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Performance Characteristics of Variable Performance Compression Ratio Engine using Esterified Cotton Seed Oil

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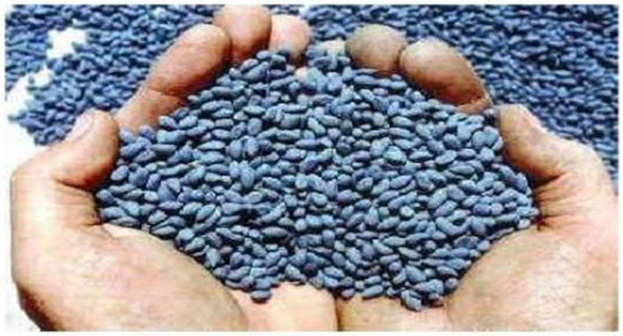
Abstract: Fast industrialization has resulted quick increment of prior conditions. High utilization of non-sustainable energy has wipen out oil resources. Pollution contamination of Diesel has impact to environment. To solve these issues wise thinking for elective assets is required. The fuel highlights as calorific value, cetane number and flashpoint properties are same as diesel fuel. The usage of diesel engine has been increased in agriculture and transport sector fields due to fuel economy and high output power. Even though bio fuel concept is old one, not a single vehicle using bio fuel is running on Indian higher output power, peak cylinder pressure, ability of cold starting with the fixed compression ratio diesel engines when fuelled with both bio fuels and conventional fuels. When cotton seed oil blends are used in VCR engine at high compression ratio gives short ignition delay, low rise in pressure, higher release of heat and vast decrease in mass fraction when burnt compared to that of diesel. Also it is seen maximum thermal efficiency. There is considerable reduction in smoke and NOx compared to diesel fuel. Crude oil which is main source for energy production resulting degradation of environment with fossil fuel combustion. The combustion products SO2, CO2 and NOx are causing global warming. Scarcity of crude oil deepened year by year. The alternative fuel like vegetable oil as source of energy has good attention. It is renewable, bio degradable, nontoxic in nature with best quality of emissions. Apart from cotton seed oil there are karanja, jatropha, palm oil, rubber seed, sunflower oil, rape seed oil, neem oil, LPG, CNG, bio gas can be used. When the vegetable oil undergoes a process called transesterification where triglyceride molecules break into methyl ester (bio diesel). The performance and emission of single cylinder four stroke variable compression ratio engine when supplied 20%, 40% and 60% cotton seed oil blended with diesel is compared with standard diesel from no load to different loading conditions 3, 6, 9 and 12kg. It has been seen that blends of methyl ester can be used as alternative fuel without modifying the engine. The experiment has been conducted with compression ratios of 13:1, 16:1, 18:1. The impact of compression ratio for fuel consumption, brake thermal efficiency and exhaust gas emission has been calculated. It is observed that higher compression ratio resulted high cylinder pressure and so improved combustion and high brake thermal efficiency and thus low specific fuel consumption. When compression ratio increased vibration and noise of the engine reduced. The experiment has been conducted at constant speed of 1500rpm. The unborn hydrocarbon, carbon dioxide and carbon monoxide emissions are reduced when compared to diesel at all loads with reduction in specific fuel consumption. The B20 blend at 18:1 compression ratio has better engine characteristics than diesel. From cotton seed oil we can obtain methyl ester upon trans esterification using methanol catalyst.

I. INTRODUCTION

In present situation there is severe scarcity of fuel. So slogans like “save oil” etc. are getting popularized. Not only scarcity the cost is also increasing regularly. Due to this, the country’s economy is also affected. The liquid petroleum fuel contributing high energy consumption due to their physiochemical and combustion properties causing pollution to environment. These fuels when burnt increase the level of CO_2 in atmosphere responsible for global warming. It is required to introduce alternate fuels to replace fossil fuels. Because the fossil fuels resources will be exhausted in few decades.

Basically vegetable oils are extracted from seeds which involve drying, grinding, steaming, air cooling and oil extraction by hydraulic press. It has been observed that lower blends of biodiesel increase brake thermal efficiency and decrease fuel consumption. Biodiesel can be mixed with diesel in any ratio and are sulphur free fuel. Biodiesel is known as mono alkyl esters of long chain fatty acids derived from vegetable oils and animal fats. The fuel derived from plants and organic waste is biodiesel which is methyl ester formed by the reaction of vegetable oil and alcohol in strong acid or base presence. The very first engine which is invented was destroyed to run on vegetable oil made from peanut in the year 1900. As the fossil fuel reserves were ample at that time. And also using vegetable oil directly in the engine caused problems like low fuel atomization and thickening of engine oil due to high viscosity. To overcome with high viscosity problem, there are four processes viz. dilution with diesel fuel, micro emulsification, pyrolysis and trasesterification. Out of these transesterification is very common which is the process of formation of bio diesel from vegetable oil. Our country imports petroleum of cost Rs.8,00,000 million per year. So mixing of at least 5% bio diesel to diesel can save Rs. 40,000 million per year.



Cotton seed

Properties of 100% pure Cottonseed oil Biodiesel

Sr. No.	Test Parameters of Pure cottonseed oil biodiesel	Units	Results	Test Standards
1	Kinematic Viscosity@40° C	cSt	7.5	IS 1448 (Part I) (P-25)
2	Density	kg/m³	904.8	IS 1448 (Part I) (P-16)
3	Fire Point	° C	190	IS 1448 (P-20)
4	Pour Point	° C	-15	IS 1448 (Part I) (P-10)
5	Cloud Point	° C	-17	IS 1448 (Part I) (P-10)
6	Flash Point	° C	142	IS 1448 (P-69)
7	Calorific Value	kJ/kg	36802	IS 1448 Bomb Calorimeter

Thermo-physical properties of Cottonseed oil biodiesel/diesel blends

Fuel	Calorific Value kJ/kg	Kinematic viscosity cSt	Cloud point °C	Pour point °C	Density Kg/m³
C100	36802	7.5	-17	-15	904.8
Diesel	43851	2.5	-23	-21	817.4
C20D80	43221	2.8	-22	-18	850.1
C40D60	42298	2.8	-21	-18	865.6
C60D40	40911	5.3	-19	-16	878.1
C80D20	39658	5.9	-18	-15	891.5
C20D75E5	39761	2.6	-24	-20	842.9

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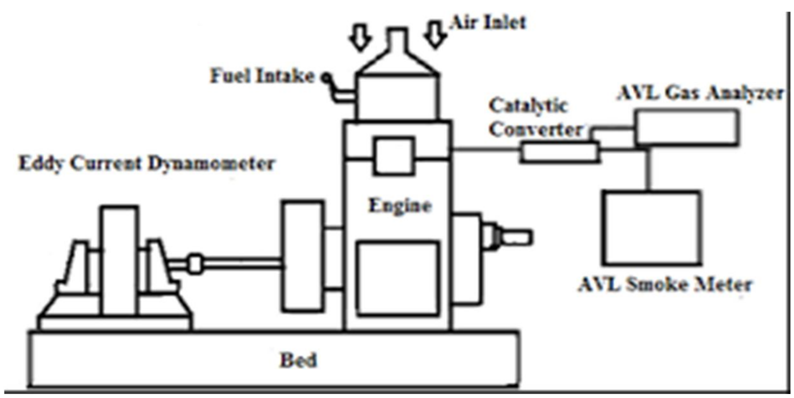

Properties of Diesel and Crude Oils

S.NO	PROPERTY	DIESEL	COTTONSEED	NEEMSEED
1	Calorific Value	43,000 kJ/kg	39,648kJ/kg	35,125 kJ/kg
2	Flash Point	44^0 C	234^0C	178^0C
3	Fire Point	49^0 C	192^0 C	209^0 C
4	Viscosity	0.278 poise	2.52 poise	1.864 poise
5	Density	835 kg/m^3	850 kg/m^3	928 kg/m^3

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100% DIESEL

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	27	25	28	127	103	20	13:01
2	1500	3	35	60	28	29	30	217	179	31	13:01
3	1500	6	35	60	28	30	31	246	205	21	13:01
4	1500	9	35	60	28	30	31	281	237	21	13:01
5	1500	12	35	60	28	30	32	322	278	17	13:01

T = TIME FOR 10CC OF FUEL CONSUMPTION

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	28	30	31	214	198	44	16:01
2	1500	3	35	60	29	30	32	230	212	40	16:01
3	1500	6	35	60	29	31	32	265	241	28	16:01
4	1500	9	35	60	29	32	33	328	299	20	16:01
5	1500	12	35	60	29	33	34	353	322	15	16:01

T = TIME FOR 10CC OF FUEL CONSUMPTION

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	31	32	33	137	131	38	18:01
2	1500	3	35	60	31	33	34	186	181	33	18:01
3	1500	6	35	60	31	33	34	220	222	25	18:01
4	1500	9	35	60	31	33	35	266	274	19	18:01
5	1500	12	35	60	31	34	36	319	329	15	18:01

T = TIME FOR 10CC OF FUEL CONSUMPTION

COTTON SEED OIL 20%

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	31	32	32	158	128	19	13:01
2	1500	3	35	60	31	32	33	202	164	19	13:01
3	1500	6	35	60	31	33	33	246	200	20	13:01
4	1500	9	35	60	31	34	34	267	224	18	13:01
5	1500	12	35	60	30	33	34	286	245	14	13:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	207	191	38	16:01
2	1500	3	35	60	30	33	33	218	202	29	16:01
3	1500	6	35	60	30	32	34	238	219	22	16:01
4	1500	9	35	60	30	33	34	259	238	18	16:01
5	1500	12	35	60	30	33	35	286	261	14	16:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	217	211	41	18:01
2	1500	3	35	60	30	33	34	227	219	32	18:01
3	1500	6	35	60	30	33	34	257	242	23	18:01
4	1500	9	35	60	30	33	34	277	263	17	18:01
5	1500	12	35	60	30	34	35	302	284	13	18:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

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COTTON SEED OIL 40%

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	31	32	32	158	128	19	13:01
2	1500	3	35	60	31	32	33	202	164	19	13:01
3	1500	6	35	60	31	33	33	246	200	20	13:01
4	1500	9	35	60	31	34	34	267	224	18	13:01
5	1500	12	35	60	30	33	34	286	245	14	13:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	207	191	38	16:01
2	1500	3	35	60	30	33	33	218	202	29	16:01
3	1500	6	35	60	30	32	34	238	219	22	16:01
4	1500	9	35	60	30	33	34	259	238	18	16:01
5	1500	12	35	60	30	33	35	286	261	14	16:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	217	211	41	18:01
2	1500	3	35	60	30	33	34	227	219	32	18:01
3	1500	6	35	60	30	33	34	257	242	23	18:01
4	1500	9	35	60	30	33	34	277	263	17	18:01
5	1500	12	35	60	30	34	35	302	284	13	18:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

COTTON SEED OIL 60%

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	31	32	32	158	128	19	13:01
2	1500	3	35	60	31	32	33	202	164	19	13:01
3	1500	6	35	60	31	33	33	246	200	20	13:01
4	1500	9	35	60	31	34	34	267	224	18	13:01
5	1500	12	35	60	30	33	34	286	245	14	13:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	207	191	38	16:01
2	1500	3	35	60	30	33	33	218	202	29	16:01
3	1500	6	35	60	30	32	34	238	219	22	16:01
4	1500	9	35	60	30	33	34	259	238	18	16:01
5	1500	12	35	60	30	33	35	286	261	14	16:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

S.NO.	N	LOAD	MANOMETER		TEMPERATURE in °C						
	in RPM	in KG	H1	H2	T1	T2	T3	T4	T5	T	C.R.
1	1500	0	35	60	30	33	33	217	211	41	18:01
2	1500	3	35	60	30	33	34	227	219	32	18:01
3	1500	6	35	60	30	33	34	257	242	23	18:01
4	1500	9	35	60	30	33	34	277	263	17	18:01
5	1500	12	35	60	30	34	35	302	284	13	18:01

T is TIME FOR 10CC OF FUEL CONSUMPTION in SECONDS

II. CALCULATIONS

A. 100% Diesel,CR 13 : 1, time 17sec, 10cc fuel, h1 & h2 = 35 & 60 for load 12kg, speed 1500 rpm.

1) B.P. $= \frac{2\pi\ NT}{60\times1000} = \frac{2\times\pi\times1500\times(12\times0.15\times9.81)}{60\times1000} = 2.7737$ kw

where B.P. is brake power

N is speed in rpm

T is torque .

