EXPERIMENTAL STUDY AND THERMAL ANALYSIS OF A COMBUSTION CHAMBER OF A DIESEL ENGINE FUELLED WITH BLEND OF DIESEL AND KUSUM OIL

Gaurav P. Nagdeve[1], Chandrakant B. Kothare[2], Kumar S. Raizada[3]

[1] *M. Tech student, Department of Mechanical Engineering, S.S.P.A.C.E Wardha, Maharastra, India*
[2] *Asst. Professor, Department of Mechanical Engineering, S.S.P.A.C.E Wardha, Maharastra, India*
[3] *Asst. Professor, Department of Mechanical Engineering, S.S.P.A.C.E Wardha, Maharastra, India*

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 nonedible feed stocks such as kusum oil are reported to be feasible choices for developing countries including India where consumption and cost of edible oil is very high .The aim of present work is to optimize the biodiesel production from kusum oil through tranesterification process. The optimum conditions for maximum yield were obtained at molar ratio of 5:1, reaction time 60 minutes, and at 0.5% catalyst concentration. The various performance and emission parameters like brake power (BP), brake specific fuel consumption(BSFC), brake thermal efficiency (BTE), CO emissions, CO2 emissions, HC emissions, NOx emissions were evaluated at different loads and compression ratios in a 4 stroke, single cylinder CI engine. These performance and emission parameters of diesel fuel were compared with that of B25, B50, B75 and B100. The performance parameters of B25 blend were similar to those of diesel. It was found that CO2, HC and CO emissions decreases as the blend content increases whereas the NOx emissions increases as the blend content increases. Also simulation of combustion chamber of CI engine is done.

Keyword: - *Alternative fuel, kusum oil, performance testing, and thermal analysis.*

1. INTRODUCTION

Today, the world has two main problems viz. fossil fuel deficiency and environmental degradation. Petroleum is the largest single source of energy consumed by the world's population, exceeding coal, natural gas, nuclear, hydro and renewable. This increasing demand of petroleum's is 30% by the year of 2020. That's why, the shortage of petroleum resources, environmental pollution, energy security, and continuous increasing petroleum costs encourage new studies or researches to develop alternative renewable fuels. So biodiesel made up from animal fats, seeds of Jatropha, palm, kusum etc. are the substitutes for the petroleum. Diesel fuels are on the heavy end of a barrel of crude oil. This gives diesel fuel its high BTU content and power, but also causes problems with diesel vehicle operation in cold weather when this conventional diesel fuel can gel. Similarly, one limitation to the use of biodiesel is the fact that it tends to gel at low temperatures. Some types of biodiesel freeze at higher temperatures than others, depending on the level of saturated components in the fuel. [2].

Due to scarcity and increasing costs of conventional fossil fuels, biodiesel as a fuel has become more attractive fuel. Experts suggested that current oil and gas reserves would tend to last only for few decades. To fulfill the rising energy demand and replace reducing oil reserves renewable fuel like biodiesel is within the

forefront of other technologies. Biodiesel obtained from vegetable oil can be used directly in diesel engines with diesel fuel, because their properties are similar to petro-diesel. In this connection there is no need for engine modifications. Several methods have been developed for biodiesel extraction, among which trans-esterification with alkali catalyst conversion of triglycerides to their corresponding methyl ester in short reaction time. The process of trans-esterification is depends on the reaction condition, molar reaction of alcohol to oil, type of alcohol, type and amount of catalyst, reaction temperature and pressure, reaction time and contents of free fatty acids and water in oils or fats. Kusum is an oilseed crop which is mainly grown in semiarid regions. It is used in both transportation and industrial sectors effectively. Kusum is a strongly top rooted annual plant belongs to Asteraceae family and its characteristics are resistance to saline conditions, to water stress, and can reach the deep-lying water. [2]

