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EXTRACTION OF SUSTAINABLE AVIATION FUELS FROM JATROPHA CURCUS, HELIANTHUS AND PONGAMIA PINNATA FEEDSTOCKS

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ABSTRACT

Biodiesel has attracted considerable attention during the past decade as a biodegradable, non – toxic fuel. Biodiesel is an alternative renewable green fuel obtainable from plant or animal oil with a low molecular weight alcohol in the presence of a catalyst. However, the cost of its production remains high due to its costly feed stocks, the majority of which pose difficulties in fuel production and resulting environmental pollution. Extraction of biodiesel through transesterification of non-edible feed stocks such as Jatropha Curcus, Helian thusand Pongamia Pinnata seeds are chosen as a raw material for the fuel production,because the seeds have higher oil content.These oils are converted into biodiesel by using methanol and sodium hydroxide (Na0H) as a catalyst. The main objective is to alter the blending ratio of biodiesel with the aircraft jet fuel to reduce the carbon footprint, including that it can also reduce the oxygen and hydrogen imbalance in the atmosphere, which causes global warming. The oil extracted seedcakes are used as bio-fertilizers to the plants to improve their yield. The fuel properties of blended Jatropha Curcus, Helianthus and Pongamia Pinnata biodiesel with the aircraft jet fuel are comparable to the American standards.

INTRODUCTION

The world's increase in energy demand has sled to the use of alternative and sustainable fuel sources. Among the different modes of transportation, aviation contributes significantly to greenhouse gas emissions, which is why researchers are explor in alternative sustainable feed stocks to produce aviation fuels.

The demand for aviation fuels has been on the rise in recent years due to the rapid growth of the aviation industry. However, the production of conventional aviation fuels from fossil fuels has led to significant environmental impacts such as greenhouse gas emissions, air pollution, and resource depletion. As a result, there is a growing need for sustainable alternatives to conventional aviation fuels .The aviation industry is a vital sector of modern transportation , providing a means of moving people and goods across the globe. However, the aviation industry is also a significant contributor to greenhouse gas emissions, which have adverse effects on the environment. One of the primary sources of emissions is the aviation fuels that power airplanes. To address this challenge ,research have explored various methods to produce aviation fuels from sustainable feedstocks, including biomass, waste materials, and renewable energy sources.

Raw materials for biodiesel production

Raw materials:

- The raw materials for biodiesel production are vegetable oils, animal fats and short chain alcohols. The vegetable oils are mainly obtained through the seeds of the oil yielding plants. Besides its higher cost, another undeniable knowledge of non-edible oils for biodiesel production lies in the fact that no foodstuffs are spent to produce fuels. Animal fats are also an interesting option, especially in countries with plenty of livestock resources, although it is necessary to carry out preliminary treatment since they are solid; furthermore, highly acidic grease from cattle, pork, poultry and fish can be used.
- Microalgae appear to be a very important alternative for future biodiesel production due to their very high oil yield; however, it must be considered that only some species are useful for biodiesel production . Although the properties of oils and fats used as raw materials may differ, the properties of biodiesel must be the same complying with the requirements set by international standards.
- Outofvariousrawmaterialswechoosethreeoilyieldingseedsasfeedstocksforourbiodieselproduction.Themaincriteria forselectingtheseedsforbiodieselproduction is seeds which have high oil content.

The sustainable feedstocks:

1. Jatropha Curcus
2. Helianthus
3. Pongamia Pinnata

Jatropha Curcus:

- Jatropha Curcas is a low-cost biodiesel feedstock with good fuel properties and more oil than other species. The seeds contain around 20%saturated fatty acid sand 80% unsaturated fatty acids, and they yield 27-40% that can be processed to produce a high-quality biodiesel fuel usable in a standard diesel engine. The oil has very purgative property. In addition, these edscontain other chemical compounds such as saccharose, raffinose ,stachyose, glucose, fructose, galactose, and protein. The oil isl argely made up of oleicand linoleic acids.

Figure1

Helianthus:

Differenttypesofsunflowerseedsareavailablewhichcontainoilshavingdifferent unsaturation. Some varieties of sunflower seeds are eaten as a delicious snack directly and are known as confectionary (non-oil) sunflower seeds. Over the decades, sunflower oil has become popular vegetable oil in world wide. The oil may be used as is or may be processed into polyunsaturated margines, the oil istypicallyextractedbyapplyinggreatpressuretothesunflowerseedsandcollecting the oil. Sunflower seeds contain 35%-42% oil and is naturally rich in linoleic acid (55-70%) and consequently poor in oleic acid (20-25%) and about20%protein.

Figure2

PongamiaPinnata:

Karanjahasa potential to be used as basic feed stock for the production of bio diesel. Karanja trees can grow on side of roads, canaland boundary portion of agricultural lands with minimum care. Its seeds contain27-39% of the oil content.

The seeds of Pongamia pinnata are rich in oil that can be refined into fuel products. As a fast-growing leguminous tree with abundant annual production of oil rich- seeds, Pongamia pinnata is particularly suitable plant for biofuels production.

