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THE INFLUENCE OF ADDITIVES ON DIESEL ENGINE PERFORMANCE AND THE ECOLOGICAL PARAMETERS

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ABSTRACT

Biodiesel is the best alternative for Diesel fuels in Diesel engines. The biggest advantage that Biodiesel has over petroleum Diesel is its environmental friendliness. Different types of additives were used to enhance Biodiesel properties and its performance in the Diesel engine 26.12 kW. Biodiesel was produced from waste vegetable oil and additives which have been used are Gasoline, Kerosene, Diesel and Turpentine. Different additives to Biodiesel were tested and compared with Diesel fuel. The engine performance, fuel consumption, and emission were tested on PTO tractor at 540 rpm. It was found that power was increased by using B50SG (Biodiesel 50 % plus 50 % Solar and Gasoline) compared to Diesel fuel about 5.14 %. While, fuel consumption decreased about 5.92 % using B50SG compared to Diesel fuel. Also, there was statistically significance difference between all levels of additives and the Diesel considering the concentration of evolved carbon monoxide (CO), indicating the dramatic decrease in the concentration of CO due to the component of Oxygen in Biodiesel treatments which resulting in complete combustion. The exhaust gas temperature decreased using additives as there was statistically significance difference between the different of 24 treatments of the additives and Diesel. Additives did not affect much on NOx compared to Diesel fuel.

INTRODUCTION

In recent years, regulations have targeted to reduce sulfur and aromatics in Diesel fuel in order to obtain cleaner air quality. Unfortunately, the processes that remove sulfur and aromatics also remove some components such as polyaromatics and nitrogen compounds that help providing the fuel with its lubricating properties. As a result, the new low-sulfur petroleum Diesel fuels tend to lack sufficient lubricity necessary for lubrication of internal moving parts of Diesel engine (Gretchen R. 2000, and EPA-1998). Biodiesel, a nontoxic, biodegradable Diesel fuel made from recycled cooking oil offers a much higher level of lubricity that can help protect delicate fuel injection equipment cost-effectively and extend the life of Diesel engines. Biodiesel blends may offer refiners a way to produce fuels that meet EPA's recently adopted low-sulfur Diesel standards, without sacrificing fuel performance. Maximum lubricity improvement occurred at blend levels of approximately 10%, however, with less than 0.5% mix of Biodiesel, a low-sulfur Diesel fuel can become a premium Diesel blend, relative to lubricity (Peterson et al.,, 1983). At the same time, when used in higher percentages Biodiesel helps reducing EPA-targeted exhaust emissions and qualifies as an alternative Diesel fuel (Gretchen, 2000, George et al., 1997 and Knothe et al., 1997). Biodiesel is described as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. It is oxygenated, essentially sulfur-free and biodegradable (Yuan *et al.,* 2004). Biodiesel consists of Fatty Acid Methyl Esters (FAMEs) of seed oils and fats and have already been found suitable for use as fuel in Diesel engine (Harrington, 1986). CO_2 emission by use of Biodiesel in Diesel engines will be recycled by the crop plant resulting in no new addition in to atmosphere (Peterson and Hustrulid, 1998). Another fact is, the blended fuel with additive reduces friction between the cylinder wall and piston thus the heat loose is controlled in the cylinder and result in considerable reduction in NOx. This condition was also observed by (Shahabuddin el al 2012). (Butkus et al., 2007) stated that knowing the chemical formula of Turpentine (C5H8)n and molecular weights of carbon and hydrogen (12 and 1 correspondingly) they find the heating capacity of Turpentine *Ha*, which is equal to 42.04 MJ/kg. The heating capacity of pure Diesel fuel is equal to 42.5 MJ/kg.

Blending Turpentine with vegetable oil to make Diesel fuel II Video: Driving 150 miles on a blend of 20% Pure Gum Turpentine with 80% waste vegetable oil (WVO) offers a purely bio-source for Diesel fuel that is more green than Biodiesel. All we need is the forest product industry to extract the volatiles from their waste products to bring down the per-gallon price of Turpentine to be competitive with gasoline prices. Then our highways and cities would smell like forests. http://youtu.be/2TyTtfRfPV4

Biodiesel has low calorific value, high viscosity, pour point, density compare to Diesel fuel, so this research has been initiated to study the influence of some additives on Diesel engine performance and the ecological parameters.

