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EXPERIMENTAL ASSESSMENT OF CROTALARIA JUNCEA SEED OIL–DIESEL BLENDS AS AN ALTERNATIVE FUEL FOR A FOUR-STROKE CI ENGINE

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Abstract: **Oil extraction from crushed seeds of Crotalaria juncea (Sunn Hemp)is done by standard solvent extraction method by usinga modified Soxhlet apparatus. Optimization studies such as size fractions of the crushed seeds, extraction time, aging of seeds, and choice of solvents and use of co-solvents are doneto improve the yield of bio oil. Further tests likeelemental analysis, moisture content, residual carbon and dynamic viscosity are investigated. Some of the basic fuel properties such as specific gravity, iodine number,saponification value, calorific value, flash point, fire point and kinematic viscosity are characterized for fuel quality. It was found that the energy content of the Sunn Hemp oil (34.128 MJ/kg), is slightly lower than that of gasoline (47 MJ/kg) and diesel fuel (44.8 MJ/kg). However the scope of bio oil as a fuel for a diesel engine was studied.**

KEYWORDS:**Crotalaria juncea seed oil, single cylinder 4-stroke diesel engine, Specific fuel consumption,exhaust emissions**

I. INTRODUCTION

[1]Global emissions of CO_2 and other harmful gases such as CO,SO_x, NO_x and particulates generated by fossil fuel combustion haveled to serious greenhouse effects, acid rain, remarkable humanhealth problem and deterioration of the global environmental conditionas a whole. The price of crude petroleum has gone up to itshighest level. [2]Therefore identification of environment friendly andrenewable sources of alternative energy is one of the thrustareas of the scientific community.Biodiesel from bio oil is proposed to serve a lot to mitigate thisproblem to a good extent. Previously, biofuel used to be producedfrom soybeans, canola oil, animal fat, palm oil, corn oil, wastecooking oil and jatropha oil, etc. However, attempts arenow made towards biofuel production from non-food crops, microalga (i.e. phytoplankton), macro algae (i.e. sea wood) etc. Recentstudies indicate that the aromatic content and type, sulphurcontent, extraction temperature, and density are important factorsfor emission control [9]. Biomass based agricultural oils have agreat potential towards production of cleaner bio-diesel substitute. Amongst the oil bearing crops already identified, only sunflower, safflower, soybean, cotton seed, rapeseed and peanut oilsare considered as potential alternative fuels for diesel engines.These bio-oils are better than diesel fuel in terms of sulphur content,flash point, aromatic content and biodegradability.Bio oil from Crotalaria Juncea (Sunn Hemp) seed is a promisingnew source for production of biofuel. The crop grows best in tropicaland subtropical climate. Sunn Hemp is an important bast fibre,used in green manuring as well as a green fodder crop of India.

II. AVAILABILITY OFRAW SEEDS

References [1], [2] The Yellow variety of the Sunn Hemp seeds is used for thisresearch work. Sunn Hemp seeds, used in our experiments, are obtained from fields of Gudivada, Vijayawada rural, Andhra Pradesh, 521301, India.The dryseed is packed and supplied in a jute bag. It is stored in cold, dryplace. Sunn Hemp seeds are firstly cleaned by separating the otherflora adhered to them. They are dried and stored carefully in a dry jute sackat ambient temperature. Dried seeds are milled using a domestickitchen mill. Crushed seedsare stored at 10^{o}C. Finally, crushed Sunn Hemp seeds are meshedto obtain a grain size of less than 2 mm.

III. GEOGRAPHY OF CROTALARIA JUNCEA

Sunn Hemp is generally considered to have originated in India,where it has been cultivated since prehistoric times. However, thisis now widely grown throughout the tropics and subtropics. Innorthern India, it is grown in summer and in rainy season whilein the southern parts of country, where the winter is not so pronounced,it is grown in rabi season. It is one of the oldest knownfibres in the Indo-Pakistan subcontinent, as mentioned in ancientSanskrit literature. Basically, Sunn Hemp is an important bast fibreused in green manuring and as a green fodder crop of India.

Fig-1: SUN HEMP PLANT

Fibreobtained from Sunn Hemp is dull white in color, strong and durable.It is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Orissa,Tamilnadu, Rajasthan and Maharashtra. The fibre contains78.3% a-cellulose, 3.6% hemicelluloses and 4% lignin. It contains 30–35% protein and can be used for makingadhesives for plywood industries. Sunn Hemp seeds are sometimesused as herbal medicine.

