[21] Lunder. O, Walmsley. J. C, Mack. P, Nisancioglu. K, 2005, Formation and characterisation of a chromate conversion coating on AA6060 aluminium, Corrosion Science, Vol. 47, pp.1604–1624

[22] Mansfeld. F, Wang. Y, 1994, Corrosion protection of high copper aluminium alloys by surface modification, British Corrosion Journal, Vol. 29, pp.194-200

[23] Mansfeld. F, Wang. Y, Shih. H, 1991, Development of stainless aluminium, Journal of Electrochemical Society. Vol. 138, pp.L74-L75

[24] Mazurkiewicz B, Piotrowski A, 1983, The electrochemical behaviour of the Al_2Cu intermetallic compound, Corrosion Science, Vol. 23, pp. 697-707

[25] Mishra AK, Blasubramanian R, 2007, Corrosion inhibition of aluminum alloy AA 2014 by rare earth chlorides, Corrosion Science, Vol. 49, pp.1027–1044

[26] Muster. T. H, Lau. D, Wrubel. H, Sherman . N, Hughes. A. E, Harvey. T. G, Markley . T, Alexander. D. L. J, Corrigan. P. A, White.P.A, Hardin. S. G., Glenn. M. A, Mardel. J, Garcia.S. J, Mol. J. M. C, 2010, An investigation of rare earth chloride mixtures: combinatorial optimisation for AA2024-T3 corrosion inhibition, Surface and Interface Analysis, Vol. 42(4), pp.170–174

[27] Pourbaix M, 1966, Atlas of electrochemical equilibria in aqueous solutions, Pergamon Press, London, p183

[28] Rosero-Navarro. N. C, Curioni. M, Bingham. R, Durán. A, Aparicio. M, Cottis. R. A, and Thom. G. E, 2010, Electrochemical techniques for practical evaluation of corrosion inhibitor effectiveness: Performance of cerium nitrate as corrosion inhibitor for AA2024-T3 alloy, Corrosion Science, Vol. 52, pp.3356-3366

[29] Schumacher. M, 1979, Seawater corrosion handbook, William Andrew Publishing/Noyes

[30] Speidel. M. O. and Hyatt. M. V, 1976, Advances in Corrosion Science and Technology, Vol. 2 (eds M. G. Fontana and R. W. Staehle), Chapter 3, Plenum Press, New York

[31] Venkatasubramanian. G, Sheik Mideen. A, Abhay Jha. K, 2012, Corrosion behaviour of aluminium alloy AA219-T87 welded plates in seawater, Indian Journal of Science and Technology, Vol. 5(11), pp. 3578-3583

[32] Venugopal. A, Sreekumar. K, and Raja V.S, March 2012, Stress corrosion cracking behaviour of multipass TIG-welded AA2219 aluminium alloy in 3.5 wt pct NaCl solution, Metallurgical and Materials Transactions A, DOI: 10.1007/s11661-012-1117-5

[33] Wang.B.B, WangY.Z, Han.W, Ke.W, 2012, Atmospheric corrosion of aluminium alloy 2024-T3 exposed to salt lake environment in Western China, Corros.ion Science, Vol. 59, pp.63-70

[34] Zhao. J, Xia. L, Sehgal. I. A, Lu. D, McCreery. R. L, G.S. Frankel. G. S, 2001, Effects of chromate and chromate conversion coatings on corrosion of aluminium alloy 2024-T3, Surface Coatings and Technology, Vol. 140, pp.51–57

Mr. G. Venkatasubramanian is a research scholar of Sathyabama University in the department of chemistry. He has more than 15 years of academic and 9 years of industrial experience. He is currently doing research in the corrosion behaviour of aluminium alloys used for space applications. He has seven publications both in reputed journals and conferences to his credit.

THE EFFECT OF INJECTION TIMING ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF A DI CONSTANT SPEED DIESEL ENGINE FUELLED WITH DUAL-FUEL BIODIESEL

Mahalingam S.[1] **and Ramesh Bapu B.R.**[2]

[1]Research Scholar, Sathyabama University, Chennai, India.
[2]Chennai Institute of Technology, Chennai, India.
Email: [1]mahathermal@gmail.com

