Experimental Study and Thermal Analysis of a Combustion Chamber of a Diesel Engine Fueled with Blend of Diesel, Cottonseed Oil along with Additives Kerosene

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Abstract— The depleting reserves of petroleum and environmental issues have led to the search for more environmental-friendly and renewable fuels. Biodiesel obtained from various renewable sources has been recognized as one of the alternative fuel due to its biodegradability, high cetane no, no sulphur emissions and low volatility. Biodiesel derived from edible feed stocks such as cottonseed oil are reported to be feasible choices for developing countries including India. The aim of present work is to optimize the biodiesel production from cottonseed oil through tranesterification process.

Key words: Alternative Fuel, Cottonseed Oil, Performance Testing, Thermal Analysis

I. INTRODUCTION

Due to gradual depletion of world petroleum reserves and the impact of environmental pollution there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, vegetable oil is a promising alternative because it is renewable, environment friendly and produced easily in rural areas, where there is an acute need for modern form of energy. In recent years systematic effort have been made by several research workers to use as fuel engines. It is said that energy consumption pattern is an indicator of the socio-economic development of a country.

II. MATERIAL AND METHOD

Cotton seed oil is available at local vendor in all over India. All materials and reagents used were analytical grade (AnalaR) chemicals except otherwise stated. Glassware, containers and other tools are initially washed with liquid detergent, rinsed with 20% (v/v) nitric acid and finally rinsed with distilled water.

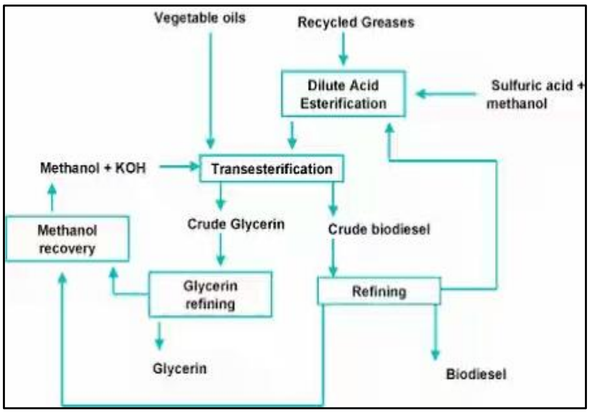


Fig. 1: Trans-esterification Process [5]

A. *Method of trans-esterification*

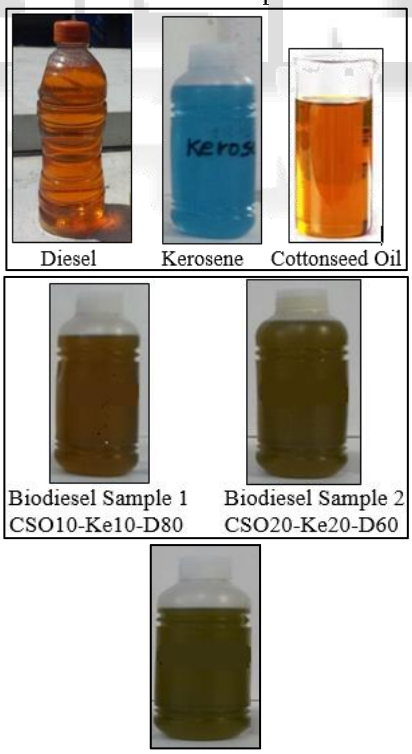
This process has two separate starting points. If vegetable oils can be obtained that are below 2.5% FFA, the esterification step is not necessary.

B. *Blend Preparation*

The blending of diesel with biodiesel was carried out in following ratios (CSO:Ke:D) ie.Biodiesel Sample1 (pure diesel), Biodiesel Sample2 (CSO10-Ke10-D80), Biodiesel Sample3 (CSO20-Ke20-D60) and Biodiesel Sample4 (CSO33.33-Ke33.33-D33.33). Blending processing of diesel and biodiesel was conducted by mixing diesel and biodiesel with certain ratio in the laboratory.

Sample No.	Blend	Mixture of Blend with Diesel and Kerosene
1.	Sample1	Pure Diesel
2.	Sample2	CSO10-Ke10-D80
3.	Sample3	CSO20-Ke20-D60
4.	Sample4	CSO33.33-Ke33.33-D33.33
5.	Raw oil	Cottonseed oil

Table 2: Blend Preparation



Biodiesel Sample 3 CSO33.33-Ke33.33-D33.33

Fig. 2: Biodiesel Samples

Fuel Sample	Kinematic Viscosity (mm^2/s)	Density (kg/m^3)	Flash Point (^0C)	Cetane Number	Calorific Value (KJ/Kg)
Diesel	3.32	823	56	49.38	42843