Figure3

The obtained results are shown in below

S.NO	Oil samples	Density g/ml	Test method
1	Jatropha curcus	0.8526 g/ml	BIS
2	Helianthus	0.9173 g/ml	BIS
3	Pongamia pinnata	0.9512 g/ml	BIS

Table1-Density of the oils

The biodiesel blending characteristics are given below:

Sl.no	Feedstocks	Percentage
1	Jatropha Curcus Biodiesel	10
2	Helianthus Biodiesel	10

3	Pongamia Pinnata Biodiesel	5
4	Aircraft Jet Fuel	75

Table2-BlendingRatioofB25

o	Feedstocks	Percentage
1	Jatropha Curcus Biodiesel	20
2	Helianthus Biodiesel	20
3	Pongamia Pinnata Biodiesel	10
4	Aircraft Jet Fuel	50

Table3-BlendingRatio of B50

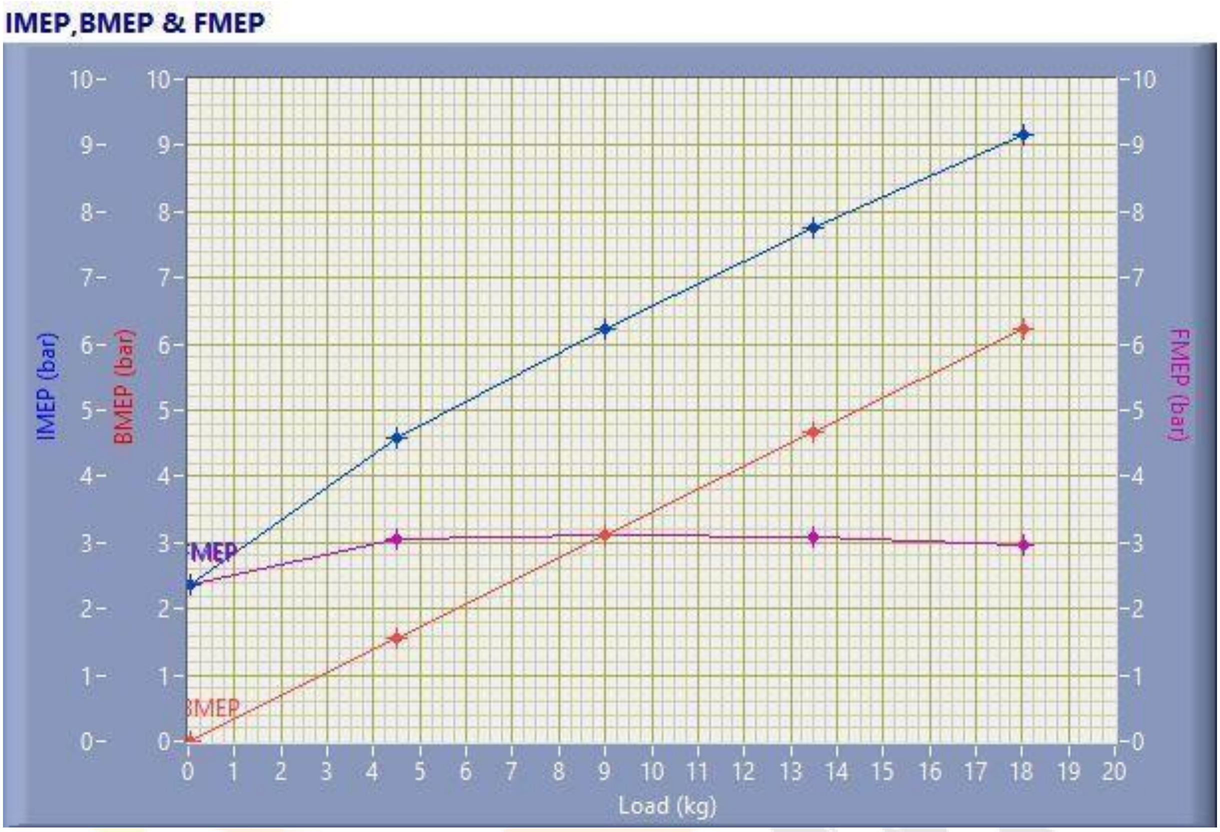
RESULTS AND DISCUSSIONS

The Sustainable Aviation Fuels obtained through the transesterification of refined Jatropha, Helianthus and Pongamia oils using NaOH and KOH catalystinmethanol or ethanol.Its final by product is refined and collected. And it is blended with the aircraft fuel its various characteristic properties are determined, these fuel properties are compared with the ASTM standards and it is more or less same in nature, which are shown below.

Fuel properties:

Sl.No	property	B25	B50	ASTM
2	Flash point	40	41	93
3	Fire point	45	46	140
4	Calorific value	42.2	41.6	42
5	Density	835	848	775-840
6	Cetane number	49	55	47-65
7	Saponification value	196	199	-
8	Iodine value	112	124	120
9	Stoichiometric ratio	13.8	15	14
10	Boiling point	182	187	188-343

B25 Fuel performance:

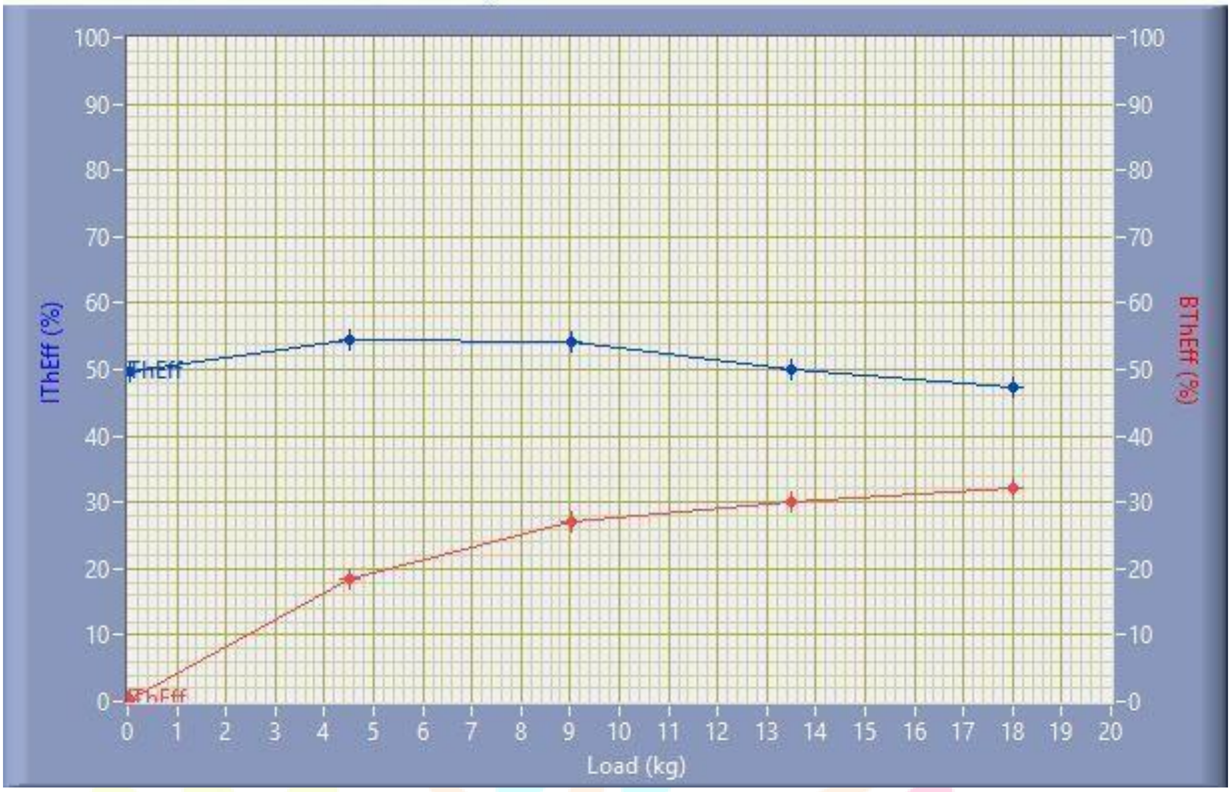


IP, BP&FP

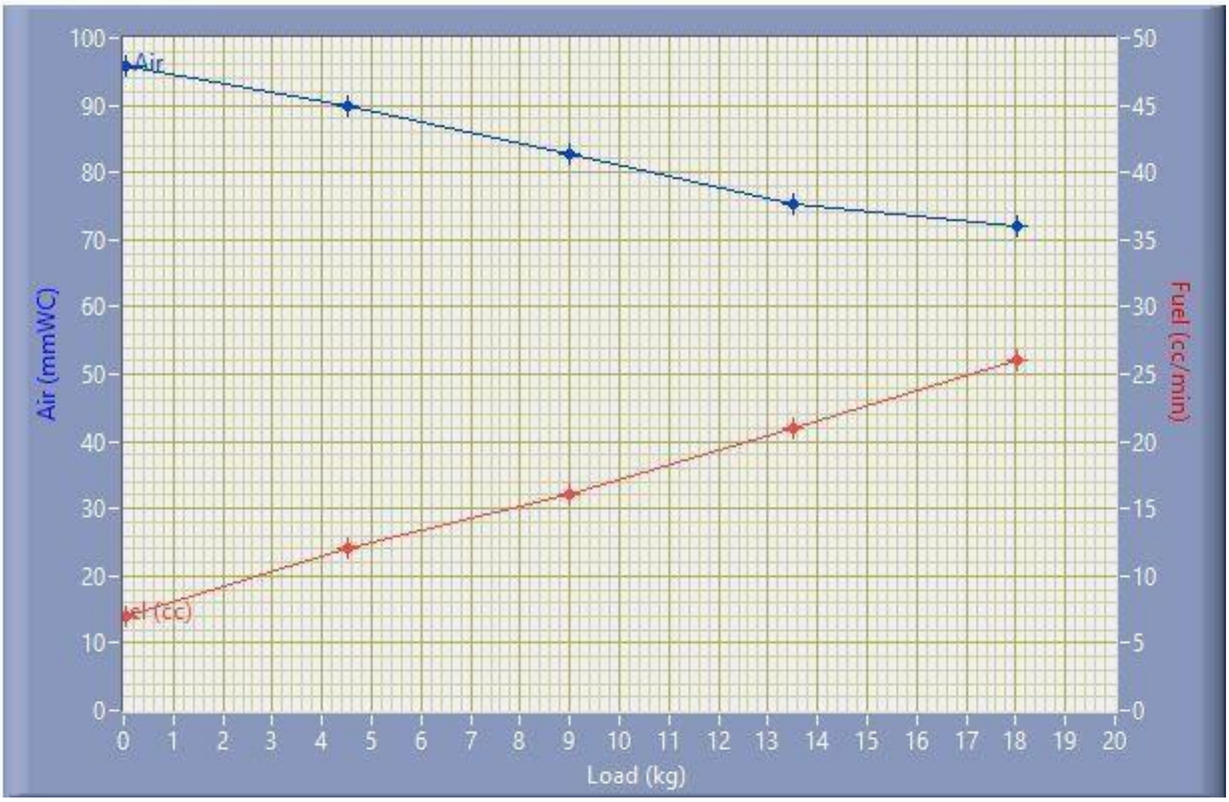
MEP,BMEP& FMEP

Speed (rpm)	Load (kg)	IMEP (bar)	BMEP (bar)	FMEP (bar)
1558.00	0.03	2.37	0.01	2.36
1513.00	4.50	4.60	1.55	3.04
1477.00	9.01	6.23	3.11	3.12

Indicated & Brake Thermal Efficiency



Air & Fuel Flow

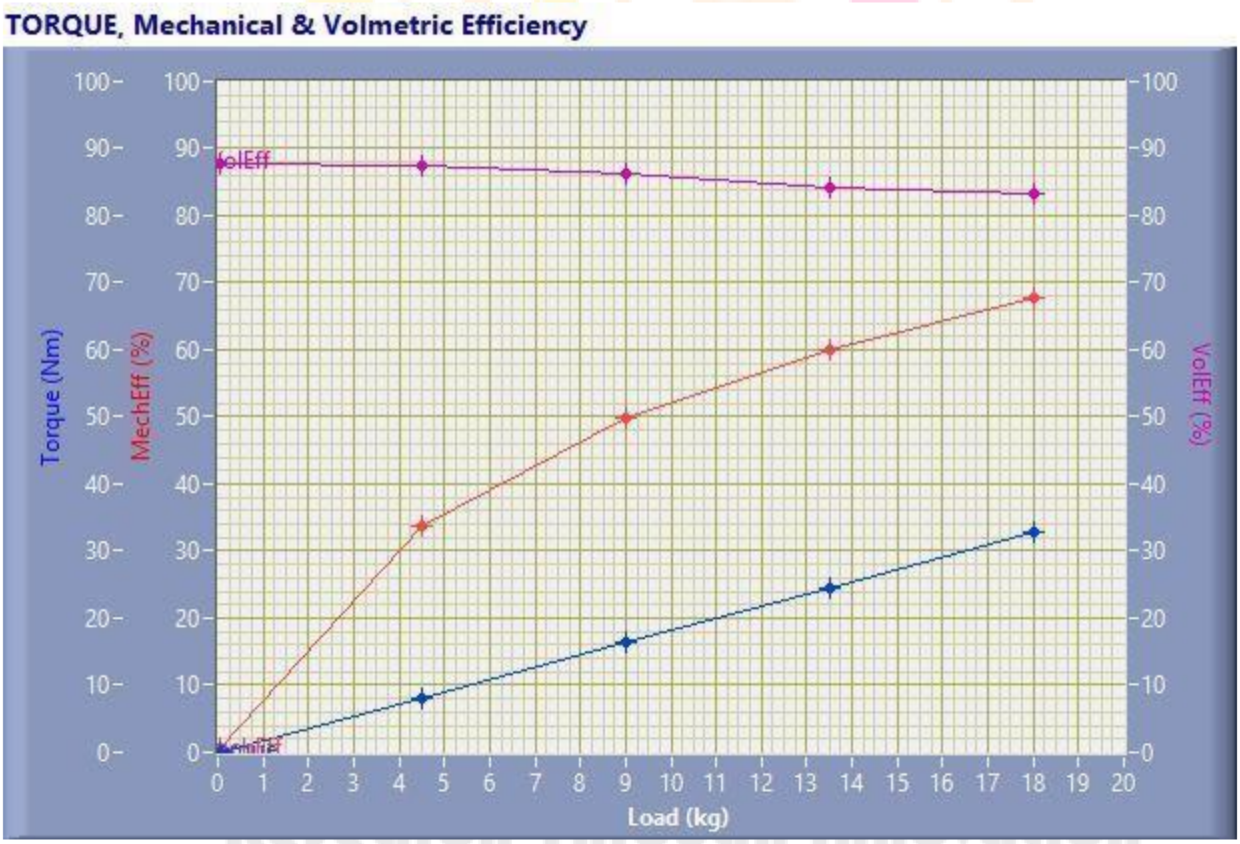


Indicated & Brake Thermal Efficiency

Speed (rpm)	Load(kg)	IThEff(%)	BThEff (%)
1558.00	0.03	49.59	0.23
1513.00	4.50	54.49	18.41
1477.00	9.01	54.05	26.98
1441.00	13.50	50.00	30.05
1426.00	18.02	47.29	32.05

SFC & FuelConsumption

Speed (rpm)	Load(kg)	SFC (kg/kWh)	Fuel(kg/h)
1558.00	0.03	36.92	0.35
1513.00	4.50	0.46	0.60
1477.00	9.01	0.32	0.80
1441.00	13.50	0.28	1.05
1426.00	18.02	0.27	1.30



