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OPTIMIZATION OF PME BIODIESEL AND ETHANOL BLENDED FUEL TO REDUCE CO EMISSION IN DIESEL ENGINE

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ABSTRACT

In this thesis the main focus is given on the alternative source of fuel as Palm Oil Methyl Ester (PME) was integrated to ethanol-biodiesel fuel in order to reduce the emissions. The percentage of ethanol is up to 20% in volume. Thus, the effects of ethanol on particulate matter (PM) components, soluble organic fraction (SOF) and dry soot (DS) utilizing variant of fuel blends were investigated. Utilizing a composite filter, the ester-ethanol-diesel characteristic such as mass concentration in term PM, SOF and DS were analyzed under different engine operating conditions utilizing four cylinder engine. The results show that incrementing ethanol in coalesced fuel will decrement the PM, SOF and DS at low and middle load. In additament, as the load is incremented, the PM component such as SOF and DS additionally increase. Thus, ethanol-biodiesel fuel can reduce the emissions for low and middle load condition.

This research focuses withal on the utilization of biodiesel integration possibilities for engenderment of biodiesel and bioethanol utilizing a single source as a feedstock (oil palm) were explored through process simulation. The oil extracted from Fresh Fruit Bunches was considered as the feedstock for biodiesel engenderment. An extractive reaction process is proposed for transesterification reaction utilizing in situ engendered ethanol, which is obtained from two types of lignocelluloses residues of palm industry (Empty Fruit Bunches and Palm Press Fiber). Several ways of integration were analyzed. The integration of material flows between ethanol and biodiesel engenderment lines sanctioned a reduction in unit energy costs down to 3.4%, whereas the material and energy integration leaded to 39.8% decrease of those costs. The proposed integrated configuration is a paramount option when the technology for ethanol engenderment from biomass reaches such a degree of maturity that its engenderment costs be commensurable with those of grain or cane ethanol.

Recently, second-generation bio-ethanol (SGB), which utilizes yarely available lignocelluloses biomass has received much interest as another potential source of liquid biofuel commensurable to biodiesel. Thus the aim of this paper is to determine the energy efficiency and to compare the efficacy of SGB and palm methyl ester (PME) processes. It was found that the engenderment of bio-ethanol is more thermodynamically sustainable than that of biodiesel as the net exergy value (NExV) of SGB is 10% higher than that of PME. Contrarily, the former has a net energy value (NEV) which is 9% lower than the latter.

Keywords: CI Engine, Ethanol, Bio-diesel, alternate fuels, CFD, Experimental Analysis, Fuel Blending etc.

I. INTRODUCTION

The development of alternative fuel were being focused since the shortage of petroleum resources in the 1970s due to ecumenical energy crisis[1]. In the past two decades, ethanol has been studied for engine testing application due to emaculate alternative fuel. Besides, ethanol can be engendered from sugarcane, sorghum, corn, barley, cassava and beets [1]. There are several feedstock of ethanol that highly efficient and low cost processes such as agricultural crops, aliment and wood [2]. The emission of engines is affected by variant of fuel. For instance, ethanol fuels contain an oxygen component which is in the past research showed that it could significantly reduce the smoke and PM emission exhausted from diesel engine. The result from Spreen [3] showed the reduction in PM of 20-27% for 10% ethanol blends. Donahue and Foster [4] reported that local oxygen concentration in the fuel plume effect the amelioration in emissions. Many researchers concluded that the main factor affecting PM emission is the fuel oxygen content. For instance, the results obtain from Miyamoto et al. [5] show that when oxygen content is approximately 30% mass in diesel fuel, the smoke levels approaching to zero. However, in some cases, some of them concluded that the differences depending on the chemical structure or volatility of a given oxygenate [6]. The numerical modeling of the chemical kinetics has been investigate in the primary soot formation region [7]. Ergo, these study provide an information of the deportment of PM reduction usig oxygenated diesel blends.

In this study, in order to avert disseverment of ethanol from diesel, the ester was integrated to the ethanol-diesel blends fuel which is act as a co-solvent. The ethanol percentage in coalesced fuel was up to 20% by volume were utilized in this experiment. Furthermore, the cetane number and viscosity for ester is higher than diesel and ethanol, thus it could balance the the esterdiesel- ethanol coalesced fuel in order to meet the requisite of diesel engine. In order to understand the effects of ethanol in diesel engine, more attention was paid on PM component, SOF and DS.The performance and emission characteristic of diesel engines have intensively investigated from the different feedstocks in the last three decades. From the studies, biodiesel from different feedstock engender kindred results [8-9] and quite minute in term of performance differences [10-12]. In term of fuel lubricity [13-14], it enhances and caused reduction on emission. Thus, all the testing must meet American Society of Testing and Material (ASTM) designation designated in ASTM D- 6751 and in Europe EN 14214. For some reasons, biodiesel will be a consequential alternative energy sources due to environmental amicable compared to mineral diesel.

Diesel fuels have been widely utilized for engineering machinery, automobiles, and shipping equipment because of its excellent drivability and thermal efficiency [1]. The development of bioenergy,especially biofuels such as ethanol and biodiesel for use in the conveyance sector, is one of the top agenda items in Thailand. A national ethanol program to promote the coalescing of 10% ethanol, engendered from sugarcane and cassava, in gasoline without paramount modification to engines has shown emboldening results. The utilization of ethanol in diesel fuel can yield a consequential reduction of exhaust emissions in terms of CO and NOx [2] and particulate matter (PM) emissions for motor conveyances [3,4]. However, there are many obstacles in utilizing ethanol in diesel engines [1].

Ethanol has constrained solubility in diesel fuel; ergo, phase disunion and dihydrogen monoxide tolerance in ethanol–diesel blend fuel are crucial quandaries. Ethanol fuel has an astronomically low cetane number, whereas diesel engines prefer high cetane number fuels, which makes autoignition facile and gives a short ignition delay. The dynamic viscosity of ethanol is much lower than that of diesel fuel, so that the lubricity is a potential concern of ethanol– diesel blend fuel. Because of these circumscriptions, ethanol–diesel blends need additives. Biodiesel is kenned to act as an additive or emulsifier due to its potential to amend the solubility of ethanol in diesel fuel over a wide range of temperatures and coalesce properties [5–7]. Adscititiously, the utilization of a higher alcohol, propanol and butanol, could solve the quandary of fuel instability at low temperature because of more solubility in the diesel. Butanol is as environmentally amicable as ethanol because it can be engendered from renewable resources via the fermentation of sugar and starch raw materials. Thus, this work is fixated on studying the utilization of biodiesel as an additive in stabilizing ethanol–diesel and butanol–diesel blends. The main objectives are to investigate the phase stability of diesel– biodiesel–ethanol and diesel–biodiesel–butanol three-component systems at different component concentrations, and the dependence of solubility upon temperature, and determinately to evaluate some fundamental fuel properties of the coalescences.

Biodiesel and bioethanol are the most paramount liquid biofuels employed in the conveyance sector. These biofuels can be utilized as a sole fuel in special motor engines or as additives in diesel and gasoline blends in order to enhance the oxygen content of such fuels. These oxygenated blends sanction the reduction of polluting gases mostly aromatic hydrocarbons and CO. The biodiesel is an amalgamation of methyl or ethyl esters of adipose acids. The ester group increases the oxygen content of diesel–biodiesel blends ameliorating the combustion efficiency of the conventional fossil diesel. For engendering biodiesel, the transesterification of vegetable oils with low molecular weight alcohols like methanol or ethanol is obligatory.