2) mfc $= \frac{\rho\times\text{vol. of fuel}\times3600}{t} = \frac{820\times10\times10^{-6}\times3600}{17} = 1.7364$ kg/hr.

where mfc is mass of fuel consumption.

ρ is density of fuel.

ρ of Diesel 820 kg/m^3. ρ of Cotton seed oil 917 kg/m^3

ρ of 20% blend (C20D80) is 0.2 × 917 + 0.8 × 820 = 839 kg/m^3

ρ of 40% blend (C40D60) is 0.4 × 917 + 0.6 × 820 = 859 kg/m^3

ρ of 60% blend (C60D40) is 0.6 × 917 + 0. 4× 820 = 878 kg/m^3

t is time taken in seconds.

3) Bsfc $= \frac{mfc}{BP} = \frac{1.7364}{2.7737} = 0.626$ kg/kw-hr

where Bsfc is Brake thermal specific fuel consumption.

4) Bsec $= \frac{mfc\times C.V.}{B.P.}$ kj/kw-hr $= \frac{0.626\times44200}{2.7737} = 99.76$ kj/kw-hr

where Bsec is Brake thermal specific energy consumption

C.V. is Calorific Value.

C.V. for Diesel 44200 kj/kg. C.V. for Cotton seed oil 39800 kj/kg.

20% blend (C20D80) = 0.2 × 39800 + 0.8 × 44200 = 43320 kj/kg

40% blend (C40D60) = 0.4 × 39800 + 0.6 × 44200 = 42440 kj/kg

60% blend (C60D40) = 0.6 × 39800 + 0.4 × 44200 = 41560 kj/kg

5) η_v Volumetric efficiency $\eta_v = \frac{V_a}{V_s} \times 100$ %

$V_a = C_d \times A\sqrt{2GH} \times 3600$ m^3/hr.

$= 0.62 \times \pi\frac{(0.02)^2}{4}\sqrt{2\times9.81\times20.96} \times3600 = 14.22$m^3/hr.

where V_a is actual volume of air sucked into the cylinder.

C_d is coefficient of discharge.

$H = \frac{h}{1000} \times \frac{\rho_w}{\rho_a}$ where $h = h_2 - h_1 = 60 - 35 = 25$.

$H = \frac{25}{1000} \times \frac{1000}{1.193} = 20.96$

$V_s = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60$

$= \frac{\pi(0.08)^2}{4} \times 0.11 \times \frac{1500}{2} \times 60 = 25.22$ m^3/hr.

where V_s is swept volume d is diameter of the orifice. L is length

$\eta_v = \frac{V_a}{V_s} \times 100 = \frac{14.22}{24.88} \times 100 = 57.2$ %

6) η_{bth} Brake Thermal efficiency (or overall efficiency) $\eta_{bth} = \frac{B.P.\times3600}{mfc\times C.V.} \times100$ %

$= \frac{2.7737\times3600}{1.7364\times44200} \times100 = 13$ %

B. 100% Diesel, CR 13 : 1, time taken 31sec, volume of fuel 10cc,h1 & h2 = 35 & 60, load applied 3kg, speed 1500 rpm.

1) B.P. $= \frac{2\pi\ NT}{60\times1000} = \frac{2\times\pi\times1500\times(3\times0.15\times9.81)}{60\times1000} = 0.69$ kw

where B.P. is brake power

N is speed in rpm

T is torque .

2) mfc = $\frac{\rho \times \text{vol. of fuel} \times 3600}{t} = \frac{820 \times 10 \times 10^{-6} \times 3600}{31}$ = 0.95 kg/hr.

where mfc is mass of fuel consumption.

ρ is density of fuel.

ρ of Diesel 820 kg/m^3. ρ of Cotton seed oil 917 kg/m^3

ρ of 20% blend (C20D80) is 0.2 × 917 + 0.8 × 820 = 839 kg/m^3

ρ of 40% blend (C40D60) is 0.4 × 917 + 0.6 × 820 = 859 kg/m^3

ρ of 60% blend (C60D40) is 0.6 × 917 + 0. 4× 820 = 878 kg/m^3

t is time taken in seconds.

3) Bsfc = $\frac{mfc}{BP} = \frac{0.95}{0.69}$ = 1.37 kg/kw-hr

where Bsfc is Brake thermal specific fuel consumption.

4) Bsec = $\frac{mfc \times C.V.}{B.P.}$ kj/kw-hr = $\frac{0.95 \times 44200}{0.69}$ = 60698 kj/kw-hr

where Bsec is Brake thermal specific energy consumption

C.V. is Calorific Value.

C.V. for Diesel 44200 kj/kg. C.V. for Cotton seed oil 39800 kj/kg.

20% blend (C20D80) = 0.2 × 39800 + 0.8 × 44200 = 43320 kj/kg

40% blend (C40D60) = 0.4 × 39800 + 0.6 × 44200 = 42440 kj/kg

60% blend (C60D40) = 0.6 × 39800 + 0.4 × 44200 = 41560 kj/kg

5) η_v Volumetric efficiency $\eta_v = \frac{V_a}{V_s} \times 100$ %

$V_a = C_d \times A\sqrt{2GH} \times 3600$ m^3/hr.

$= 0.62 \times \pi \frac{(0.02)^2}{4} \sqrt{2 \times 9.81 \times 20.96} \times 3600$ = 14.22m^3/hr.

where V_a is actual volume of air sucked into the cylinder.

C_d is coefficient of discharge.

$H = \frac{h}{1000} \times \frac{\rho_w}{\rho_a}$ where $h = h_2 - h_1$= 60 - 35 = 25.

$H = \frac{25}{1000} \times \frac{1000}{1.193} = 20.96$

$V_s = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60$

$= \frac{\pi (0.08)^2}{4} \times 0.11 \times \frac{1500}{2} \times 60$ = 25.22 m^3/hr.

where V_s is swept volume d is diameter of the orifice. L is length.

$\eta_v = \frac{V_a}{V_s} \times 100 = \frac{14.22}{24.88} \times 100$ = 57.2 %

6) η_{bth} Brake Thermal efficiency (overall efficiency)

$= \frac{B.P. \times 3600}{mfc \times C.V.} \times 100$ % $= \frac{0.69 \times 3600}{0.95 \times 44200} \times 100$ = 5.93 %

C. 20%blend (C20D80), CR 13:1, time 19sec, 10cc fuel, h1 & h2 = 35 & 60 for load 3kg, speed 1500 rpm.

1) B.P. = $\frac{2\pi NT}{60 \times 1000} = \frac{2 \times \pi \times 1500 \times (3 \times 0.15 \times 9.81)}{60 \times 1000}$ = 0.693 kw

where B.P. is brake power

N is speed in rpm

T is torque .

2) mfc = $\frac{\rho \times \text{vol. of fuel} \times 3600}{t} = \frac{839 \times 10 \times 10^{-6} \times 3600}{19}$ = 1.59 kg/hr.

where mfc is mass of fuel consumption.

ρ is density of fuel.

ρ of Diesel 820 kg/m^3. ρ of Cotton seed oil 917 kg/m^3

ρ of 20% blend (C20D80) is 0.2 × 917 + 0.8 × 820 = 839 kg/m^3

ρ of 40% blend (C40D60) is 0.4 × 917 + 0.6 × 820 = 859 kg/m^3

ρ of 60% blend (C60D40) is 0.6 × 917 + 0.4× 820 = 878 kg/m^3
t is time taken in seconds.

3) Bsfc = $\frac{mfc}{BP} = \frac{1.59}{0.69}$ = 2.3 kg/kw-hr

where Bsfc is Brake thermal specific fuel consumption.

4) Bsec = $\frac{mfc \times C.V.}{B.P.}$ kj/kw-hr

$= \frac{1.59 \times 43320}{0.69}$ = 99824 kj/kw-hr

where Bsec is Brake thermal specific energy consumption
C.V. is Calorific Value.
C.V. for Diesel 44200 kj/kg C.V. for Cotton seed oil 39800 kj/kg
20% blend (C20D80) = 0.2 × 39800 + 0.8 × 44200 = 43320 kj/kg
40% blend (C40D60) = 0.4 × 39800 + 0.6 × 44200 = 42440 kj/kg
60% blend (C60D40) = 0.6 × 39800 + 0.4 × 44200 = 41560 kj/kg

5) η_v Volumetric efficiency $\eta_v = \frac{V_a}{V_s} \times 100$ %

$V_a = C_d \times A\sqrt{2GH} \times 3600\ m^3$/hr.

$= 0.62 \times \pi\frac{(0.02)^2}{4}\sqrt{2 \times 9.81 \times 20.96} \times 3600 = 14.22 m^3$/hr.

where V_a is actual volume of air sucked into the cylinder.
C_d is coefficient of discharge.

$H = \frac{h}{1000} \times \frac{\rho_w}{\rho_a}$ where $h = h_2 - h_1 = 60 - 35 = 25$.

$H = \frac{25}{1000} \times \frac{1000}{1.193} = 20.96$

$V_s = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60$

$= \frac{\pi (0.08)^2}{4} \times 0.11 \times \frac{1500}{2} \times 60 = 25.22\ m^3$/hr.

where V_s is swept volume d is diameter of the orifice L is length.

$\eta_v = \frac{V_a}{V_s} \times 100 = \frac{14.22}{24.88} \times 100 = 57.2$ %

6) η_{bth} Brake Thermal efficiency (or overall efficiency) $\eta_{bth} = \frac{B.P. \times 3600}{mfc \times C.V.} \times 100$ %

$= \frac{0.69 \times 3600}{1.59 \times 43320} \times 100$ = 3.6 %

D. 40%blend (C40D60),CR 13:1,time taken 23sec, volume of fuel 10cc,h1 & h2 = 35 & 60,applied load 3kg, N = 1500 rpm.

1) B.P. $= \frac{2\pi NT}{60 \times 1000} = \frac{2 \times \pi \times 1500 \times (3 \times 0.15 \times 9.81)}{60 \times 1000}$ = 0.693 kw

where B.P. is brake power
N is speed in rpm
T is torque .