MATERIALS AND METHODS

The main reason for using these additives is to enhance the properties of the fuel for instance Turpentine has cetane no. 120 to 130 compared to 51 for Biodiesel, Gasoline is a very strong solvent therefore, it helps keeping your blend well mixed. It could reduce the viscosity of Biodiesel. Kerosene has a similar cetane value as # 2 Diesel fuel but is thinner. It can be blended with Biodiesel to a ratio that yields a similar viscosity as # 2 Diesel fuel. It also has a low gel point so it is ideal for blending in cold climates.

Engine specifications.

Technical specifications of the tested tractor Diesel engine are a 2-cylinder, Helwan 35-IMT of maximum power 26.12 kW at 2200 rpm. The bore x stroke is 105 mm x 125 mm, where the compression ratio is 16:1, engine rated speed is1800 rpm.

Hydraulic dynamometer

The tractor was coupled to AW P.T.O dynamometer for applying load according to ASAE Standard of tractor PTO performance was 540 rpm

speed. Engine speed was controlled by a throttle positioner. Some characteristics for hydraulic dynamometer presented as in Table 1.
Torque was measured at PTO speed 540 rpm and its power was calculated from the following equation:
Where:

$$P = \frac{2 \times \pi \times N \times T}{C}$$

P = Power, kW
N = Speed of PTO shaft, rpm
T = Torque, N.m.
C = Conversion constant = 1000

Table 1: The technical specification of hydraulic dynamometer.

Model	**made in the UAS**
Maximum power	220 kW
Maximum torque	1360 N.m
Maximum RPM	3500
Constant torque number	10

Fuel consumption meter

Local manufactured fuel consumption meter was used to measure fuel consumption (Fig. 1). It consists of a secondary tank of 4.5 liters capacity with a level marked tube and bulb with volume 17 cm^3. After data for a given fuel had been obtained the engine was shut off and the fuel was bled from the fuel system. The engine was run long enough to remove all of the previous fuel. Each blend was prepared by using a graduate cylinder (1 liter) at the lab of tractor test station, Alexandria.

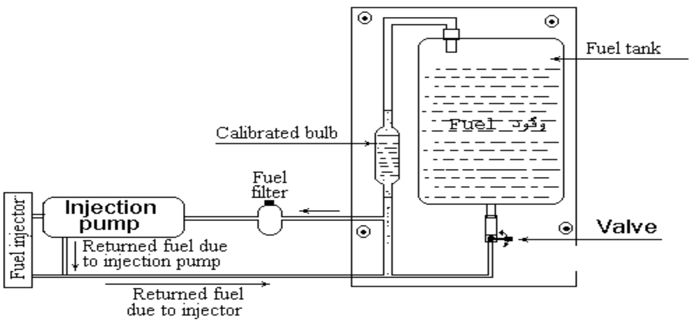

Fig. 1. Local manufactured fuel consumption meter (Tractor Res. Station)

Gas analyzer:

The emissions stack measurement as shown in (Fig.2) consists of a probe to sample gaseous emissions from the exhaust combustion effluents in the stack pipe at a rate of 2.8 L/min. The probe is connected to a direct reading combustion gas analyzer IMR 1400 (IMR Environmental Equipment, Inc., USA). In each test series CO, NOx, exhaust temperature and combustion efficiency were recorded. Exhaust temperature was measured by a chromel-alumel thermocouple.

Fig. 2: The exhaust gas analyzer

Pilot Biodiesel Plant

Biodiesel was made in a pilot Biodiesel plant which manufactured at Research and Tractor Test Station in Sabahia – Alexandria (Fig.3). The pilot plant consists of two processors with heater for each one and three agitating pumps, a chemical mixing tank and two washing tank. The Biodiesel production capacity of the plant is 400 liters/day and the reaction time per batch is about 1-hour.