Fig-2: SUN HEMP POD

Fig-3a: SUN HEMP SEEDS

Fig-3b: SUN HEMP SEEDS

IV. OIL EXTRACTION PROCESS

Extraction

References [2], [3] Solvent extraction is one of the traditional techniques ofextracting vegetable oil from oilseeds. In this method, pretreated(if necessary) oil seeds are put in contact with a suitable solvent,in its pure form, for extracting the oil from the solid matrix tothe liquid phase. Solvent extraction technique is one ofthe cheapest and most efficient processes, applied to produce oilfrom seeds. Jojoba oil, soybean oil, palm oil, jatropha oil and manyother oils are produced by this method.The main objective of this research work is to produce a bio-oilfrom Sunn Hemp seeds with the help of a conventional Soxhletapparatus. The yield of the production is optimized with respectto size fractions of the crushed seeds, extraction time, aging ofseeds, and choice of solvents and use of co-solvents along with the primarysolvent.

Apparatus

[2] In the present study, a batch extractor (Soxhlet Extractor) withround-bottom flask of capacity 1 lt is used. The cylindrical Soxhletextractor (Capacity: 700 ml) is placed onto the round-bottom flaskcontaining the extraction solvent. Top of the Soxhlet is equippedwith a bulb-condenser, operated on cooling water. The solvent isheated to reflux. The solvent vapour travels up a distillation armand floods into the chamber housing the thimble packed with solidseeds. The condenser ensures a zero loss of any solvent vapour. Thevapour cools and drips back into the chamber. When the Soxhletchamber is full, the chamber is automatically emptied through asiphoning action along a special side arm, with the solvent runningback, down into flask. This cycle may be allowed to repeat manytimes until extraction is complete.

In earlier days, hydraulic pressing is usually used to extract oilfrom an oil-containing seed. But, in recent days Soxhlet extractorsare employed for leaching the oil from any seed.Solvent extraction in a modified Soxhlet apparatus is done toextract the Sunn Hemp oil from its seeds. This particular Soxhlet apparatus consists of a glass extractor, fitted in betweena round bottom flask at the bottom and a bulb condenser at thetop.

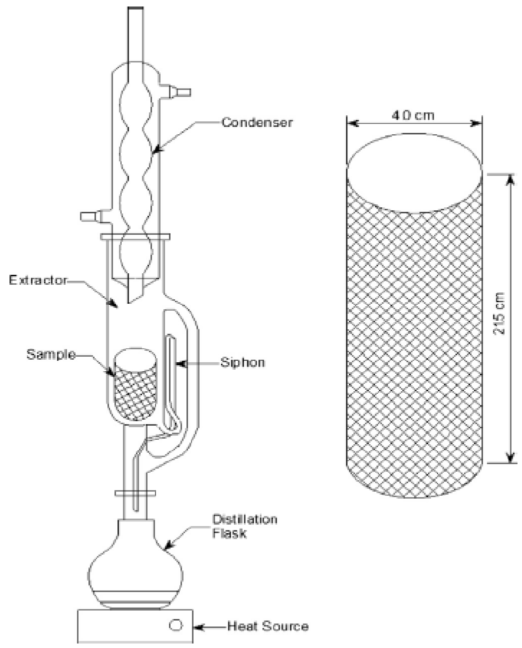

Fig-4: SOXHLET EXTRACTOR WITH A WIRE-MESHED CYLIDRICAL SAMPLE HOLDER PUT INSIDE A CONVENTIONAL SOXHLET EXTRACTOR

Inside the glass thimble holder, solid matrix of seeds is placedwithin a cylindrical packed bed of wire-mesh. The round-bottomdistillation flask initially contained an extracting solvent and it isheated up. As the solvent vapour goes up to the condenser, it condensesand accumulates inside the extractor. Here, the solventcomes in contact with the seeds and oil is leached out of the seeds.When the condensate moves down through the bed of seeds, masstransfer takes place. However, major amount of mass transfer of oilfrom the seeds to solvent occurs when the accumulated solventmoves up purely due to the hydrostatic pressure head. So, surfacearea offered by the bed and the seed-solvent contact time are thetwo major factors for the yield of the oil production. For eachrun, crushed Sunn Hemp seed is used because it is found that thewhole seeds are unable to produce oil by the solvent extractionprocedure. Generally, ground, naturally dried seeds (moisturecontent of 8.6%) are screened using B.S. standard sieves. The averageseed diameter is 1.29 _ 10_3 m. Instead of placing the seedsright into a thimble, a cylindrical wire-mesh (length: 21.5 cm;diameter: 4 cm and one end closed) is used to hold the seeds. Finally the vapor condensed is collected to use it as a bio fuel.

