Study of long duration utilization effect of denatured aqueous ethanol in petrol start kerosene run type small constant speed SI engines

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ABSTRACT: The study conducted for observing effect of long duration utilization effect of aqueous ethanol on fuel consumption, emission, crank case oil quality and engine cleanliness on petrol start kerosene run type small SI engine coupled with an alternator running on denatured ethanol 190°proof in place of kerosene. The result indicated no significant deposition of foreign matter on carburetor component, deterioration in the crank case oil quality and shoot formation within the recommended change period of 100 hours. The emission of carbon monoxide (CO), nitric oxide (NO) and nitrogen dioxide (NO_2) was found less, whereas hydrocarbon (HC) found more than petrol run SI engines. The operation of engine on denatured 190° proof ethanol was found satisfactory.

Key words: Ethanol, long duration test, petrol start kerosene run engine, small SI engine, India.

The rising petroleum costs, increasing environmental pollution and ballooning oil import bill have necessitated that fossil fuels in India be substituted with less polluting and easily available renewable fuels in internal combustion engines. It has been suggested that use of renewable liquid fuels like methanol and ethanol suitably blended with petrol be promoted as their use helps in reducing emission of CO, HC and NOx from engine exhaust (Sriram and Reda, 1993; Beyeriein, *et al.,* 2001; Kumar, 2002 and Iliev, 2018).In agriculture sector and for domestic use small petrol start kerosene run engines are being promoted. Because manufacturing and burning of ethanol do not increase greenhouse effect and for achieving Bharat IV emission standards it is obligatory to use ethanol by taking advantage of low emission property in spark ignition engines. The government of India proposed Bharat VI from April 2020 with mandate. However, the use of ethanol as engine fuel poses the problem of absorption of moisture from atmosphere. It absorbs moisture until it has the composition of 95:5 of alcohol and water, respectively. The commercially available ethanol grades contain 10-20% water and therefore, they are aqueous in nature (Kumar, 2002).Whereas, the use of denatured aqueous ethanol as engine fuel in place of kerosene in four stroke, single cylinder, and constant speed petrol start kerosene run SI engines was reported satisfactory on 200°, 190°, 180° and 170°denatured ethanol proofs (Kumar, 2002; and Kumar and Bhattacharya, 2012).

In general, the engine oil in the crankcase of an engine is properly doped with appropriate additives to improve their performance and extend their service life, but they deteriorate with time. The deterioration of engine oil takes place due to contamination, oxidation and chemical breakdown. The contamination occurs due to air borne matter, unburnt fuel, products of combustion, metallic particles, and water etc. The oxidation occurs due to reaction with oxygen forming peroxides, aldehydes and acids forming asphaltic compounds. The water present in aqueous ethanol can also affect engine oil quality and engine parts and is a subject of rigorous investigation for recommendation of fuel in above described engines. In light of the above facts, a research work was undertaken on the effect of long duration running of a constant speed, petrol start, kerosene run type engine on denatured ethanol (190° proof).

MATERIALS AND METHODS

The experiment was conducted in the Bio Energy Technology Laboratory of the Department of Farm Machinery and Power Engineering, College of Technology, G.B. Pant University of Agriculture and Technology, Pantnagar. A petrol start kerosene run type engine coupled with a 425 VA alternator (Table 1) was selected for the long duration test. The engine was run on 100% of rated load for 150 hours on denatured ethanol 190° proof (Ethanol: distilled water: kerosene :: 85.5%:4.5%:10%). The above said fuel having relative density, kinematic viscosity at 38°C, gross heat of combustion, flash point and fire point reported as 0.8105, 1.779cS,31588.3 kJ/kg, 15.0°C and 20.8 °C (Kumar and Bhatacharya, 2011). The ethanol for experiment was procured from Bajpur Distillery, US Nagar, Uttarakhand. The engine on above fuel was continuously run for 5 hours in a particular day. The load on the engine was applied through an alternator. The alternator of 425 VA rating was loaded to 425 VA i.e. 100% of its rated output by attaching two incandescent lamps of 200 W each and one incandescent lamp of 25 W.

