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Performance characteristics of 4-stroke single cylinder diesel engine, fueled with tyre pyrolysis oil and diesel

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ABSTRACT

The present rate of consumption of Gasoline would lead to a severe shortage of it within a further few decades. An urgency of finding an alternative fuel in its place has led to several types of research around the world. A study was carried out to evaluate the use of various Tyre Pyrolysis Oil (TPO) blends with diesel fuel. Performance and emission characteristics of TPO blends with diesel on a single-cylinder direct-injection engine are presented in this study. In the initial stage, the test was conducted on four strokes single-cylinder diesel engines by using diesel and baseline data was generated. A constant speed will be maintained throughout the experiment. Then commercially available TPO was blended with diesel fuel at some volumetric ratios [(5% TPO ,95% DO) (10% TPO ,90%DO) (15% TPO ,85%DO) (20% TPO ,80%DO) (25% TPO ,75%DO) (30%TPO, 70%DO) (35% TPO ,65%DO) (40%TPO ,60%DO)] which will be going to give the performance characteristics and also to assess at what volumetric ratio the indicated thermal efficiency will be maximum and ISFC will be less when compared to only diesel blends. How will be the exhaust gas emissions which will be studied here, if the emissions are more then we will add some additives to decrease the emissions in further work.

Keywords— *Compression ignition engine, Tire pyrolysis oil, Diesel, Mechanical efficiency, Brake thermal efficiency, Indicated thermal efficiency, Basic specific fuel consumption*

1. INTRODUCTION

Approximately 1.5 billion tires are produced each year globally and 300 million in the USA, which will eventually become waste tires. Tyre piles often provide breeding grounds for pests and insects such as mosquitoes, because their shape and impermeability allow them to hold water for extended periods. Waste tyre stockpiles are difficult to ignite; however, once ignited, tires burn very hot and are very difficult to extinguish, resulting in the considerable release of air pollutants, including particulates. In 2011, 82 % of the waste tire tonnage in the US was beneficially re-used, with the top uses being tire-derived fuel and ground rubber. However, 18 % (696,000 tons, or 59million tires), were still disposed of in landfills or dumped illegally, where they could harbor pests or lead to difficult-to control fires. Such disposal also represents a loss of a high-value material. The negative impacts of landfill disposal or illegal dumping of tyres can be minimized by recovering constituent chemicals and energy from these tyres using available technologies made predominantly from the petroleum product rubber, they have a high heating value, as well as high volatile content and medium sulfur content, properties which make them excellent candidates for pyrolysis, which can be used to recover energy and by-products.

Not only in the United States all over the world there is an increase in waste tyres, so scrap tyres are used in the form of pyrolysis tyre oil which is used as a blend with diesel oil, which increases the-efficiency of the engine. The purpose of this work is to compare used tyre pyrolysis oil blends with conventional diesel fuel when fueled in a diesel engine. Before this, there is a need for a survey on various alternate fuels used in diesel engines by various researchers such as:

S.Murugan who carried out to evaluate the performance and emission characteristics of a single cylinder direct injection diesel engine fuelled by 10, 30 and 50 percent blends of Tyre Pyrolysis Oil (TPO) with Diesel Fuel (DF).Results showed that the brake thermal efficiency of the engine fuelled by TPO-DF blends decreased with increase in blend concentration and higher than Diesel. NOx, HC, CO, and smoke emissions were found to be higher at higher loads due to high aromatic content and longer ignition delay. M. Mani who conducted a performance test on diesel engine by using waste plastic oil as an alternate fuel. The experimental results have shown stable performance with brake "thermal efficiency similar to that of diesel. Carbon dioxide and unburned hydrocarbons were marginally higher than that of the diesel baseline. The toxic gas CO emission of waste plastic oil was higher than diesel. Smoke reduced by about 40% to 50% using waste plastic oil at all loads.

From the above citations, it is clear that TPO can be produced easily from the waste tire and that blending it with diesel in small proportions can improve performance parameters and reduce emissions without modifying the engine design.

1.1 Pyrolysis Process

Pyrolysis is the process of thermally degrading a substance into smaller, less complex molecules. Pyrolysis produces three principal products: such as pyrolysis oil, gas, and char. The quality and quantity of these products depend upon the reactor temperature and design.

Pyrolysis involves heating a feedstock to temperatures>400 °C without oxygen in order to volatilize and decompose the feedstock, producing oil, gas, and char. The oil resulting from pyrolysis may be used directly as a fuel, upgraded to a higher quality fuel, or used to produce chemicals. The gases typically consist of C1–C4 hydrocarbons and hydrogen with a high heating content, so that the gases can serve as a fuel for the pyrolysis process. The solid char consists of carbon black filler along with pyrolysis char.

1.2 Influence of Various Parameters on the Yield of Pyrolysis Products from Waste Tires

1.2.1 Temperature: The pyrolysis temperature must be high enough to thermally degrade the tires; however, higher temperatures and long gas residence times in the reactor hot zone can volatilize the oil togas. Thus, an optimal temperature exists for maximizing oil production. Maximizing oil production is typically the goal since it is the most valuable of the products. Across the studies, optimal temperatures for oil production range from425 °C to 720 °C, and maximum yields range from 38 % to 60 %. This considerable variability inoptimal temperatures and maximum yields are likely due to differences in heating rate, gas residence time, reactor type, tyre mass flow rate, and tire particle size. These secondary factors can particularly influence secondary reactions, which convert liquid compounds to the gas phase or gas phase to the solid phase.

1.2.2 Heating Rate: Increasing the heating rate increases the degradation rate, and also affects the temperature at which maximum volatilization starts and stops. Higher heating rates lead to higher temperatures, which can lead to more secondary reactions, which can produce more gas-phase products. The nature of the secondary reactions can impact the composition of the gas as well as the liquid. Heating rate, as well as temperature and particle size, can produce different impacts depending On values of other parameters. The heating rate also impacts the time to complete pyrolysis and energy required: lower heating rates necessitate longer residence times, but require less energy heating rate is linked to reactor type, with certain reactor types producing higher heating rates.

1.2.3 Atmospheric Pressure: Increasing atmospheric pressure has been found to increase oil viscosity. On the other hand, reduced pressure (often associated with vacuum pyrolysis), has been found to reduce secondary reactions in the gas phase, by reducing volatiles residence time; this would tend to increase oil yield. Also, reducing secondary reactions can reduce gas deposition onto the solid char surface, which can make the char more valuable as an activated carbon adsorbent, with higher surface area and increased reactivity. Decreasing process pressure may also decrease process temperature (PV=nRT), according to the ideal gas law); decreasing process temperature decreases energy demand.

1.2.5 Catalyst: Catalysts can be used to improve pyrolysis rate, oil quality, oil yield, and yields of compounds such as aromatics for chemical production. To enhance pyrolysis rate and oil quality, Dung, et al. (2009), used ITQ-21 and ITQ-24 as additives to commercial HMOR zeolite for catalytic pyrolysis of waste tyres.

1.2.6 Presence of Steam in Carrier Gas: In addition to producing oil for transportation purposes and chemical products, tyre pyrolysis can produce hydrogen, which can be used as a fuel.

1.2.7 Pyrolysis Time/Tire Residence Time: Pyrolysis time is related to particle size: in general, larger particles require longer residence times to achieve the same degree of conversion. Longer residence times require a larger reactor, with larger capital costs. Pyrolysis time is also linked to a heating rate, with lower heating rates requiring longer pyrolysis times. Finally, several researchers have found a time-temperature trade-off: higher temperatures needing shorter tire residence times, and lower temperatures require longer residence times.

2. FLOW CHART REPRESENTATION FOR THE PREPARATION OF TYRE PYROLYSIS OIL

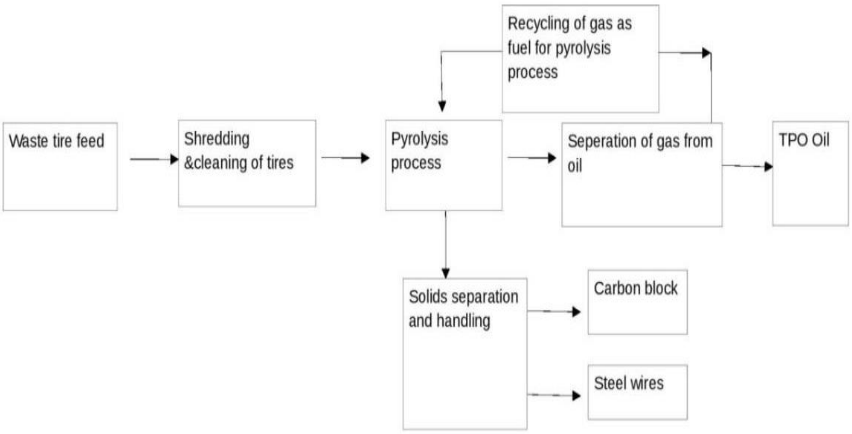

Fig. 1: Flow chart

3. TYRE PYROLYSIS OIL

Tyre pyrolysis oil plant has been established around the world in order to produce the substitute liquid fuel for heating purpose as found that the tyre pyrolysis oil has a high gross calorific value (GCV) of around 41-44 MJ/kg. The waste tyre is needed to be shredded before the process. The desulphurization is required in the pyrolysis system to eliminate the Sulphur. The process is done in the absence of Oxygen (Anaerobic). The process takes place and it was determined that the oil production yield of tyre pyrolysis process has a maximum at 350°C and decomposes rapidly above 400°C for 3 hours. It was reported that the yield is:

3.1 Fuel Oil (45% to 50%)

The main oil product produced by our recycling application is the fuel oil that is wide used for industrial and commercial purposes. The oil has 45% to 50% of the number of recycled scrap tyres, which will be carried with licensed tanker trucks.