2) mfc = $\frac{\rho \times vol.\ of\ fuel \times 3600}{t} = \frac{859 \times 10 \times 10^{-6} \times 3600}{23}$ = 1.3 kg/hr.

where mfc is mass of fuel consumption.
ρ is density of fuel.
ρ of Diesel 820 kg/m^3. ρ of Cotton seed oil 917 kg/m^3
ρ of 20% blend (C20D80) is 0.2 × 917 + 0.8 × 820 = 839 kg/m^3
ρ of 40% blend (C40D60) is 0.4 × 917 + 0.6 × 820 = 859 kg/m^3
ρ of 60% blend (C60D40) is 0.6 × 917 + 0.4× 820 = 878 kg/m^3
t is time taken in seconds.

3) Bsfc = $\frac{mfc}{BP} = \frac{1.3}{0.69}$ = 1.94 kg/kw-hr

where Bsfc is Brake thermal specific fuel consumption.

4) Bsec = $\frac{mfc \times C.V.}{B.P.}$ kj/kw-hr

= $\frac{1.3 \times 42440}{0.69}$ = 82289 kj/kw-hr

where Bsec is Brake thermal specific energy consumption

C.V. is Calorific Value.

C.V. for Diesel 44200 kj/kg   C.V. for Cotton seed oil 39800 kj/kg

20% blend (C20D80) = 0.2 × 39800 + 0.8 × 44200 = 43320 kj/kg

40% blend (C40D60) = 0.4 × 39800 + 0.6 × 44200 = 42440 kj/kg

60% blend (C60D40) = 0.6 × 39800 + 0.4 × 44200 = 41560 kj/kg

5) η_v Volumetric efficiency $\eta_v = \frac{V_a}{V_s} \times 100$ %

$V_a = C_d \times A\sqrt{2GH} \times 3600$ m^3/hr.

$= 0.62 \times \pi\frac{(0.02)^2}{4}\sqrt{2 \times 9.81 \times 20.96} \times 3600 = 14.22 m^3$/hr.

where V_a is actual volume of air sucked into the cylinder.

C_d is coefficient of discharge.

$H = \frac{h}{1000} \times \frac{\rho_w}{\rho_a}$ where $h = h_2 - h_1$= 60 - 35 = 25.

$H = \frac{25}{1000} \times \frac{1000}{1.193}$ = 20.96

$V_s = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60$

$= \frac{\pi(0.08)^2}{4} \times 0.11 \times \frac{1500}{2} \times 60 = 25.22$ m^3/hr.

where V_s is swept volume   d is diameter of the orifice   L is length.

$\eta_v = \frac{V_a}{V_s} \times 100 = \frac{14.22}{24.88} \times 100 = 57.2$ %

6) η_{bth} Brake Thermal efficiency (or overall efficiency)

$= \frac{B.P. \times 3600}{mfc \times C.V.} \times 100$ % $= \frac{0.69 \times 3600}{1.3 \times 42440} \times 100$ = 4.37 %

E. <u>60%blend (C60D40), CR 13:1, time taken 17sec, volume of fuel 10cc,h1 & h2 = 35 & 60, applied load 3kg, N = 1500 rpm.</u>

1) B.P. = $\frac{2\pi NT}{60 \times 1000} = \frac{2 \times \pi \times 1500 \times (3 \times 0.15 \times 9.81)}{60 \times 1000}$ = 0.693 kw

where B.P. is brake power

N is speed in rpm

T is torque .

2) mfc = $\frac{\rho \times vol.\ of\ fuel \times 3600}{t} = \frac{878 \times 10 \times 10^{-6} \times 3600}{17}$ = 1.86 kg/hr.

where mfc is mass of fuel consumption.

ρ is density of fuel.

ρ of Diesel 820 kg/m^3.   ρ of Cotton seed oil 917 kg/m^3

ρ of 20% blend (C20D80) is 0.2 × 917 + 0.8 × 820 = 839 kg/m^3

ρ of 40% blend (C40D60) is 0.4 × 917 + 0.6 × 820 = 859 kg/m^3

ρ of 60% blend (C60D40) is 0.6 × 917 + 0. 4× 820 = 878 kg/m^3

t is time taken in seconds.

3) Bsfc = $\frac{mfc}{BP} = \frac{1.86}{0.69}$ = 1.88 kg/kw-hr

where Bsfc is Brake thermal specific fuel consumption.

4) Bsec = $\frac{mfc \times C.V.}{B.P.}$ kj/kw-hr

= $\frac{1.86 \times 42440}{0.69}$ = 111435 kj/kw-hr

where Bsec is Brake thermal specific energy consumption

C.V. is Calorific Value.

C.V. for Diesel 44200 kj/kg   C.V. for Cotton seed oil 39800 kj/kg

20% blend (C20D80) = 0.2 × 39800 + 0.8 × 44200 = 43320 kj/kg
40% blend (C40D60) = 0.4 × 39800 + 0.6 × 44200 = 42440 kj/kg
60% blend (C60D40) = 0.6 × 39800 + 0.4 × 44200 = 41560 kj/kg

5) η_v Volumetric efficiency $\eta_v = \frac{V_a}{V_s} \times 100\ \%$

$V_a = C_d \times A\sqrt{2GH} \times 3600\ m^3/hr.$

$= 0.62 \times \pi\frac{(0.02)^2}{4}\sqrt{2 \times 9.81 \times 20.96} \times 3600 = 14.22 m^3/hr.$

where V_a is actual volume of air sucked into the cylinder.
C_d is coefficient of discharge.

$H = \frac{h}{1000} \times \frac{\rho_w}{\rho_a}$ where $h = h_2 - h_1 = 60 - 35 = 25.$

$H = \frac{25}{1000} \times \frac{1000}{1.193} = 20.96$

$V_s = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60$

$= \frac{\pi (0.08)^2}{4} \times 0.11 \times \frac{1500}{2} \times 60 = 25.22\ m^3/hr.$

where V_s is swept volume d is diameter of the orifice L is length.

$\eta_v = \frac{V_a}{V_s} \times 100 = \frac{14.22}{24.88} \times 100 = 57.2\ \%$

6) η_{bth} Brake Thermal efficiency (or overall efficiency)

$= \frac{B.P.\times 3600}{mfc \times C.V.} \times 100\ \% = \frac{0.69 \times 3600}{1.86 \times 41560} \times 100 = 3.23\ \%$

100 % Diesel, Density = 820 kg/cu.m., C.V. = 44200 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	Mfc	Bsfc	Bsec	Bte (ηbth)
	in KG	in SEC		in KW	in KG/HR	KG/KW-HR	KJ/KW-HR	in %
1	3	31	13	0.69	0.95	1.37	60698	5.93
2	6	21	13	1.39	1.41	1.01	44801	8.04
3	9	21	13	2.08	1.41	0.68	29867	12.05
4	12	17	13	2.77	1.74	0.63	27671	13.01

S.no.	Load	Time	c.r.	B P	Mfc	Bsfc	Bsec	Bte (ηbth)
	in KG	in SEC		in KW	in KG/HR	KG/KW-HR	KJ/KW-HR	in %
1	3	33	16	0.69	0.89	1.29	57019	6.31
2	6	25	16	1.39	1.18	0.85	37633	9.57
3	9	19	16	2.08	1.55	0.75	33011	10.91
4	12	15	16	2.77	1.97	0.71	31361	11.48

S.no.	Load	Time	c.r.	B P	Mfc	Bsfc	Bsec	Bte (ηbth)
	in KG	in SEC		in KW	in KG/HR	KG/KW-HR	KJ/KW-HR	in %
1	3	40	18	0.69	0.74	1.06	47041	7.65
2	6	28	18	1.39	1.05	0.76	33601	10.71
3	9	20	18	2.08	1.48	0.71	31361	11.48
4	12	15	18	2.77	1.97	0.71	31361	11.48

100 % Diesel, Density = 820 kg/cu.m., C.V. = 44200 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	31	13	0.69	0.95	1.37	60698	5.93
2	6	21	13	1.39	1.41	1.01	44801	8.04
3	9	21	13	2.08	1.41	0.68	29867	12.05
4	12	17	13	2.77	1.74	0.63	27671	13.01
							in %	

C20D80, Density = 839 kg/cu.m., C.V. = 43320 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	19	13	0.69	1.59	2.29	99311	3.62
2	6	20	13	1.39	1.51	1.09	47173	7.63
3	9	18	13	2.08	1.68	0.81	34943	10.30
4	12	14	13	2.77	2.16	0.78	33695	10.68

C40D60, Density = 859 kg/cu.m., C.V. = 42440 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	23	13	0.69	1.34	1.94	82289	4.37
2	6	20	13	1.39	1.55	1.11	47316	7.61
3	9	16	13	2.08	1.93	0.93	39430	9.13
4	12	13	13	2.77	2.38	0.86	36397	9.89

C60D40, Density = 878 kg/cu.m., C.V. = 41560 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	17	13	0.69	1.86	2.68	111435	3.23
2	6	17	13	1.39	1.86	1.34	55717	6.46
3	9	16	13	2.08	1.98	0.95	39467	9.12
4	12	11	13	2.77	2.87	1.04	43054	8.36

100 % Diesel, Density = 820 kg/cu.m., C.V. = 44200 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (η bth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	33	16	0.69	0.89	1.29	57019	6.31
2	6	25	16	1.39	1.18	0.85	37633	9.57
3	9	19	16	2.08	1.55	0.75	33011	10.91
4	12	15	16	2.77	1.97	0.71	31361	11.48

C20D80, Density = 839 kg/cu.m., C.V. = 43320 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (η bth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	29	16	0.69	1.04	1.50	65066	5.53
2	6	22	16	1.39	1.37	0.99	42884	8.39
3	9	18	16	2.08	1.68	0.81	34943	10.30
4	12	14	16	2.77	2.16	0.78	33695	10.68

C40D60, Density = 859 kg/cu.m., C.V. = 42440 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (η bth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	29	16	0.69	1.07	1.54	65264	5.52
2	6	22	16	1.39	1.41	1.01	43015	8.37
3	9	18	16	2.08	1.72	0.83	35049	10.27
4	12	14	16	2.77	2.21	0.80	33797	10.65

C60D40, Density = 878 kg/cu.m., C.V. = 41560 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (η bth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	22	16	0.69	1.44	2.07	86109	4.18
2	6	18	16	1.39	1.76	1.27	52622	6.84
3	9	15	16	2.08	2.11	1.01	42098	8.55
4	12	13	16	2.77	2.43	0.88	36431	9.88

100 % Diesel, Density = 820 kg/cu.m., C.V. = 44200 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	40	18	0.69	0.74	1.06	47041	7.65
2	6	28	18	1.39	1.05	0.76	33601	10.71
3	9	20	18	2.08	1.48	0.71	31361	11.48
4	12	15	18	2.77	1.97	0.71	31361	11.48