Abstract

The fast depletion of Petroleum fuels and increasing costs concerns have led to an intensive search for alternative fuels such as biodiesel. In this experimental study a dual fuel includes rubber seed oil and jatropha oil blended with the pure diesel fuel was used. The dual fuel was estrified to reduce the viscosity and it was blended with the diesel fuel for the different proportions like 20%, 40%, 60% of biodiesel blended with diesel namely B20, B40, and B60. The performance and emission test was carried out in a single cylinder constant speed (1500 rpm) direct injection (DI) diesel engine. In this engine the injection timing was varied to study the performance and emissions from biodiesel fuelled diesel engine. The experiment was performed at the injection timing of 27^{o} BTDC and 220 bar of injection pressure with reference to the standard injection timing of 24^{o} BTDC and the normal injection pressure. The performance test resulted with the increased Brake thermal efficiency (BTE) and reduction in the specific fuel energy consumption (SFEC) for B20 blend as compared to the other proportions. From the emission characteristics results the carbon monoxide (CO), unburned hydrocarbon (UHC), oxides of nitrogen (NOx) and carbon dioxide (CO_2) were decreased for B20 when compared with the other proportions.

Keywords: Jatropha oil, rubber seed oil, performance, emission

I. INTRODUCTION

An experimental study was conducted using the rapeseed oil blended with the diesel with increase in the injection pressure and injection timing of modified engine with the ECR system. The significant reduction of NOx emissions at the expense of CO, THC, SN, BSFC compared to diesel [1]. In a performance study, the ethanol was blended diesel fuel from 0% to 15% and with an every increment of 5%, the injection timings variation increases the NOx and CO_2 emissions and decreases the CO and UHC emissions considerably. For the retarded injection timings, the NOx and CO2 emissions were increased, and UHC and CO emissions were decreased for all no load to full load conditions [2]. A test was analyzed with the waste plastic oil blended with diesel fuel. Four injection timings were used such as 23^{o}, 20^{o}, $17^{o}$and 14^{o} BTDC while the designed injection timing is 23^{o} BTDC. At the injection timing of 14^{o} BTDC shows a decrease in the oxides of nitrogen, carbon monoxide and unburned hydrocarbon. And the brake thermal efficiency, carbon dioxide and exhaust temperatures were increased under all the load conditions [3]. In a study, the change of position of pistons in hemispherical and Toroidal Reentrant Combustion Chamber (TRCC) geometries the test results showed an improved BTE up to 5.64%. The SFC decreased up to 4.6 and oxides of nitrogen increased up to 11% as compared to that of the normal design diesel engine [4]. From an analysis using water and hydrogen as an alternative fuel for diesel engines with the different crank angle, the water injection timing of 20^{o} ATDC and 20^{o} CA shows an increased indicated thermal efficiency, reduced the NOx concentrations and exhaust gas temperatures when the engine runs at 2500 rpm [5]. A Dimethyl Ether (DME) engine was used to reduce the total unburned hydrocarbons, NOx and CO at low speed to middle engine speed conditions. The engine injection timing retarded the further NOx was reduced but other emissions like CO, THC, DME and CH_2O were increased [6]. Both of the injection pressure and injection timing were changed in the compression ignition engine decreases the smoke opacity, CO, THC emissions while NOx emissions were increased [7]. When dimethoxymethane (DMM) was blended with diesel fuel at different load conditions, the BTE and other emissions are CO_2, CO UHC were decreased but NOx slightly increased [8]. The effect of compression ratio and injection timing was studied to analyze the BTE, SFC and the exhaust emissions [9].

Table 1. Properties of Fuels

Property	Diesel	Rubber seed oil	Jatropha oil	Biodiesel (Rubber seed and Jatropha)
Sp. Gravity	0.74	0.82	0.96	0.90
Viscosity at 40^0C(mm^2/s)	4.15	70.2	4.4	4.2
Calorific Value (KJ/kg)	42000	37000	38500	39500
Carbon residues%	0.12	0.19	0.61	0.26
Iodine value	0.067	133.46	120.5	133.32

The proportion of biodiesel increased BSFC and exhaust temperature increased while brake thermal efficiency (BTE) decreased in the blends at all compression ratios (18:1 to 20:1) and injection timings 35^o to 45^o BTDC [10]. In this experimental study, a modified diesel engine was tested for the variations in the rated power to measure the performance and emissions characteristics. Table 1 shows the properties of fuels used in the tested engine.

