Performance evaluation of a low speed IDI engine fueled with diesel and Jatropha straight vegetable oil

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Abstract

In context to the global objective of search for alternate energy source, the possibility of using Jatropha straight vegetable oil (JSVO) in diesel engine is studied in this work. The experimental investigations are carried out to analyze the performance and emission characteristics of neat JSVO fueled in single cylinder, low speed IDI diesel engine. The engine was initially run by the diesel to take the data as base line and then the engine was run with 100% JSVO to find out the deviations in their performance and emission characteristics in comparison with diesel fuel. To improve the performance some of the minor modifications are suggested in fuel injection system of the engine. These modifications are changing the advance angle of fuel injection, optimizing the fuel injection pressure and preheating the fuel by exhaust gases. The performance parameters evaluated include brake thermal efficiency (B T E) and brake specific fuel consumption (BSFC) where as the exhaust emission parameters include CO, CO_2 , HC, NOx and smoke. It has been found that the BTE of engine with diesel fuel is 32.96% where as under similar operating conditions the BTE with JSVO was found to be 30.62%. This difference is very high as far as the efficiency of energy utilization is concerned. The deviations in performance are due to high viscosity of JSVO, high surface tension, low cetane rating and ultimately low calorific value. The emission parameters of JSVO are not favorable because the emission parameters of JSVO are much higher than the diesel fuel. Based upon the findings it can be concluded that the existing engine under present design can not run on JSVO because of low BTE, High BSFC and even bad emission characteristics. In case we want to make the engine compatible will JSVO the engine modification is to be carried out. There are many major modifications which can meet the requirement but this modification will affect the techno economic aspect of the engine. In light of these facts and data, some of the minor modification can be suggested. These modifications can improve the fuel atomization characteristics of JSVO and will improve the performance and emission characteristics of engine.

Key words: Jatropha straight vegetable oil (JSVO), IDI engine

1. Introduction

The world is confronted with the twin crises of fossil fuel depletion and environmental degradation. The indiscriminate extraction and consumption of fossil fuels have led to a reduction in petroleum reserves. Alternative fuels, energy conservation and management, energy efficiency and environmental protection have become important in recent As the economy of the countries is growing at rapid pace and also the technological developments have taken place very rapidly during near past, so the energy requirements of human being not only in cities has hiked. In rural areas the energy requirements to meet the livelihood and agricultural needs has become critical. The search of alternate fuel source which can be easily accessible and sustainable to the people residing in rural areas will enhance their prosperity as well as reduce the load on conventional energy. There are many possibilities of getting the non edible vegetable oil which can be produced by the users themselves. The feasibility of using such oil is required to be evaluated.

In this work the main focus is on the farmers, remotely established people and small scale industries located in rural areas. The production of biodiesel needs a costly processing plant which is beyond the reach of users taken in consideration in this study. If the production of biodiesel is done on industry level then it will be again sold in the market at even higher prices than the diesel. In case any other method of utilizing the straight vegetable oil is searched which

years. The increasing import bill has necessitated the search for liquid fuels as an alternative to diesel, which is being used in large quantities in transport, agriculture, industrial, commercial and domestic sectors. Biodiesel obtained from vegetable oils has been considered a promising option.

does not need processing of oil then it will be not only convenient to the farmer but also the production can be done at village level. By doing so the farmers are not required to run to the market for diesel and also do not need to pay high cost.

Considering the above aspect an initiative is taken through this study to make the farmers self dependent. If we replace the petro diesel by vegetable oil directly which farmers can cultivate in their field the requirement can be met. If the entire world production of 115 billion liters of vegetable oil had been used for fuel in 2007, neglecting the conversion losses as well as the debate on the use of food materials for fuel, this would only satisfy about ¾ of US diesel demand. The use of locally grown non edible plant oil as fuel in slow speed diesel engine has potential to provide a low cost sustainable energy solution. The JSVO has high viscosity and low cetane rating which has direct impact on its combustion quality and ultimately brake output. The etane number (CN) is a measure of fuel's ignition delay quality, a high CN corresponds to a shorter ignition delay. Long ignition delay is undesirable due to the consequences of engine knock [1]. Because of low CN and