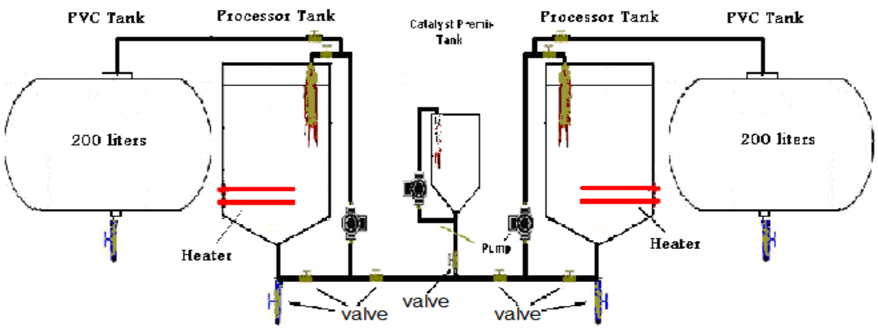

Fig. 3. Pilot Biodiesel plant

The theory of this operation is the fatty acids of the vegetable oil exchange places with the OH group of the alcohol producing glycerol and the methyl ester. (Moussa, 2003).

Waste vegetable oil and its fatty acids

Physical and chemical properties of bio-Diesel derived from waste vegetable oil are measured in Miser Petroleum labs, as shown in Tables [2 and 3].

Table 2: Fatty acid composition of waste vegetable oil

Components	Wt,%
Mystric(C_{16}:O)	1.4
Menstotic (C_{14}:1)	0.1
Palmitic (C_{16}:0)	23
Palmitic (C_{16}:1)	2
Stearic (C_{18}:0)	1.1
Oleic (C_{18}:1)	22.9
Linolenic (C_{18}:2)	47.9
Linolenic (C_{18}:3)	0.3
Erucic (C_{22}:1)	1.3

One may observe that when waste oil is heated it becomes hydrogenated and produces free fatty acids that lead to higher gelling temperature. As a consequence, many waste oils are existed as solid at room temperature. Therefore, on processing these waste oil source must be neutralized and the free fatty acids must be eliminated (Moussa. 2003 and Peterson *et al.,,*1999).

Table 3: Properties of methyl-ester waste vegetable oil and Diesel fuels

Parameter	Waste oil bio Diesel	Diesel fuel
Density at 15 ^{0}C	0.888	0.846
Viscosity,mm^2/s at 40 ^{0}C	6.75	3.3
Viscosity indix, mm^2/s at 40 ^{0}C	205	97
Cetane number	51	47
Heating value MJL^{-1}	38.3	40
Pour point, ^{0}C	-3	3.0
Flash Point ^{0}C	170	34
Ash, %	0.001	0.4
Water and Sediment, %	0.0	0.075

The greater number of unsaturated double bonds, the more easily the compound reacts with oxygen from the air and deteriorates, while saturated fats turn solid at low temperatures and forms solid crystals plugging fuel lines. (Zumdahl et al.1995 and Goering *et. al* 1982).

The degree of saturation of the fatty acid governs the quantity of energy contained within. The presence of double bonds in unsaturated fat lowers the energy of the molecule, with respect to a saturated fat, which has only single bonds. The bond energy of a single bond is approximately 3.5 eV and that of a double bond is 6.4 eV. Therefore, the breakdown of two single bonds releases more energy than one double bond (7eV versus 6.4 eV) This confirms that a saturated fat has more energy than unsaturated fats (Zumdahl et al.1995 and Corinna *et al.* 1998).

Instability increases by a factor of one for every C=C bond on the fatty acid chain (Tyson 2001). Because oleic acid has only one double bond, it doesn't react with oxygen as readily as polyunsaturated oils. High levels of saturates (C14:0, C16:0, C17:0, C18:0, C20:0) in jatropha oil tend to improve stability and raise Cetane number (the higher Cetane number the hiegher quality of fuel). (Reid et al., 1989) found that some vegetable oil fuels produce injector nozzle cooking when burned in Diesel engines with a corresponding 14% reduction in power output.