II. EXPERIMENTAL SETUP AND TEST PROCEDURE

A single cylinder constant speed Kirloskar DI engine was used to evaluate the engine performance and emission characteristics biodiesel. The diesel runs under different load condition at a constant speed of 1500 rpm with the different biodiesel proportions. The diesel engine was directly attached with an eddy current dynamometer for changing the loads. A measuring device was attached in the test engine such as orifice meter with U tube manometer for measuring air consumption, a one liter burette for fuel consumption and the Separate bio fuel tank. An AVL415 smoke meter was provided for measuring the smoke opacity and exhaust temperatures. The test rig was installed with AVL software to obtain various curves and results during operation. A five gas analyzer was used measured the emission characteristics such as CO2, CO, HC, NOx, and O2 values from the exhaust gas. The performance and emission tests were conducted at the compression ratio of 17.5 for different injection pressures of 200, 220, and 240 bar with rated power of 4.4 kW. The test was carried out for different proportions of biodiesel blended with the diesel fuel. The performance analysis of the engine at different rated power was evaluated in terms of brake specific fuel consumption (BSFEC), brake thermal efficiency (BTHE) and emissions characteristics of CO, CO_2, UHC and NOx. The engine specifications are given below.

Bore	:	87.5 mm
Stroke	:	110.0 mm
Speed	:	1500 (constant speed)
Compression ratio	:	17.5:1
Rated power	:	4.4 kW
Number of cylinders	:	One
Type of cooling	:	Air cooled - eddy current dynamometer
Injector opening	:	240 BTDC
Pressure	:	220 bar
No. of stroke	:	4 stroke

III. RESULTS AND DISCUSSIONS

A. Carbon monoxide (CO)

Fig. 1 shows the carbon monoxide (CO) emissions of the tested constant speed diesel cengine. From the graph, when compared to the pure diesel fuel, the CO emissions of blended fuels decreased at low engine loads and the same was increased from 75% to full load engine condition. For B20, from zero loads to 50% load there is a slight change and from 75% to full load conditions, the CO was increased from 0.07% to 0.09%. For the B40 to B100 proportion, the CO emission is increased from 0.35% to 0.43%. From the graph, B20 have better result compared to the other bio blends.

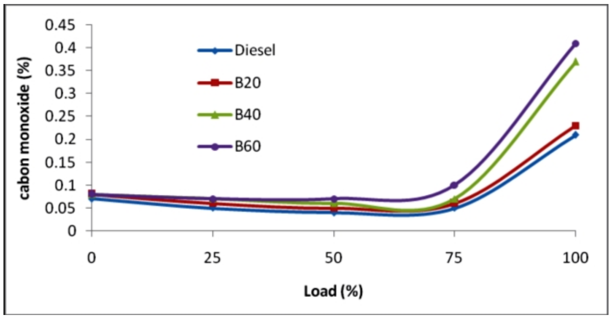

Fig. 1. Variation of carbon monoxide with respect to load

B. Oxides of nitrogen (NOx)

Fig. 2 shows the oxides of nitrogen (NOx) emissions for different load conditions for the engine with different blended fuels. When the engine ignition timing was advanced from 24^{O} to 27^{O}, the oxides of nitrogen increased for all proportions. The NOx emissions increases with increase in engine loads and exhaust temperature for all bio diesel blends. From the study for the blend B20,the NOx was slightly increased when compared to the diesel fuel. For the B100 blend used in the test engine the NOx emission gradually increases due to it's less HC than the diesel fuel from 220 ppm to 1400 ppm.

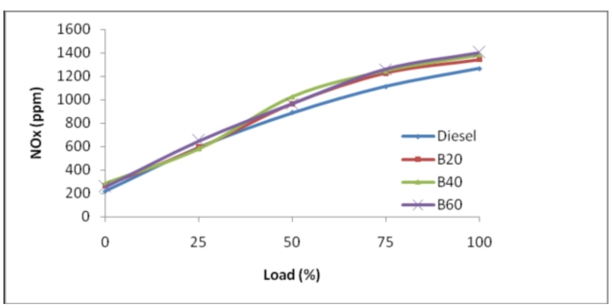

Fig. 2. Variation of NOx with respect to Load

C. Unburned hydro Carbon (UHC)

The Unburned hydrocarbon proportions were varied from 7 ppm to 29 ppm released in the exhaust at the ignition timing of 27^{O} and 220 bar at various load conditions and shown in the figure. It was observed for B20, at zero load conditions, the amount of UHC release is lower than that of the diesel fuel. At 25% to 50% of load condition, the UHC increases gradually. For the bio-fuel of B40 and B60, the UHC increased from 14 ppm at zero load condition to 30 ppm at full load conditions.

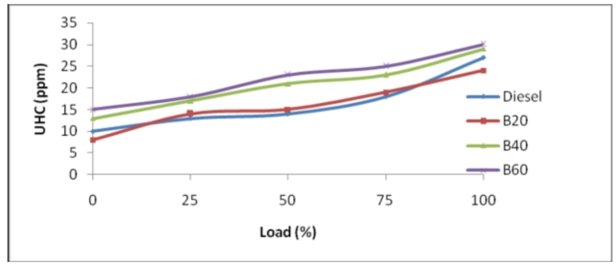

Fig. 3 Variation of Unburned Hydro Carbon with respect to load

D. Brake thermal efficiency (BTE)

Fig. 4 shows the thermal efficiency based on the different injection timings at various load conditions. From the graph for the diesel fuel which has higher calorific value, the brake thermal efficiency was increased up to 32%. For the blend of B20, the BTE was increased to 30% when compared to the other biodiesel proportions. In case of B40 and B60 the efficiency was lower when compared to that of the B20.