3.2 Carbon Black (30% to 35%)

Carbon Black is the main product recycled by Pyrolysis technology. The amount of recycled carbon black is 30% to 35% (depending on the type of tyres) of the total amount of scrap tyres recycled in the system. Carbon black is used as raw material or the main ingredient in many industries and the chemical structure of carbon black strengthens lengthens the endurance and improves the coloring features of the materials. Carbon black produced by Pyrolysis process (CBp) is more economical compared to carbon black produced primarily from petroleum and is more price-efficient to be used as an ingredient in the industries listed:

- Electric cable jacketing
- Conveyor band
- Hose and doormat
- Black nylon bag, Plastic pipes
- Rubber additive
- Automotive spare parts
- Industrial rubber products
- Fire fighting

3.3 Steel Wire (10% to 15%)

Tyres contain steel wires and the amount range of 10% to 15% of the total tyre wastage. All of the steel present in the tyre can be detached after the Pyrolysis recycling process is completed. Valuable steel wires are pressed and sold to steel and scrap dealers.

3.4 GAS (5% to 8%)

Non-Condensable gases arise during the pyrolysis process. There are some advantages such as:

- It has a higher calorific value as compared to natural gas.
- It can be replaced where natural gas and propane are stored.
- The high energy gas may be utilized as a source of energy for the Pyrolysis process.

4. PROPERTIES OF TYRE OIL AND DIESEL

Table 1: Properties of tyre oil and diesel

Property	Tyre Pyrolysis Oil	Diesel Oil
Heating Value(KJ/KG)	43225.9	45814.74
C%	84.67	87
H%	10.44	13
O%	4.17	-
Flash point(Celsius)	68	70
Density(g/cc)	0.924	0.7994
Viscosity(cp)	2.69	70

5. MAGNETIC STIRRER

Fig. 2: Magnetic stirrer

Magnetic Stirrer is mainly used in proper mixing of two fluids and to remove the waste from it.

In this project firstly two fluids, tyre oil and diesel are taken in 500ml volumetric composition by weight with various composition of tyre oil and diesel in it and then placed in a beaker and mounted onto the top of stirrer component and a magnetic stirrer is put inside the beaker and maintaining the pressure and after 15to 20minutes electric supply is cut off and the stirrer is taken out with desired clean and proper mixed fluids.

Fig. 3: 4-stroke single cylinder diesel engine

6. EXPERIMENTAL SETUP

The engine showed figure 3 is a 4 stroke, vertical, single-cylinder, air-cooled and constant speed diesel engine which is coupled to rope brake drum arrangement to absorb the power produced. The engine crank started. Necessary dead weights and spring balance are included to apply load on the brake drum. The engine cooling takes place through atmospheric air. A measuring system for fuel consumption consisting of a fuel. A tank, burette, and a 3- way cock mounted on a stand and stop watch are provided. A fitted with an orifice meter and a water U- tube differential manometer. Also, a tachometer is provided for the measurement of the speed

7. EXPERIMENTAL PROCEDURE

For experimental investigations, biodiesel derived from tyre oil was mixed with diesel in varying proportions 5%, 10%, 15%,20%,25%,30%,35%,40%by volume and Isobutanol as an additive was added as 5% and 10% by volume respectively to all the blends. The engine was started with standard diesel fuel and warmed up. The warm up period ends when the cooling air temperature is stabilized. Then various performance parameters such as BTE, Mechanical efficiency, BSFC, Indicated thermal efficiencies and different exhaust emissions like NOx, HC, CO, CO2, and smoke were measured. A similar procedure was repeated for biodiesel mixed with Isobutanol for various blends.

8. SPECIFICATION OF ENGINE

Table 2: Specification of engine

Type of Engine	**Four strokes single cylinder air cooled diesel engine**
Rated power	**4.4kw**
Rated speed	**1500 rpm**
Bore diameter	**87.5 mm**
Stroke length	**100 mm**

9. FORMULA USED

(a) r(cm) =1/100[(c/2π)+t/2] ,where r =radius of torque arm
(b) T(N-M) = F(kgf)*9.81* r(m)
(c) B.P(kw) =[T * (2πn/60 * 1000)]
(d) mf = [(vf(cm^3)*sgf * 10^{-3})/ t]
(e) F.P = negative intercept on x- axis, where mf(y-axis) and BP(x- axis)
(f) I.P(kw) =B.P + F.P
(g) EI(kw) = mf(kg/s) * cv(kj/kg) , where cv= calorific value of the fluid
(h) η mech % =[(B.P/I.P) *100]
(i) η bth % = [(B.P/I.P) *100]
(j) η ith % = [(I.P/EI) *100]
(k) BSFC (kg/kwh) = [(mf *3600)/B.P]
(l) Δ hw(m) = [(h1-h2)/100]
(m) ρa (kg/m^3) =[(ρa / R * T)] , where ρa = atm. Pressure, R(J/kg k)= 287
(n) Δ ha (m) = Δ hw[(ρw/ρa) -1] , where ρw = density of water = 1000
(o) V_{act} (m^3/sec) = cd * ((π/4) d^2) * (√2g * Δ ha) , where cd =0.64 , d =0.020 m
(p) V_{act}1 (m^3/ rev) = [(V_{act} *60)/
(q) n] , where n =speed =1500 rpm
(r) V_{th}(m^3/ rev) = ((π/4) D^2*L) , where D = 0.078 m , L = 0.068 m
(s) η vol % = [(V_{act}1/ V_{th}) * 100]

10. OBSERVED READING

10.1 Diesel

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	70	5	109	17.3	16	0.013
2	1500	87	5	52.37	17.4	16	0.014
4	1500	107	5	40.34	17.4	16	0.014
6	1500	118	5	36.02	17.4	16	0.014

(5%TPO+95%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	57	5	103	17.5	16	0.015
2	1500	69	5	54.95	17.5	16	0.015
4	1500	88	5	44.70	17.4	16	0.014
6	1500	98	5	37.09	17.4	16	0.014

(10%TPO+90%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	52	5	54.62	17.4	15.9	0.014
2	1500	66	5	48.50	17.4	16	0.014
4	1500	82	5	41.70	17.3	15.9	0.014
6	1500	100	5	73.67	17	16.4	0.006

(15%TPO+85%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	58	5	102.30	17.4	15.9	0.015
2	1500	68	5	54.45	17.3	16	0.013
4	1500	81	5	42.55	17.3	16	0.013
6	1500	95	5	34.01	17.3	16	0.013

(20%TPO+80%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	47	5	103.36	17.4	16	0.014
2	1500	63	5	49.23	17.4	16	0.014
4	1500	77	5	41.04	17.3	16	0.013
6	1500	96	5	33.22	17.4	16	0.014

(25%TPO+75%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	47	5	103.96	17.4	16	0.014
2	1500	62	5	52.85	17.4	16	0.014
4	1500	76	5	43.54	17.4	16	0.014
6	1500	91	5	35.65	17.3	16	0.013

(30%TPO+70%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	45	5	57.05	17.4	15.9	0.015
2	1500	63	5	49.97	17.4	15.9	0.015
4	1500	78	5	39.66	17.3	16	0.013
6	1500	93	5	33.44	17.3	16	0.013

(35%TPO+65%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	44	5	55.37	17.4	16	0.014
2	1500	58	5	46.94	17.3	15.9	0.014
4	1500	73	5	42.64	17.3	15.9	0.014
6	1500	91	5	33.96	17.3	15.9	0.014

40%TPO+60%DIESEL)

LOAD(F) (kgf)	SPEED (rpm)	EXHAUST GAS TEMP.	VF(CM)	T(SEC)	h1	h2	(h1-h2) /100
0	1500	48	5	103.07	17.3	15.9	0.014
2	1500	63	5	51.19	17.3	15.9	0.014
4	1500	76	5	43.83	17.3	15.9	0.014

11. TABULATED RESULTS

DIESEL

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.31	20.129	0	0	0	36.59
2	0.6305	19.65	50.8	9.99	0.8579	37.91
4	0.95103	22.83	67.4	15.39	0.556	37.91
6	1.2715	27.25	75.61	20.64	0.4157	