This reaction is accomplished with the avail of acid, rudimental or enzymatic catalysts. Conventionally, world biodiesel engenderment is carried out employing methanol and rudimental catalysts (mostly KOH). In such case, the biodiesel engendered is considered as partially renewable since methanol is mainly obtained from natural gas. The European countries are the bellwethers in the engenderment of biodiesel being Germany the first world engenderer. The most employed vegetable oils are rapeseed, soybean and sunflower oils. On the other hand, the oil from palm (Elaeis guineensis) is considered an excellent feedstock for biodiesel engenderment in tropical countries as Thailand, Malaysia and Colombia. Processing of palm for oil extraction leads to the formation of several by-products and residues that have an economical potential. These products, by-products and residues are illustrated in Fig. 1 along with their current and potential applications. The vacuous fruit bunches (EFB) are the solid residue that is engendered in the highest amount. Their composition is shown in Table 1 according to the data of Abdul Aziz et al. (2002a,b) and Wan Zahari and Alimon (2004). Due to its high moisture content, this material is not felicitous as a fuel. For this reason, it is mostly utilized as a manure [10]. Composting has been suggested as an option for engendering high quality manure from EFB. This microbial process sanctions the reduction of the volume of the obtained manure in 50% as well as its convey costs [2]. The utilization of EFB as a substrate for cultivation of mushrooms by solid-state fermentation has been proposed. In this case, anterior treatment of this material is not required [3]. In additament, the remaining material after mushroom harvest presents better fertilizing properties. On the other hand, the fiber resulting from disunion of press cake (palm press fiber, PPF) has a paramount content of the lignocellulosic intricate and a lower content of moisture (optically discern Table 1.1). The oil retained in the fiber makes this material to be a good solid fuel. When palm processing facilities engender both process steam and electricity, the total amount of PPF undergoes combustion. However, if only steam is to be engendered, 70% of PPF remains without utilization and becomes a waste (Prasertsan and Prasertsan, 1996). The lignocellulosic Forms with dashed edges correspond to potential applications. Gasf: gasification, Pyr: pyrolysis, FPyr: expeditious pyrolysis, Comp: composting, SSF: solid-stage fermentation, SRf: steam reforming, WGS: dihydrogen monoxide-gas-shift reaction, FTS: Fischer-Tropsch synthesis, PT: pretreatment, CH: cellulose hydrolysis, Fm: fermentation, Trans: transesterification, CC: catalytic cracking, HAS: higher alcohol synthesis biomass contained in both EFB and PPF can be utilized for ethanol engenderment as described below. The palm kernel shell (PKS) is another residue engendered in lower amounts than EFB and PPF during palm oil extraction. This material is the most arduous residue to decompose. For this reason, it is conventionally disposed of by landfill method. PKS has a high energy value, but its use in burners or boilers designed for wood or fossil fuels implicatively insinuates a substantial modification of these equipments. This expounds why it is not widely utilized as a fuel. Its use has been proposed for engenderment of activated carbon [4]. The palm kernel cake (PKC) is a waste from palm processing obtained during the extraction of oil contained in the kernels engendered after nuts cracking. It withal contains

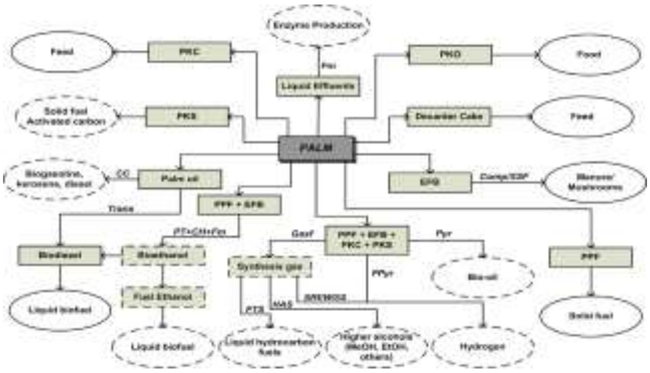

Fig.1.1 Products, by-products and residues obtained during the processing of oil palm. Forms with continuous edges correspond to current applications of products and byproducts

II. LITERATURE REVIEW

Conventional fossil fuels perpetuate as the major energy source in meeting the expeditious incrementing world energy demand. With the incrementing demand on the utilization of fossil fuels, a more vigorous threat to emaculate environment is being posed as the burning of fossil fuels is associated with emissions like CO2, CO, SOX, NOX and particulate matter. These emissions are major causes of air pollution. India.s energy security would remain vulnerably susceptible until alternative fuels to supersede/supplement petro-predicated fuels are developed predicated on indigenously engendered renewable victual stocks.

Effect of Longer ignition delay in NOx Engenderment and prelude of advancement injection timing has been discussed in [1]. Consequential decrease in CO and HC and decrement in NOx due to the utilization of antioxidants in biodiesel have been discussed in [2]. Decrement of NOx by the utilization of Tri-compound fuels (ethanolbiodiesel- diesel) with the avail of additives and retarded fuel injection timing in EGR accompanied bio-diesel fuelled engine have been discussed in [4]. Implementation of fine-tuned commencement of injection with the effect of crank angle has been discussed in [10]. Study of Distilled tyre pyrolysis oil diesel of coalescences of different proportion with the result of failure in 100% blend and NOx reduction of 21% in 80% blends have been taken from [6]. Cetane numberestimation and the hydrogenation process in incrementing the Cetane number in diesel fuels have been dealt in [7]. Utilization of different Cetane number improvers (Aniline Nitrate) which has incremented Cetane number significantly with standard pressure resulting in NOx and SO2 reduction by 10% [8]. Higher Cetane number by increase in adipose acid compounds (CH2) with long chain reaction have been discussed in [9]. Coalesced and fumigated mode of methanol bio-diesel with ultra low-sulphur diesel blend resulting in reduction of CO, HC, NOx and dissever injection type have been discussed in [5]. NOx reduction due to dual fuel mode (Biogas and Biodiesel) with different load condition and lower exhaust gas temperature has been discussed in [3]. In this research paper, Soyabean oil as Biodiesel fuel and Diethyl ether as a cetane improver are utilized for reducing the NOx emission in Diesel engine.

Objectives of the present study

Research objectives of the project:-

- It is proposed to utilize Bio diesel in the diesel engine (CI engine).
- The emissions like CO, HC, NOx in the exhaust gases are withal proposed to be reduced by integrating of Cetane Improver (DEE).
- To study the emission characteristics when utilizing Bio fuel as fuel in the diesel engine by quantification and analysis of the exhaust emissions.

Properties of soyabean bio-diesel:-

Kinematic viscosity AT CSE 40°C = 4.78
Specific Gravity =865
Flash point =163°C
Total sulphur % by mass = Nil
Distillation % volume/Vol =90 to 335°C
Cetane number =51
Ash % by mass =Nil
Oil Ester Methyl Ester % =95.69

Soya biodiesel is better for the environment because it is made from renewable resources and has lower emissions compared to petroleum diesel. The utilization of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide, and soot. The utilization of biodiesel does not increment the CO2 level in the atmosphere, since growing soybeans consumes additionally CO2. Biodiesel is withal more biodegradable than conventional diesel. Studies at the University of Idaho have illustrated biodiesel degraded for 95 percent after 28 days compared to 40 percent for diesel fuel. Inchoations of soyabean are in Southeast Asia with first domestication reported in the 11th century BC in China. First planted in the U.S. in 1765, soybeans spread to the Cornmunist Belt by the mid 1800s with major acreage not visually perceived until the 1920s when it was utilized mainly as a forage crop. Major U.S. expansion as an oilseed crop commenced in the 1940s [6]. Soybeans contain approximately 18 to 20% oil compared to other oilseed crops such as canola (40%) and sunflower (43%) [20] Soybean oil is currently a major feedstock for engenderment of biodiesel by National Biodiesel Board (NBB). The most mundane method of biodiesel engenderment is a reaction of vegetable oils or animal fats with methanol or ethanol in the presence of sodium hydroxide (which acts as a catalyst). The transesterification reaction yields methyl or ethyl esters (biodiesel) and a byproduct of glycerin. Numerous studies between 1980 and 2000 have shown the utilization of straight vegetable oil including soybean oil to cause carbon deposits and truncate engine life [10]. Biodiesel use in diesel engines does not have kindred negative effects.