TORQUE, Mechanical & Volumetric Efficiency

Speed(rpm)	Load(Kg)	Torqu(Nm)	MechEff. (%)	VolEff. (%)
1558	0.03	0.06	0.47	87.87
1513	4.50	8.17	33.78	87.54
1477	9.01	16.35	49.91	86.15
1441	13.50	24.51	60.10	84.14
1426	18.02	32.71	67.78	83.19

HBP, HJW & HGas

Speed(rpm)	Load(kg)	HBP(%)	HJW(%)	HGas(%)	HRad(%)
1558.00	0.03	0.23	15.28	24.06	60.43
1513.00	4.50	18.41	19.25	21.70	40.64
1477.00	9.01	26.98	21.28	21.17	30.57
1441.00	13.50	30.05	20.05	19.95	29.95
1426.00	18.02	32.05	21.16	20.61	26.17

Result Data

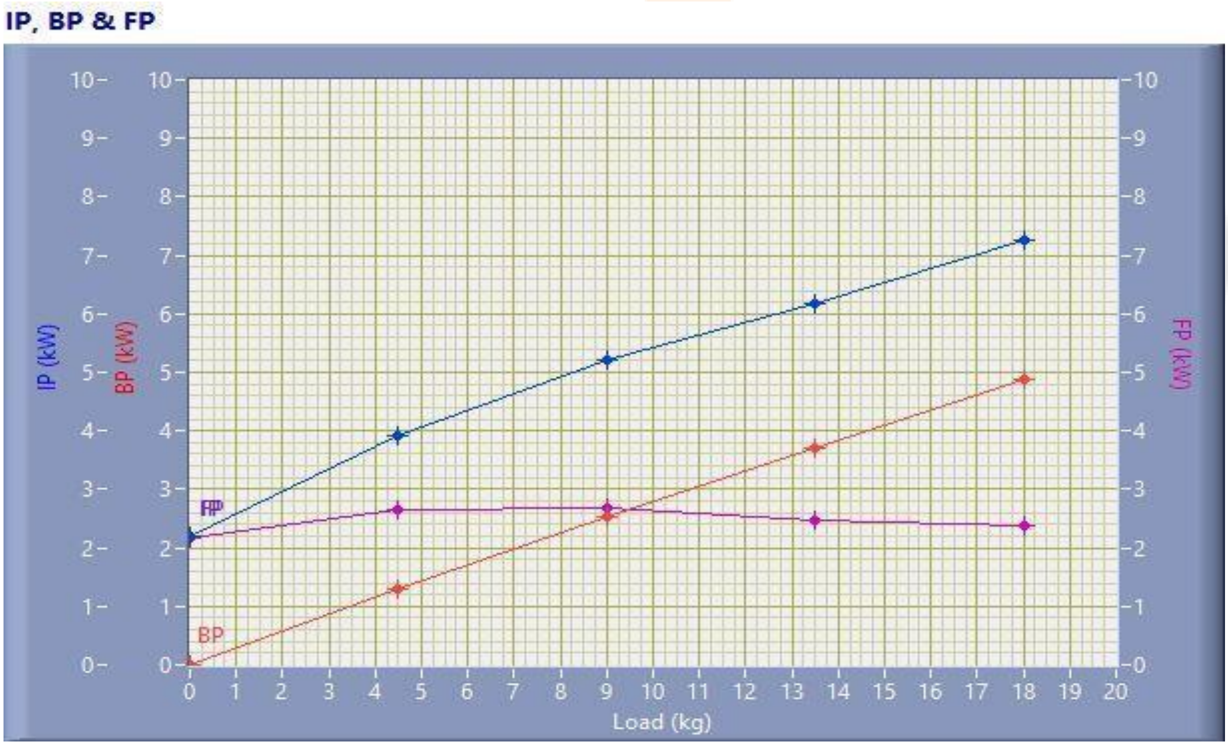
Torque(Nm)	**BP(kW)**	**FP(kW)**	**IP(kW)**	**BMEP (bar)**	**IMEP (bar)**	**BTHE(%)**	**ITHE(%)**	**MechEff. (%)**
0.06	0.01	2.02	2.03	0.01	2.37	0.23	49.59	0.47
8.17	1.29	2.54	3.83	1.55	4.60	18.41	54.49	33.78

16.35	2.53	2.54	5.07	3.11	6.23	26.98	54.05	49.91
24.51	3.70	2.46	6.15	4.66	7.75	30.05	50.00	60.10
32.71	4.88	2.32	7.21	6.21	9.17	32.05	47.29	67.78