IV. LITERATURE REVIEW

Dr. B.Durga Prasad and G. Kishore conducted experiment on 4-stroke diesel engine with Crotalaria Juncea seed oil and diesel blends. The details of the engine are as shown in table 1 below.

Table I
ENGINE SPECIFICATIONS

Model	AV1
Make	KIRLOSKAR
Type	Single cylinder, four stroke, water cooled
Bore	85mm
Stroke	110mm
Speed	1500rpm
Rated power	5hp

Procedure

Experiment is done on conventional engine fuelled with Crotalaria Juncea seed oil of 10%, 20%, 30% and diesel from no load to full load and the following readings are noted,

a. Engine speed
b. Time taken for 10cc of fuel consumption.
c. Voltmeter and ammeter readings.
d. Temperatures at different locations.
e. exhaust emissions such as CO_2,CO,HC and NO_x by using exhaust gas analyzer.

V. RESULTS AND DISCUSSIONS

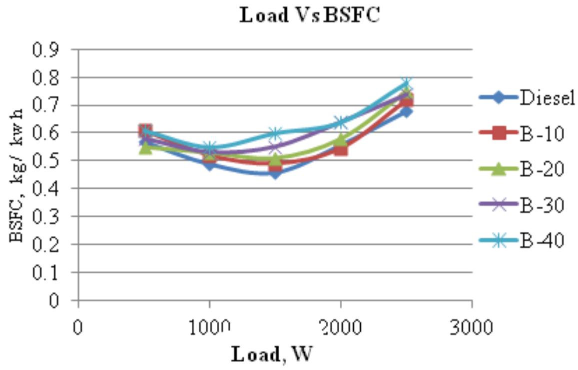

Fig-5 LOAD Vs BRAKE SPECIFIC FUEL CONSUMPTION

The result for the variations in the brake specific fuel consumption (BSFC) with load is presented in the above Fig.5. The BSFC value at full load is 0.69kg/kW-hr for diesel (standard engine). It can be observed that the engine fuelled with Crotalaria Juncea seed oil blends B10, B20, B30and B40 gives BSFC of 0.72 kg/kW-hr, 0.68 kg/kW-hr, 0.79 kg/kW-hr and 0.83kg/kW-hrrespectively at full load. The BSFC of Crotalaria Juncea seed oil blends are little more compared to diesel fuel. The Crotalaria Juncea seed blend B20 has less BSFC compared to other Crotalaria Juncea seed blends as well as diesel fuel.

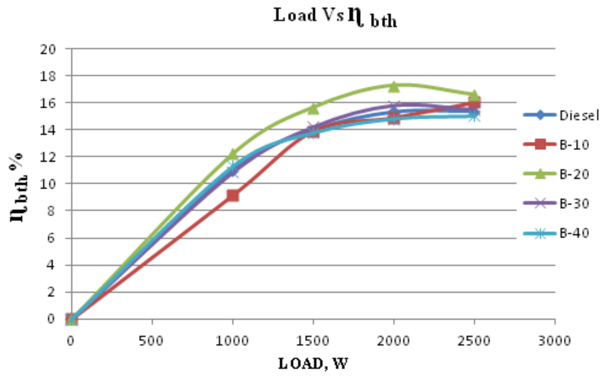

Fig-6 LOAD VS BRAKE THERMAL EFFICIENCY

The variation of brake thermal efficiency with respect to load for Crotalaria Juncea seed oil blends and diesel are shown in above Fig.6Brake thermal efficiency of the engine by different blends B10, B20, B30, B40 and Diesel is observed as 15.38%,15.70%, 17.05%, 15% and 14.89% at full load respectively. The values of Brake thermal efficiency of blends are higher compared to diesel fuel (standard engine). Particularly the B20 fuel gives more brake thermal efficiency than the other fuels. As the engine produces higher power output, the frictional losses are changed and hence change in the brake thermal efficiency.