Manufacturer warranties cover engine problems related to any type of fuel including traditional petroleum Diesel. Manufacturers state that fuel must meet certain criteria, which may differ slightly by manufacturer, but basically follow the standards set forth by the American Society for Testing and Materials (ASTM). The standard for Diesel fuels is covered under ASTM D975, and for Biodiesel under ASTM PS 121. ASTM, 1997.

Methodology Adopted for Engine Testing

A two cylinder direct injection air cooled tractor engine was tested in the laboratory conditions at Tractor Test Station in Sabahia Alexandria during 2013. Biodiesel was mixed with additives such as Kerosene (K), Turpentine (T), Diesel (D) and gasoline (G) at different percentages to improve the properties of Biodiesel. Before the tests the stability of the different additives with Biodiesel blend was examined. Different proportions of the 24 blends were observed for 14 days and neither sediment nor formations of any layers were found.

Engine and Equipment Details

Bio-Diesel derived from waste vegetable oil (WVO) with different additives were used to operate an agriculture tractor. The tractor is coupled with hydraulic dynamometer to apply varying loads to engine at PTO speed 540 rpm. The dynamometer is equipped with measurement facility of engine speed and brake torque. The twenty four levels of additives to Biodiesel (B80KG, B80KT, B80K, B70KG, B70KT, B70K, B60KG, B60KT, B60K, B50KG, B50KT, B50K, B80SG, B80ST, B80S, B70SG, B70ST, B70S, B60SG, B60ST, B60S, B50SG, B50ST, and B50S) were compared with Diesel fuel. Where:-

B = Biodiesel K = Kerosene
G = Gasoline T = Turpentine
S = Solar
N = Biodiesel percentage in the treatment (50, 60, 70, 80 %)
The general form BN (additives of K, G,T and S)

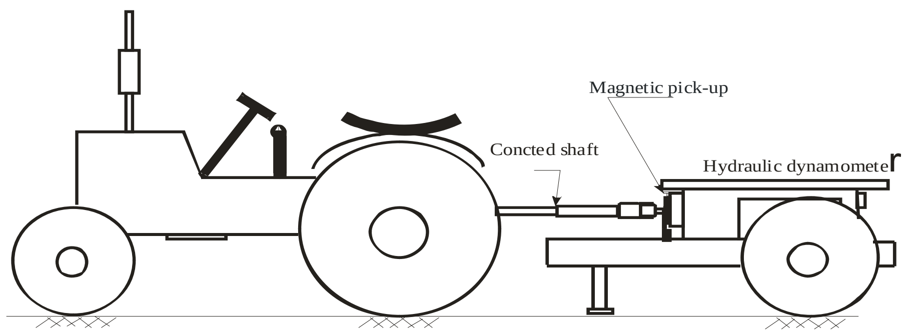

Fig. 4:The tractor P.T.O was coupled to the dynamometer for applying loads

The engine speed was measured by a magnetic pick-up mounted to the vertical bar senses the rotation of toothed gear with 120-tooth gear which was attached to the dynamometer. The output signal from magnetic pickup converted to rpm through the daytronic data PAC model 10k4.

Fuel meter installed and connected to the tractor fuel tank through hoses and two valves. The secondary tank was first filled with fuel to the mark on the top of the tape during the actual run. The tractor was first let go on its fuel from the main tank to measure the fuel consumption, the secondary tank was utilized through the valves. At the end of run, the valves were refilled off the secondary tank was refilled to the mark on the tube and amount of refuel was taken as the fuel consumption during the specific operation duration. The elapsed time to consume this amount of fuel was recorded.

Each blend was prepared by using a graduated cylinder 1 liter. After data for a given fuel had been obtained the engine was shut off and the fuel was bled from the fuel system. The engine was run for a long time to remove all residual of the previous fuel.