III. METHODOLOGY

Engine tests will be carried out on a bench-mounted and instrumented automotive diesel engine. A four stroke multi cylinder Mitsubishi 4D68 SOHC 2.0 liter was utilized in this study.
Table 3.1shows the details of the engine designations.

Table 3.1 Specifications Of Mitsubishi 4D68 Diesel Engine

Descriptions	Specifications
Number of cylinders	4 in-line
Combustion chamber	Swirl chamber
Total displacement cm	1.998 cc (121.925 cu in)
Cylinder bore mm x Piston stroke mm	82.7 x 93
Bore/stroke ratio	0.89
Compression ratio	22.4:1
Fuel system	Pump distributor-type injection

A pressure transducer (Kistler 6041A), a dihydrogen monoxide cooled piezoelectric pressure transducer was flush mounted with cylinder head to quantify combustion pressure. The flush mounting was preferred in order to minimize the lag in the pressure signal and to evade pipe connecting passage resonance. The test bench was equipped with Cole Palmer pressure gauges and K-type thermocouples for mean temperatures and pressure quantifications in order to characterize and monitor accurately the KANE gas analyzer consummate with a 3 meter sampling probe was utilized for emissions quantifications. The sampling probes of smoke meter and gas analyzer were mounted centrally at the terminus of the engine exhaust pipe. Kane gas analyzer has been used to quantify and monitor the exhaust emission of the engine including NOx, carbon dioxide (CO), carbon dioxide (CO2) and unburned hydrocarbon. The engine was mounted with Kistler CAM crank angle encoder type 2613B connected to Kistler signal conditioner type 2613B2 for crank angle quantification and combustion characteristics. Crank angle encoder being connected to PC DEW-800 with connecting cable type 2613B3 utilizing the signal conditioner. A 150 kW eddy-current brake ECB dynamometer equipped with a Dynalec load controller was directly coupled by a shaft. The engine and dynamometer are mounted on a seismic steel bed (2.49 m x 1.3 m) to absorb the engine vibration emitted during the tribulation. Air flow and fuel flow rate were quantified by a CENTERTEK anemometer and AIC fuel flow meter respectively. Figure 1 shows the diesel engine with four cylinders.

Fig.3.1 Specification of Mitsubishi 4D68 Diesel Engine

Table 3.2 Properties Of The Fuels

Properties	Diesel	B20	B20 E5	B20 E10	B20 E15	B20 E20
Flash point (°C)	70	110	43	48	45	49
Viscosity (mm^2/s)	4.24	3.07	3.08	3.09	3.28	3.63
Density (kg/m^3)	837	845	843	842	844	843
Cetane number	50	41.2	41.7	42.6	43.4	44.2

Afore the experiment, the engine was run with diesel fuel for a period of 15 minutes to reach steady state condition. Engine performance and exhaust emissions tests were conducted from range of 20% to 60% load. The total mass concentration of the diesel PM on composite filter is quantified by a high precision electric balance. The filters were weighted under controlled temperature and relative sultriness. Utilizing dichloromethane, SOF and DS can be extracted and the concentration can be quantified.

3.1 Palm oil characterization:-

Vegetable oil is composed of many kinds of adipose acids, accounting for 94–96% of the molecular weight of the triglycerides. To determine the adipose acid composition and molecular weight of palm oil, there is an indirect method which analyzes the composition of the derived biodiesel product by a gas chromatograph (GC) equipped with a 30 m capillary coated with a 0.25 lm film of DBWAX and a flame ionization detector (FID).

3.2 Biodiesel Engenderment:-

The biodiesel was engendered through the transesterification of palm oil as raw material with a base catalyst by varying the types of alcohol. Palm oil methyl esters (PME) were synthesized in a batch-type reactor utilizing

NaOH as a catalyst. The reaction utilized a molar ratio of methanol to oil of 9:1 and a catalyst of 0.5% by weight of oil. This cumulation was stirred vigorously for 2 h at 60 C, and the product was poured into a separatory funnel. The top ester layer was dissevered and washed with 200 ml of distilled dihydrogen monoxide. Palm oil ethyl esters (PEE) were yare in much the same way as the methyl esters. The reaction utilized a molar ratio of ethanol to oil of 12:1 in order to achieve the maximum conversion. Palm oil butyl esters (PBE) were yare utilizing a molar ratio of butanol to oil of 12:1 and sodium metal as a catalyst.

3.3 Splash-coalescing:-

The coalescence was yare by the splash-coalescing method [7]. Diesel, biodiesel (methyl, ethyl, or butyl esters), and alcohol (ethanol or butanol) were commixed together into a homogeneous coalescence by a magnetic stirrer. The stirring celerity was set at 1000 rpm for 5 min. Then, the final blend was kept in a vial tube for observing the physical appearance. The same procedure was carried out with other ratios of diesel, biodiesel, and alcohol. Each component was varied from 0% to 100% by volume in 10% increments. In this study, the phase deportment of the three-component systems was investigated by utilizing a physical-state diagram. All of the coalescences from the anterior step were kept motionless for 7 days at 10, 20, and 30 _C to observe the physical stability. After 7 days, the observation data were habituated to develop the physical-state diagrams at different temperatures. However, all of the coalescences were kept motionless at room temperature for 3 months to observe the long term stability.

3.4 Fuel Properties Testing:-

Laboratory tests were then carried out utilizing ASTM standards to determine the following fuel properties: density, kinematic viscosity, cetane index, heat of combustion, flash point, pour point, and oxidation stability. All of these properties were tested by following ASTM D4052, D445, D93, D97, D240, D976, and EN 14112, respectively.

3.5 Integration Approach:-

Proposed integrated configuration for engenderment of biodiesel and bioethanol from oil palm is depicted in Fig. 4. The FFB are the feedstock for crude oil engenderment. In integration, different solid lignocellulosic residues are engendered. The utilization of these residues, concretely the EFB and PPF, is proposed as raw materials for ethanol engenderment. They enter the pretreatment reactor where react with dilute acid at high pressure. Then, the pretreated lignocellulosic biomass undergoes the transformations described in Section 2.1.2 obtaining dehydrated ethanol with purity more preponderant than 99.5% by weight. This stream of ethanol, along with crude oil, is alimented to a multi-stage reactor–extractor , where transesterification reaction is perpetually accomplished by reactive extraction process utilizing KOH. There subsist several calibers of integration in the proposed scheme. Bioethanol engenderment implicatively insinuates the reaction–reaction integration of cellulose hydrolysis, hexose fermentation and pentose fermentation through the SSCF process.

In a homogeneous way, the reaction-separatio integration is considered in the multi-stage reactor– extractor leading to the amelioration of the biodiesel engenderment process as exposed above. Other level of integration corresponds to the recirculation of material streams in order to achieve a better utilization of sugars, e.g. by implementing the recycling of dihydrogen monoxide streams. In this case, the bottoms of rectification column and a fraction of the thin stillage (visually perceive Fig. 4), which mostly contain dihydrogen monoxide but withal a low content of non-utilized by microorganisms sugars, are recycled back to the washing step of lignocellulosic biomass leaving the pretreatment reactor. Thus, non-consumed pentoses and hexoses return to the SSCF reactor to be converted into ethanol. In additament and with the aim of reducing the volume of wastewater that should be treated, the secondary steam from evaporators is condensed and recycled back to the pretreatment reactor where it is utilized as process dihydrogen monoxide. above-mentioned streams correspond to the ethanol engenderment process, but it is withal possible the recirculation of streams between the biodiesel engenderment line and ethanol engenderment line incrementing the integration degree of the overall process. In this work, the recirculation of the distillate from the distillation column utilized for glycerol disunion is proposed. This stream contains ethanol with a low content of dihydrogen monoxide. For this reason, it cannot be utilized as a gasoline oxygenate.