From Fig.7, the variation of mechanical efficiency with respect to load can be observed. Mechanical efficiency of the engine by different blends B10, B20, B30, B40 and Diesel is observed as 58.38%, 65.13%, 69.98%, 59.99% and 60% at full load respectively. The values of mechanical efficiency of blends are higher compared to diesel fuel (

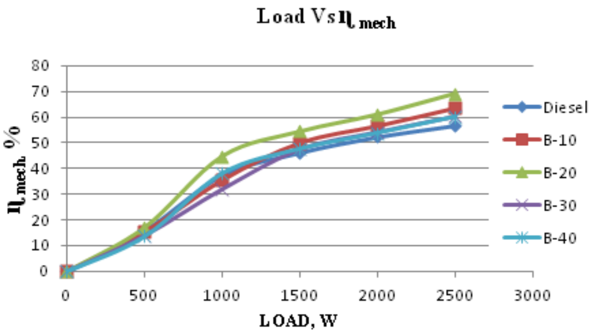

Fig-7 LOAD Vs MECHANICAL EFFICIENCY

standard engine). Particularly the B20 fuel gives more mechanical efficiency than the other fuels. As the engine produces higher power output, the frictional losses are changed and hence change in the mechanical efficient.

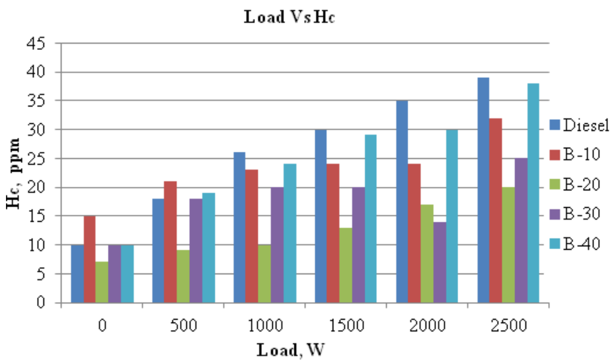

Fig-8 LOAD Vs HC

Fig.8 represents the variation of HC emissions with different loads of Crotalaria Juncea seed oil. There is increase in HCemissions with the load increases. From the above graph it is cleared that B20 has the lowest HC emissions at all loads compared to other blends of Crotalaria Juncea seed bio-diesel this may due to the availability of oxygen percentage in fuel may lead to complete combustion cause reduce HC emissions in exhaust. The HC values at full load as follows, Diesel-38, B10-34, B20-21, B30-25.Therefore B10 gives lower HC emissions compared to other blends of Crotalaria Juncea seed oil bio-diesel.

Fig.9 represents the variation of CO_2 emissions with different loads of Crotalaria Juncea seed oil.CO_2 emissions are increased linearly with the load, may due to complete combustion at higher loads. There is no significant difference for CO_2 emissions for all fuel Crotalaria Juncea seed fuel blends.However, CO_2 emitted from bio-diesel is entirely different with CO_2 emitted from fossil fuel. Since CO_2 emitted by bio-diesel can be utilized for respiration in plants and it recycled.Also, this CO_2 is decomposed in atmosphere with in short period of time, but CO_2 emitted byfossil fuel is retained over several hundred years and can cause ozone layer depletion.

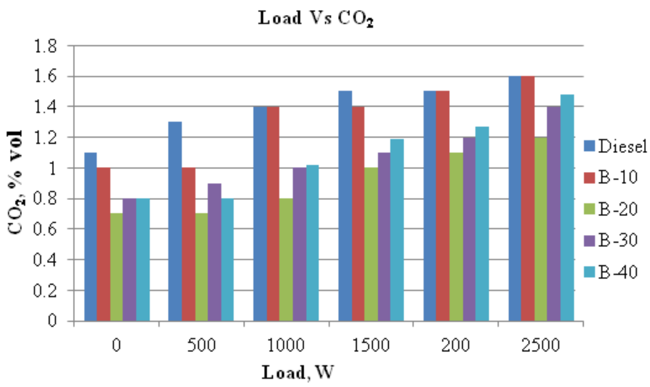

Fig-9LOAD Vs CO_2

VI. CONCLUSION

- Brake thermal efficiency is 17.5% higher for the Crotalaria Juncea seed oil-20(B-20) at full load compared to diesel and other blends.
- Brake specific fuel consumption is reduced 6.6% for the blend -20(B-20) compared to diesel and other blends.
- The Crotalaria Juncea seed oil -20(B-20) has lower HC emissions compared to diesel and other blends.
- CO_2 levels are lower for the blend -20(B-20) as compared to diesel and other blends.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency. The emission characteristics of the engine were studied in terms concentration ofCO, CO_2, HC. The results obtained for Crotalaria Juncea seed oil and their blends with diesel were compared with the results of diesel.

VII. SCOPE OF FUTURE WORK

The present work can be extended by varying the blend percentage and the engine can be tested for better performance with various alternative fuels also.

VIII. ACKNOWLEDGMENT

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