fuels compounds [12].

Physical Properties	Petrodiesel	Biodiesel
Density (kg/liter)	0.84	0.87
Viscosity (cSt)	2.5321	4.9248
Flash Point (^{o}C)	72	85
Contents	Hydrocarbons	98% FAME

Petrodiesel and biodiesel were blended to create Bx fuel mixture. B0 means the mixture contains petrodiesel only. B5 means the mixture contains 95% petrodiesel and 5% biodiesel by volume (v/v). In this experiment, the fuel mixtures were blended from B0 to B30 by 5 increments.Each fuel mixture was then combusted in a boiler burner. The burner used was Rosbell steam boiler model RBS 400, made in 2007 and delivered by PT Trimitra Wisesa Abadi. The burner was water tube type with capacity 0.4 ton/hr, heating area 8 m^2, maximum pressure 10 bar, and maximum steam temperature 185 ^{o}C. During each combustion, the emission was collected by a flue gas trap then analyzed gravimetrically [13].

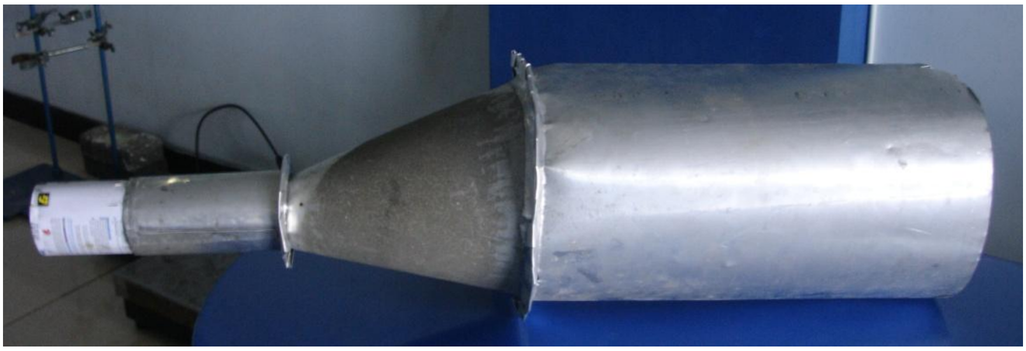

Figure 1. Particulate Trap

III. RESULTS AND DISCUSSION

Initial combustion process took twenty minutes to steady state. After steady, each mixture of biodiesel and petrodiesel fuel was combusted for ten minutes. Particulate trap was set for twenty minutes. During combustion, air supply was set with 10% over stoichiometric requirement. The result of this experiment is shown on following table.

Fuel Mixture	Particulate Mass, Sample 1 (gr)	Particulate Mass, Sample 2 (gr)
B0	0.6276	0.6002
B5	0.5061	0.5101
B10	0.4406	0.4402
B15	0.7433	0.7404
B20	0.6889	0.6903
B25	0.6585	0.6801
B30	0.5762	0.5704

From fuel composition B0 (petrodiesel only), the amount of collected particulate tends to decrease. From B0 to B5, the decrease is almost 20%. A further increase in biodiesel percentage on the blended fuel, from B5 to B10, another 10 % decrease is achieved. This composition is the best in particulate reduction point of view. After this point, the higher biodiesel percentage in the mixture, the higher is the amount of particulate emission. It continuously happened up to B15. Increasing the percentage of biodiesel from B15 to B30 cause a decrease in collected particulate emission. Unfortunately, B30 is the maximum blended fuel that can be used for the boiler burner. A major alteration of the burner must be carried in order to use B35 or higher.

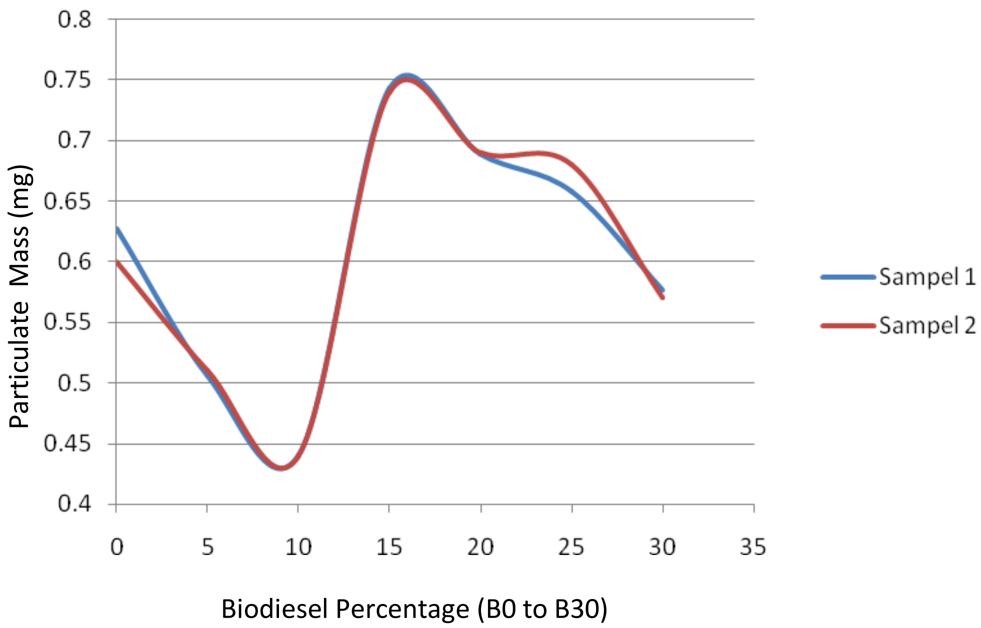

Figure 2. Graphic of Particulate Mass vs Biodiesel Percentage

The result of this research is similar to several previous ones. With respect to percentage of biodiesel in a blended diesel fuel, application of B10 that originated from palm oil on a light-duty common-rail Euro 3 engine reduced particulate emission [14]. In a direct injection diesel engine, application of B15 reduced the concentration of acenaphthene, acenaphthylene and anthracene present in the particulate matter emitted [13]. Meanwhile, compare to application of Euro V diesel fuel, B15 on a car engine reduced particulate emission [15]. Further, application of B20 produced from karanja oil on CRDI (Common Rail Direct Injection) diesel engine operated at different loads at two different engine speeds at 1800 rpm reduced particulate emission by almost 50% [16]. Application of pure biodiesel on a stationary diesel engine reduced particulate emission up to 26% [11].

IV. CONCLUSION

Biodiesel has a contribution to reduce particulate emission from combustion on a boiler burner with reduction of 29.796%. This percentage of reduction is significant to decrease air pollution, creating a better and healthier environment .

V. ACKNOWLEDGEMENT

Appreciations should be delivered to Sandra, Zulriadi, Kaliawan, Rio, and Wantok who have given valuable assistance to complete this project at The Chemical Engineering Department in The State Polytechnic of Malang, Indonesia. Also to Eni Purnamawati, Aisyah Vanadia, Natasya Aurumi, and Azzahra Florensia for keeping up spirit to finish this manuscript.

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