(5%TPO+95%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.5	31.055	0	0	0	39.3
2	0.82	27.07	39.08	10.577	0.808	39.3
4	1.141	30.63	56.17	17.21	0.496	37.98
6	1.461	32.54	65.77	21.40	0.399	37.98

(10%TPO+90%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	1.6	52.98	0	0	0	39.3
2	1.92	56.45	16.66	9.407	0.9055	37.98
4	2.241	56.64	28.60	16.20	0.5265	37.98
6	2.561	52.26	37.52	19.61	0.435	24.867

(15%TPO+85%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.38	23.77	0	0	0	39.19
2	0.7005	23.33	45.71	20.02	0.797	36.4
4	1.021	26.58	62.78	21.35	0.509	36.4
6	1.3415	27.91	71.63	20	0.421	36.4

(20%TPO+80%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.3	19.23	0	0	0	37.4
2	0.6205	18.90	51.61	9.75	0.871	37.4
4	0.9413	23.88	68.11	16.25	0.522	36.0
6	1.2615	25.89	76.20	19.72	0.430	37.4

(25%TPO+75%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.33	21.42	0	0	0	37.4
2	0.6505	21.41	49.2	10.56	0.80	37.4
4	0.971	26.35	66	17.39	0.486	37.4
6	1.2915	28.71	74.43	21.37	0.396	36.0

(30%TPO+70%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	1.7	59.44	0	0	0	37.4
2	2.02	59.76	15.84	9.48	0.89	37.4
4	2.341	62.90	27.39	17.2	0.490	37.4
6	2.661	56.89	36.11	20.54	0.411	

(35%TPO+65%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.33	21.62	0	0	0	37.4
2	0.6505	21.17	49.2	10.43	0.807	37.4
4	0.971	27.10	66	17.89	0.471	37.4
6	1.2915	29.21	74.45	21.74	0.387	37.4

(40%TPO+60%DIESEL)

Load(F) (kgf)	Indicated power	Efficiency ith %	Efficiency mech %	Efficiency bth %	BSFC	Efficiency vol %
0	0.9	32.96	0	0	0	38.76
2	1.22	39.14	26.2	10.28	0.818	38.76
4	1.541	39.27	41.59	16.33	0.515	36.06
6	1.861	39.96	51.63	20.64	0.407	36.06

12. GRAPHICAL REPRESENTATION OF RESULTS

DIESEL

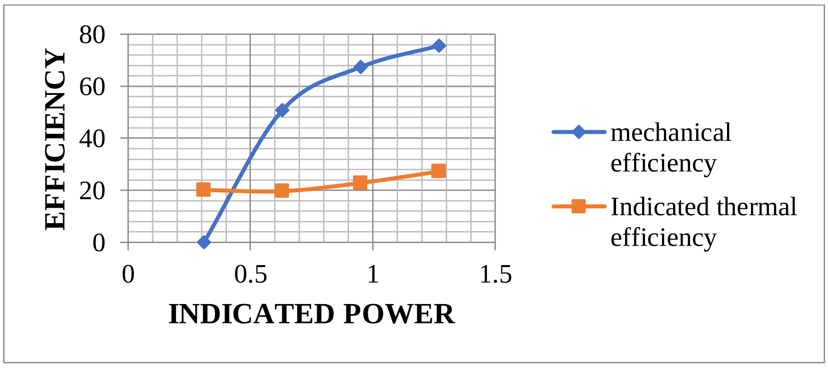

Fig. 4: Result 1

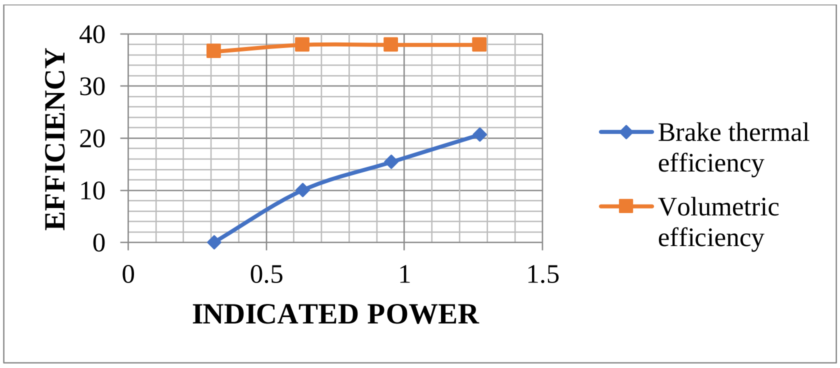

Fig. 5: Result 2

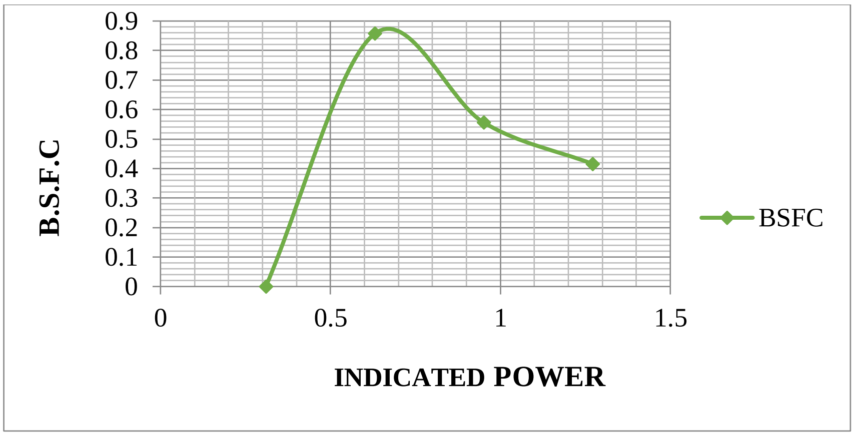

Fig. 6: Result 3

(5%TPO+95%DIESEL)

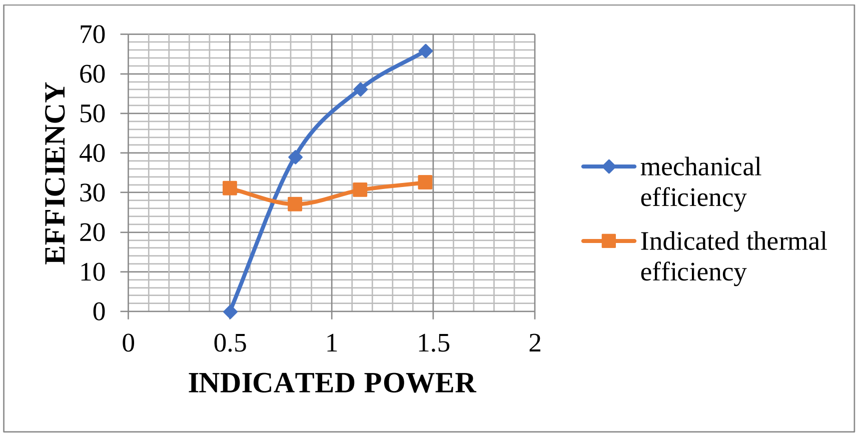

Fig. 7: Result 4

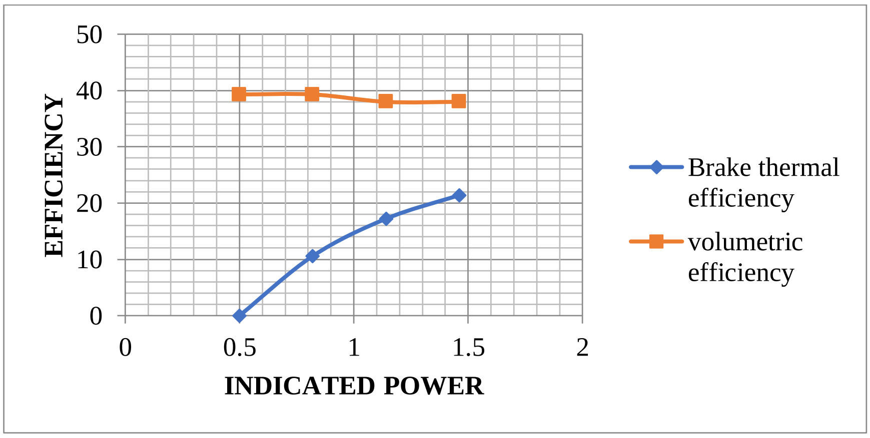

Fig. 8: Result 5

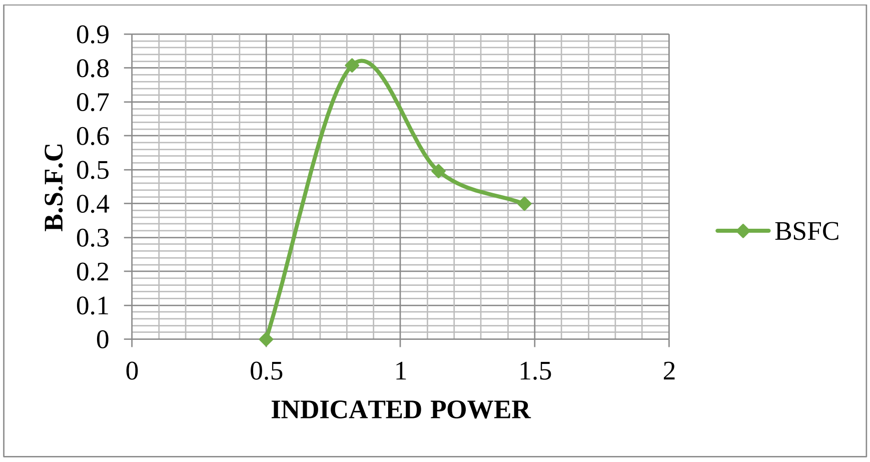

Fig. 9: Result 6

(10%TPO+90%DIESEL)