C20D80, Density = 839 kg/cu.m., C.V. = 43320 kj/kg, 10cc fuel, N = 1500 RPM

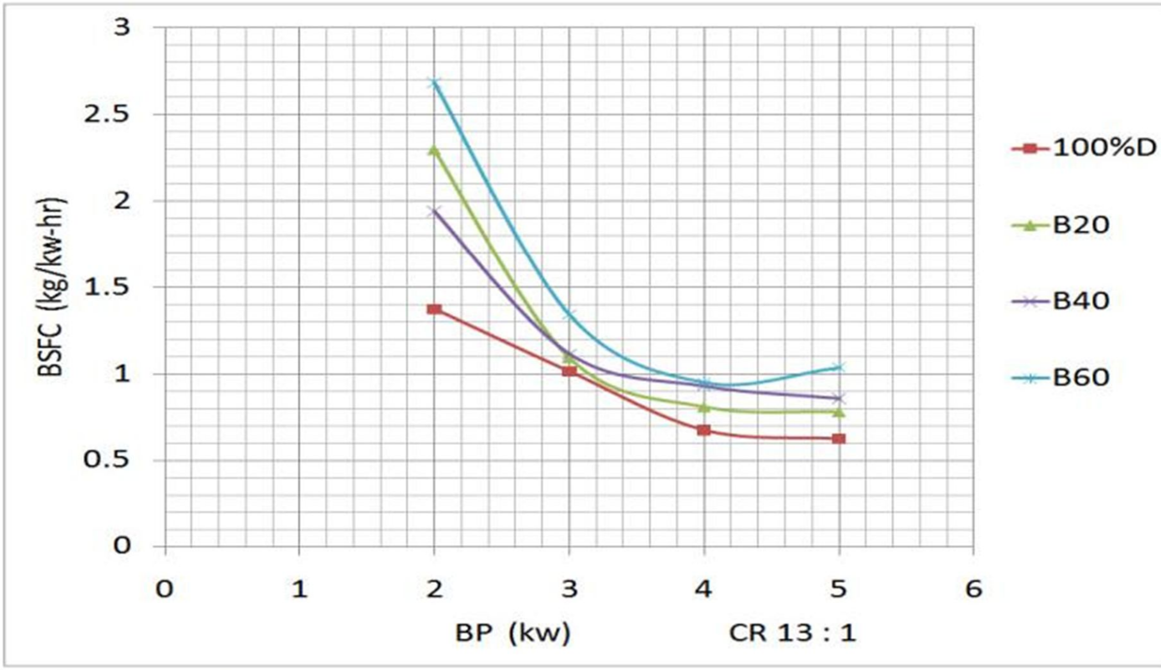
S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	32	18	0.69	0.94	1.36	58966	6.11
2	6	23	18	1.39	1.31	0.95	41020	8.78
3	9	17	18	2.08	1.78	0.85	36998	9.73
4	12	13	18	2.77	2.32	0.84	36287	9.92

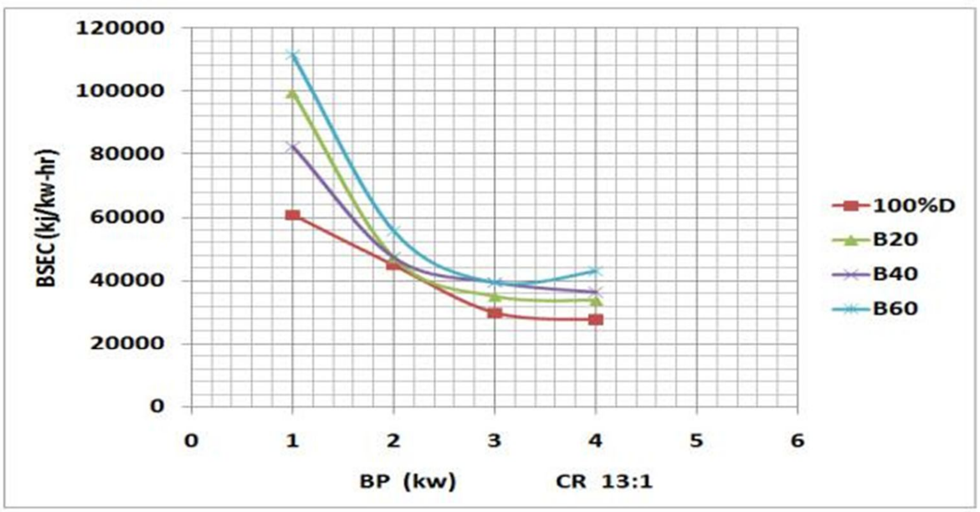
C40D60, Density = 859 kg/cu.m., C.V. = 42440 kj/kg, 10cc fuel, N = 1500 RPM

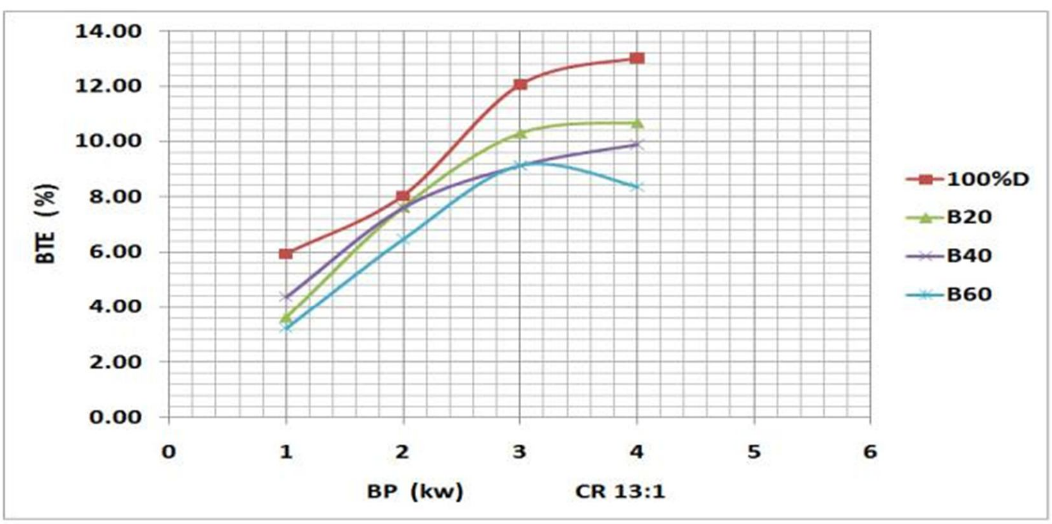
S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	30	18	0.69	1.03	1.49	63088	5.71
2	6	24	18	1.39	1.29	0.93	39430	9.13
3	9	17	18	2.08	1.82	0.87	37111	9.70
4	12	14	18	2.77	2.21	0.80	33797	10.65

C60D40, Density = 878 kg/cu.m., C.V. = 41560 kj/kg, 10cc fuel, N = 1500 RPM

S.no.	Load	Time	c.r.	B P	mfc	Bsfc	Bsec	Bte (ηbth)
	in kg	in sec		in kw	in kg/hr	kg/kw-hr	kj/kw-hr	in %
1	3	25	18	0.69	1.26	1.82	75776	4.75
2	6	21	18	1.39	1.51	1.09	45105	7.98
3	9	16	18	2.08	1.98	0.95	39467	9.12
4	12	12	18	2.77	2.63	0.95	39467	9.12


BSFC (kg/kw-hr)
BP (kw)
CR 13 : 1
100%D
B20
B40
B60


BSEC (kj/kw-hr)
BP (kw)
CR 13:1
100%D
B20
B40
B60


BTE (%)
BP (kw)
CR 13:1
100%D
B20
B40
B60

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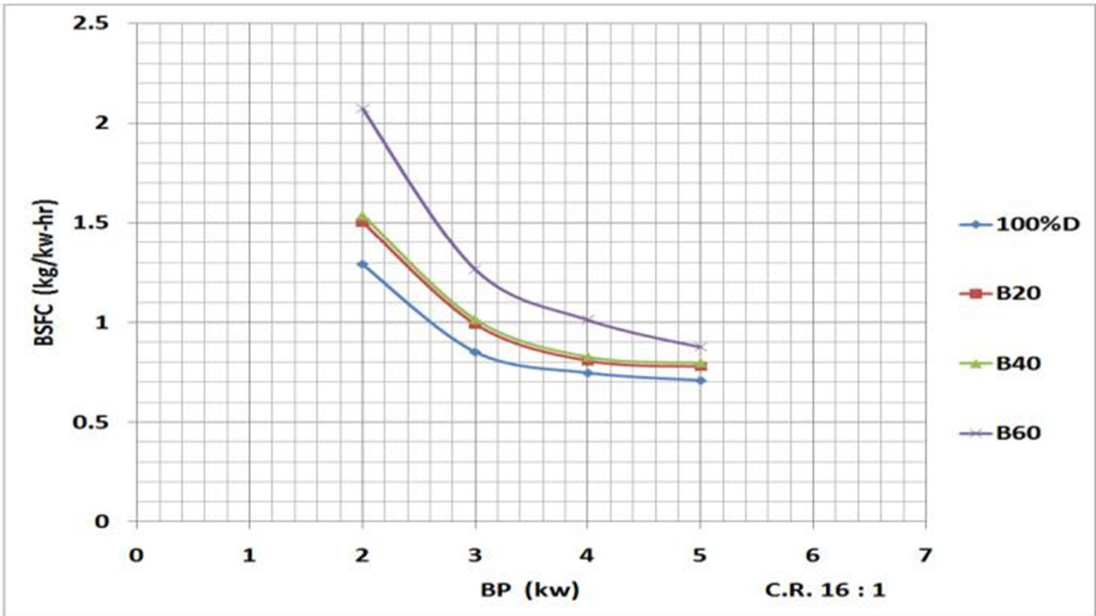