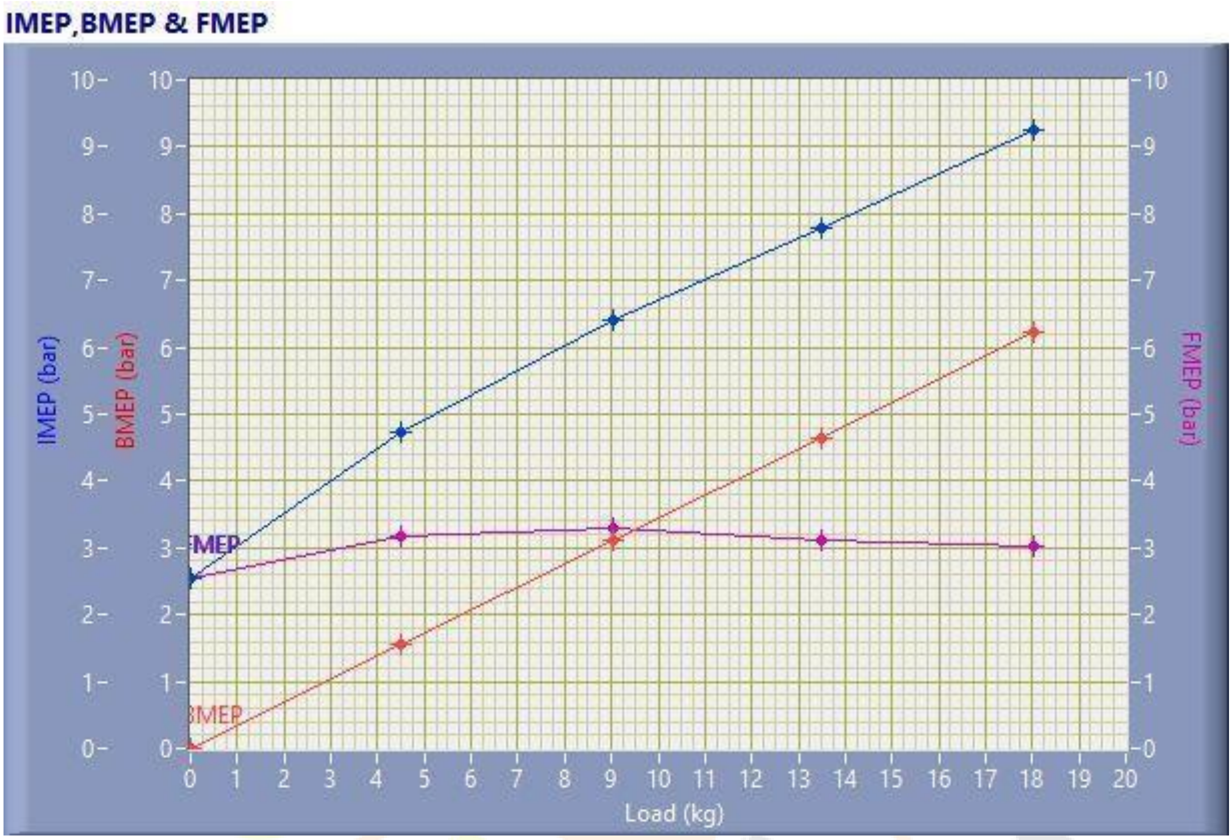
Result Data

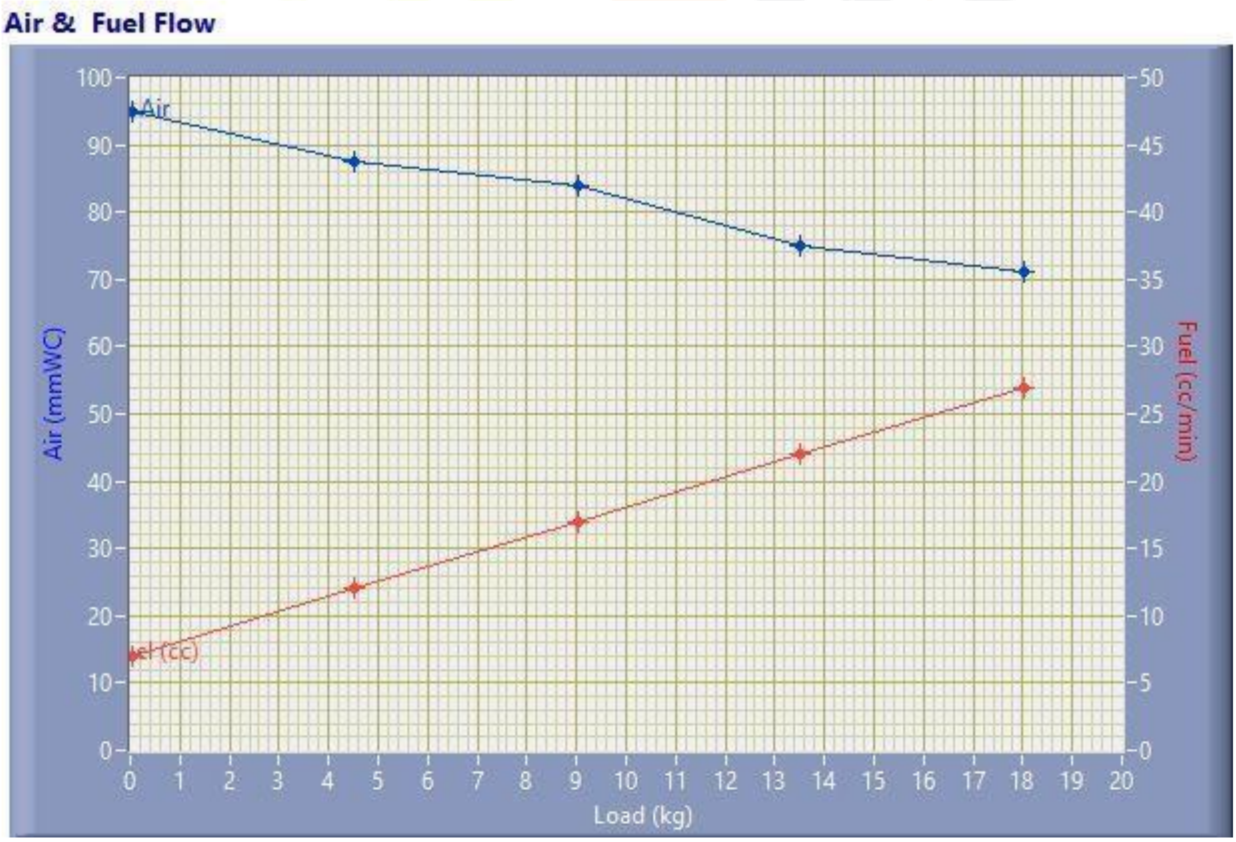
AirFlow(kg/h)	FuelFlow(kg/h)	SFC (kg/kWh)	Vol Eff(%)	A/F Ratio	HBP	HJW(%)	HGa(%)	HRad(%)
31.89	0.35	36.92	87.87	91.15	0.23	15.28	24.06	60.43
30.85	0.60	0.46	87.54	51.44	18.41	19.25	21.70	40.64
29.64	0.80	0.32	86.15	37.07	26.98	21.28	21.17	30.57
28.24	1.05	0.28	84.14	26.91	30.05	20.05	19.95	29.95
27.63	1.30	0.27	83.19	21.26	32.05	21.16	20.61	26.17