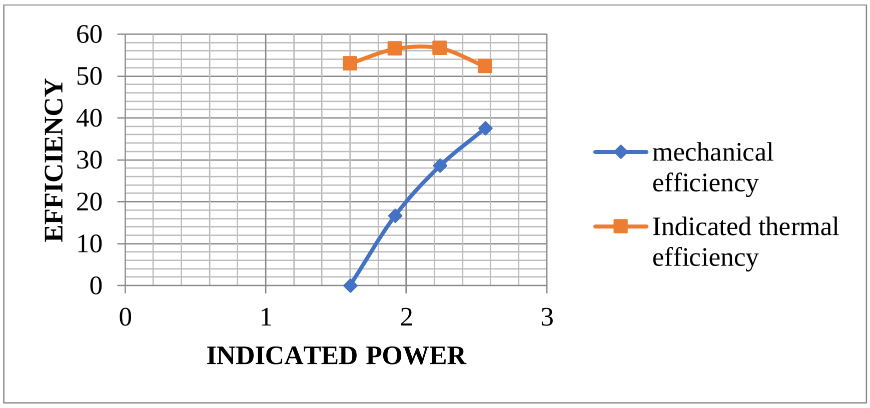

Fig. 10: Result 7

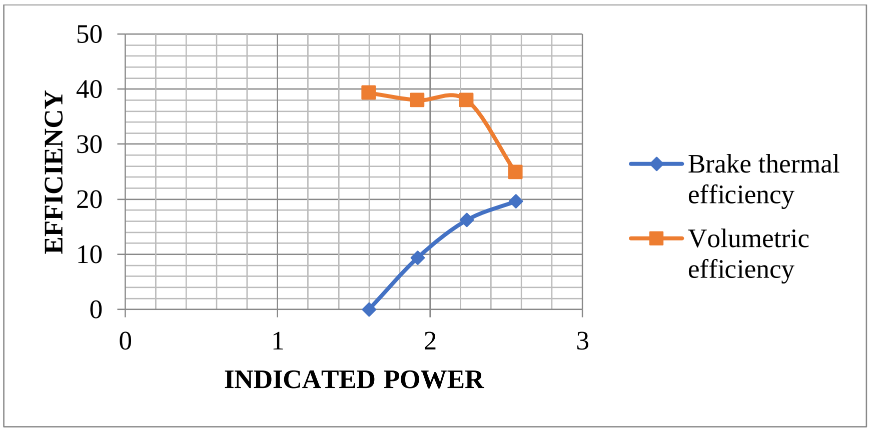

Fig. 11: Result 8

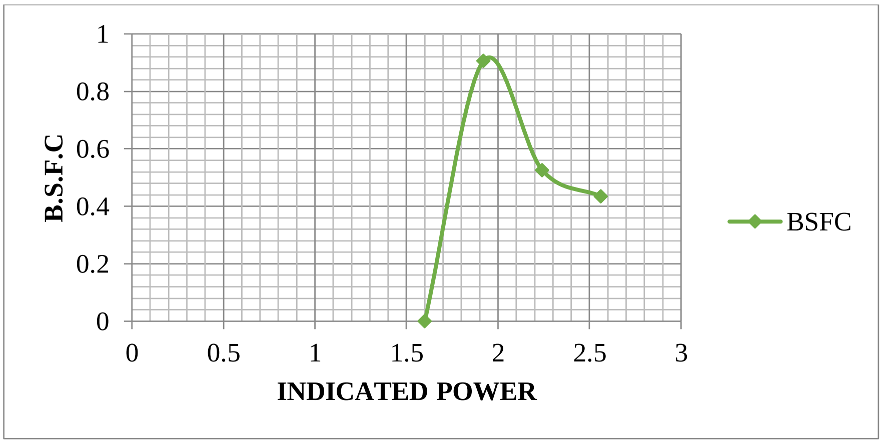

Fig. 12: Result 9

(15%TPO+85%DIESEL)

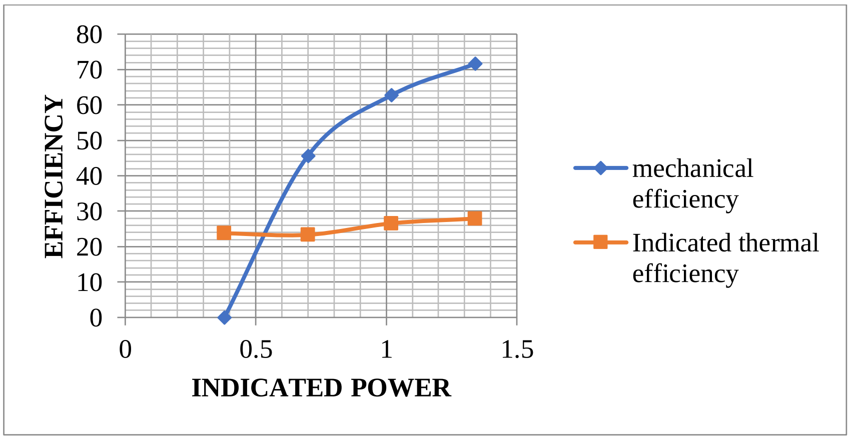

Fig. 13: Result 10

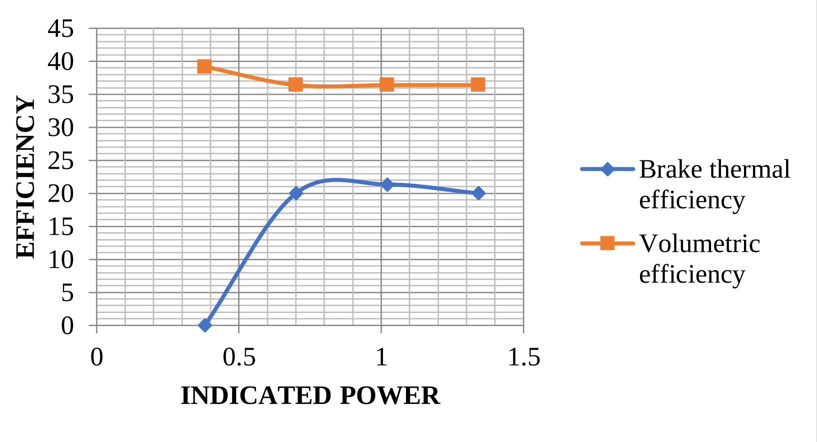

Fig. 14: Result 11

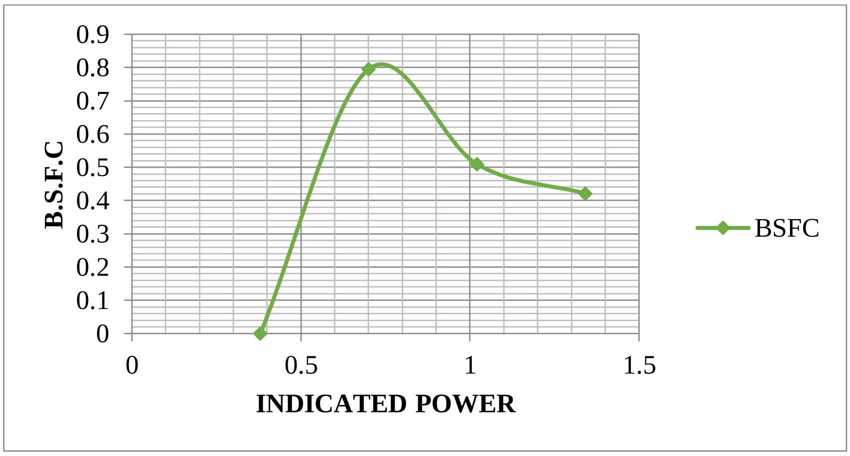

Fig. 15: Result 12

(20%TPO+80%DIESEL)