Table 1: Specification of Engine Selected for Long Duration Test

Engine Type	Engine	
Alternator type	AC rated output	425 VA
	AC rated voltage	220

In this study fuel consumption, exhaust emissions (CO, HC, NO and NO_2), crankcase oil quality and engine cleanliness were measured. The top up method was used for measurement of fuel consumption. The CO content of exhaust gases emanating on account of combustion of fuel at specified load conditions was analysed using a NUCON-5700 gas liquid chromatograph. Three replications were made for exhaust gas sample collected at each of the loads and their average was calculated. A Nucon make, model 4900 hydrocarbon analyser was used for the measurement of hydrocarbon in the exhaust gases. The analyser has an electrochemical sensor and indicated the % hydrocarbon in the exhaust gas. A Nucon make, nitric oxide analyser, model 500-NO was used for the measurement of nitric oxide in engine exhaust gases. It uses an electrochemical transducer and has a range of 0–199.9 ppm. The nitrogen dioxide content in engine exhaust gases emanating from burning of different fuel sample was measured with the help of a Nucon make, series 500 analyser.

The quality of crankcase oil used to lubricate various engine parts was also assessed at different time intervals using a Lube Oilab Kit, manufactured by SS Engineering Industries, New Delhi (Fig. 1). It is a portable test kit, which has a Visgage for measurement of kinematic viscosity, Hydrogage for determination of water content in oil.

The estimation of Total Base Number (TBN) value was done using various reagents provided with the kit and then observing color of oil. An appearance of violet color

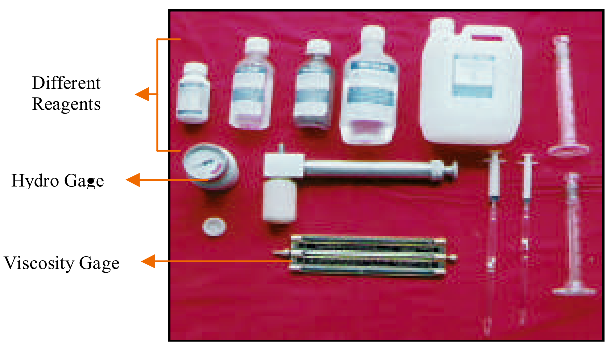


Fig. 1: Lube oilab kit

indicates that oil has required minimum TBN value and fit for further use. The appearance of yellow color indicates that oil has lower TBN value than the recommended limit and therefore, need to be replaced. During the experiment, the colorimetric observation of the oil was made after every 10 hours of engine operation.

The dispersancy and insoluble rating was observed by putting an oil drop on an absorbent paper. The diffusion of oil on the pores of paper produced a circular blot. When the oil has high dispersancy, the blot formed has a relatively uniform grey or black color. The lower dispersancy is indicated by a blot having a grey or black centre surrounded by a halo of clear oil. The dispersancy is more qualitatively expressed as the ratio of the diameter of dark to that of whole blot and is expressed as percentage. When the whole blot is uniformly darkened, the dispersancy is said to be 100%. The dispersancy is said to be 50% if the dark zone is half the diameter of whole blot. Oil should have a dispersancy of at least 50% and preferably 70% minimum. The insoluble rating of the oil is an indicator of amount of soot present in the oil and is shown by depth of color of the darkened area of the blot. The soot between 2 to 3% causes the blot to become completely black and opaque as shown in standard chart depicted in Fig. 2. The replacement of engine oil is recommended once the soot causes the insoluble rating to buildup up to 3%. The standard chart was used to compare the insoluble rating of oil after certain hours of engine operation as stated above.