2. MATERIALS AND METHODS

2.1 Characterisation of Kusum seeds oil

In India, Kusum is one of the forest-based tree-borne non-edible oil. The botanical name of Kusum is Schlichera oliosa is widely found in the sub-Himalayan region, Chhattisgarh, throughout central and southern India. The estimated availability of *Schlichera oleosa* seed is about 25, 000 oil potential per tones per annum. In the past *Schlichera Oliosa* seed oil was exported from India to Germany. This market has now fallen away. Current (1979) production in India is 4000-5000 tons. Schlichera Oliosa seed kernels (0.45 lacks of tones of seed) contain 40.3% of yellowish brown colored oil. The one or two almost round seeds some 1.5cm in diameter and weighing between 0.5 and 1.0 g.[4]

The weight of 1000 seeds is 500-700 g. Schlichera oleosa evergreen trees with the height up to 30 m and the growth up to 3 m. The leaves are paripinnate, 20-40 cm long. The leaflets are 2 to 4 pairs, elliptic or elliptic-oblong, coriaceous, margins entire and apex rounded. The flowers are minute, yellowish green; male or bisexual, fascicled in spike like axillary racemes 7.5 to 12.5 cm long. The fruits are berry, glucose or ovoid, and hard skinned. The seeds are brown, irregularly elliptic, slightly compressed, oily, enclosed in a succulent aril. [4]

Figure: 2.1 Kusum tree with fruits [9]

2.2 Collection of seeds

The kusum oil used for this study was from Kusum seeds that are collected from seeds market Raipur (C.G) and expelled in a mechanical expeller and oil from seed kernel was extracted in M/s Bulchand Chhabaldas Oil Mill, Urla, Raipur (C.G.)

Fig: 2.2 Kusum seeds [4]

2.3 Extraction of Kusum oil

For extraction of Kusum oil from Kernel, two methods have been identified. They are the chemical extraction with n-hexane and mechanical extraction method in two stages using screw type of expellers. In the present study, the Mechanical extraction process is used and it gave the oil content about 23 to 33% from the kernel. In the two stages expellers the oil extracted were 30 to 38%.[3,19]

Fig: 2.3 Mechanical Type Expeller

2.4 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**.**

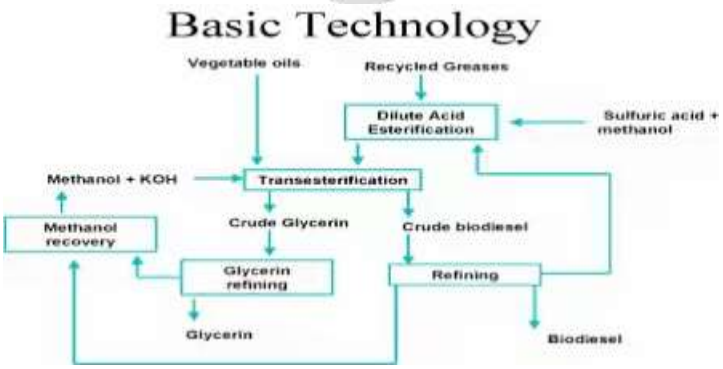


Figure: 2.4 Trans-esterification Process [5]

2.5 Blend Preparation

The blending of Kusum oil (KME) is prepared with diesel in different proportions such as

- B25 (Kusum oil 25% & Diesel 75%),
- B50 (Kusum oil 50% & Diesel 50%),
- B75 (Kusum oil 75% & Diesel 25%),
- B100 (Kusum oil 100% & Diesel 00%),
- Raw oil

Figure: 2.5 Blended fuel samples

2.6 Properties of Kusum oil and its blends

Table: 2.1 Properties of Kusum oil, KME and its blends with Diesel

Blends of KME	Density@ 40^0C	Calorific Value (KJ/kg)	Kinematic Viscosity@ $40(^0C)$ (cSt)	Flash Point (^{0}C)	Fire Point (^{0}C)
B25 (K25-D75)	816	41,550	4.162	83	85
B50 (K50-D50)	827	41,010	9.01	87	90
B75 (K25-D75)	836	40,790	11.03	98	109
B100 (K100-00D)	850	40,210	14.2	150	157
Raw oil	860	38,140	40.33	225	231
Diesel	840	42,490	3.05	85	78
Reference :- Anacon Lab					