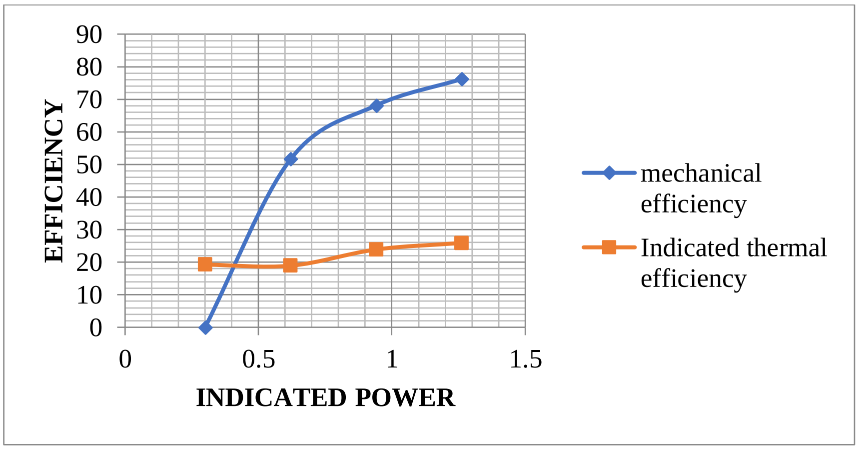

Fig. 16: Result 13

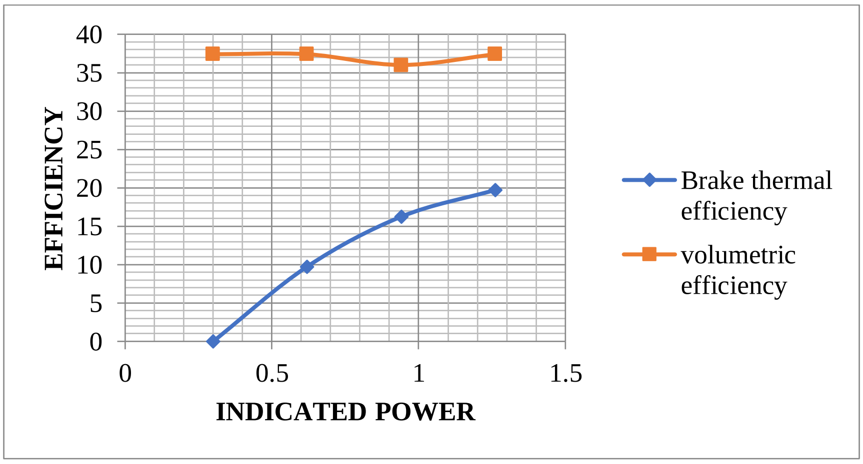

Fig. 17: Result 14

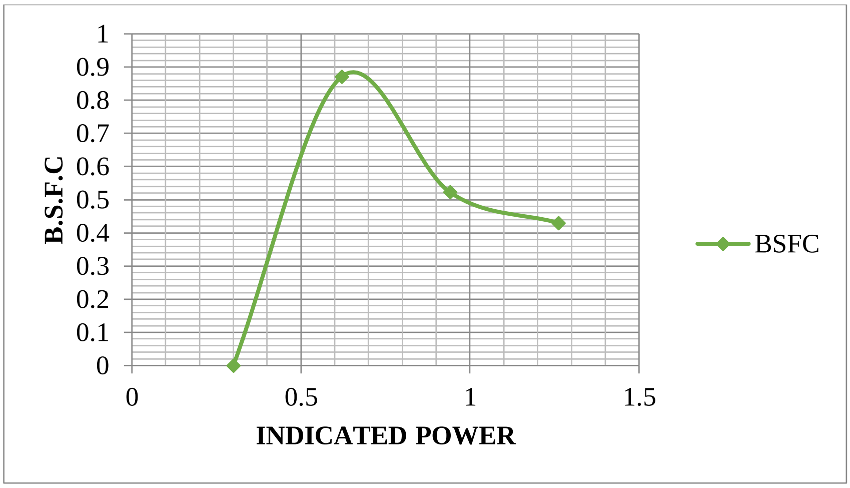

Fig. 18: Result 15

(25%TPO+75%DIESEL)

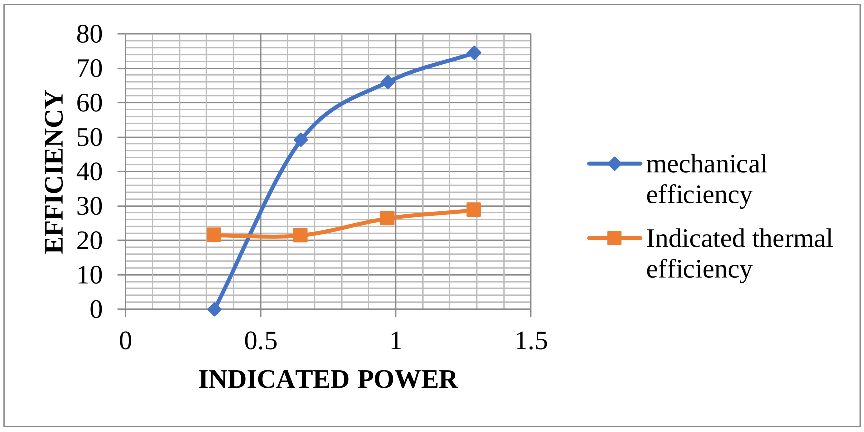

Fig. 19: Result 16

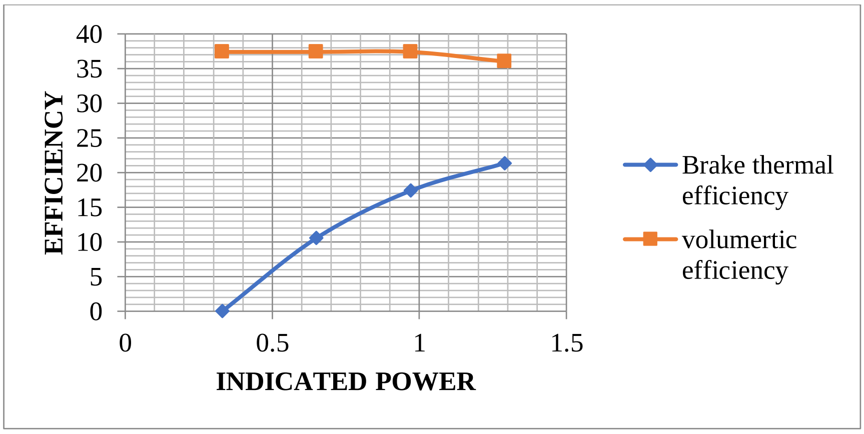

Fig. 20: Result 17

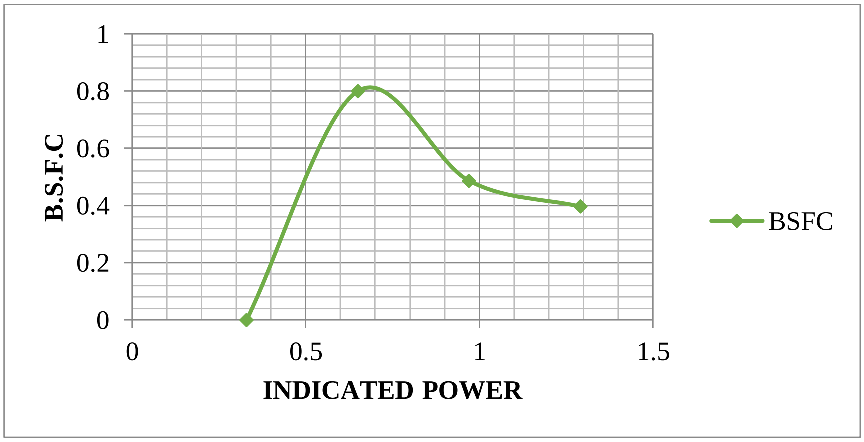

Fig. 21: Result 18

(30%TPO+70%DIESEL)