high viscosity of non edible vegetable oil in comparison to diesel several difficulties in engines such as engine choking cease of injector, gun formation and piston sticking under long term use has been encountered [2]. Mustafa Cancasi [3] reported that the excessive carbon build up in IDI engine has be observed because of high viscosity of sunflower oil. He also reported that the viscosity and volatility of the fuel have very important role to increase atomization rate and to improve air fuel mixing formation. The high viscosity, polyunsaturated character, and extremely low volatility of vegetable oil are responsible for the operational and durability problems associated with its utilization as fuel in diesel engines [4,5]. O M I Nwafer [6] reported that the flow ability of neat vegetable oil is problem as the temperature decreases. The selection of fuel inlet temperature of 70^0 C for preheating the fuel was based upon the laboratory test results of viscosity – temperature relationship. Due to higher viscosity we expect the longer ignition delay but in an study od using coconut oil as fuel it was found that the shorter ignition delay was suitable. This contradicts the logic for fuel atomization phenomena. So the reporter agreed that further investigations are to be undertaken to justify the adverse findings [7].Although IDI engines tend to endure the harsh conditions of longevity tests with straight plant oil fueling. The DI engines often do not [8,9]. It has also been reported that another modification which can improve the usability of straight vegetable oil in engine is increasing the fuel injection pressure. The size of fuel particle released by injector at high pressure in reduced which improves the fuel atomization ability [10, 11].

Having the SVO as alternative fuel in not enough but also we must have machines which can use those alternative fuels with optimum efficiency and economy. In present study we have undertaken the evaluation of engine performance fuelled with JSVO in reference with diesel fuel performance. The JSVO expelled from Jatropha seeds is required to be filtered properly to separate any kind of contamination and put into the fuel tank of engine.

The energy need is tremendously increasing not only in cities but also in rural areas for the application of agricultural machineries and also the small scale industries. The availability and cost of diesel becomes big constraints for the farmers which sometimes affect the productivity badly. In this work we have undertaken task of searching such alternate fuel which can cater both the problems. There are two methods, one to have alternate fuel which can be produced at user end and be used in engine efficiently and the other to have the engine which can be compatible to the alternate fuel. One such source is Jatropha oil, which can be cultivated by the farmers. The Jatropha plant can be cultivated in barren land so the productive land use will also increases. In order to develop the engine compatible with the JSVO as fuel we need to do the comparative evaluation of

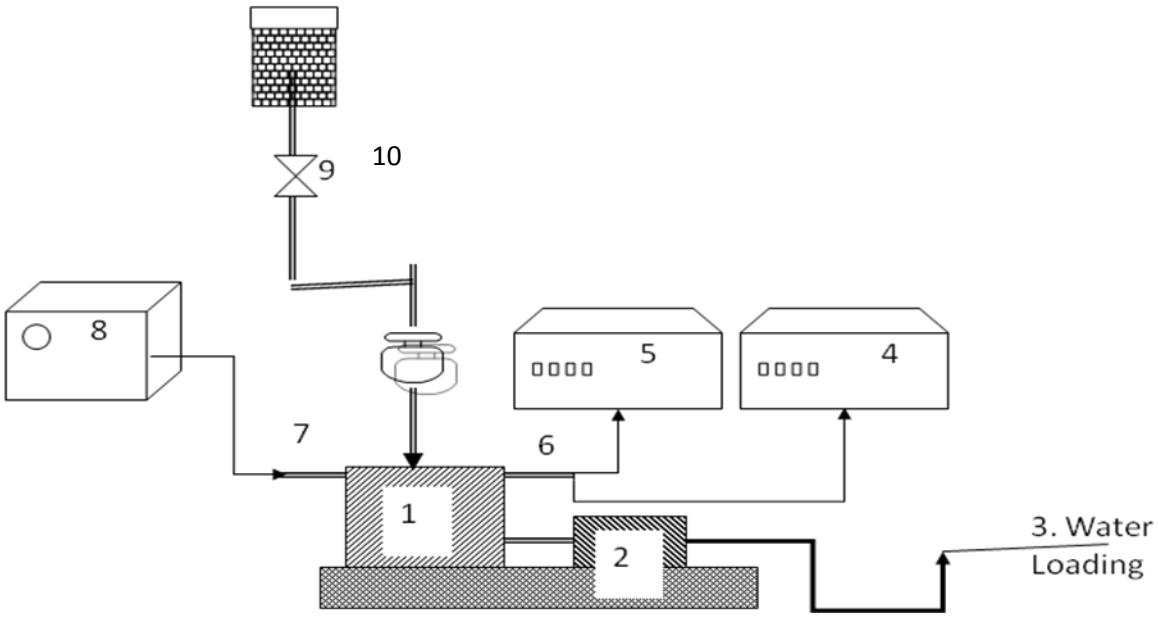
existing engine performance fueled with diesel and JSVO. Initially the engine is run with the diesel to take the performance parameters as base line, and then the engine is run with JSVO under same operating parameters to find the performance parameters. The comparative evaluation is done between these two sets of engine performance. Based upon the observed results the minor modifications are suggested which can make the engine suitable for JSVO fuel in long term use. This will make the farmers self dependent and their socioeconomic