The Hindustan petroleum cooperation limited HP engine oil (IS 13656-1993) was used as crankcase oil. The oil is of high dispersancy. The observation on kinematic viscosity, water content and minimum TBN of the new oil as well as every 10 hours engine operation till completion of 150 hours was made. Whereas, the dispersancy and insoluble rating of the new oil as well as after every 20 hours of engine operation till completion of 150 hours was made. In addition to that, the engine cleanliness was also measured by observing the cleanliness of carburetor or amount of foreign material deposited and deterioration of carburetor component.

RESULTS AND DISCUSSION

The average fuel consumption, exhaust emission, crankcase oil quality and cleanliness of the engine coupled with an alternator at rated load were shown following trends during long duration test.

Fuel consumption

The observed fuel consumption of the engine during long duration test is shown in Fig. 3. It was indicated that the fuel consumption of the engine gradually decreased from 0.64 to 0.48 l/h with engine use. Similarly it was higher (0.58 – 0.64 l/h) up to 40 hours and it may be due to reason that the engine was brand new. With subsequent operation it was found fuel consumption remain less than 0.5 l/h.

The emission of CO, HC, NO and NO_2 at full load was found in range 0.052 to 0.699%, 0.19 to 0.98% , 27 to 188 ppm and 0.6 to 3.8 ppm as shown in Fig. 4. The emission of CO, HC and NO from a spark ignition engine may be around 1 to 10%, 0.05 to 0.1% and 400 to 2750 ppm, respectively (Mathur and Sharma, 2001). Thus above results reveal that emission from engine coupled with an alternator satisfactory on denatured ethanol of 190° proof.

Crankcase oil quality

The kinematic viscosity of engine oil used during the operation was measured using Visgage after certain periods of engine operation during the experiment. The new engine oil had the kinematic viscosity 126 cSt. After 50 hours of operation it dropped to 124 cSt, further dropped to 102 after 100 hours of operation and it was observed 88 cSt after 150 hours of operation. The kinematic viscosity after 25, 50, 75, 100, 125 and 150 hours of engine operation was observed 120, 124, 116, 102, 95 and 88 cSt, respectively. The observed values indicate that there was 30.2% decrease in the kinematic viscosity after 150 hours of engine operation. Generally, for the kind of engine used in the experiment, the manufacturer recommends the replacement of engine oil first at 20 hours of engine operation and then every 100 hours of engine operation. (Note- After 30 hours, 170 ml of new lubricating oil was added in crankcase).
The engine oils are formulated with a variety of additives that enhance lubricity, retard oxidation and reduce tendency for sludge and deposit formation. With use, TBN value decreases and oil is changed after TBN value reaches to a critical limit. For most engine oils used in diesel and petrol engines, the minimum TBN should be 2.0 mg of KOH per gm of oil. The results indicate that during entire period of 150 hours of engine operation, the TBN of used engine oil remained within the desired limit as no change in color from violet to yellow was noticed as per the procedure adopted using Lube Oilab kit. Hence, it can be concluded that during the prescribed oil change period of 100 hours, the TBN of lubricating oil used remained within the limit when the engine was operated on denatured ethanol of 190° proof.

The dispersancy and insoluble rating of engine oil as observed after every 20 hours of engine operation is shown in Fig. 5. The comparison of observations made with that of standard chart provided with Lube Oilab kit shows that the new oil had 100% dispersancy and 0% insoluble rating. After 100 hours of engine run on denatured ethanol of 190° proof, the dispersancy was observed as 78.1% and insoluble rating between 0.5 to 1%. The dispersancy and insoluble rating of the oil was found as 95.4% and 0.5%, 83.8% and 0.5 to 1%, 76.5% and 0.5 to1% and 71.2% and 0.5 to 1% after 40, 80, 120 and 150 hours of operation, respectively (Table 2). These results indicate that even after 150 hours of engine operation the dispersancy of the engine oil remained above minimum desirable limit of 70%. Further, it is evident from the observations that the insoluble rating