Cotton Seed Oil	34.57	934	198	41.8	39687
Kerosene	1.85	783	43	47.13	43386
CSO10-Ke10-D80	6.28	804	68	52.34	42683
CSO20-Ke20-D60	7.85	819	79	54.67	41287
CSO33.33-D33.33-Ke33.33	9.16	841	96	57.81	39982

Table 1: Properties of Cottonseed oil, CSO and its blends with Diesel and Kerosene

III. EXPERIMENTAL SETUP & EXPERIMENTATION

Fig. 3: Diesel Engine Test Rig with AVL DiTEST (Exhaust gas analyzer)

Sr. No.	Constraints	Value / Characteristics
1	Engine	Four stroke single cylinder
2	Make	Kirloskar
3	Brake Power	5 HP
4	RPM	1500
5	Fuel	Diesel
6	No of Cylinder	Single
7	Bore	87.5 mm
8	Stroke Length	110 mm
9	Starting	Cranking
10	Working Cycle	Four Stroke
11	Method of Cooling	Water cooled
12	Method of ignition	Compression Ignition
13	Dynamometer	Eddy Current type
14	Dynamometer Arm Length	145 mm
15	Rated Speed	200-1500 Rpm
16	Rated Power	3.5 KW (max)
17	Torque	3.62 kg-m

Table 2: Specification of Diesel Engine Test rig

IV. RESULT AND DISCUSSION

A. Brake specific fuel consumption (BSFC-Kg/Kw-hr)

The variation of brake specific fuel consumption with brake power is shown in table 5.10.The plot it is reveals that as the brake power increases brake specific fuel consumption decreases.

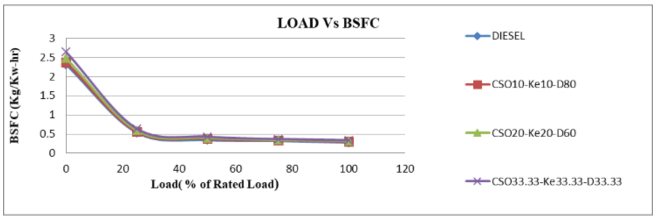


Fig. 4: Brake specific fuel consumption (BSFC-Kg/Kw-hr)

B. Brake thermal efficiency (BTE)

Fig. 5 shows the brake thermal efficiency of cottonseed oil-diesel blend with diesel. Graph indicates that brake thermal efficiency increases with increasing load in all cases. CSO10-Ke10-D80 blend gives result slightly less than the pure diesel.

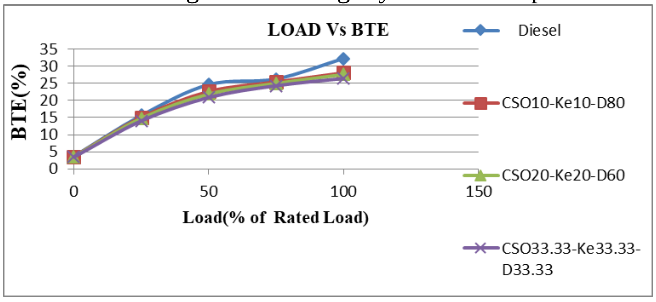


Fig. 5: Brake thermal efficiency (BTE)

C. Exhaust Gas Temperature (EGT)

Fig 6 shows the exhaust gas temp of CSO-Ke-D blend with diesel. Graph indicates that with increase in load the exhaust gas temp also increases in all cases. CSO10-Ke10-D80 blend gives result slightly similar result than the pure diesel.

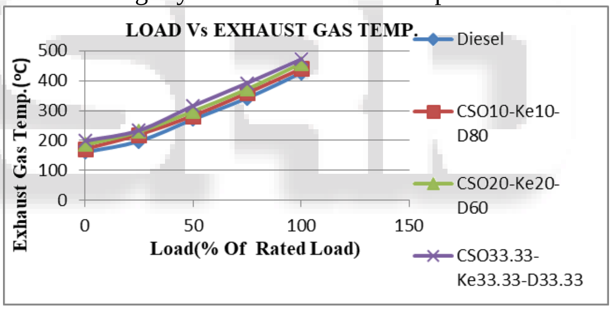


Fig. 6: Exhaust Gas Temperature (EGT)

D. Carbon Dioxide (CO_2) Emission

Fig 7 shows the comparison of CO_2 emission of CSO-Ke-D blend with diesel. Graph indicates that CO_2 increases with increasing load in all cases.