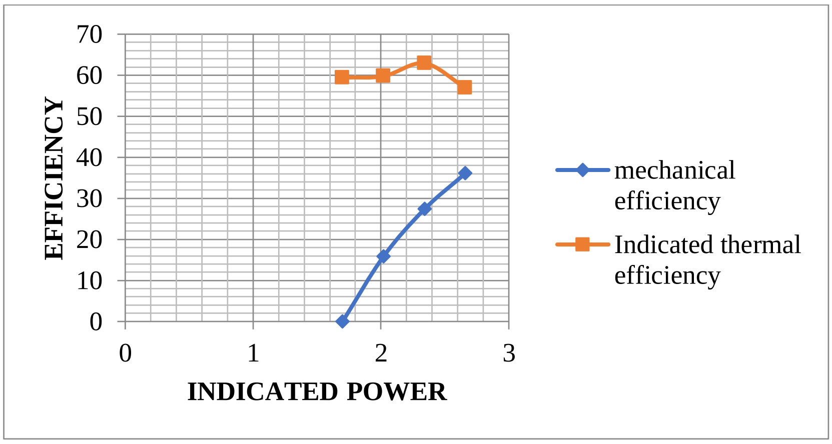

Fig. 22: Result 19

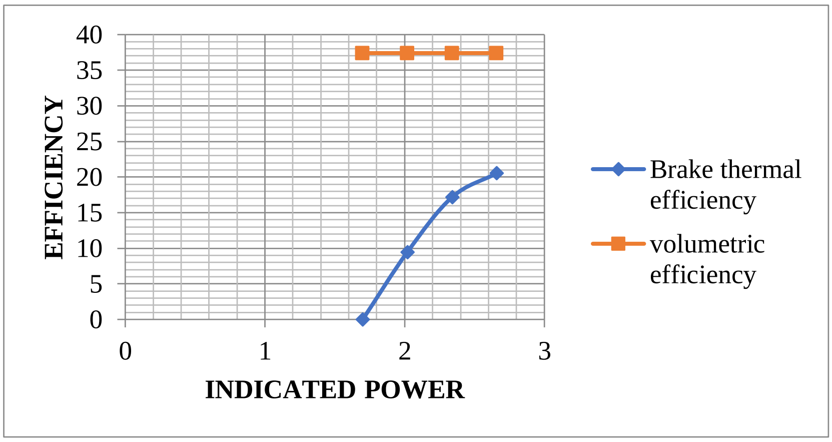

Fig. 23: Result 20

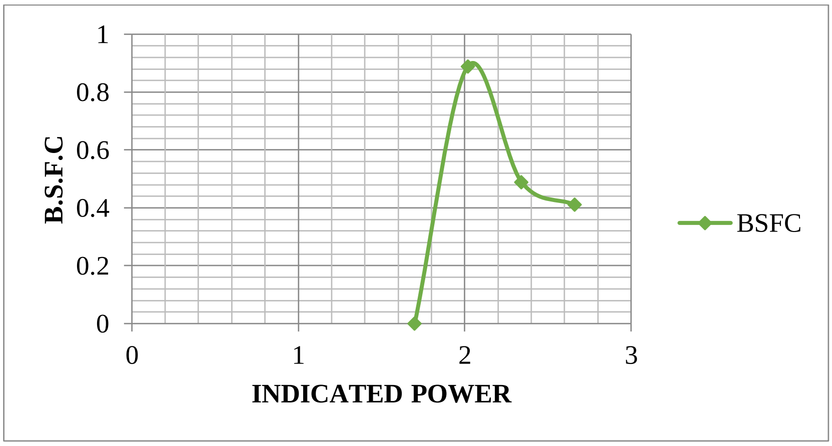

Fig. 24: Result 21

<u>(35%TPO+65%DIESEL)</u>

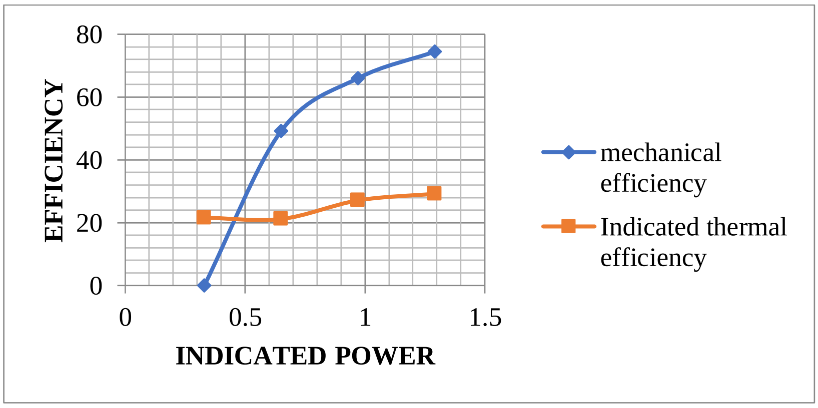

Fig. 25: Result 22

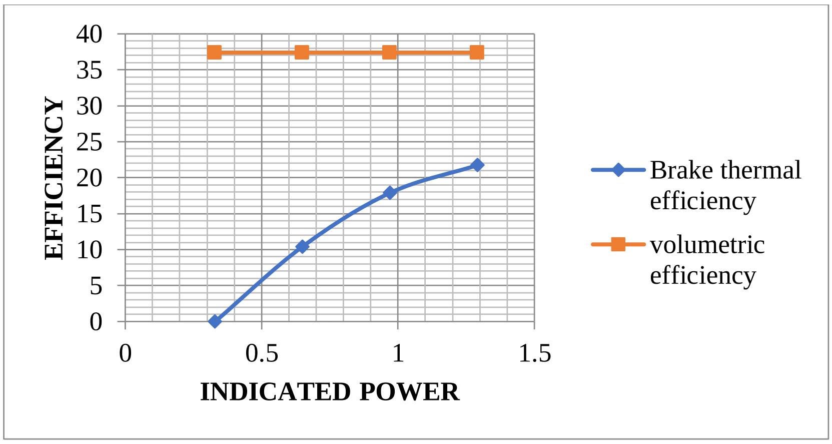

Fig. 26: Result 23

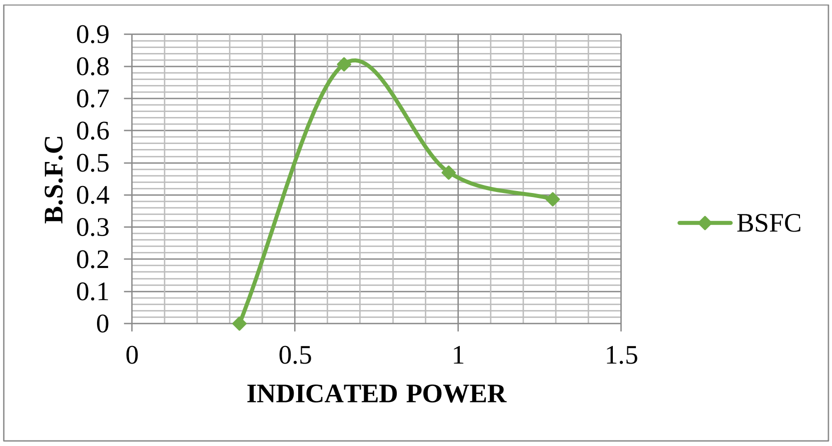

Fig. 27: Result 24

(40%TPO+60%DIESEL)