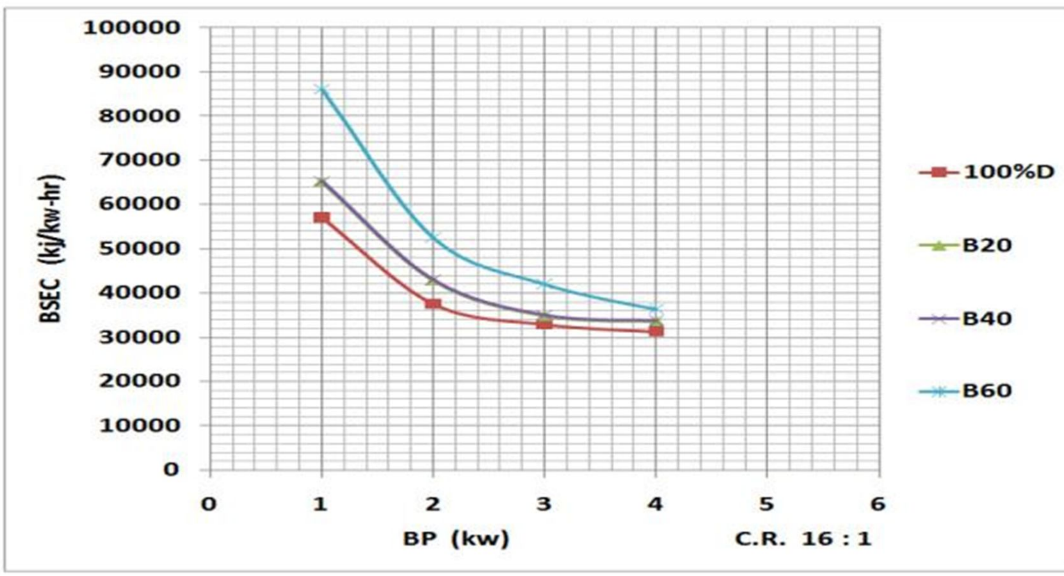

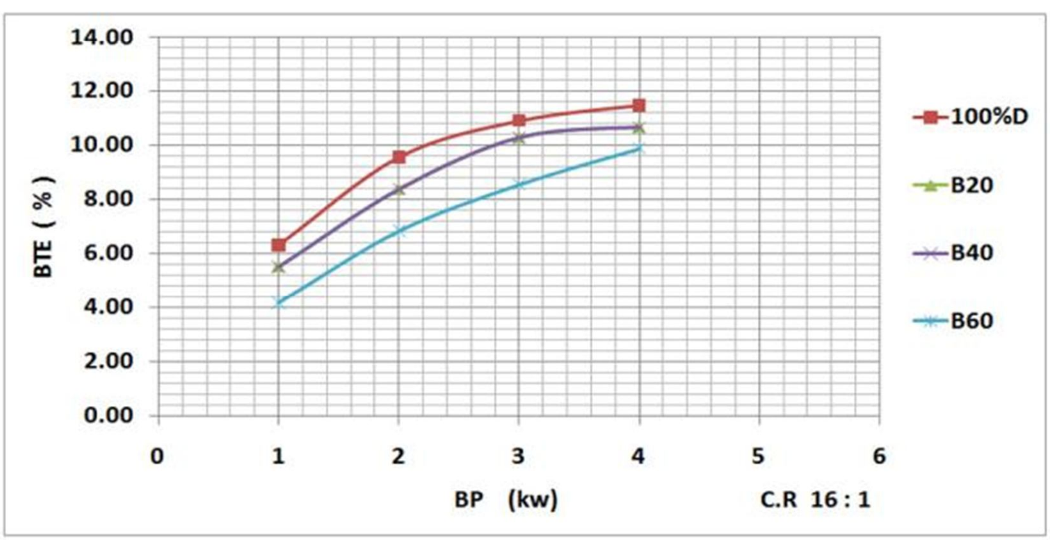

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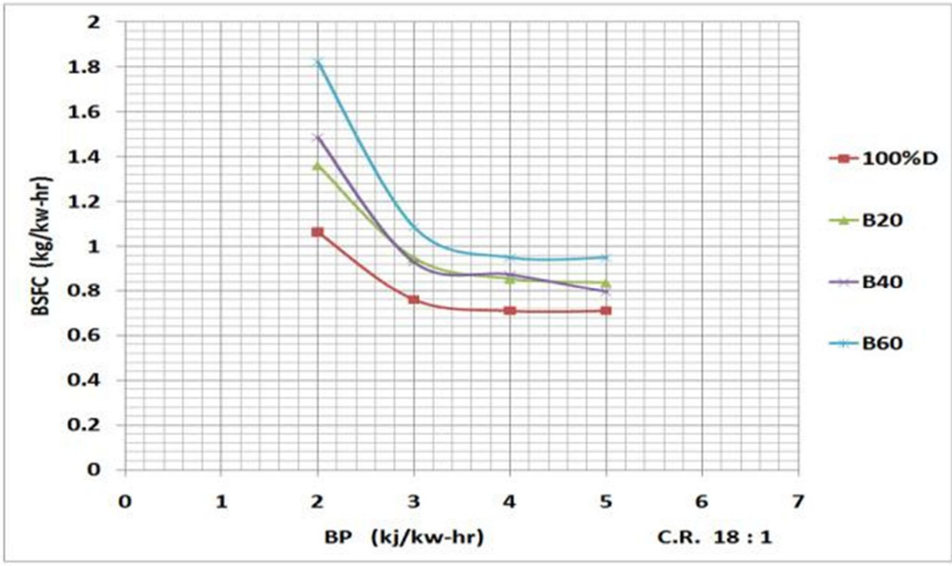

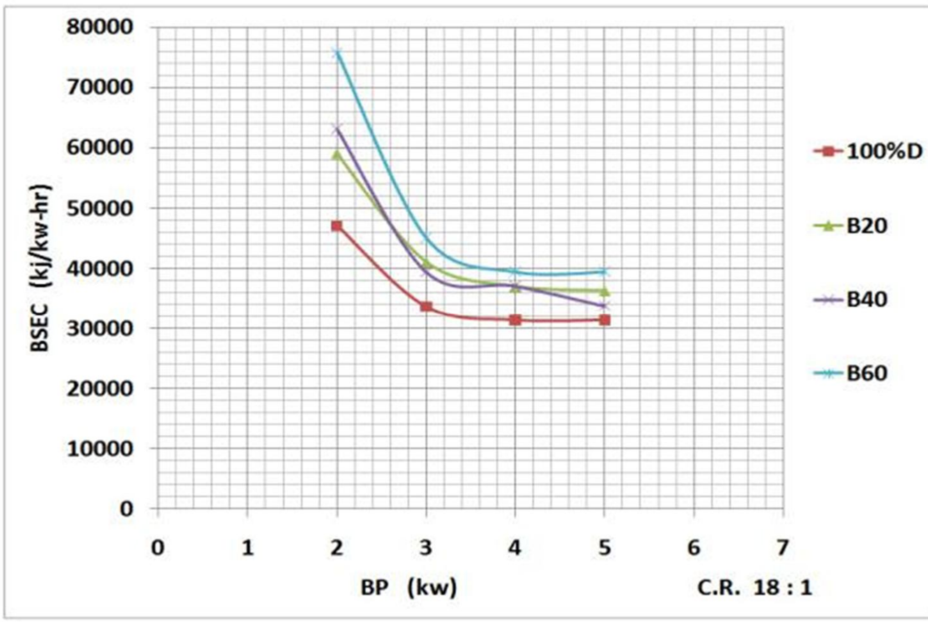

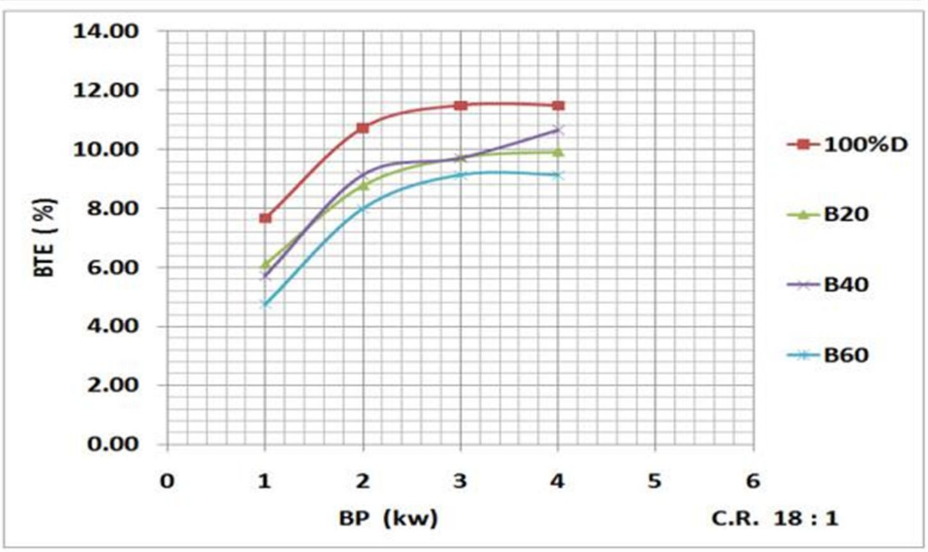

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EMISSIONS

100 % DIESEL (CR 13 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.23	2	594	19
2	3	0.25	1.6	571	19
3	6	0.21	1.2	475	21
4	9	0.2	1.3	470	19
5	12	0.2	0.9	460	18

100 % DIESEL (CR 16 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.3	1.9	343	21
2	3	0.3	2	239	23
3	6	0.24	1.7	268	24
4	9	0.19	1.3	292	24
5	12	0.23	1	297	24

100 % DIESEL (CR 18 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.4	1.5	262	25
2	3	0.38	21	284	26
3	6	0.27	17	270	26
4	9	0.21	13	283	24
5	12	0.27	1	287	28

20 % C (CR 13 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.23	2.1	436	27
2	3	0.26	2.1	510	25
3	6	0.27	2.3	463	23
4	9	0.27	1.9	434	24
5	12	0.31	1.5	459	25

20 % C (CR 16 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.38	2.2	371	26
2	3	0.39	2.2	350	25
3	6	0.3	2.1	345	26
4	9	0.27	1.5	368	28
5	12	0.31	1.2	366	25

20 % C (CR 18 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.4	2.5	255	20
2	3	0.34	2.7	286	20
3	6	0.36	2.7	303	23
4	9	0.34	2.4	348	25
5	12	0.37	1.9	368	23

40 % C (CR 13 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.31	1.6	525	22
2	3	0.29	202	605	24
3	6	0.32	2.7	558	21
4	9	0.37	2.6	535	21
5	12	0.41	2.1	545	22

40 % C (CR 16 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.39	2.5	439	21
2	3	0.3	2.6	423	21.5
3	6	0.35	2.2	414	21
4	9	0.31	1.8	450	23
5	12	0.34	1.8	429	22

40 % C (CR 18 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.36	2.5	373	19
2	3	0.36	2.4	368	20
3	6	0.35	2.5	370	21
4	9	0.33	2.1	400	22
5	12	0.4	1.7	417	20

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60 % C (CR 13 : 1)

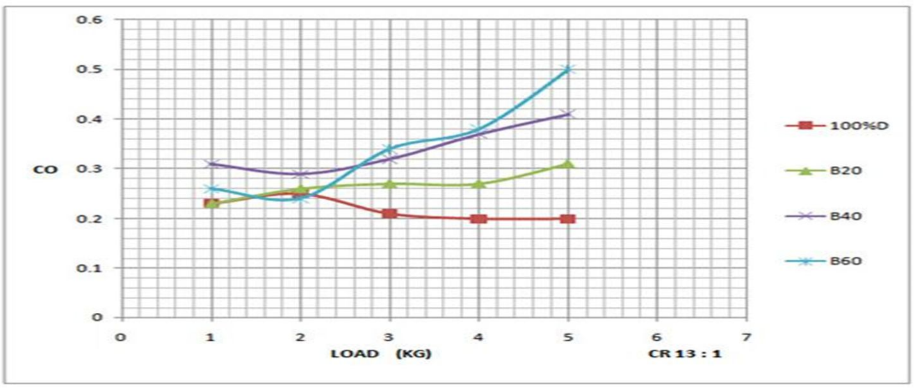
S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.26	1.9	316	20
2	3	0.24	2.2	427	20
3	6	0.34	2.7	470	23
4	9	0.38	2.8	487	21
5	12	0.5	2.3	550	22