3. EXPERIMENTAL SETUP & EXPERIMENTATION

A 3.75 KW diesel engine AV1 Single Cylinder water cooled, Kirloskar Make was used to test blends of diesel with kusum biodiesel. Engine test setup was developed to carry the trials using these blends. This paper presents a study report on the performance of IC engine using blends of kusum with diesel with various blending ratio. The engine performance studies were conducted with eddy current dynamometer setup. Parameters like speed of engine, fuel consumption and torque were measured at different loads for pure diesel and various combination of dual fuel. Break Power, BSFC, BTE and heat balance were calculated. Paper represents the test results for blends B25% to

B100%.

Figure: 2.6 Diesel Engine Test Rig with AVL DiTEST (Exhaust gas analyzer)

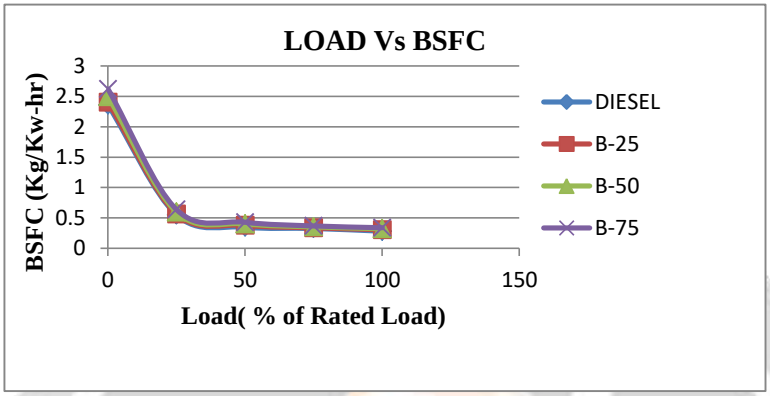
Table: 2.2 Specification of Diesel Engine Test rig

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

4. RESULT AND DISCUSSION

A. Effect on Brake specific fuel consumption (BSFC)

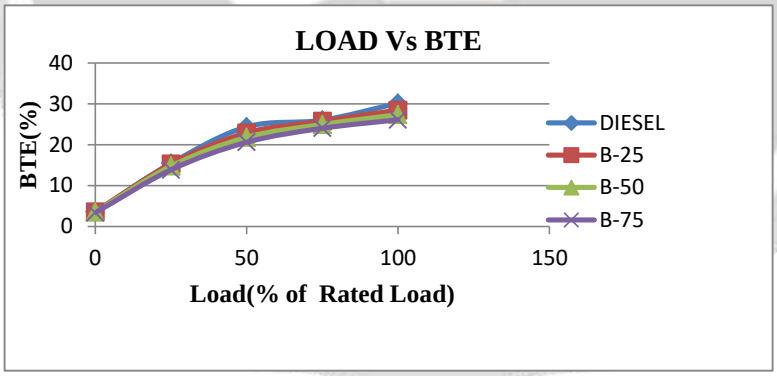
With increase in the load at constant speed the BSFC of blends gets decreases. The BSFC of diesel is 2.359 Kg/Kw-hr. at the no load condition. As the load increases the BSFC gets decreases from B-75 to B-25. It was found that the Blend B-75 gives the highest value of 2.622 Kg/Kw-hr at the no load condition.