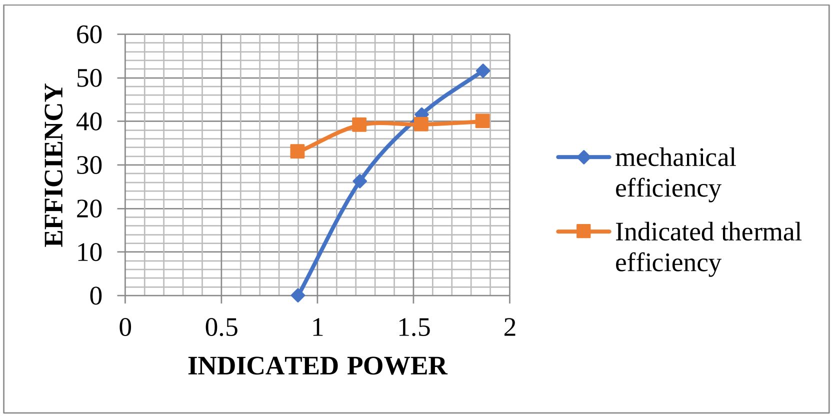

Fig. 28: Result 25

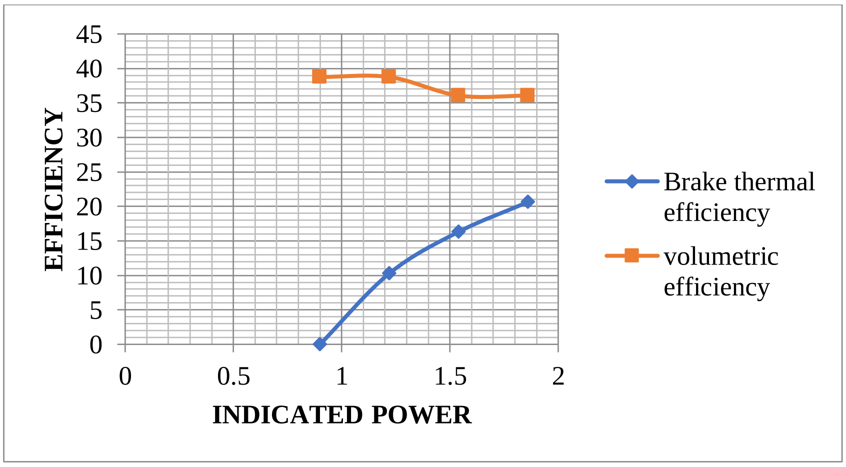

Fig. 29: Result 26

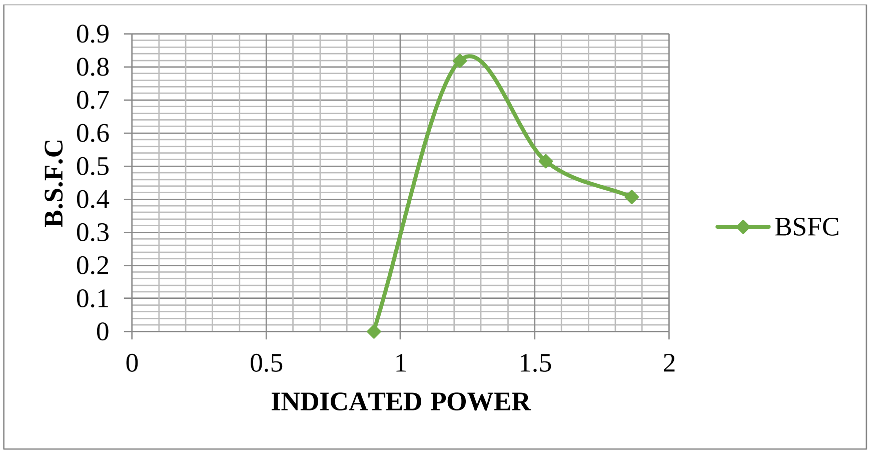

Fig. 30: Result 27

GRAPHICAL COMPARISION BETWEEN DIESEL AND DIFFERENT VOLUMETRIC COMPOSITIONS OF BLENDED TYRE OIL

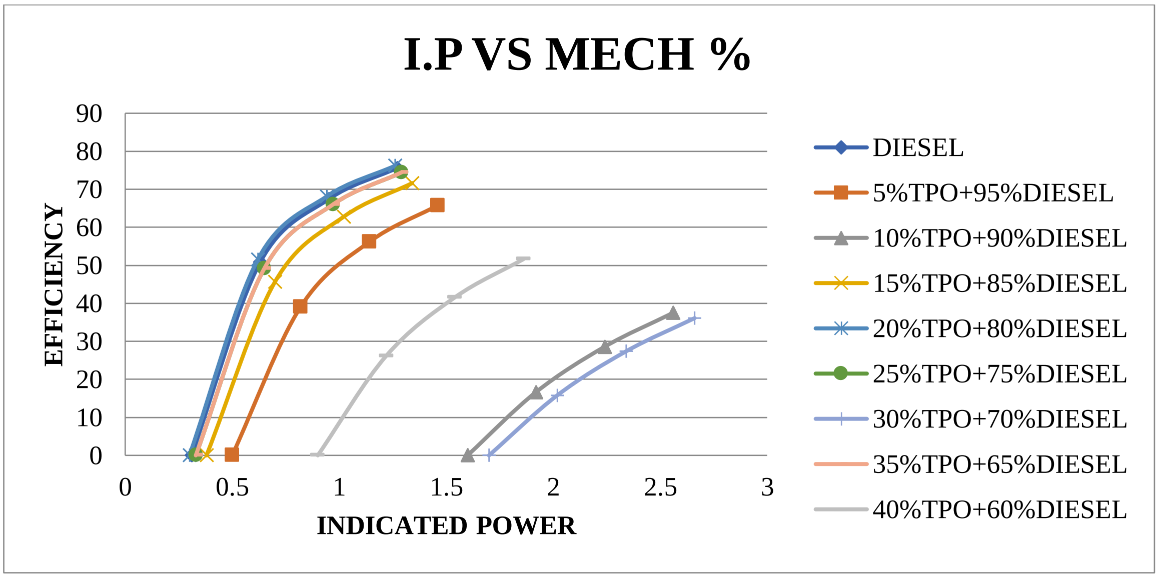

Fig. 31: I.P VS MECH %

The variation of mechanical efficiency with indicated power is shown in above figure 31 the plot it is revealed that as the load increases the mechanical efficiency increases. At full load condition the mechanical efficiency obtained are 75.61%, 65.77%, 37.52%,71.636%,76.20%,74.43%,36.11%,74.45%and51.63%.forfuelsofdiesel,TPO5,TP010,TPO15,TPO20,TPO25,TPO30,TPO35, PO40. The mechanical efficiency of tyre oil blend TP020 increased when compared to the diesel at full load condition.

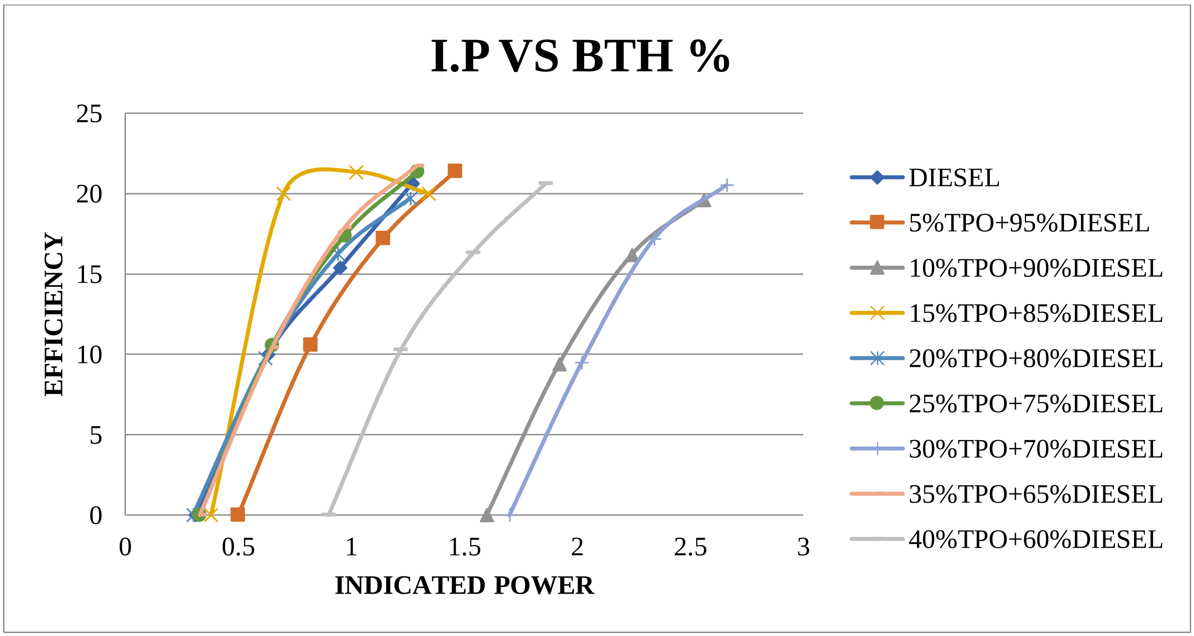

Fig. 32: I.P VS BTH %

The variation of brake thermal efficiency with indicated power is shown in figure 32 from the plot it is observed that as the load increases the brake thermal efficiency increases. At full load condition the brake thermal efficiency obtained are 20.64% ,21.40% ,19.61% ,20% ,19.72% ,21.37% ,20.54% ,21.74% and 20.64% for fuels of diesel, TPO5,TP010,TPO15,TPO20,TPO25,TP30 ,TPO35,TPO40. The brake thermal efficiency of tyre oil blend TPO35 increased when compared to the diesel at full load condition.