Data was recorded at 30 seconds intervals during the last two minutes of each test. Baseline data was taken on Diesel fuel at 100 percent before fueling with the Biodiesel/Diesel fuel blends. Each blend was tested three times. One way analysis using Minitab program to determine which of the 24 samples of additives blended with Biodiesel have significant effect on engine performance. The decision-making process for a hypothesis test can be based on the probability value (p-value) for the given test.

- If the p-value is less than or equal to a predetermined level of significance (α-level of 5%), then you reject the null hypothesis and claim support for the alternative hypothesis.
- the p-value is greater than the α-level, you fail to reject the null hypothesis and cannot claim support for the alternative hypothesis.

Fisher's test provides grouping information and two sets of multiple comparison intervals. Factor levels within the same group are not significantly different from each other. Each shipping center is in a different group . Therefore, all levels means have significantly different average delivery times.

RESULTS AND DISCUSIONS

The statistical analysis of the obtained results showed that there is no significant difference between the BKG, BSG and BST. Whereas, there is significant deference among these previous blends and the rest of treatments.

Effect of different additives on engine power

The engine was tested at standard PTO of 540 rpm for 24 samples, Table (4) shown that the effect of additives on tractor engine performance. Four samples of these are chosen according to the statistical analysis which have the higher power values among the other additives. Also from Table (4) the additives contain Biodiesel of B50, the power which generated from them are higher than those that contains Biodiesel of B60, B70 and B80.

Table 4: Effect of additives on engine power, kW.

	KG	KT	k	SG	ST	S
B50	17.7	17.4	17.2	18.4	18.1	17.2
B60	17.4	17.1	17	18.1	17.6	17
B70	17.3	17.1	17	17.6	17.4	16.9
B80	17.3	17.2	16.8	17.5	17.2	16.8

The best additives of the 24 treatments gave the highest engine power compared with Diesel fuel are B50KG, B50ST and B50SG.

Effect of additives on fuel consumption

Table (5) showed the effect of additives blended with Biodiesel for the four treatments which gives the best engine performance according to statistical analysis among 24 treatments. It is obvious that engine fuel consumption is decreased with additives/Biodiesel for all treatments compared to Diesel fuel. The decreasing percentages of fuel consumption are 6, 4.7 and 5.58 for treatments B50KG, B50ST and B50SG respectively.

Table 5: Effect of additives / Biodiesel on fuel consumption

Biodiesel	additives	Fuel consumption, l/h
B0	Diesel	8.41
B50	KG	7.85
B50	ST	8.01
B50	SG	7.94

Effect of additives on emissions.

The emissions due to burning of twenty four levels of additives to Biodiesel in comparison to Diesel, there was statistically significance difference between all levels of additives and the Diesel considering the concentration of evolved carbon monoxide (CO), $p < 0.01$, indicating the dramatic decrease in the concentration of CO due to additives. CO gained due to Diesel fuel was the highest value than the other which contains Biodiesel with additives fig. 5.

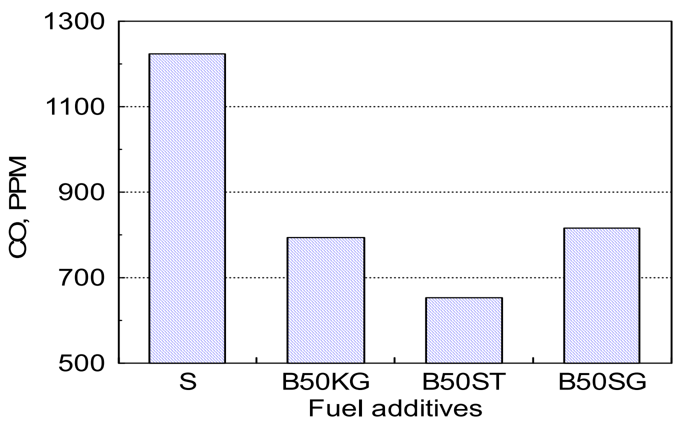

Fig. 5: The effect of different additives on CO

On the other hand, there is no statistically significance difference between all levels of additives and the Diesel fuel on the combustion efficiency. According to the obtained data, the availability of oxygen in the Biodiesel blends leads to better combustion and reduced the smoke emission. That is why Biodiesel is considered a renewable and eco- friendly alternative Diesel fuel for Diesel engine. Using fuel additives to the Biodiesel in CI Engine improve performance, combustion efficiency, and diminish emission characteristics and also improved fuel properties which enhance the combustion characteristics. This agreed with what Suthar et al 2012 mentioned in his review study.