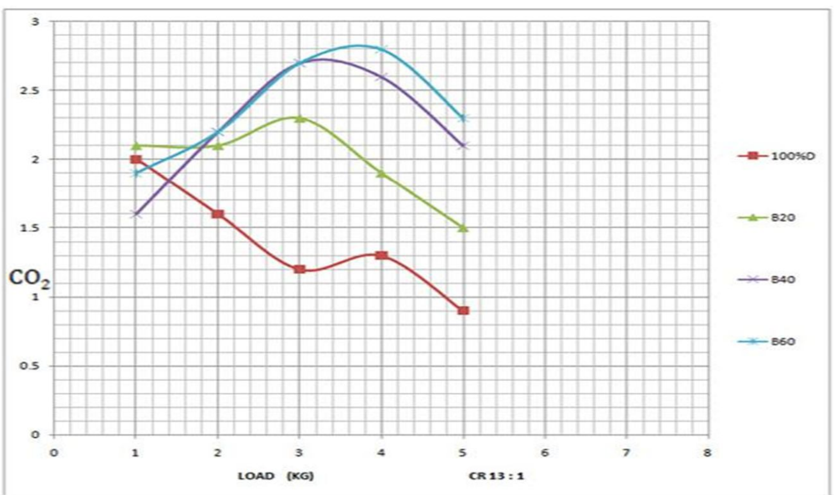
60 % C (CR 16 : 1)

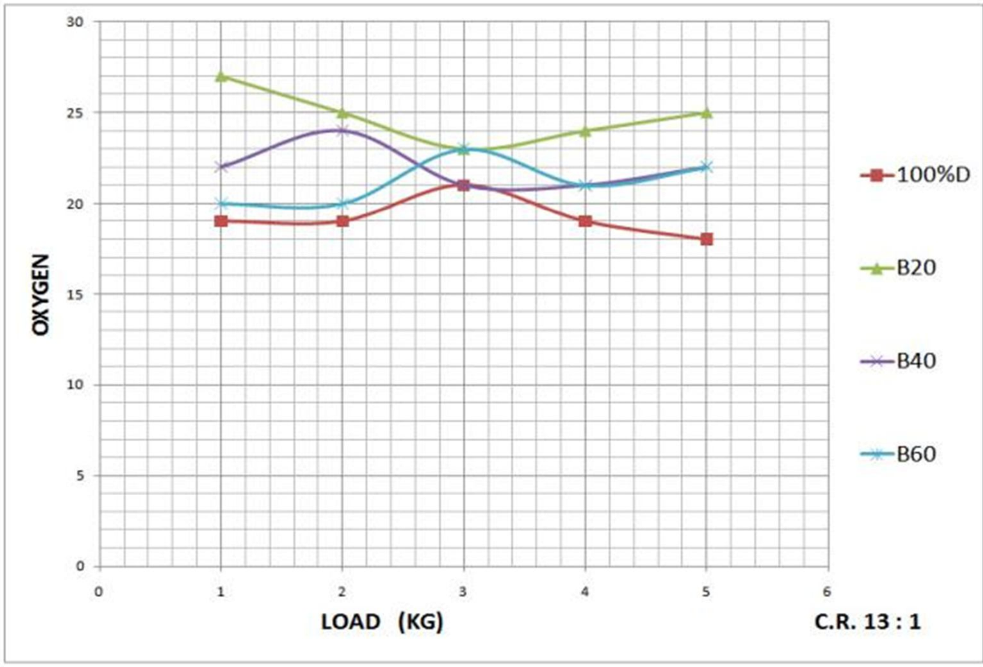
S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.67	2	514	21
2	3	0.23	2.4	376	22
3	6	0.32	2.8	378	22
4	9	0.38	2.7	409	22
5	12	0.48	2.3	478	22

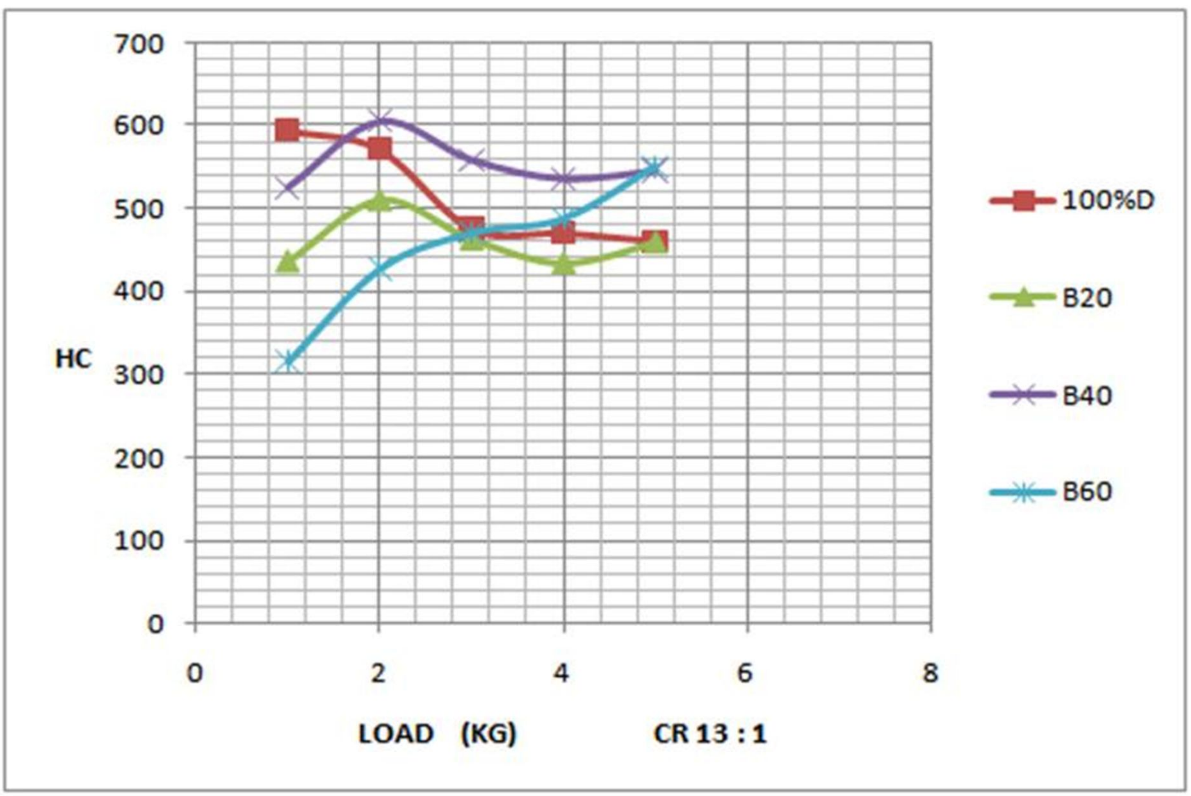
60 % C (CR 18 : 1)

S.NO.	LOAD	CO	CO_2	HC	O_2
1	0	0.3	1.8	342	22
2	3	0.3	2.4	317	22
3	6	0.3	2.5	321	23.5
4	9	0.31	2	386	23
5	12	0.37	1.7	378	21