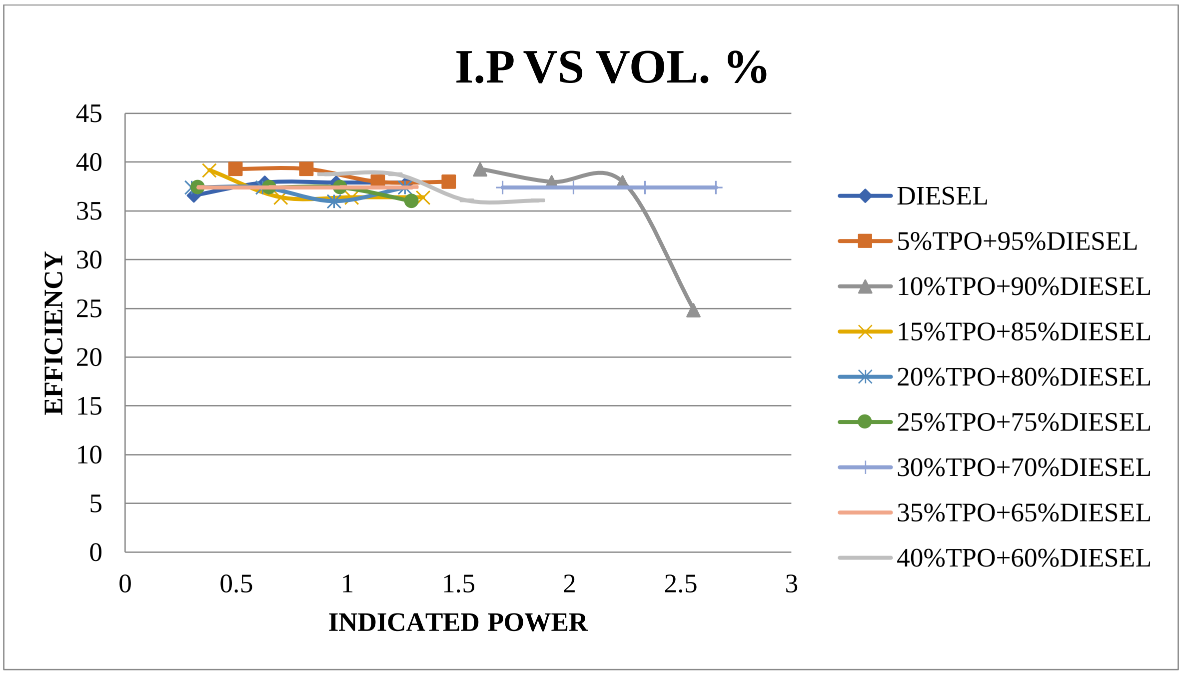

Fig. 33: I.P VS VOL. %

The variation of volumetric efficiency with indicated power is shown in figure 33 from the plot it is observed that as the load increases the brake thermal efficiency varies and at some loads, it is constant. At full load condition the volumetric efficiency obtained are 37.91% ,37.98% ,24.86% ,36.4% ,37.4% ,36% ,37.4% ,37.4% and 36.06% for fuels of diesel, TPO5, TP010, TPO15, TPO20, TPO25, TP30 ,TPO35,TPO40. The volumetric efficiency of tyre oil blend TPO5 increased when compared to the diesel at full load condition.

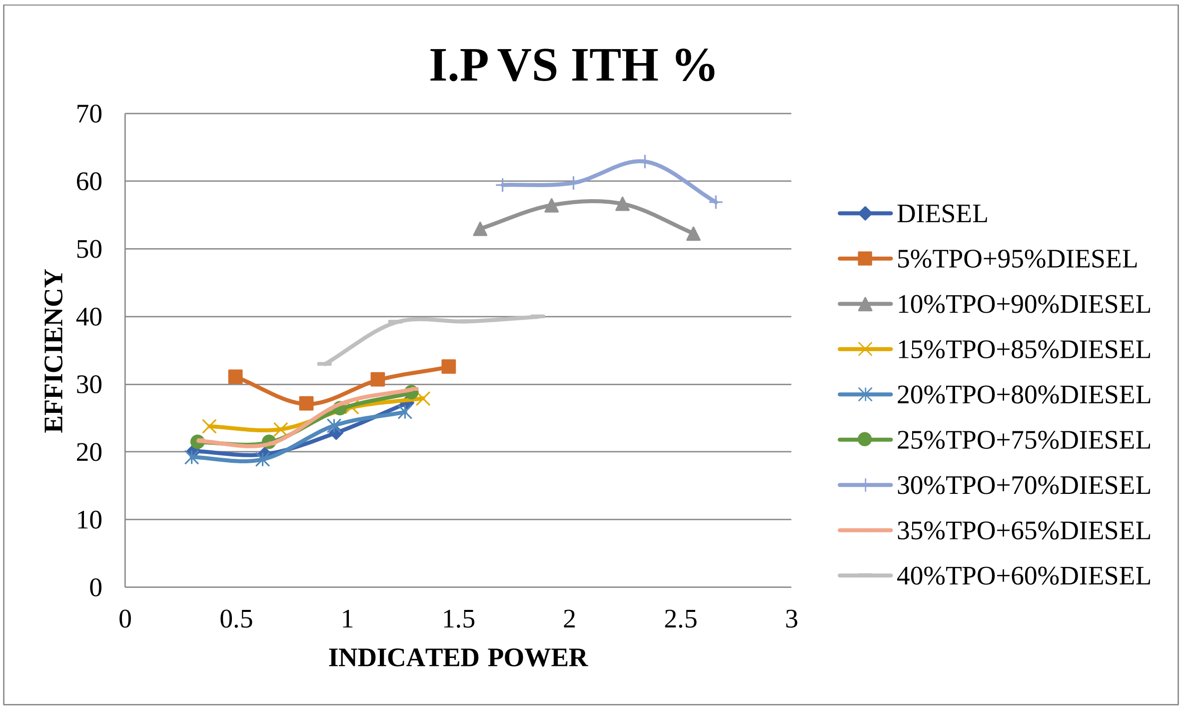

Fig. 34: I.P VS ITH %

The variation of indicated thermal efficiency with indicated power is shown in figure 34 from the plot it is observed that as the load increases the indicated thermal efficiency increases and at some loads, and decreases at some load. At full load condition the indicated thermal efficiency obtained are 27.25% ,32.54% ,52.26% ,27.91% ,25.89% ,28.71% ,56.89% ,29.21% and 39.96% for fuels of diesel, TPO5,TP010,TPO15,TPO20,TPO25,TP30 ,TPO35,TPO40. The indicated thermal efficiency of tyre oil blend TPO30 increased when compared to the diesel at full load condition.

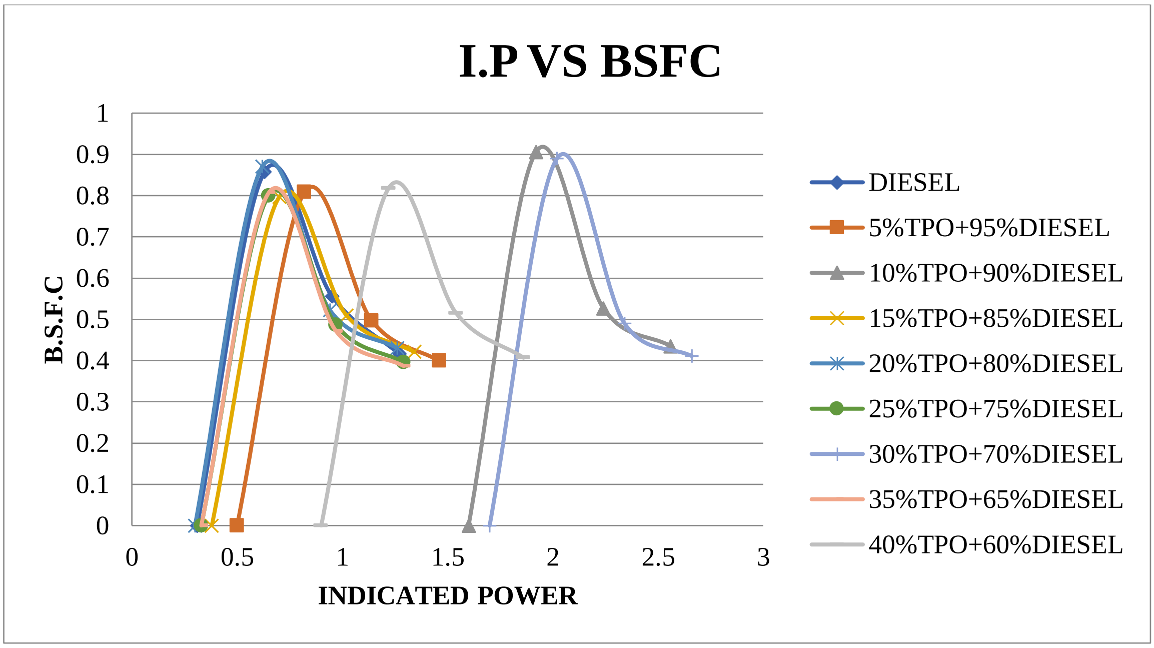

Fig. 35: I.P VS BSFC

The variation of brake specific fuel consumption with indicated power is shown in figure 35 from the plot it is observed that as the load increases the brake specific fuel consumption decreases. At full load condition the brake specific fuel consumption obtained are: 0.4157kg/kw-hr,0.399kg/kw-hr, 0.435kg/kw-hr ,0.421kg/kw-hr, 0.430kg/kw-hr, 0.396kg/kw-hr, 0.411kg/kw-hr,0.387kg/kw-hr and0.407kg/kw-hr and for fuelsofdiesel,TPO5,TP010,TPO15,TPO20,TPO25,TP30,TPO35,TPO40. The brake specific fuel consumption of tyre oil blends TPO35 decreases when compared to the diesel at full load condition.

14. CONCLUSION

The conclusions derived from present experimental investigations to evaluate performance and emission characteristics on four strokes single-cylinder diesel engine fueled with diesel TPO blends with Ethanol and EHN as additives are summarized as follows:

- Mechanical efficiency increased with all blends when compared to conventional diesel fuel.
- Brake thermal efficiency increased with all blends when compared to the conventional diesel fuel.
- The Brake specific fuel consumption is decreased with the blends when compared to diesel.
- CO, CO_2 and HC emissions will be decreased significantly with the blends when compared with diesel when additives like Ethanol and Isobutanol are added to the volumetric compositions.
- From the above analysis, the blend at (35%TPO+65%DIESEL) shows better performance compared to other blends with different volumetric composition.

15. REFERENCES

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