In this work the engine is tested with both the fuel in IDI engine under same environment. The data observed is processed to get the performance parameters and finally the comparison is done between the diesel performance and JSVO performance. The probable methods to make the JSVO usable in IDI engine are also disused.

2. Methodology:

2.1 Experimental set up

The low speed IDI diesel engine manufactured by field marshal was taken for experiment duel to large scale utilization of such engine in agricultural and small scale industries. The detailed specifications are listed in table 1. The main components of experimental set up are alternator, hydraulic loading unit, fuel consumption measuring unit, voltmeter, ammeter, temperature measuring thermocouples, AVL -437 smoke meters and AVL gas analyzer used for emission measurement. The engine was started after integrating all the subsystem to enable data collection. The digital tachometer was used to find the engine RPM.



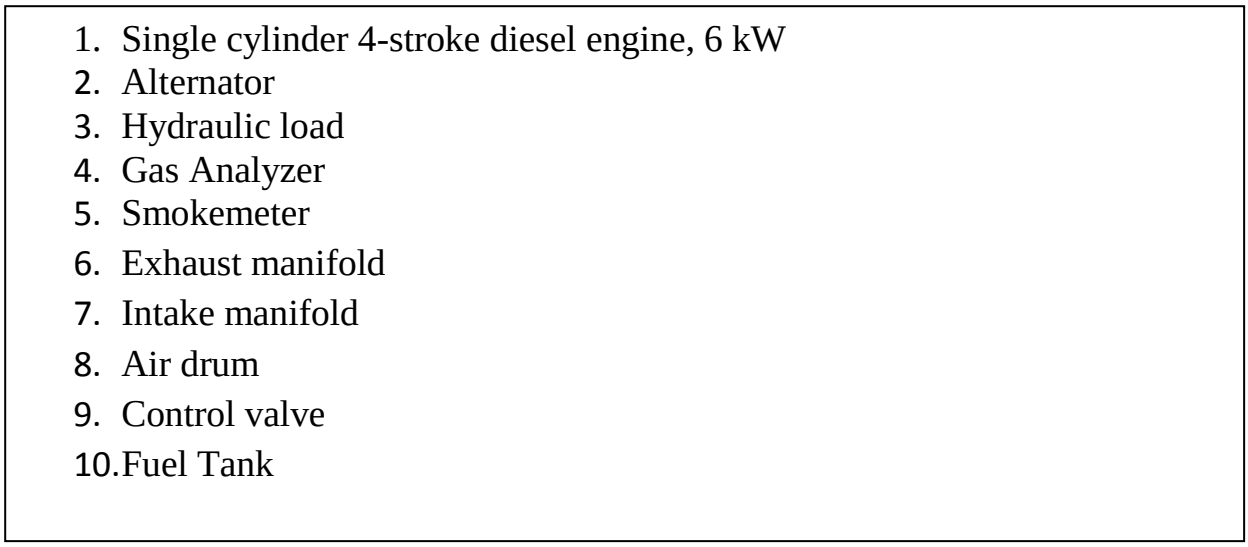


Figure 1: Schematic diagram of experimental test set up

Particulars	Specifications
Make/ Type	Field Marshal/ Diesel engines
Model	FM-4
Rated Brake Power (BHP/kW)	10/7.35110
Rated speed (rpm)	1000
Number of cylinder	One
Bore x Stroke (mm)	120x139.7
Compression ratio	17:1
Cooling System	Water Cooled
Lubrication System	Forced Feed
Cubic Capacity	1580 cc
Nozzle	DL30S1202MICO

Table 1: Engine specifications

2.2 Experimental Procedure

Properties	Diesel	JSVO

The engine was planned to be operated in two cycles. In one cycle, the diesel fuel was to be used as test fuel and in other cycle the JSVO was to be used. The some of the important properties of these test fuels were found out in the laboratory. These properties are listed below in table 2. The preliminary preparations for data collection and engine operation were carried out. The serviceability and the accuracy of the instruments going to be used were checked.