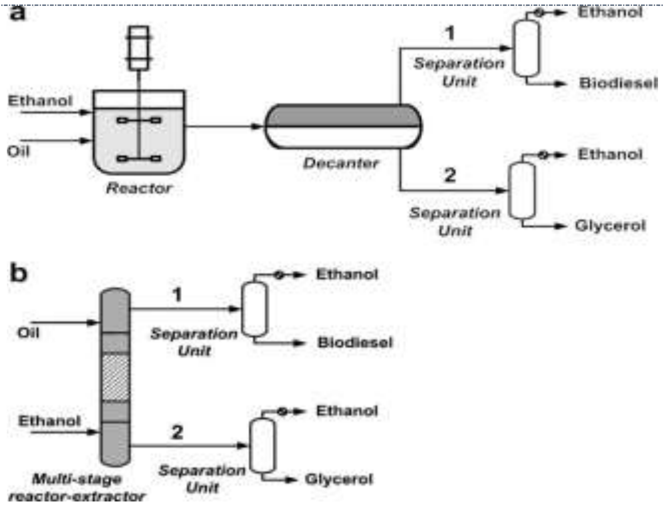

Fig.3.2 Flowsheet configuration for biodiesel production from oil palm and ethanol

a. Conventional configuration. b. Integrated configuration involving reactive extraction.

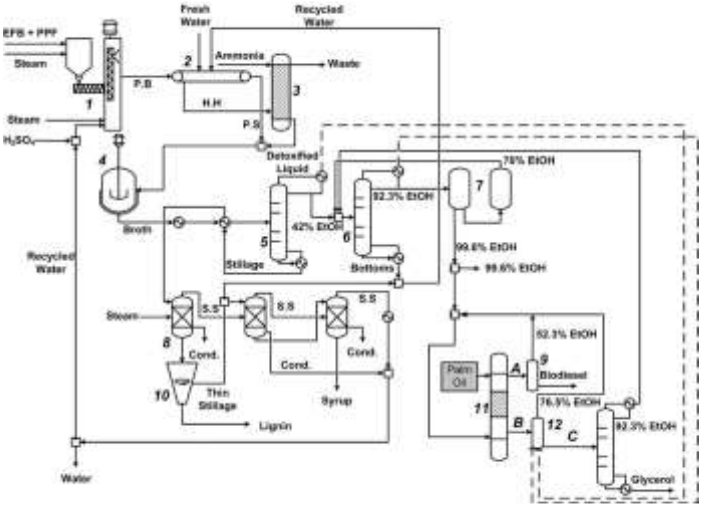

Fig.3.3 Integrated process flowsheet of the combined production of biodiesel and bioethanol using a flash unit for biodiesel purification

(1) Pretreatment reactor
(2) Washing
(3) Ionic exchange
(4) Simultaneous sacharification and co-fermentation
(5) Concentration column
(6) Rectification column
(7) Molecular sieves
(8) Evaporation train
(9) Flash unit
(10) Centrifuge
(11) Multi-stage reactor–extractor
(12) Flash unit

Material streams are represented by continuous lines whereas dashed lines represent heat streams.
A: biodiesel-enriched stream,
B,C: Glycerol-enriched streams
H.H: Hemicellulose hydrolyzate

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P.B: Pretreated biomass
P.S: Pretreated solids
S.S: Secondary steam

In addition, this column is also fed with the regenerate resulting from the adsorption in the molecular sieves. The corresponding flowsheet involving the mentioned ways of material integration is called Configuration 1 in Table 3.1. Other option for integrating the whole process is the energy integration between both production lines. For this, the utilization of the heat released during the condensation of overhead vapors exiting the concentration and rectification columns is proposed. This heat is employed to provide the energy required by the flash unit processing the glycerol-enriched stream that leaves the reactor– extractor. In this way, the supply of steam generated in boilers is not needed decreasing the total energy costs. This flowsheet involving both material and energy integration is named Configuration 2 in Table 3.2 and is depicted in Fig.3.2. An alternative way of integration is also studied. For this case (Configuration 3), the purification of the two streams exiting the multi-stage reactor–extractor undergoes distillation using two columns. The first column is aimed at separating the biodiesel, which is removed from the bottoms, and an ethanol-enriched stream that is removed from the top (see Fig. 3.3). The second column purifies the glycerol contained in the heavy stream from the multi-stage reactor–extractor. As in the first column, the distillate contains high amounts of ethanol. These two ethanol-enriched streams are recycled back to the reactor–extractor unlike the Configuration 1 where ethanol is recirculated to the concentration column in the bioethanol production line. Finally, the Configuration 4 is based on Configuration 3 and includes the energy integration possibilities by using the available heat of the condensers of both concentration and rectification columns in the ethanol production line.

3.6 Simulation Procedure:-

Material balance of the oil extraction process was based on the data reported by Prasertsan and Prasertsan (1996) for processing FFB towards crude palm oil. The data on composition of the analyzed lignocellulosic residues (EFB and PPF) shown in Table 1.1 were employed for simulating bioethanol production scheme. The simulation of the global technological scheme including both material and energy integration was performed using the process simulator Aspen Plus[11]. Main process data of such simulation are presented in Table 1.2 For ethanol production line, the approach and principles employed for simulation were mostly taken from a previous work [16]. For process units involved in ethanol production, NRTL thermodynamic model was utilized to calculate the activity coefficients of the liquid phases. For units related to the biodiesel production, UNIFAC model was employed for the simulation of the properties of the two formed liquid phases. In particular, modified values of the group interaction parameters were utilized for the substances involved in the transesterification reaction.

The coverage of system boundaries employed for the analysis of biodiesel production from palm oil is more comprehensive in this study where the agricultural crop production has also been delved into accordingly. In this case, four main steps were accounted – oilpalm plantation, crude palm oil extraction, palm oil refining and transesterification. Should there be any discrepancy in the analyses, it is attributable to the waste properties of EFB. This is based on the assumption that EFB is generated without energy input as it is the waste residue produced from palm oil mills. Nonetheless, EFB will no longer be a waste in the future if its usage is well established especially when the production of ethanol is successful at commercial scale. From that time on, some energy/exergy must be allocated to it and this may change the energy/exergy balance of the ethanol produced from EFB. Furthermore, the system boundaries considered in this study merely involve the content of energy products (raw materials) used in the system, not reckoning the inputs of non-renewable resources required for the production of raw materials. It is noted here that excluding the energy inputs for the production of raw materials in the analysis may yield higher net energy as well as net exergy value in final outcome if compared to similar analysis in which included the energy for producing raw materials into the system boundary. All energy inputs involved in the ethanol and biodiesel productions were calculated based on 1 kg and 1 MJ of ethanol and biodiesel generated.