OXYGEN
LOAD (KG)
C.R. 13 : 1
100%D
B20
B40
B60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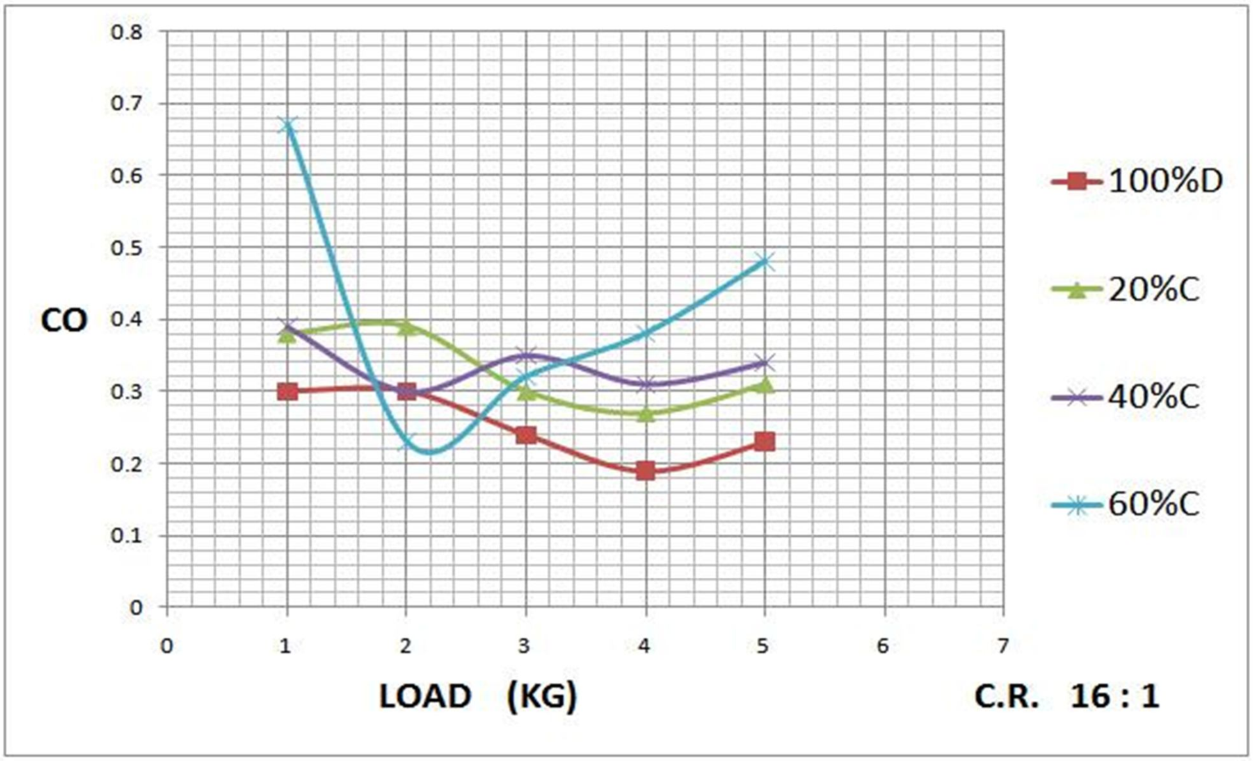
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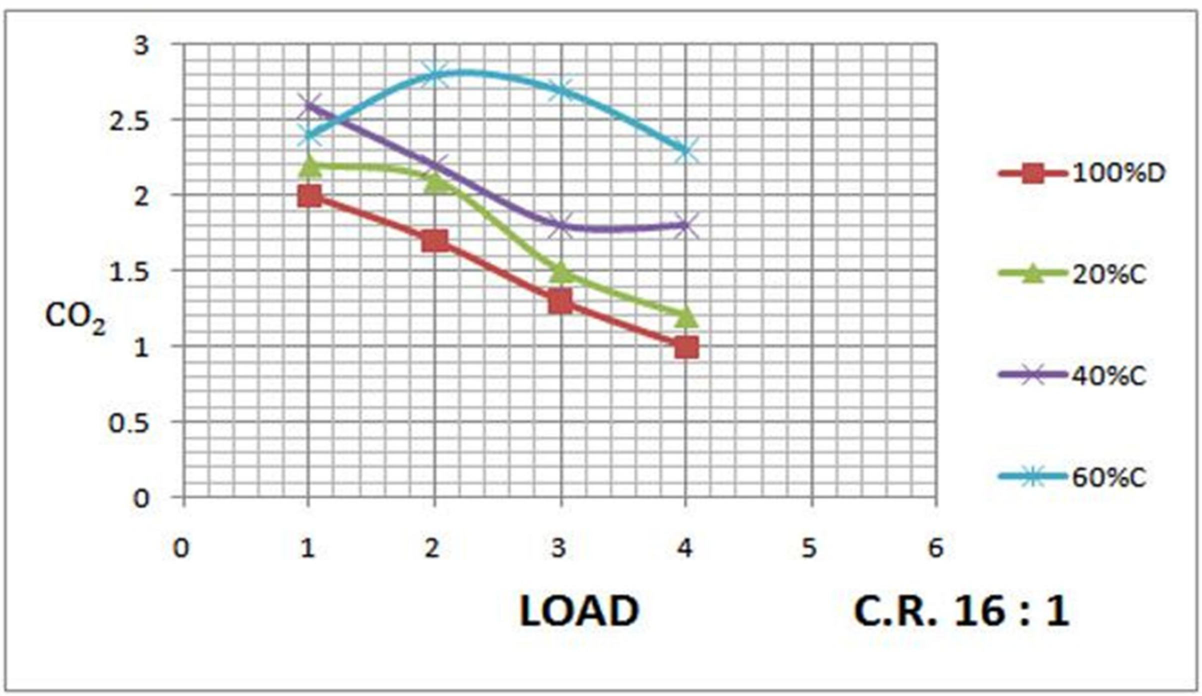
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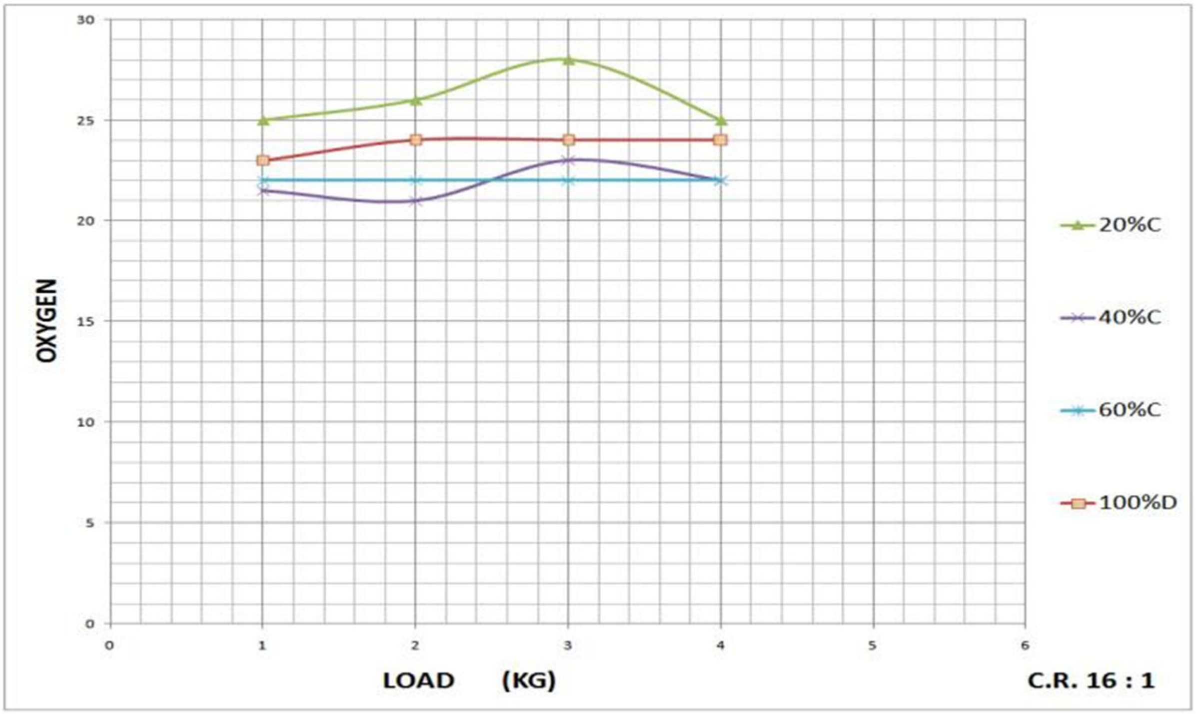
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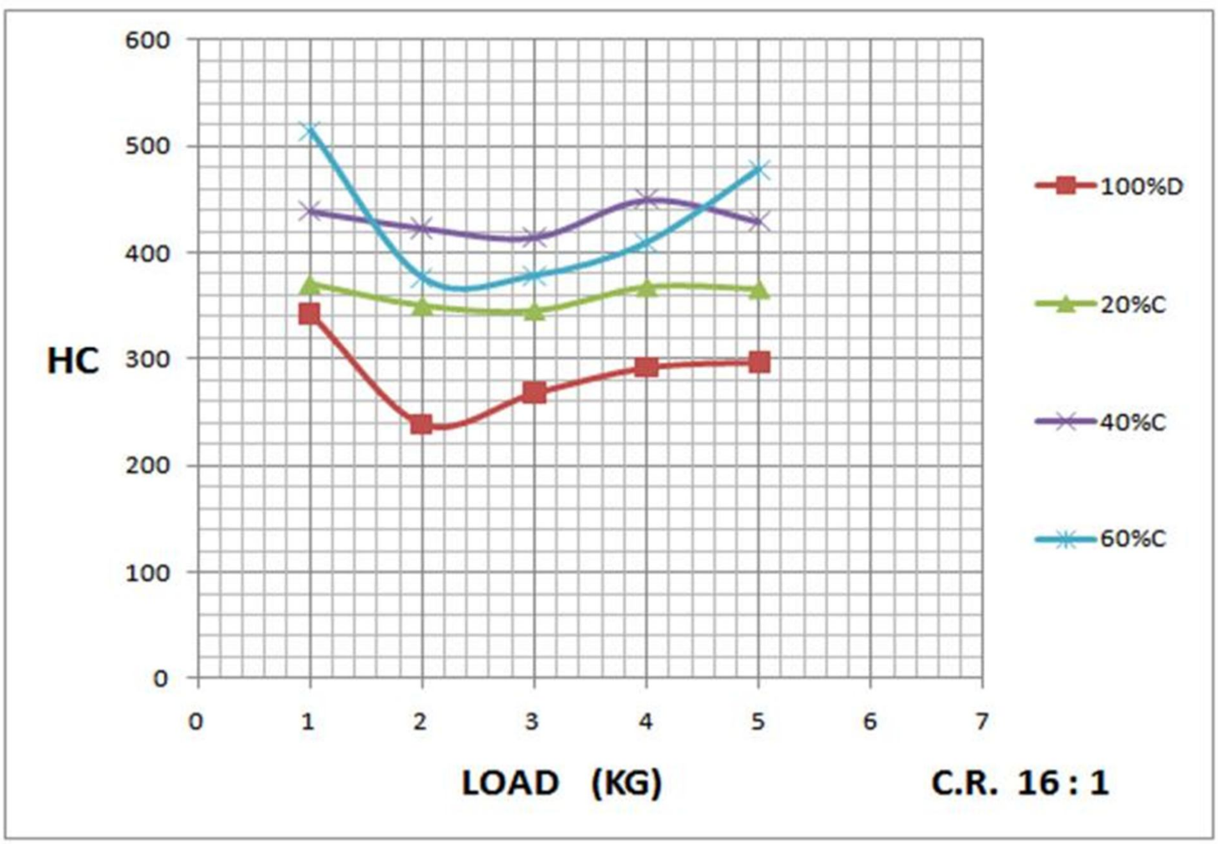
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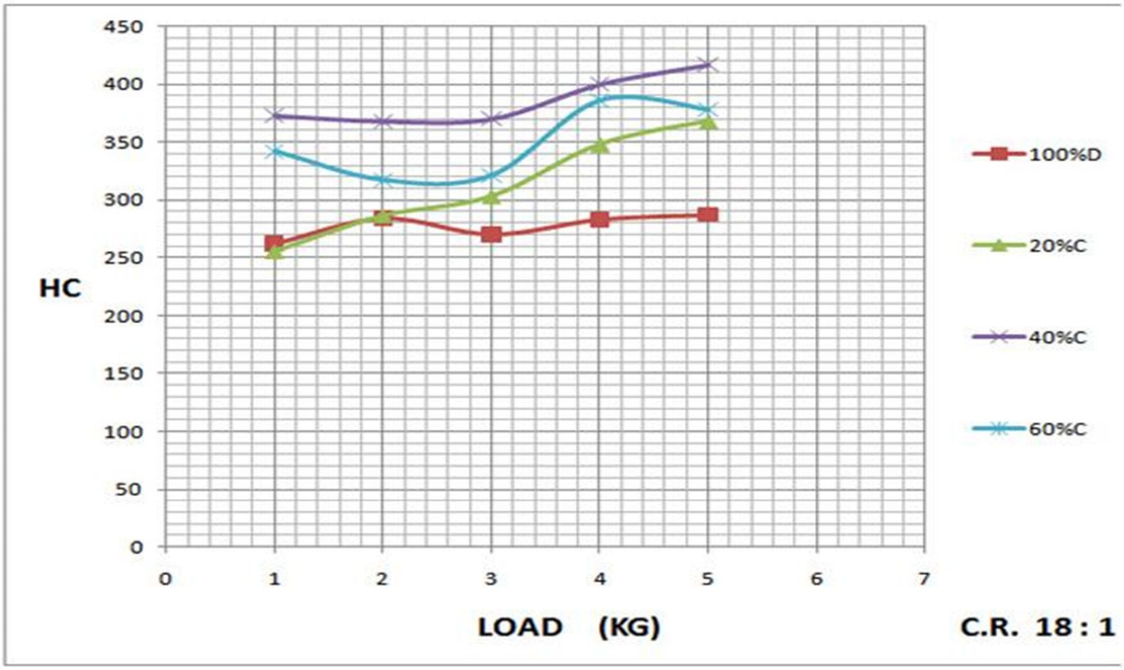
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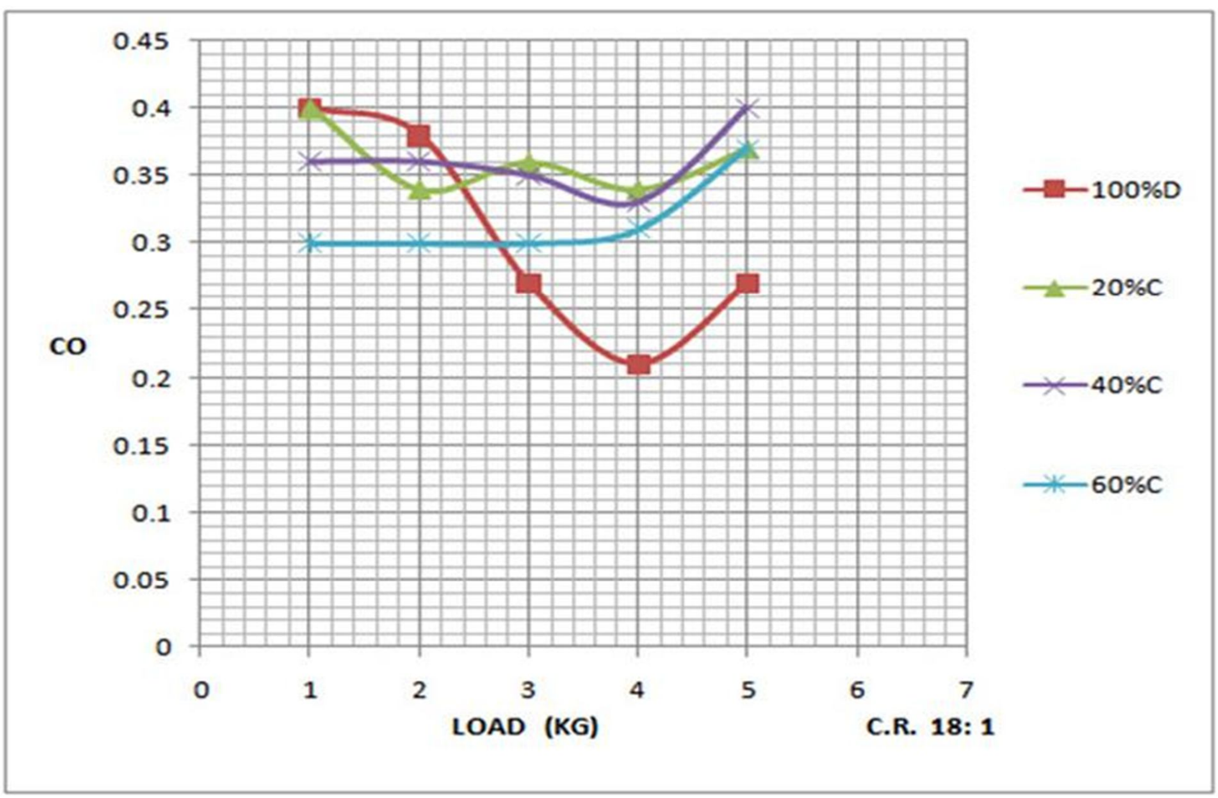
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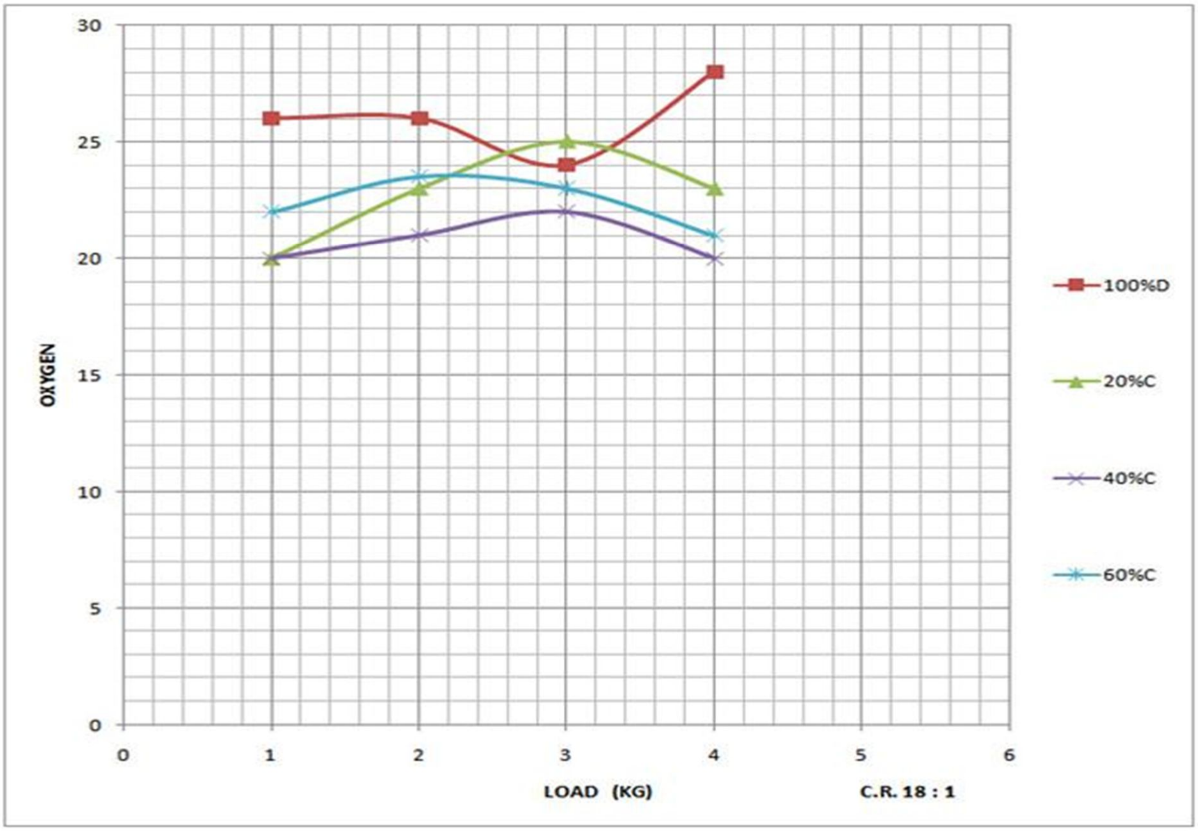
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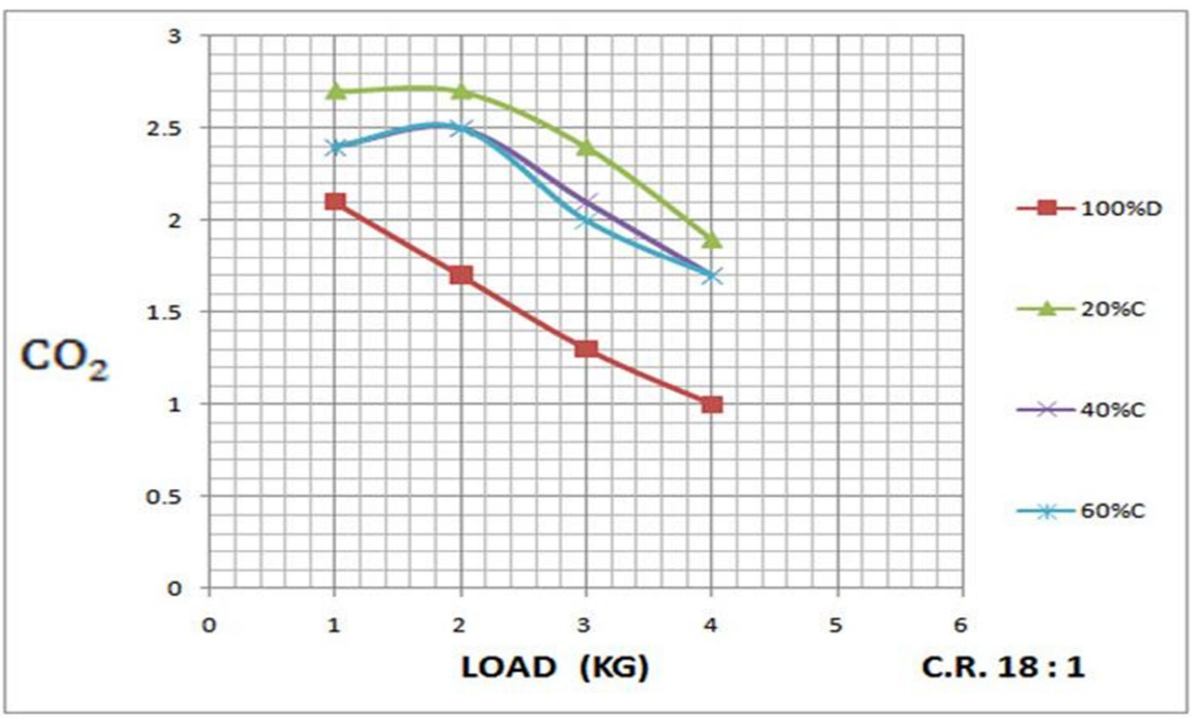
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III. ACKNOWLEDGEMENT