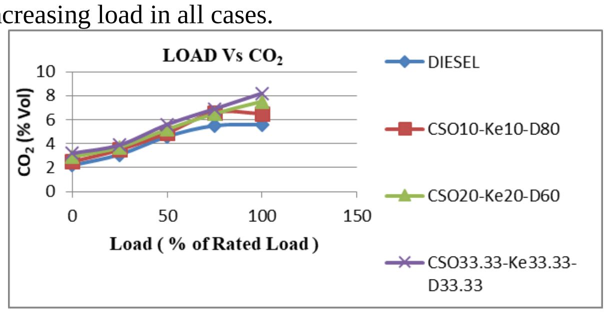


Fig. 7: Carbon Dioxide (CO_2) Emission

V. THERMAL ANALYSIS

A. Cylinder

- Material: Grey Cast Iron
- Combustion temperature: 1190^0C
- Thickness of Cylinder: 10 mm

- I.D. = 87.5 mm
- Length: 110 mm (including top thickness)

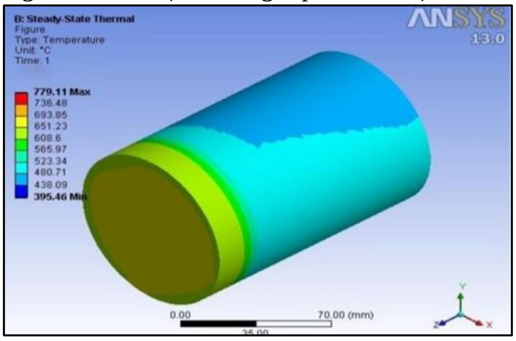


Fig. 8: Temperature Distribution on Outer wall

The above figure 8 is drawn is of cylinder of an Diesel engine. The temp is higher at the top and become lower from top to bottom surface.The temperatures are high at the top and become low at bottom due to thermal conductivity of the material.

B. Piston

- Material: Aluminum Alloys
- Thickness at the Top = 4 mm
- Thickness in Top Portion of Piston: 9.5 mm (portion inline with rings)
- Skirt Thickness: 3.5mm
- Piston Rings: Grey Cast Iron (Nos. 3)
- Axial Thickness = 2.5 mm
- Radial Thickness = 2.5 mm
- O.D. = 87.5 mm

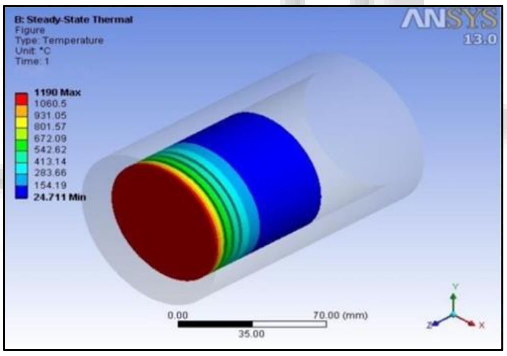


Fig. 9: Temperature distributions in Piston

The temperature is defined as the measure of the molecular activity of a substance where higher the temperature greater the movement of molecules. Since piston is subjected to non-constant thermal loads from region to region, the temperatures of the piston is constant but will be distributed along piston body from maximum temperature to minimum temperature.

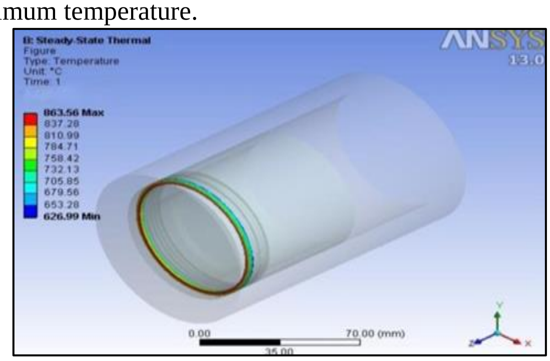


Fig. 10: Temperature distributions in Piston Ring

In above case temperature is varying in all direction of model. The fig.9 shows highest temperature at top face of piston and decreases with height in down. The maximum temperature at top is 1190^0C and 24.71^0C at bottom of piston model. So the heat loss in piston due to temperature difference with conduction.

C. Piston Ring

The above figure 10 is of temp distribution of the piston ring. As shown in the above figure it is clear that the temp is maximum at the top of piston which is 863^0C and reduces continuously upto the 626^0C.

Thermal Stress Distribution in Engine Parts: Cylinder:

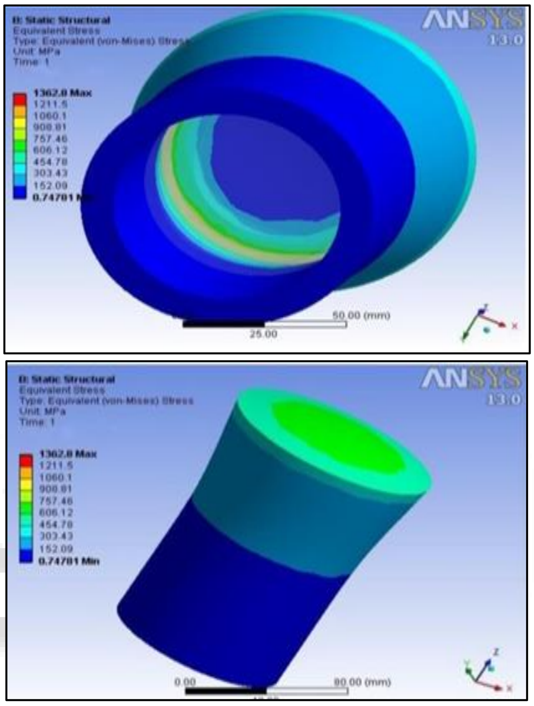


Fig. 11: Thermal stresses on cylinder body

Thermal stresses are higher at the top surface of the piston and become lower from top to bottom surface. This is due to the thermal conductivity is increased, the amount of heat flow will be high and this causes a temperature drop between the warm and cold walls while when thermal conductivity value is decreased the temperature drop is increased by a particular value. From this comparison it is noted that the first compression ring of piston receives a high quantity of heat.

D. Piston

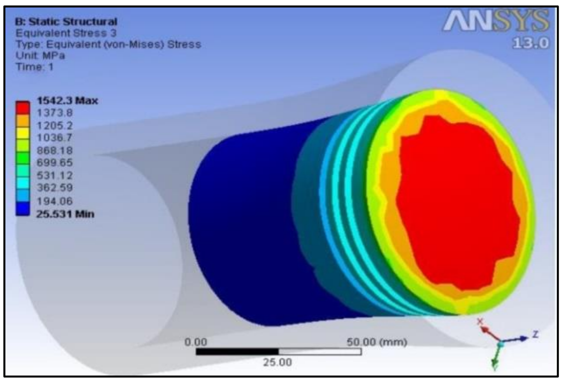


Fig. 12: Thermal stresses on piston

The temperature field analysis to the piston is as shown in Figure 8 and Figure 9. Through the analysis, we can get that the temperature field distribution is basically reasonable. Then carry out a thermal stress analysis according to the temperature field of the piston. In the thermal stress analysis, it is necessary to convert thermal units within ANSYS. After conversion, the thermal stress analysis can be carried out.

During the thermal stress analysis, it is necessary to make sure that no rigid body displacement will occur to the model. So it is necessary to carry out constraint to the piston in every direction, and the constraint applied cannot bring in additional mechanical load. The applied temperature load during the thermal stress analysis is the temperature load when the result for the temperature field automatically converts to nodes.

The above figure shows thermal stresses acting on the piston. The maximum stresses is acting on the upper surface of piston which is 1542Mpa. And reduces upto 24Mpa.

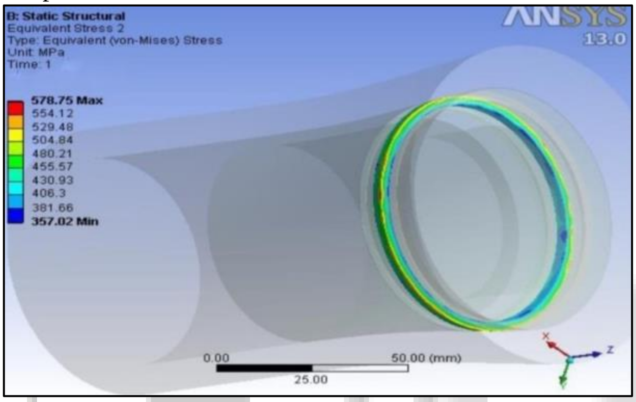


Fig. 13: Thermal stresses on piston Ring

Piston thermal boundary conditions consist of the piston pin thermal boundary condition, skirt and ring land thermal boundary condition, underside thermal boundary condition, combustion side thermal boundary condition. The reasonable boundary conditions are given to calculate temperature distribution with finite element method of diesel engine piston.

From figure 13 it can say that the maximum stress acting on the piston ring and it is 578 MPa and minimum upto 357Mpa.

VI. Conclusion

The optimization of biodiesel production from Cottonseed oil was evaluated using tran-esterification process. The performance and emission parameters for diesel fuel were compared with CSO10-Ke10-D80, CSO20-Ke20-D60, CSO33.33-Ke33.33-D33.33.

The following conclusions can be drawn from the present study:

The optimum conditions for maximum biodiesel production were obtained at molar ratio of 5:1, reaction time 60 minutes and 0.5% KOH concentration. A maximum yield of 98% was determined.

The fuel properties of optimized biodiesel were found to be comparable to diesel and were conforming to the latest biodiesel standards.

The calorific value of optimized Cottonseed oil biodiesel CSO10-Ke10-D80 was 42,683 KJ/Kg which is 0.37 % lower than diesel fuel.

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