IV. EXPERIMENTAL SETUP AND PROCEDURE

This study was conducted on a single cylinder, direct injection, dihydrogen monoxide cooled diesel engine mounted on a test bed. Fig.4.1 shows the engine setup. Major designations of this engine are provided in Table 1.2. To quantify the intake air flow, an air flow meter turbine was employed. Two fuel tanks were utilized; one was for diesel fuel and the other for coalesced fuels. The engine was coupled to an eddy current dynamometer, which can be operated at a maximum power of 20 kW. A Bosch BEA-350 exhaust gas analyzer was utilized for engine emissions analysis of HC and CO. Bosch RTM 430 smoke opacimeter was acclimated to quantify the smoke opacity and AVL DICOM\ 4000 was habituated to quantify NOx emissions. The designations of the analyzers are shown in Table 3.1. For combustion analysis, the test system was equipped with obligatory sensors. In-cylinder pressure was quantified by utilizing a Kistler 6125B type pressure sensor. A dedicated mounting sleeve was fabricated and installed to mount the sensor in the engine head through the dihydrogen monoxide cooling jacket. Kistler 5041 type charge amplifier was habituated to amplify the charge signal outputs from the pressure sensor. A high precision Leine and Linde incremental encoder (model: 632-00685-1) was acclimated to acquire the top dead center (TDC) position and crank angle signal for every engine rotation. samplings of the cylinder pressure and encoder signals were performed by a computer with ADLINK DAQe-2010 data acquisition card. One hundred consecutive combustion cycles of pressure data were accumulated and averaged to eliminate cycle-tocycle variation in each test. To reduce noise effects, Savitzky-Golay smoothing filtering was applied to the sampled cylinder pressure data. Other combustion parameters, such as heat release rate, cylinder temperature and commencement of combustion (SOC), were computed by utilizing Matlab software. The engine was first operated with diesel to warm-up and to define baseline parameters. The quantified engine performance parameters are brake power and BTE (brake thermal efficiency). The engine performance tests were carried out at 100% load. Engine speed varied between 1200 rpm and 2400 rpm at a 200 rpm interval. For data acquisition, Dynomax 2000 data control system was utilized, which was monitored with the avail of Dynomax 2000 software. Emission analysis was withal conducted at full load with an engine speed between 1200 rpm and 2400 rpm.

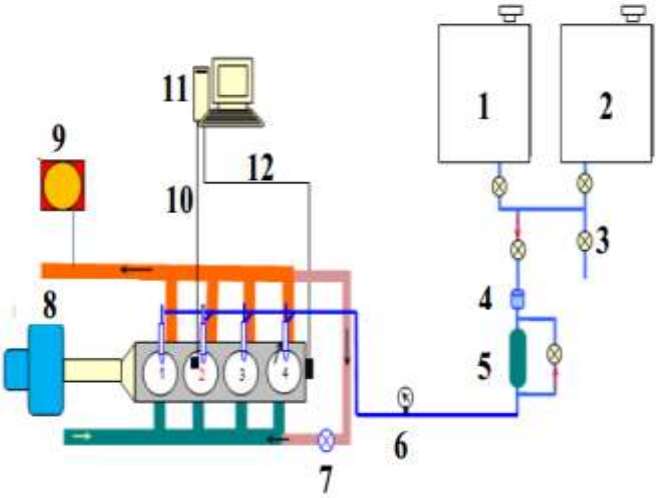


Fig.4.1 Schematic diagram of experimental engine setup

(1) Diesel Fuel Tank
(2) Biodiesel Fuel Tank
(3) Drain Valve
(4) Fuel Filter
(5) Fuel Pump
(6) Pressure Transducer
(7) EGR Valve
(8) Dynamometer
(9) Gas Analyser
(10) In-Cylinder Pressure Transducer
(11) Orion 1624 DAQ
(12) Crank Angle Encoder

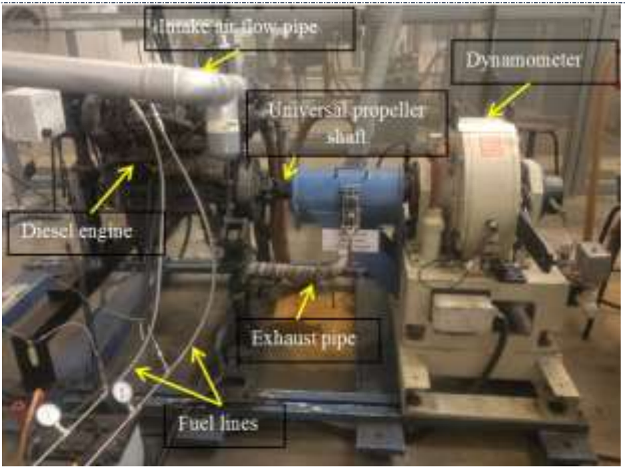


Fig.4.2 Experimental Engine test bed

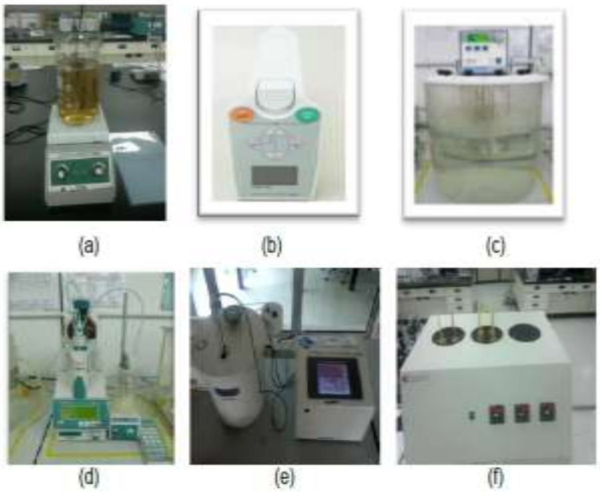


Fig.4.3 Analytical Instruments used to Measure Fuel Properties

(a) Magnetic Stirrer
(b) Density Meter
(c) Viscosity Bath
(d) Acid Value & Acidity Tester
(e) Oxygen Bomb Calorimeter
(f) Cloud and Pour Point Measuring Equipment

In this research Palm Oil Methyl Ester (PME) biodiesels have been considered as potential renewable energy sources. Consequently, this experimental investigation was conducted to amend the coalescence of these two biodiesels (20% biodiesel blend, designated P20 and J20, respectively) with the avail of oxygenated additives. The comparative amelioration of P20 and J20 blends with ethanol, n-butanol, or diethyl ether as additives was evaluated in terms of performance and emissions characteristics of a four-stroke single cylinder diesel engine. The final blend consisted of 80% diesel, 15% Palm Oil Methyl Ester (PME), and 5% additive. Tests will be conducted at different speeds (1200 - 2400 rpm) at constant full load conditions. Utilization of additives will significantly ameliorate brake power and brake thermal efficiency (BTE). Compared with P20 blend, the utilization of diethyl ether as additive incremented brake power and BTE by about 4.10% and 4.4%, respectively, at 2200 rpm.

A kindred amendment was observed for J20. The other two additives additionally ameliorated performance. Albeit HC emission incremented scarcely, all blends with additives reduced more NOx and CO emissions than P20 and J20 virtually throughout the entire engine test. The utilization of ethanol as additive reduced CO emission by up to 40%, while the utilization of diethyl ether as additive reduced NOx emissions by up to 13%. The additives' oxygen content, volatility, and latent evaporation heat controlled the emissions characteristics of the coalescences. An analysis of the combustion chamber pressure, temperature and heat release rate of the modified blends revealed fascinating features of combustion mechanism, which are indicative of the performance and emissions characteristics. This experiment reveals the potential amelioration of palm and jatropha biodiesel blends with the integration of three promising additives. Ergo, the most acceptable option for ameliorating the properties of biodiesel is the utilization of a fuel additive. In the present scenario, the properties of palm oil methyl esters with incrementing additive content were investigated after additament of ethanol, butanol and diethyl ether.

The results revealed varying amendment in acid value, density, viscosity, pour point and cloud point, accompanied by a remote decrease in energy content with an incrementing additive ratio. The viscosity reductions at 5% additive were 12%, 7%, 16.5% for ethanol, butanol and diethyl ether, respectively, and the maximum reduction in pour point was 5°C at 5% diethyl ether blend. Engine test results revealed a salient amendment in engine brake power and categorical fuel consumption compared to palm oil biodiesel and the best performance was obtained with diethyl ether. All the biodiesel-additive blend samples meet the requisites of ASTM D6751 biodiesel fuel standards for the quantified properties.

Alternative fuels, like biodiesel, are being utilized as a renewable energy source and an efficacious substitute for the perpetually depleting supply of mineral diesel as they have kindred combustion characteristics. However, the utilization of pristine biodiesel as a fuel for diesel engines is currently inhibited due to quandaries relating to fuel properties and its relatively poor cold flow characteristics.