Graph: 4.1 Comparison of BSFC of kusum-diesel blends with load

B. Effect on Brake Thermal Efficiency (BTE)

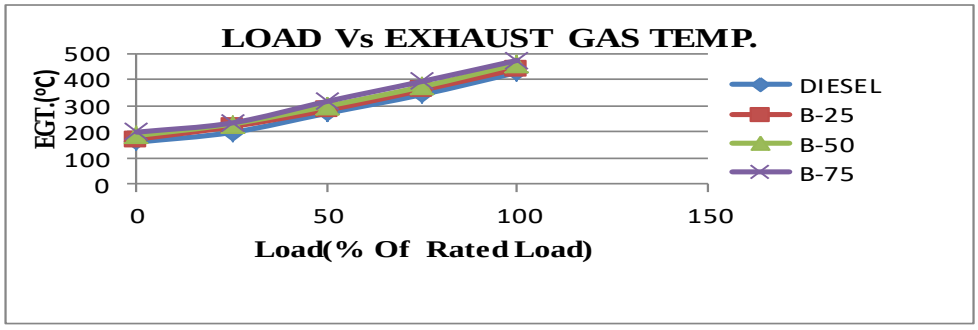
As the load on the engine increases at the constant speed then there is increase in the Brake Thermal Efficiency. The BTE of the diesel is 30.16 % which is the highest value. As the blend ratio of kusum-diesel is minimum then BTE of B-25 is nearly equal to the diesel and as the blend ratio increases then BTE gets decreases. It was found that among the all blends B-25 is having highest value of 28.47 % at 100 % load.



Graph: 4.2 Comparison of BTE of kusum-diesel blends with load

C. Effect on exhaust gas temp.(EGT)

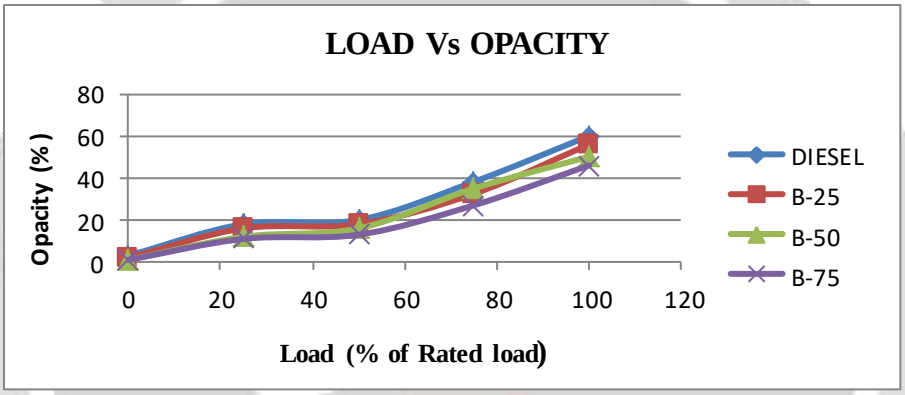
During the experiment with the increase in the load at constant speed the EGT gets increases. The EGT of diesel is 472^0C at full load. At the Initial blend of kusum-diesel the EGT is low which is 440^0C and as the blend is increases the EGT gets increases. It was found that among the all blends the B-75 blend gives the highest EGT of472^0C. at full load.



Graph:4.3Comparison of Exhaust gas Temp. of kusum-diesel blends with load

D. Effect on Opacity

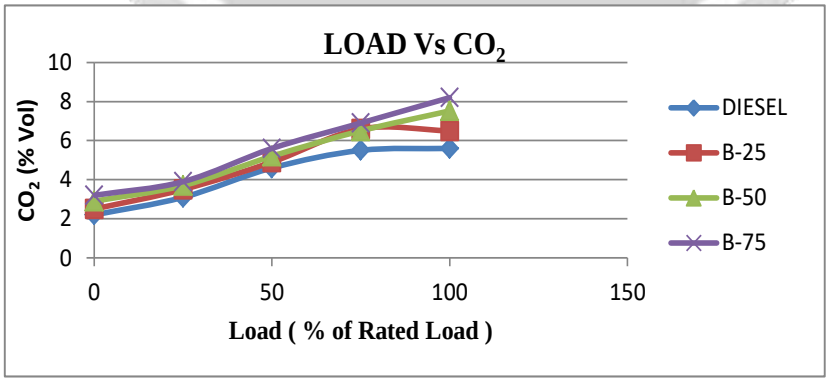
From the experiment it is clear that as the load increases at constant speed the opacity gets increases. The highest value of opacity is 60 % for pure diesel at full load. Among the all blends the blend B-25 is the highest value is 56 % at full load.