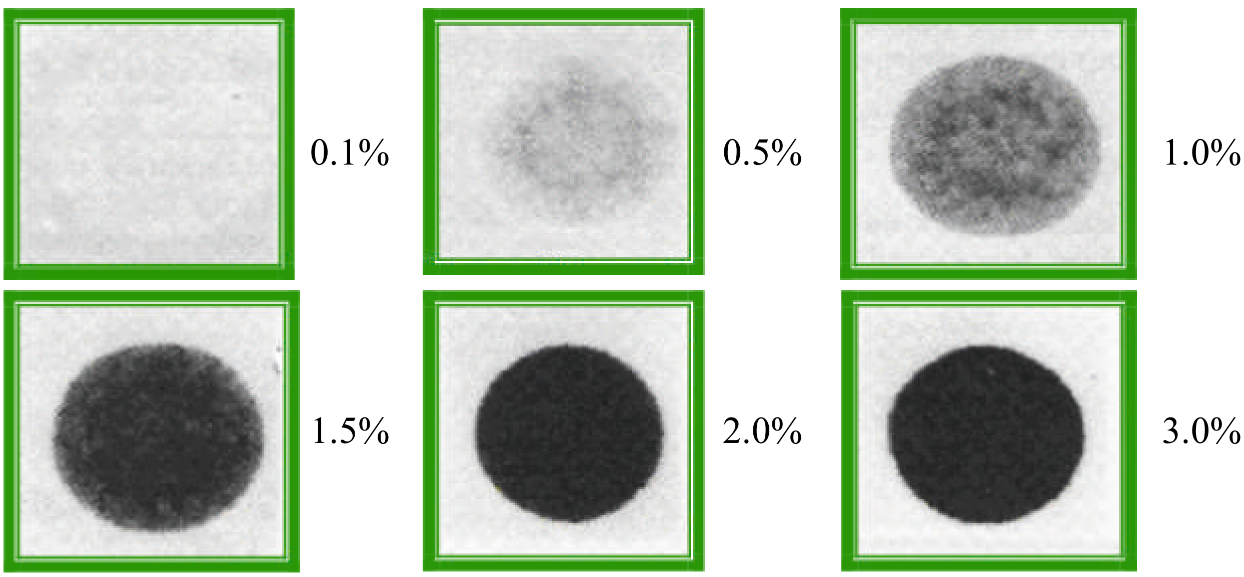


Fig. 2: Standard chart showing insoluble rating

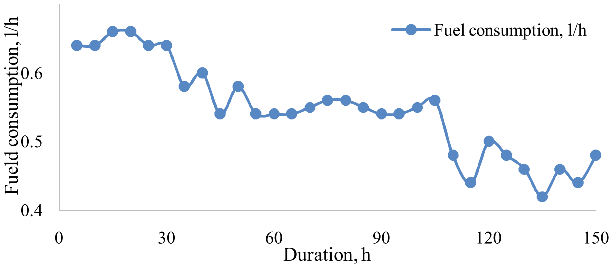
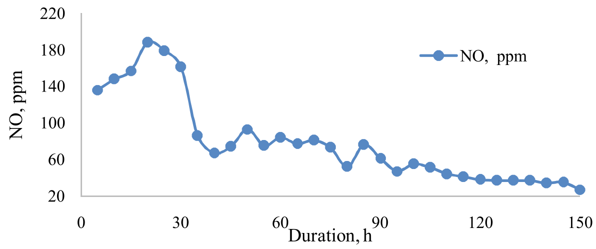
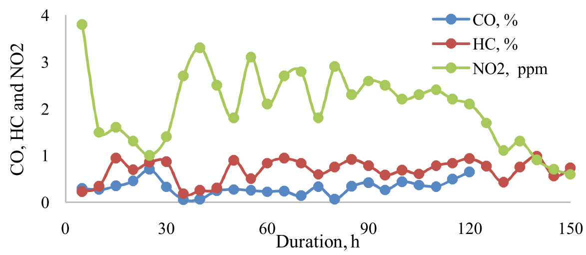