V. RESULTS AND DISCUSSION

5.1. Performance Analysis:-

The results obtained by performing experiments utilizing diesel and different of coalescences of biodiesel fuel with cetane improver with a variation in percentage cumulation of exhaust gas recirculation are presented in the graphical form. Figure 5.1 shows the variation of BTE at different EGR by varying the percentage of biodiesel under 50% and 100% load. It is found that brake thermal efficiency increases up to an optimum value of EGR and then decreases. BTE is withal found to be incrementing with increase in biodiesel at a given EGR percentage. The coalesced effect of optimum EGR and DTBP can increment the BTE by 6-7%. The reason for increase in BTE with EGR is due to re burning of HC that enters combustion chamber with the recirculation of exhaust gases and additionally EGR increases intake charge temperature which increases the rate of combustion. Cetane number is a denotement of ignition quality of fuel, its increment reduces delay period and leads to better combustion. Figure 5.1 shows the variation of BSFC with EGR by varying the percentage of biodiesel under 50% and 100% load. It is found that brake concrete fuel consumption decreases with increase in EGR and reaches a minimum value at about 10% EGR and then increases marginally up to 20% EGR. Further with increase in biodiesel percentage additionally BSFC increases. It is due to the fact that Biodiesel blends have less energy content than diesel which causes fuel consumption to increment. Figure 5.2 shows the variation of exhaust gas temperature with EGR mass fraction. It is found that with increase in percentage of EGR as well as biodiesel, the exhaust gas temperatures reduced. This can be attributed to the oxygen deficient operation under EGR which results in lower combustion temperatures and furthermore categorical heat of exhaust gas is more than that of intake air which additionally contributes to the lower combustion temperatures. This reflects an efficacious utilization of heat energy.

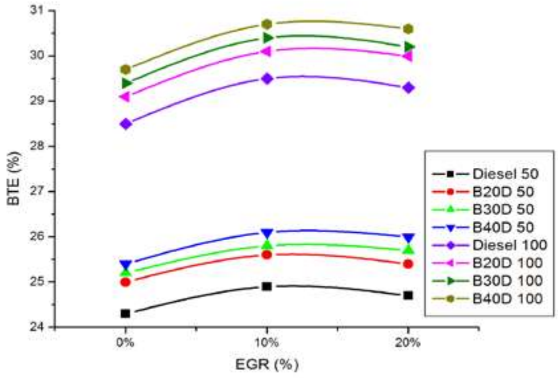


Figure 5.1. Effect of Exhaust Gas Recirculation on Brake Thermal Efficiency at 50% and 100% Loads

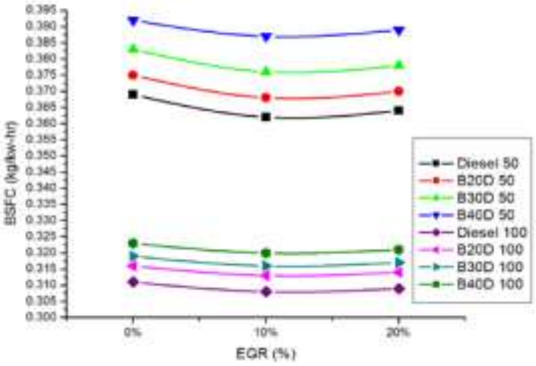


Figure 5.2. Effect of Exhaust Gas Recirculation on Brake Specific Fuel Consumption at 50% and 100% Load

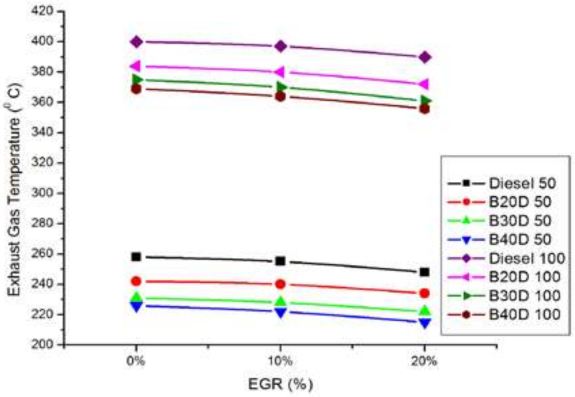
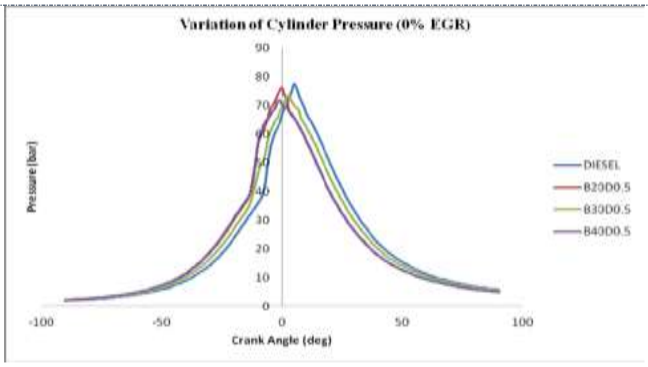


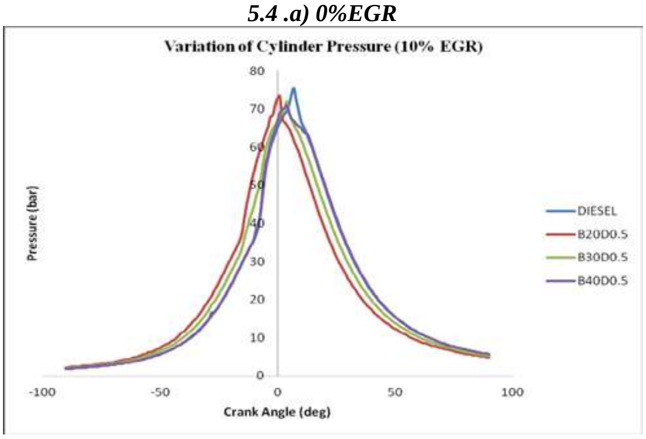
Figure 5.3. Effect of Exhaust Gas Recirculation on Exhaust Gas Temperature at 50% and 100% Load

5.2. Combustion Analysis:-

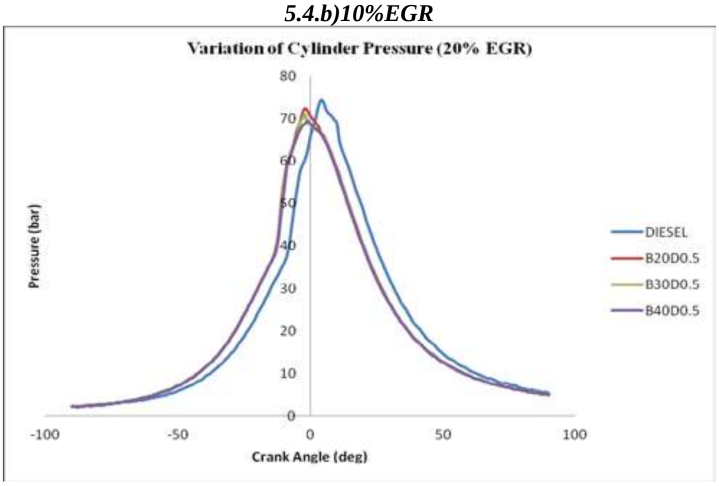
Combustion characteristics results such as cylinder pressure versus crank angle are shown in Figure 5.4, Figure 5.4.a, 5.4.b & 5.4.c show the variation of cylinder pressure at different crank angle with 0%, 10% and 20% EGR respectively. It can be optically discerned from these figures that the maximum cylinder pressure decreases marginally with the EGR and it can withal be optically discerned that the coalescences ignite earlier and culminate the combustion earlier than that of diesel. This may be attributed to the integration of DTBP which decreases ignition delay and reduces the accumulation of unburned fuel in the premixed phase of combustion resulting in reduction of cylinder pressure and delay period, these results are additionally good in accidence with the literature [36].