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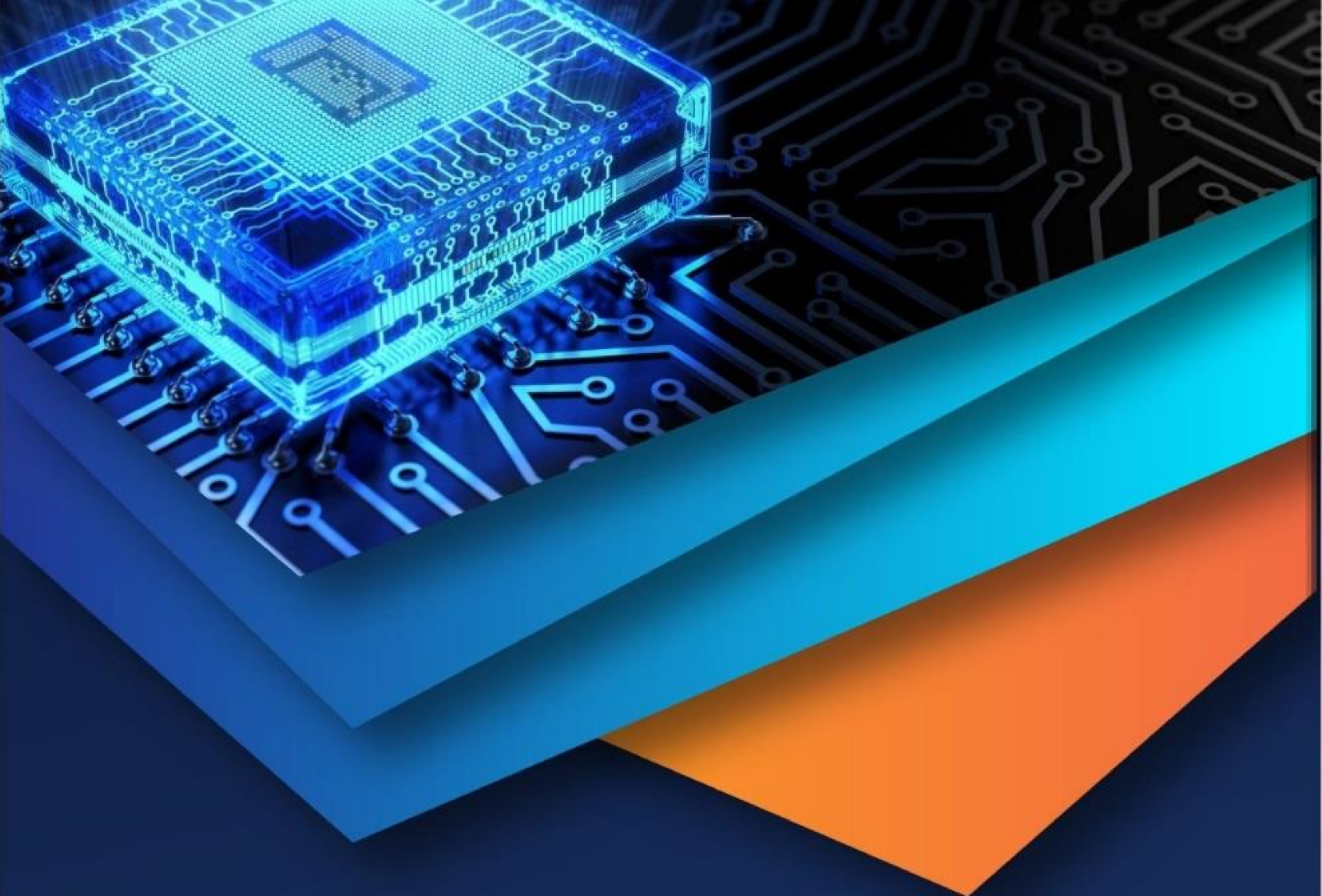

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