3. Result and discussion

The important physicochemical properties of Jatropha oil were determined and shown in table 2 to compare with diesel. The variation of brake thermal efficiency (BTE) at different load conditions is shown in figure 2(a). It has been found that the BTE of engine increases as the load on the increased from 0% to 100%. This loss remains same in both the cases. AVL gas analyzer used for emission measurement. The engine was started and allowed to run for 30 minutes with diesel fuel to stabilize the performance parameters then the observations were recorded with variable engine loads. The engine was tested at 0%, 25%, 50%, 75% and 100% of rated engine load. The parameters recorded were rate of fuel consumption, voltage, current and CO, CO_2, NO_x, HC, smoke emissions. After completing one cycle the engine was run with JSVO and another set of data were recorded.

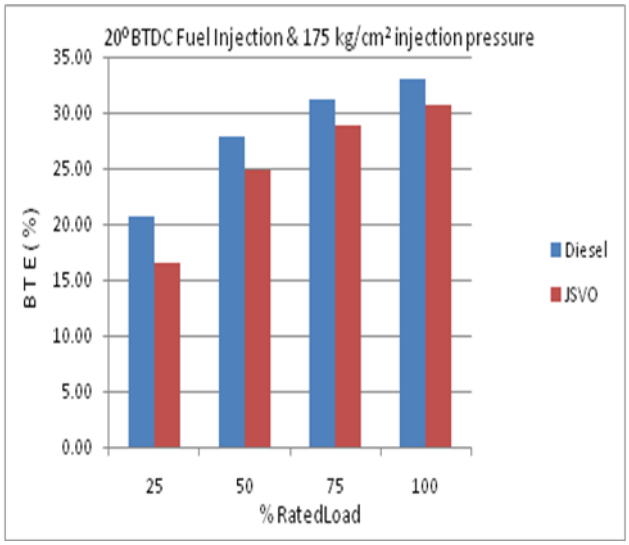
trend is observed in both the case i.e. first when the diesel was used as test fuel and second when the JSVO was used as test fuel. The BTE is observed to be increased when the load on the engine was increased. The maximum BTE is observed at 100% load, which indicates that the combustion efficiency is improved there by giving net output higher than the part load because the frictional power

engine was started after integrating all the

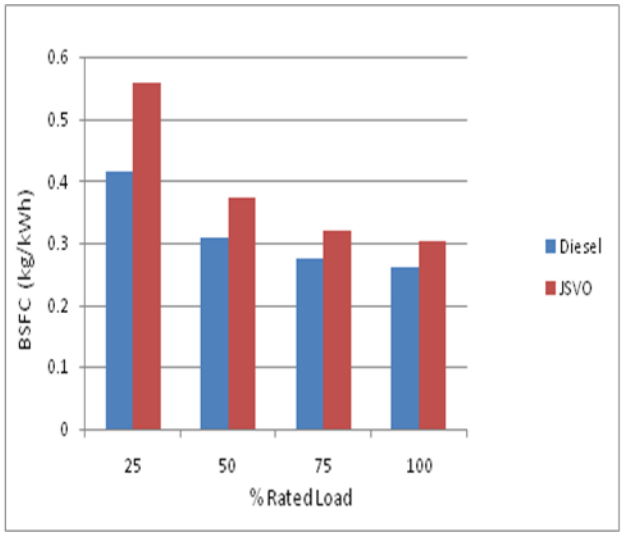
subsystem to enable data collection.

Density at 30^0 C (gm/cc)	0.817	0.910
Kinematic Viscosity at 30^0 C (cSt)	4.3	48.7
Calorific Value (kJ/kg)	42000	39000
Cetane Index	46	38
API gravity	31.7	22.7
Carbon residue (%,w/w)	0.1	0.64
Observation	Stable	Stable

Table 2: Properties of diesel and JSVO



(a)



(b)