5.4 .a) 0%EGR



5.4.b)10%EGR



5.4.c)10%EGR

Figure 5.4. Effect of Exhaust Gas Recirculation on Cylinder Pressure at Different Crank Angle

5.3. Exhaust Emission Analysis:-

The exhaust emission results such as CO, NOx, HC and smoke opacity of different fuels at different EGR mass fractions are shown in Figures 5.7-5.8. Figure 5.5 shows the variation of CO emissions with increase in percentage of EGR at 50% and 100% loads. It is found that with the incrementation in the percentage of EGR, CO increases however the effect of CO emission is found less at higher percentages of biodiesel. Further, the emissions are found rapidly incrementing with EGR up to 10% and beyond which there is only a nonessential elevate. The deficiency of oxygen with the incrementation in EGR percentage can be attributed to the rapid magnification of CO at initial stages of the EGR. However the excess oxygen content in bio-diesel can compensate for the oxygen deficient operation under EGR. Figure 5.6 shows the variation of NOx emissions with increase in percentage of EGR at 50% and 100% loads. Figure 5.6 shows that the amalgamated effect of EGR and DTBP could reduce the NOx emissions significantly. The reason for reduction in the NOx with EGR is the reduction of the combustion temperatures as a result of the integration of exhaust gases to the intake air which increases the amount of combustion accompanying gases mainly CO2 which reduces the combustion temperature. It was shown in literature that higher EGR rates (beyond 20%) are able to reduce NOx emissions by a substantial amount, which however is accompanied by a reduction in the BTE and increment in the CO, HC and smoke emissions [4]. Figure 5.7 shows the variation of HC emissions with increase in percentage of EGR at 50% and 100% loads. It can be visually perceived from the figure that the HC emissions incremented remotely from 0% to 10% EGR for all fuels and beyond which there is a reduction. However with the incrementation in biodiesel percentage, the HC emissions found decrementing. Figure 5.8 shows the variation of smoke opacity with increase in percentage of EGR at 50% and 100% loads. It shows that the incrementation in the smoke opacity is frivolous initially and increases with further increase in EGR which withal increases with the incrementation in percentage of biodiesel. This can be attributed to the additament of cetane improver which increases the combustion temperatures and the amount of fuel burned in the diffusive combustion phase resulting in the remote increase of engine smoke.

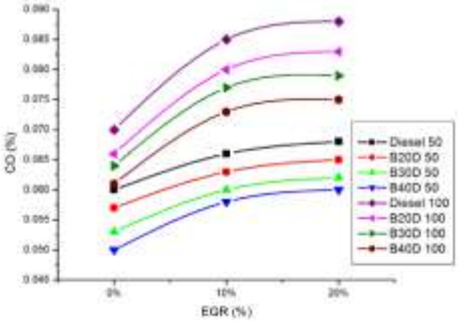


Figure 5.5. Effect of Exhaust Gas Recirculation on CO Emissions at 50% and 100% Load

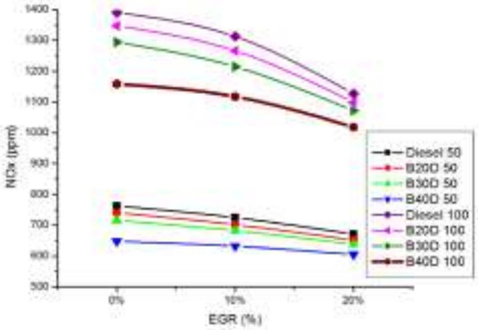


Figure 5.6. Effect of Exhaust Gas Recirculation on NOx Emissions at 50% and 100% Load

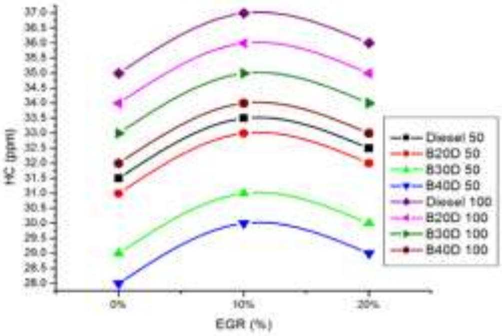


Figure 5.7. Effect of Exhaust Gas Recirculation on HC Emissions at 50% and 100% Load

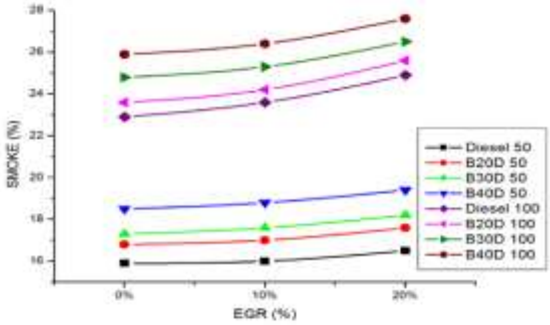


Figure 5.8. Effect of Exhaust Gas Recirculation on Smoke opacity at 50% and 100% Load

5.4. Brake Thermal Efficiency:-

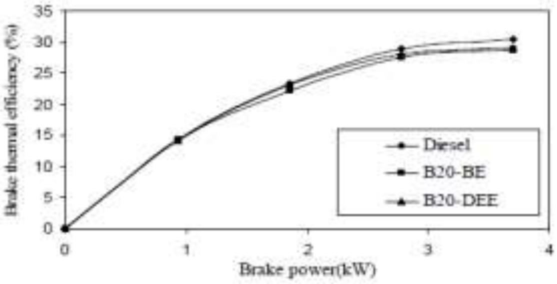


Figure 5.9. Variation of Brake thermal efficiency with BP

Figure 5.9 shows the variation of the brake thermal efficiency with brake power for diesel, B20 and B20 with DEE fuels. The brake thermal efficiency is incremented for B20 with DEE as compared to B20 blend full load. The thermal efficiency obtained for diesel and B20 are 30.45%, 28.72% respectively at full load, whereas for B20 with DEE it is 29.12% at full load. The incrementation in BTE may be due to better evaporation of DEE that commixes with air and forms a homogeneous cumulation, and results in combustion, engendering a hotte environment to avail the combustion of B20 fuel, whch leads to higher thermal efficiency.

5.5. Brake Specific Fuel consumption:-
5.6.

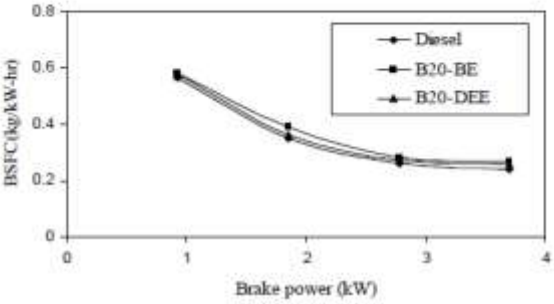


Figure 5.10 Variation of BSFC with BP

Figure 5.10 depicts the variation of the brake thermal efficiency with brake power for diesel, B20 and B20 with DEE fuels. The BSFC values obtained for diesel with B20 are 0.240 kg/kWh and 0.267 kg/kWh respectively, whereas for the B20 with DEE it is 0.256 kg/kWh at full load. The incrementation in BSFC for B20 may be due to high density and viscosity,which affects the coalescence formation, leading to slow combustion.When a diminutive quantity of DEE is integrated, it enhances the combustion of biodeisel, resulting in lower BSFC compared with B20 fuel.