The temperature of ignition, Tg (°C), was decreased by additives as there was statistically significance difference between 24 of the additives and the Diesel (94%. n=24), $p< 0.05$.

Temperature of ignition gained due to Diesel fuel was the highest value than the other which contains Biodiesel with additives as shown in fig. 6.

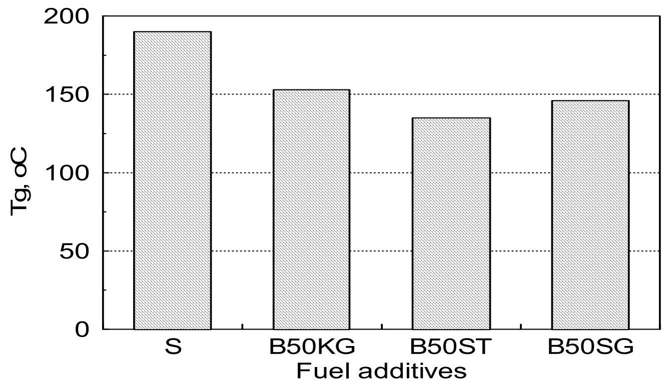

Fig. 6: The effect of different additives on the temperature of ignition

Considering the nitrogen oxides (NO_x), there was a decrease in NO_x emissions of relatively all the additives. There was a statistically significance difference between 24 additives and the Diesel (67%, n=24), $p<0.01$. This phenomenon shows that fuel is the optimum composition in order to achieve better fuel quality with less NOx formation. In addition, with the presence of additive, the combustion temperature could be reduced which cause to control the NOx . This is also mentioned by Pugazhvadivu 2009.

The NOx gained due to Diesel fuel was the lowest value than the other which contains Biodiesel with additives as shown in fig. 7.

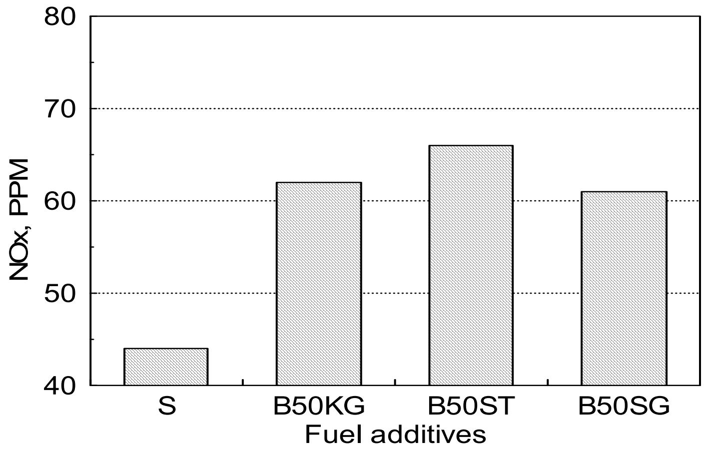

Fig. 7: The effect of different additives on the NOx

CONCLUSION

The additives improved both engine power and fuel consumption. The treatments which contained 50% Biodiesel (B50) mixed with the additives generate extra power than the others for all treatments under study. Besides; using additives affect positively on the ecological parameters. Additives decrease the concentration of CO and availability of oxygen in Biodiesel blends cause better combustion and reduced the smoke emission. The additives combustion temperature could be reduced which cause control the NOx. The nitrogen oxides (NOx), are decreased in emissions of relatively all the additives.