B50 Fuel Performance:



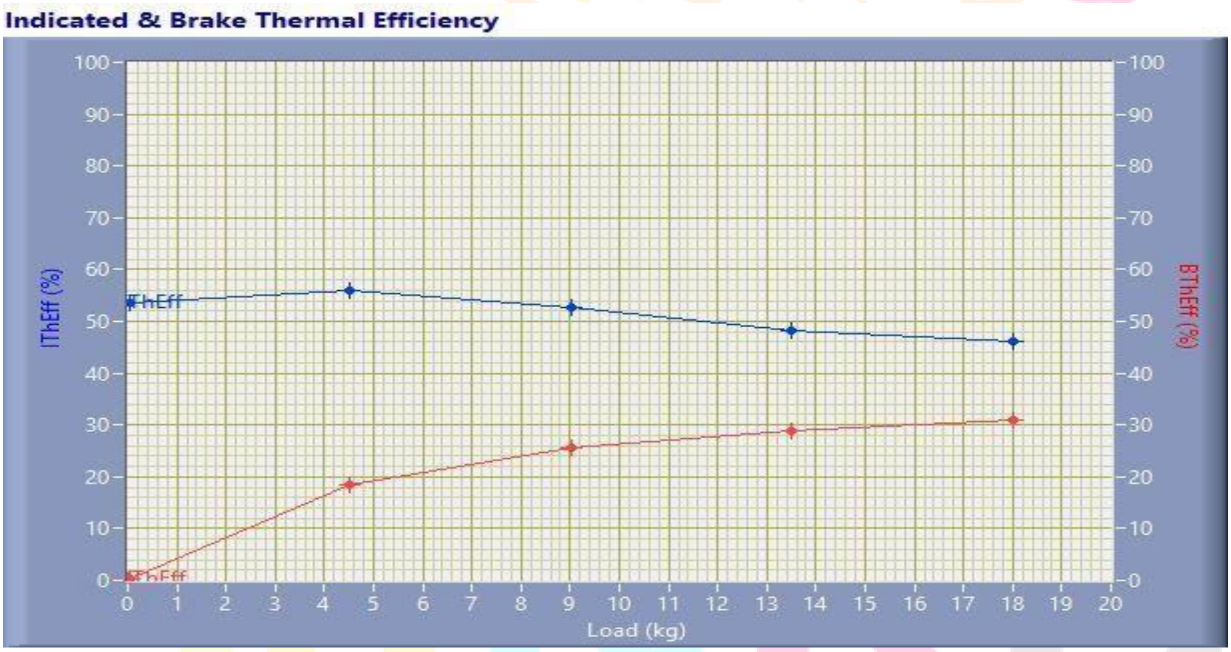
IMEP,BMEP& FMEP





Air & Fuel Flow

Speed (rpm)	Load(kg)	Air (mmWC)	Fuel (cc/min)
1551.00	0.02	94.89	7.00
1509.00	4.50	87.57	12.00
1481.00	9.02	83.84	17.00
1442.00	13.50	75.12	22.00
1425.00	18.02	71.03	27.00