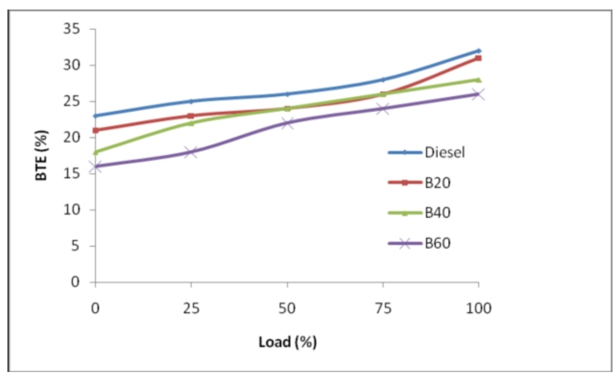

Fig. 4. Variation of Thermal efficiency with respect to load

IV. CONCLUSIONS

From the experimental study and emission analysis of a dual fuel diesel engine for the variation of injection timing the following results were obtained. For the B20 blend with diesel, the CO emission was lower when compared to the other biodiesel blends. For the variations of different loads from no load (zero loads) to 75% of load, the CO emissions were from 0.07 %to 0.22%. In unburned hydrocarbon emission for the biodiesel B20 was less compared to that of the other bio fuel blends. The NOx emission was increased for all proportions from no load condition to full engine load conditions. The brake thermal efficiency was also increased to 30% when using B20 blended with the diesel 30%. It was concluded that when the injection timing was varied from 24^{o} to 27^{o}, the blend B20 gave the appreciable performance when compared to the other blends.

REFERENCES

[1] Labecki L., Ganippa L.C., 2012 "Effects of Injection Parameters and EGR on Combustion and Emission Characteristics" of Rapeseed Oil and its Blends in Diesel Engines, Fuel 98, PP. 15-28.

[2] Cenk Sayina, Kadir Uslub, Mustafa Canakcic. D, 2008, "Influence of Injection Timing on the Exhaust Emissions of a Dual-Fuel CI Engine", Renewable Energy 33 PP. 1314–1323.

[3] Mani M., Nagarajan G., 2009 "Influence of Injection Timing on Performance, Emission and Combustion Characteristics of a DI Diesel Engine Running on Waste Plastic Oil". Energy 34 PP. 1617–1623.

[4] Jaichandar S., Senthil Kumar P., Annamalai K. "Combined Effect of Injection Timing and Combustion Chamber Geometry on the Performance of a Biodiesel Fueled Diesel Engine", Energy 47 PP. 388-394.

[5] Adnan R., Masjuki H.H., Mahlia M.I., "rmance and Emission Analysis of Hydrogen Fueled Compression Ignition Engine with Variable Water Injection Timing" Energy 43 PP. 416-426.

[6] Zhu Z., Liu D.K. Li, J., Wei Y.J., Liu S.H., 2012 "Investigation on the Regulated and Unregulated Emissions of a DME Engine under different Injection Timing", Applied Thermal Engineering 35 PP. 9-14.

[7] Cenk Sayin, Ahmet Necati Ozsezen, Mustafa, 2010, "The Influence of Operating Parameters on the Performance and Emissions of a DI Diesel Engine using Methanol-Blended-Diesel Fuel". Fuel 89 PP. 1407–1414.

[8] Ruijun Zhu, Haiyan Miao, Xibin Wang, Zuohua Huang, 2012 "Effects of Fuel Constituents and Injection Timing on Combustion and Emission Characteristics of a Compression-Ignition Engine Fuelled with Diesel-DMM Blends", Proceedings of the Combustion Institute 34 PP. 3013–3020

[9] Biplab K. Debnath, Niranjan Sahoo, Ujjwal K. Saha, 2013, "Thermodynamic Analysis of a Variable Compression Ratio Diesel Engine Running with Palm Oil Methyl Ester" Energy Conversion and Management 65 PP. 147–154.

[10] Raheman H., Ghadge S.V., 2008 "Performance of Diesel Engine with Biodiesel at Varying Compression Ratio and Ignition Timing", Fuel 87 PP. 2659–2666.