REFERENCES

ASTM, American Society for Testing Materials. Standard specification for fuel oils. Annual Book of ASTM Standards, ASTM, Philadelphia, Part 05.01, ASTM D396-96, 1997, pp. 165-168.

Butkus 1, Saugirdas Pukalskas 2, Zenonas Bogdanovičius 3. The influence of additives on Diesel engine performance and the ecological parameters . accepted 1 February 2007 Dept of Automobile Transport, Vilnius Gediminas Technical University, J. Basanavičiaus g. 28, LT-03224 Vilnius, Lithuania

Corinna WU. Vegetable oils are moving from the kitchen table to the car engine. Science News, Vol. 154, No. 23, December 5, 1998, p. 364.

Encyclopedia of Chemical Technology; Third Ed., John-Wiley & Sons, New York, NY, 1980, Vol. 9; pp. 795-811.

George W. Mushrush, Erna JB, Janet MH, James HW, Joseph VS, Dennis RH.1997. Biodiesel fuels: The use of soy oil as a blending stock for middle distillate petroleum fuels. Naval Research Laboratory, Materials Chemistry, Code 6121, Washington, DC 20375. Chemistry Department, George Mason University, Fairfax, VA 22030, and Geo-Centers Inc. Fort Washington, MD 20749.

Goering CE, Schwab AW, Daugherty MJ, Pryde EH, Heakin AJ. 1982Fuel properties. Trans. ASAE, 25, 1472-1477 & 1483.

Gretchen R. 2000Biodiesel fuel meets clean air requirements. Environment & Climate News, September.

Harrington, KJ. 1986 Chemical and physical properties of vegetable oil esters and their effect on Diesel fuel performance. Biomass, 9 (1):1–17.

Knothe G, Dunn RO, Bagby MO. 1997. Biodiesel: The use of vegetable oils and their derivatives as alternative Diesel fuels. Fuels and Chemicals from Biomass. Washington, D.C.: American Chemical Society.

Moussa A.I. 2003. Transestrification Process to Manufacture Methyl Ester of Waste Vegetable Oils ", The 11th Annual Conference of Misr Society of Agricultural Engineering, 851-866,October.

Pugazhvadivu, M. 2009. Studies on the effect of ethanol addition to Biodiesel: performance and emissions of a Diesel engine. Indian J of Science and Technology. 2(11): 23-26

Shahabuddin, M., H.H.Masjuki, M.A. Kalam, M. Mofijur, M.A.Hazrat, A.M.Liaquat. 2012. Effect of Additive on Performance of C.I. Engine Fuelled with Bio Diesel. 2011 2nd International Conference on Advances in Energy Engineering (ICAEE 2011). Energy Procedia 14: 1624-29. Available online at www.sciencedirect.com

Peterson CL, Wagner GL, Auld DL. 1983. Vegetable oil substitutes for Diesel fuel. Transactions of the ASAE, 26(2): 322-327.

Peterson, CL. and T. Hustrulid. 1998. Carbon cycle for rapeseed oil Biodiesel fuels. Biomass and Bioenergy, 14 (2):91–101.

Peterson C., Cook J. and Thomson J. 1999. Continuous Flow Bio-Diesel Production ", ASAE Paper No.996110, ASAE St.Josoph, MT, 4908-9659.

Reid JF, Hansen AC, Goering CE. 1989. Quantifying Diesel injector coking with computer vision. Transactions of the ASAE, 32(5): 1503-1506.

Suthar Dinesh Kumar L, Rathod Pravin P, Patel Nikul K. 2012. erformance and Emission by Efffect of Fuel Additives for CI Engine Fuelled with Blend of Biodiesel and Diesel – A Review Study. Journal of Engineering Research and Studies (JERS)Vol.III, Issue IV.Oct.-Dec.: 01- 04

Tyson KS. 2001. Biodiesel handling and use guidelines. National Renewable Energy Laboratory Prepared under Task No. BFP18101 September.

US Environmental Protection Agency (EPA). 1998. Environmental effects testing for Biodiesel under the requirements for USEPA registration of fuels and fuel additives. 40 CFR Part 79, Sec 21 1 (b) (2) and 21 1 (e) final repot, March.