Figure 2: Performance parameters Vs % rated engine load

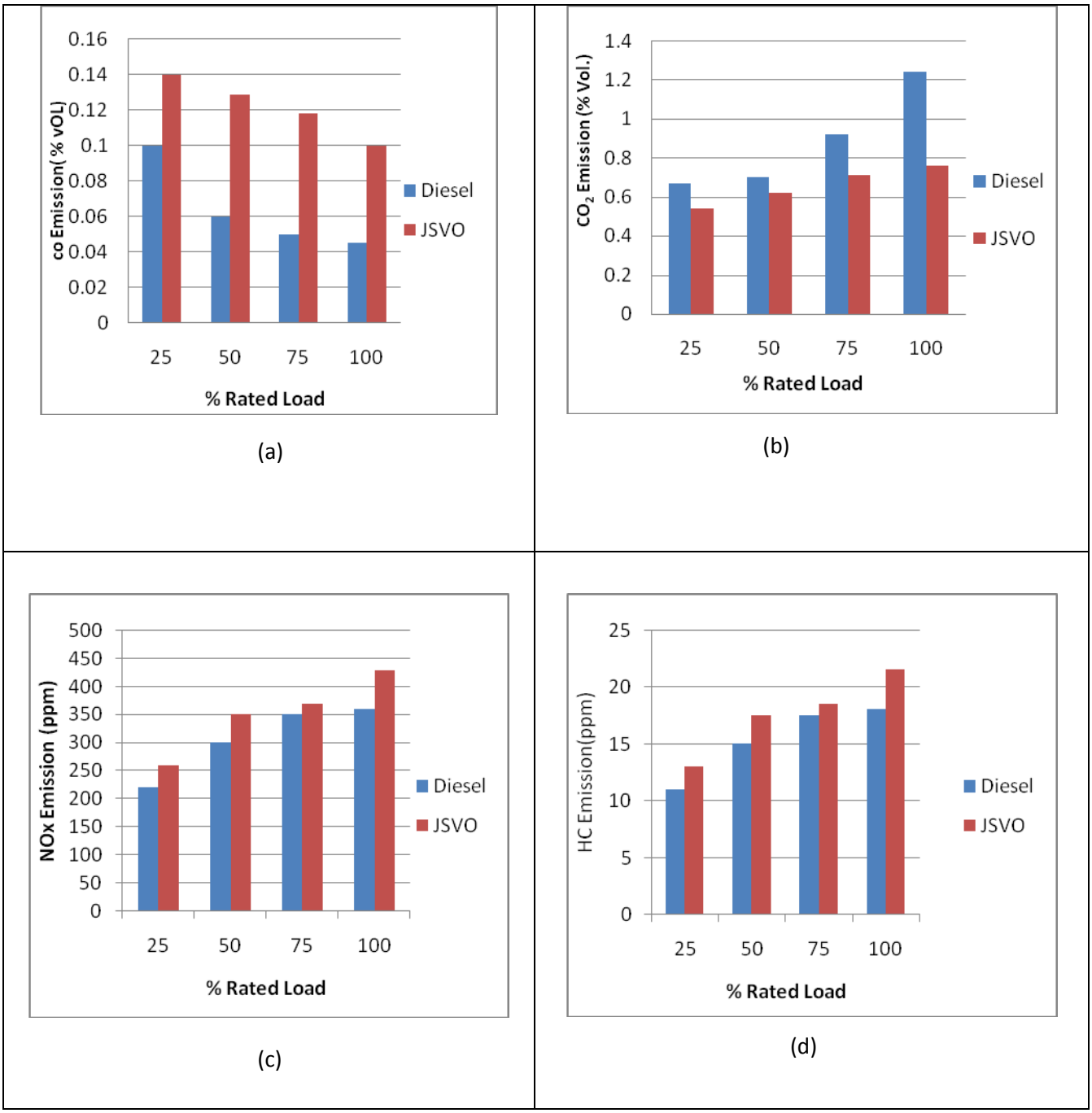


Figure 3: Emission parameter Vs % rated engine load

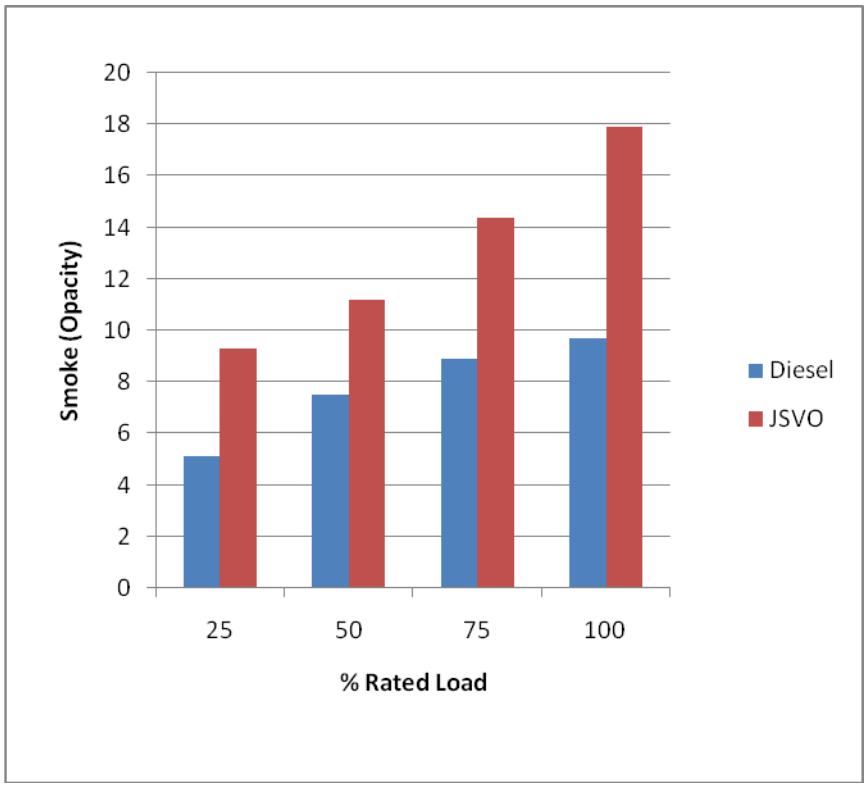


Fig. 4: Smoke Emission

The BTE with diesel fuel at rated load is 32.96% in comparison with 30.62% with JSVO. The lower efficiency is primarily because of poor combustion quality of JSVO which is due to very high viscosity of JSVO in comparison with diesel fuel. The BSFC of the engine is increasing as the load on the engine is increasing [Fig. 2 (b)]. The increase in BSFC is observed even after improvement in efficiency because the engine governor increases the fuel supply to meet the increased load requirement. The BSFC of the engine at 100%load with diesel fuel is 260 gm/kWh in comparison with BSFC of JSVO which is 301 gm/kWh. The difference of BSFC is because of low BTE of JSVO which is ultimately due to high viscosity. The high viscosity leads to poor fuel atomization characteristics.

The CO emission which is indicative of incomplete fuel combustion decreases as the load on the engine is approaching to rated load [Fig.3 (a)]. At a constant load the CO emission of diesel fuel is lower than the CO emission of JSVO. As the load increases towards rated load the gap between the CO emission of diesel and JSVO is increased this indicates that even at rated load the CO emission of diesel is lowered due to high combustion efficiency but the CO emission of JSVO at this point is still much higher than the diesel. The CO emission at design operating parameter of this engine is 0.10% by volume with JSVO fuel in comparison with 0.045% by volume with diesel fuel. This difference shows that the combustion efficiency of JSVO is very poor. To make the JSVO as suitable fuel for this engines the factors affecting the fuel atomization characteristics are to be considered for modification.. The CO_2 emission of JSVO is less than the CO_2 emission of diesel fuel. But the CO_2 emission in both the cases increases with increase in engine load [Fig.3 (b)]. It shows that the combustion is not complete in the case of JSVO at pert load which improves as the load on engine approaches to rated load.