Fig. 3: Fuel consumption of engine during the long duration test Exhaust emission



(a)



(b)

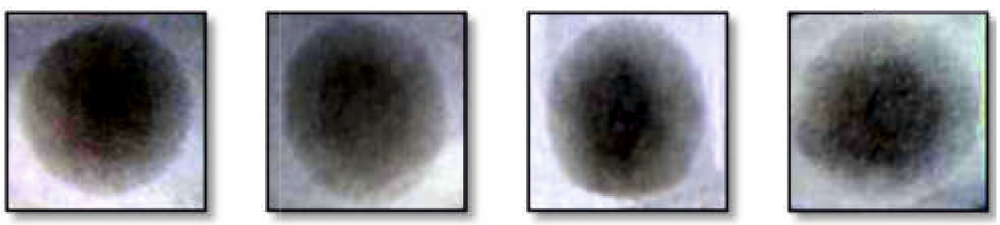
Fig. 4: Emission of CO, HC, NO and NO_2 of engine during the long duration test

remained much below the limit of 3% (at which change of oil is recommended) indicating that the soot formation when using the denatured ethanol of 190° proof was less. Hence, the use of denatured ethanol of 190° proof did not cause any appreciable degradation in the quality of lubricating oil used.

Cleanliness of engine

The cleanliness of carburetor was observed by visually observing the deposition of foreign material on carburetor component. No undue deposition of foreign material on carburetor component when the engine was operated for 150 hours on the 190°proof of denatured ethanol. It is also evident from the figure that there was no significant deterioration of carburetor components.

After 0 hours After 20 hours After 40 hours After 60 hours After 80 hours



After 100 hours After 120 hours After 140 hours After 150 hours

Fig. 5: Observed insoluble rating

Table 2: Variation of dispersancy and insoluble ratings of lubricating oil with engine operational duration

Duration,h	Dispersancy,%	Insolublerating,%	Duration,h	Dispersancy,%	Insolublerating,%
0	100	0	100	78.1	0.5 – 1
20	98.1	0.5	120	76.5	0.5 – 1
40	95.4	0.5	140	74.4	0.5 – 1
60	89.2	0.5	150	71.2	0.5 – 1
80	83.8	0.5 – 1			

CONCLUSION

A petrol start kerosene run engine coupled with an alternator was run on denatured aqueous ethanol of 190°proof for long duration test. Based on results obtained the following conclusions were drawn:

(a) The fuel consumption of engine was found less than 0.5 l/h.
(b) The emission of CO, HC, NO and NO_2 at full load was found in range 0.05 to 0.69%, 0.19 to 0.98%, 27 to 188 ppm and 0.6 to 3.8 ppm. The emissions of CO, NO and NO_2were lower side, whereas HC emission is little bit higher side as compared to SI engines.
(c) There was 30.2% drop in kinematic viscosity of crank case oil. The kinematic viscosity of new engine oil was observed 124 cS which dropped to 88 cS after 150 hours of engine operation on denatured ethanol of 190° proof.
(d) The minimum TBN value of the crank case oil remained within the acceptable limit.
(e) The dispersancy of new oil was 100% reduced to 71.2% after 150 hours of engine operation, which shows that dispersancy remained above minimum desirable limit of 70 %.
(f) The insoluble rating of new crank case oil was 0% that was found to vary between the ranges to 0.5 to 1.0% after 150 h of use. The observed value is below the critical limit of 3%, indicating less shoot formation in the engine.
(g) There was no significant deterioration of carburetor components of the engine.

So, the use of 190° proof ethanol in constant speed petrol start kerosene run type small SI engine for 150 hours have not shown any undesired effect in engine components and crankcase oil quality. So ethanol proof of 190°may be used as replacement fuel for kerosene in above said engine for agricultural and other use.

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