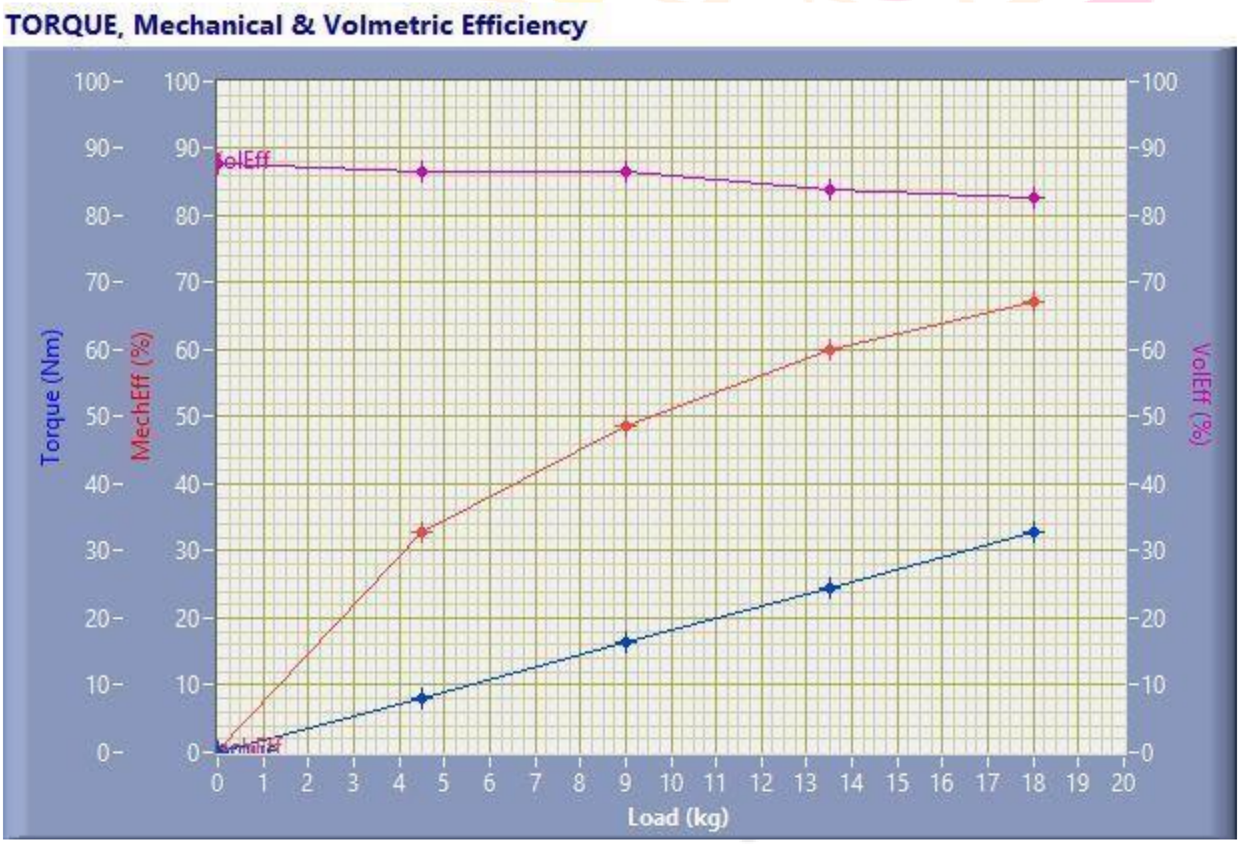


Indicated & Brake Thermal Efficiency

Speed (rpm)	Load(kg)	IThEff(%)	BThEff (%)
1551.00	0.02	53.43	0.15
1509.00	4.50	56.03	18.42
1481.00	9.02	52.60	25.57
1442.00	13.50	48.10	28.79
1425.00	18.02	46.05	30.94

SFC & Fuel Consumption

Speed (rpm)	Load(kg)	SFC (kg/kWh)	Fuel(kg/h)
1551.00	0.02	57.06	0.35
1509.00	4.50	0.47	0.61
1481.00	9.02	0.34	0.86
1442.00	13.50	0.30	1.11
1425.00	18.02	0.28	1.36



TORQUE, Mechanical & Volumetric Efficiency

B25 Fuel Emissions:

Blends	**CO**	**HC**	**CO2**
B25AC75	0.03	17	1.01
B25AC75	0.04	19	2.88
B25AC75	0.01	19	4.2
B25AC75	0.011	20	6.03
B25AC75	0.087	32	7.1

Blends	**02**	**NO**	**Smoke**
B25 AC75	20.04	90	3.5
B25 AC75	17.7	501	5.4
B25 AC75	14.99	991	9
B25 AC75	12.9	1408	31.4
B25 AC75	10.05	1691	52.7

B50 Fuel emissions:

Blends	**CO**	**HC**	**CO2**
B50AC50	0.061	16	1.32
B50AC50	0.037	15	3.1
B50AC50	0.025	15	4.46
B50AC50	0.036	21	6.4

B50AC50	0.15	30	8.57

CONCLUSIONS

SAF is a promising alternative to fuels because of its ecological and renewable nature. In our project, two types of biofuels are blended with aircraft jet fuel.They are B25 and B50. In this B25 (JB10,HB10,PB5) & B50 (JB20,HB20,PB10) is added with aircraft jet fuel. These fuels are investigated in internal combustion engines to know their emissions in atmosphere, combustion, and performance in the engines. Along with that their fuel properties are also investigated. The result showed significant reduction in carbon footprint. In addition, it also reduces the hydrogen and oxygen imbalance in the atmosphere. The smoke emission report of the B25 and B50 blend of our sustainable aviation fuel shows low smoke opacity. So, resulting in the reduction of pollution caused due to burning of fuel.By analyzing all the data, we collected in our study, it is clear that B25 and B 50blend of our fuel meet the density, flash point, fire point, cetane number, calorific value, kinematic viscosity, elemental analysis, Saponification, and iodine value according to the ASTM standards. While comparing two blends B25 and B50 with the aircraft jet fuel, B25 shows better results in all perspectives. The oil cakes from the feed stocks can be used as a bio fertilizers and insecticides. And the by product of transesterification, the glycerin can be used to make soaps. Moreover, burning of Sustainable Aviation Fuels create less environmental impact than burning of fossil fuels.

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