Yuan, Y., A. Hansen and Q. Zhang. 2004. The Specific Gravity of Biodiesel Fuels and Their Blends With Diesel Fuel. Agricultural Engineering International: the CIGR Journal of Scientific Research and Development, Manuscript EE 04 004. Vol. VI. September.
Zumdahl S. Chemical Principles. D.C. Heath and Co.: Lexington, 1995.http://youtu.be/2TyTtfRfPV4

تأثير الاضافات علي اداء محرك الديزل والبيئة

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أدى التزايد الشديد على الطاقة التقليدية الى ارتفاع اسعار المنتجات البترولية عالميا وبالتالى التفكير فى استحداث طاقات جديدة ومتجددة. وشجع تقارب اسعار المنتجات البترولية من اسعار الوقود الحيوى على البحث عن طرق تزيد من كفاءة الوقود الحيوى. لذلك فى هذا البحث تم استخدام بعض الأضافات (الجازولين ، الكيروسين ، السولار ، التربنتين) إلى الوقود الحيوى الناتج من زيوت الطعام المستعملة لتحسين خواصه .
تم تحضير ٢٤ معاملة من الوقود الحيوى والأضافات ومقارنتها بالوقود التقليدى (السولار) على أداء محرك ديزل قدرة ٢٦,١٢ كيلوات وذلك بمحطة أختبار الجرارات والآلات الزراعية بالأسكندرية. تم قياس قدرة المحرك ومعدل استهلاك الوقود والأنبعاثات الناتجة من عملية الأحتراق لكل من الوقود التقليدى (السولار) ومعاملات الوقود الحيوى مع الأضافات وذلك مع تثبيت عدد لفات المحرك عند ٥٤٠ لفة فى الدقيقة أثناء التشغيل. ويمكن تلخيص النتائج المتحصل عليها فيما يلى

أولاً تأثير الأضافات للوقود الحيوى على قدرة المحرك

- أعطت المعاملات التى تحتوى على وقود حيوى بنسبة ٥٠% مع الأضافات (B50kG k , B50SG B50ST) أعلى قدرة للمحرك ، حيث توجد فروق معنوية بين هذه المعاملات الثلاثة وبين باقى المعاملات تحت الدراسة بالأضافة الى السولار.
- القدرة الناتجة عن استخدام الوقود الحيوى مع الأضافات كانت أكبر من القدرة الناتجة عن استخدام الوقود الاحفوري.

ثانياً تأثير الأضافات للوقود الحيوى على معدل استهلاك الوقود

- استخدام الوقود الحيوى مع الأضافات أدى إلى أنخفاض معدل أستهلاك الوقود مقارنة بالسولار.
- أعطت المعاملات التى تحتوى على وقود حيوى بنسبة ٥٠ % مع الأضافات (B50kG , B50SG B50ST) أقل معدل لأستهلاك الوقود ، حيث أنخفض المعدل مقارنة بالسولار بنسبة ٦ ، ٤,٧ ، ٥,٨ على التوالى

ثالثاً تأثير الأضافات للوقود الحيوى على الأنبعاثات الناتجة عن عملية الأحتراق

- أظهرت نتائج التحليل الأحصائى أن هناك فروق معنوية فى الأنبعاثات الناتجة عن عملية الأحتراق بين معاملات الوقود الحيوى مع الأضافات وبين السولار ، حيث قلت نسبة تركيز أول أكسيد الكربون معنوياً مقارنة بالسولار وذلك لوجود مكون الأكسجين فى الوقود الحيوى مما أدى إلى أحتراق كامل للوقود.
- قلت نسبة أكاسيد النتروجين معنويا فى حالة معاملات الوقود الحيوى مقارنة بالسولار.
- المعاملات التى تحتوى على ٥٠% وقود حيوى مع الأضافات أعطت أفضل النتائج لقدرة المحرك واستهلاك الوقود بالأضافة إلى ناتج عملية الأحتراق.