Graph: 4.4 Comparison of opacity of Kusum-diesel blends with load

E. Effect on Carbon Dioxide (CO2)

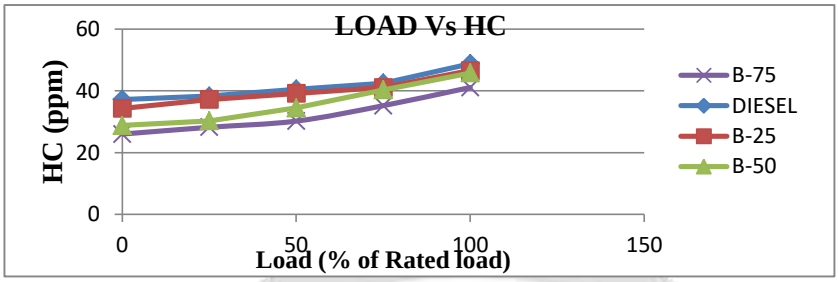
As the load on the CI engine with constant speed increases the % of C02 on volume basis increases. Diesel contain 0 % of O_2 hence diesel contain the lowest value of CO_2. Among the all blends the highest value of blend i.e. B-75 is having the highest value which is 8.2 %.



Graph: 4.5 Comparison of CO_2 of Kusum-diesel blends with load

F. Effect on Hydrocarbons (HC)

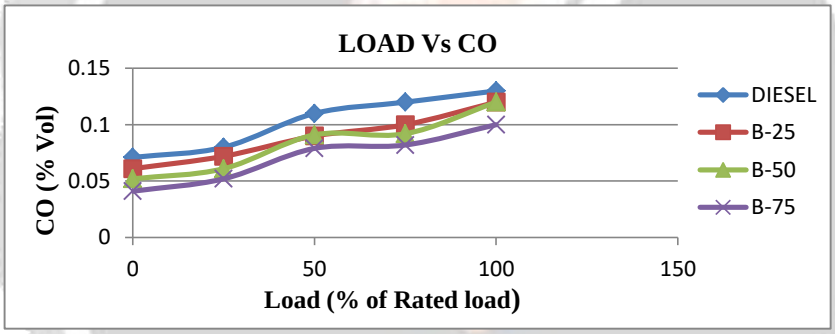
From the experiment it was found that as the load on the engine at full load increases HC also increases. The highest value of diesel is 48.8 ppm at the full load. From the calculation it is clear that the among the all blend of kusum-diesel the B-25 is having the highest value of 46.6 ppm.



Graph: 4.6 Comparison of HC of Kusum-diesel blends with load

G. Effect on Carbon Monoxide (CO)

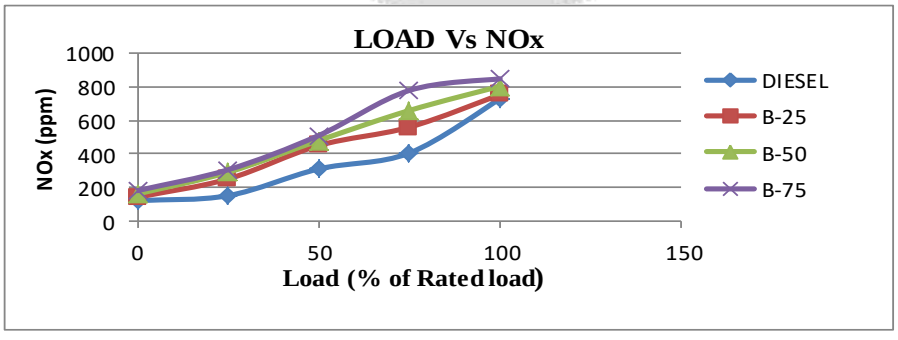
Carbon Monoxide percentage increases with increase in load at constant speed. The value of the CO is found to be 0.13 % for pure diesel at full load. As the blend of kusum-diesel gets increase then there is decrease in % of CO from B-25 to B-75. The highest value of the blend B-25 is 0.12 % at full load.