The NOx emission of JSVO is higher at all load conditions than the diesel fuel [Fig. 3(c)]. The NOx emission increases as the load increases to rated load, this is because as the load increases the governor supplies more fuel which liberates high heat and that results high temperature. The high temperature generates high NOX emission.

The HC emission of JSVO is higher than the diesel fuel at all the operating point and load conditions [Fig. 3(d)]. The smoke emission of JSVO is more than the diesel fuel [Fig 4]. The BSFC at higher engine load is high so the smoke generation is also high. But at all the operating point the smoke generation of JSVO is higher than the diesel fuel. The modifications improving the combustion efficiency will improve the smoke emission.

3. Conclusion

This investigation can attract the researches to test the IDI engine using the facts reported in this paper. Here is clear comparison made between the performance and emission parameters. The minor modification not affecting the techno economic aspects of the engine is suggested. Under ordinary conditions the JSVO is not a suitable fuel for low speed IDI diesel engine because of high BSFC and low BTE. Its emission characteristics are also inferior to the diesel fuel. To make the JSVO a suitable fuel there has to be some modification in the engine. Some of the minor modifications which can improve the performance are (1) advancing the fuel injection angle so that the available for fuel atomization can improve (2) The increase of fuel injection pressure and (3) preheating the fuel before it is admitted into the combustion chamber. The possibility of using the JSVO will make the remotely established people self dependent and it will also improve the socioeconomic conditions. This will reduce the load on energy reserve to a large extent.

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