5.7. Exhaust gas temperature:-

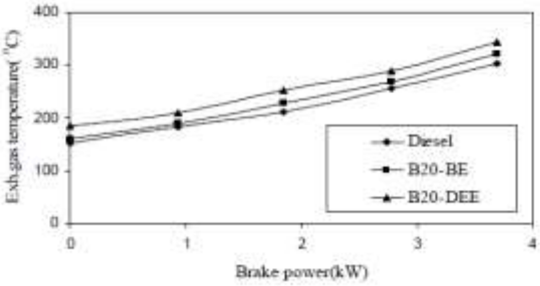


Figure 5.11. Variation of Exhaust gas Temperature with BP

Figure 5.11 shows the variation of the exhaust gas temperature with brake power for diesel, B20 and B20 with DEE fuels. The exhaust gas temperature obtained for diesel and B20 are 302°C and 320°C respectively at full load. For the B20 with DEE it is 314 °C at full load. The reduction in temperature may be due to more expeditious combustion rates of DEE with biodiesel blend. Due to the amelioration in the diffusion combustion rate, tardy burning of biodiesel is reduced and thus results in a reduced exhaust gas temperature. Withal DEE has high latent heat of vaporization property which cools the charges and thus reduced the peak combustion temperature. Hence lower exhaust gas temperature.

5.8.

5.9. Carbon monoxide emission (CO):-

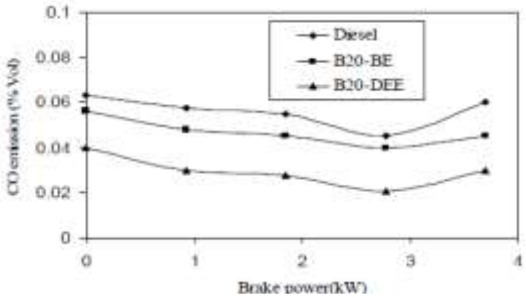


Figure 5.12 Variation of CO emissions with BP

Figure 5.12 depicts the variation of the carbon monoxide emission with brake power for diesel, B20 and B20 with DEE fuels. The CO values obtained for diesel and B20 are 0.06%Vol and 0.045 %Vol respectively at full load, whereas for B20 with DEE it is 0.035 %Vol at full load. The decrementation in CO with DEE may be due to better evaporation of DEE that commixes with air and forms a homogeneous amalgamation and results in better and consummate combustion, engendering a sultrier environment to avail the combustion of B20 fuel, whch leads to lower CO emissions.

5.10. Hydrocarbon emission (HC):-

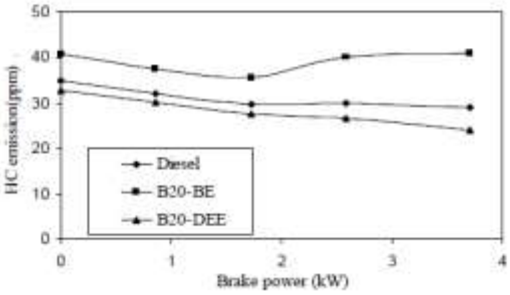


Figure 5.13 Variation of HC emissions with BP

Figure 5.13 shows the variation of the hydrocarbon emission with brake power for diesel, B20 and B20 with DEE fuels. The hydrocarbon emission for diesel and B20 are 29 ppm and 42 ppm respectively for the base engine at full load. For the ceramic coated piston with B20, it is 24 ppm at full load. The reduction in HC emission is due to additament of DEE that makes the coalescence homogeneous, which results in better combustion. The ignition improver (DEE) forms a number of ignition centers in the combustion chamber, which results in consummate combustion.

5.11. Nitrogen oxide emission (NO):-

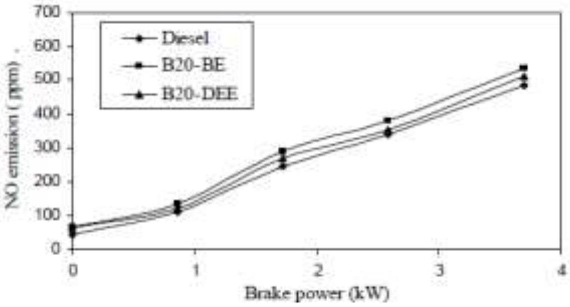


Figure 5.14 Variation of NO emissions with BP

Figure 5.14 illustrates the variation of the nitrogen oxide emission with brake power for diesel, B20 and B20 with DEE fuels. The NO forms by oxidation of atmospheric nitrogen at amply high temperatures. The NO values obtained for diesel and B20 are 486 and 536ppm, respectively at full load, whereas for B20 with DEE, it is 512ppm at full load. The decrementation in NO level for B20 with DEE may be due to the evaporation of DEE and it has lowered the charge temperature, resulting in decremented the NO level compred to B20 at full load.

5.10 . Smoke emission:-

Figure 5.15 depicts the variation of the smoke density with brake power for diesel, B20 and B20 with DEE fuels. The smoke values obtained for diesel and B20 are 3.6 BSU and 2.8 BSU respectively, whereas for the B20 with DEE, it is 3.0 BSU at full load. The decrementation in smoke for the B20 with DEE may be due to better combustion of biodiesel blend and more oxygen content present in the biodiesel and DEE are withal thereasons for lower smoke levels.

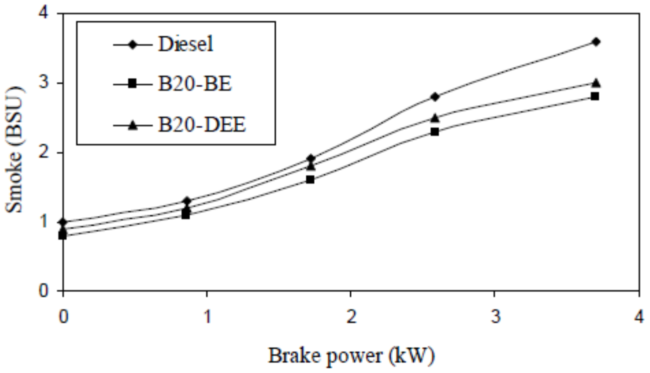


Figure 5.15 Variation of Smoke emissions with BP

VI. CONCLUSION

The research is aimed at exploring the utilization of edible vegetable oil methyl esters and its blends with petro-diesel as fuel in internal combustion engines without any engine modifications. Vegetable oil biodiesel have potential to be considered as congruous alternate fuel and possess the properties kindred to that of diesel. Moreover, review of the literature revealed that with the utilization of edible vegetable oil methyl esters as fuel in diesel engines, deleterious exhaust emissions, like CO2, HC, SOx, smoke and CO are reduced as compared to diesel engine. Area, engenderment, paramountcy, by-products utilization, characterization and properties of edible oilseeds (groundnut, sesame, rapeseed and mustard, sunflower, safflower and Niger) are considered for presenting this review.

In order to surmount escalating ecumenical consumption of fossil fuel and ecumenical warming, an alternative fuel that is economically feasible, sustainable and environmental cordial must be developed for sizably voluminous-scale adoption. Alternative fuels like biodiesel, are being utilized as efficacious alternative for diesel. The feasibility of biodiesel engenderment from palm oil was investigated with reverence to its fuel properties. Though biodiesel can supersede diesel satisfactorily, quandaries cognate to fuel properties persist. In this study ethanol (E) additive was coalesced in the ratios of 1%, 2%, 3% and 4% with palm oil biodiesel (POME) and tested for their properties amelioration. These coalescences were tested for energy content and sundry fuel properties according to ASTM standards. Qualifying of the effect of additive on palm biodiesel fuel properties can accommodate the researchers who work on biodiesel fuels to designate the fuel congruousness for diesel engines according to fuel standards.

Of coalescences of ethanol in POME resulted in an amelioration in acid value, viscosity, density and pour point with incrementing content of ethanol in the coalescence. Further amelioration in the pour point temperature of the palm oil methyl esters ethanol blends (B-E) at 5oC can be achieved by integrating 4% ethanol additive to POME, accompanied by less than 1% decrease in energy content of biodiesel which still within designations contained in ASTM D6751 and EN 14214 standards, suggesting that ethanol may be the congruous prudent cull as biodiesel additive.

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