Graph: 4.7 Comparison of CO of Kusum-diesel blends with load

H. Effect on Oxides of Nitrogen (Nox)

The % of NO_x is increases from as the load on the engine at constant speed is increases. The highest value of the diesel is found out to be 730 ppm at full load. As the % of blend kusum-diesel increases the value of NO_x also gets increases. The highest value of the blend B-75 is 850ppm at the full load.



Graph: 4.8 Comparison of NOx of Kusum-diesel blends with load

5. ANSYS SIMULATION

A. Thermal Stress Distribution in Engine Parts

a. Cylinder

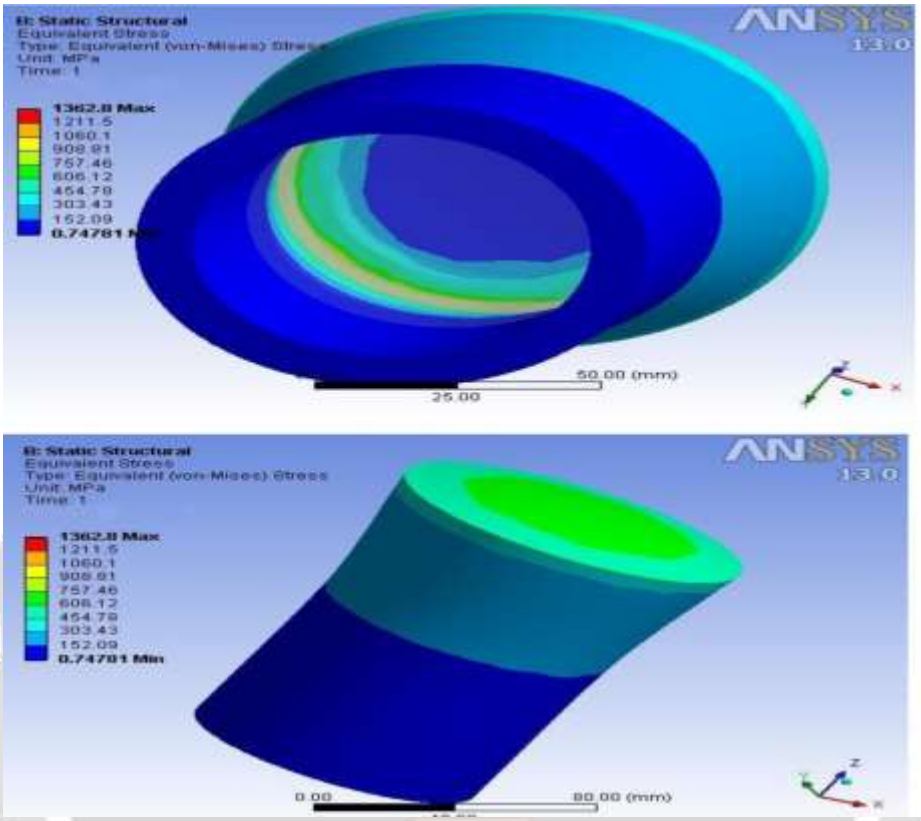


Figure: 5.1 Thermal stresses on cylinder body

b. Piston

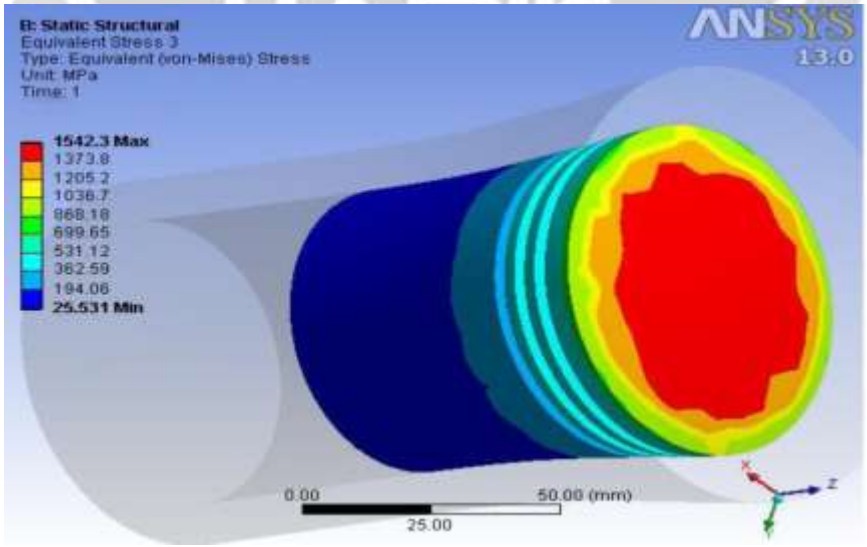


Figure: 5.2 Thermal stresses on piston

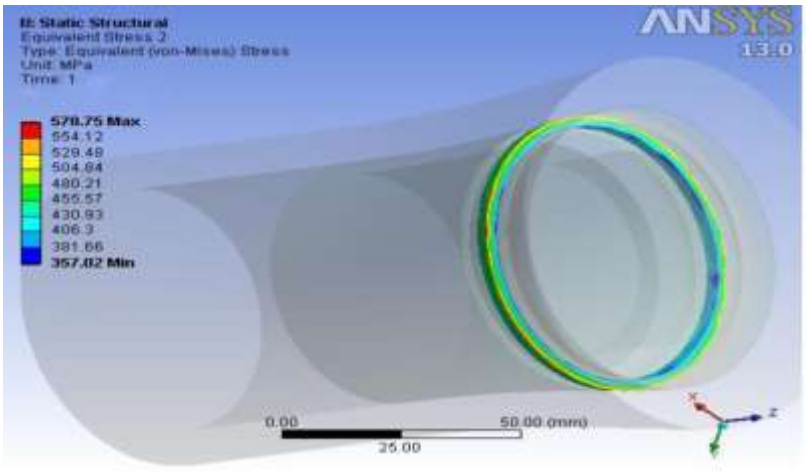


Figure: 5.3 Thermal stresses on piston Ring

6. CONCLUSIONS

Based on the experimental investigation carried with blends of kusum methyl ester and diethyl ether with simultaneous influence of fuel injection pressure following conclusion are drawn.

- With increase in the load at constant speed the BSFC of blends gets decreases.
- As the load on the engine increases at the constant speed then there is increase in the Brake Thermal Efficiency.
- It was found that among the all blends the B-75 blends gives the highest EGT of 472^0C. at full load.
- Among the all blends the blend B-25 is the highest value of Opacity i.e. 56 % at full load.
- From the experimental calculations from the all blends the highest value of blend i.e. B-75 is having the highest value of CO_2 which is 8.2 %.
- From the calculation it is clear that the among the all blend of kusum-diesel the B-25 is having the highest value of HC is 46.6 ppm
- As the blend of kusum-diesel gets increase then there is decrease in % of CO from B-25 to B-75. The highest value of the blend B-25 is 0.12 % at full load.
- As the % of blend kusum-diesel increases the value of NO_x also gets increases. The highest value of the blend B-75 is 850 ppm at the full load.
- As internal temperature of cylinder and piston using pure diesel and biodiesel blend (B25) is nearly equal so that internal stresses and temperature distribution is same in both cases so no need to change engine modification.

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