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PERFORMANCE EVALUATION AND ECONOMICAL SPEED OF FOUR-STROKE SINGLE CYLINDER DIESEL ENGINE FOR COTTONSEED BASED BIO DIESEL

Pilla Deviprasad[1] & Karteek Pragada[2]

[1]*Department of Mechanical Engineering,AITAM,Tekkali,Andhra Pradesh.*

[2]*Department of Mechanical Engineering,AITAM,Tekkali,Andhra Pradesh .*

ABSTRACT

The world is getting modernized and industrialized day by day, majority of the world's energy needs are supplied through petrochemical sources, coal and natural gases with the expectation of hydroelectricity and nuclear energy, of all, these sources are finite and at current usage rates will be consumed shortly. From the point of view of protecting global environment and for long term security, it becomes necessary to develop alternate fuels wit properties comparable to petroleum based fuels. Biodiesel a promising substitute as a alternative fuel has gained significant attention due to the predicted shortness of conservation of fuels and environmental. The utilization of fuels such as bio diesel produced from cottonseed oil is one of the most promising options for the use of fossil fuels. Cotton plant is a renewable non edible plant. Cotton is a widely growing plant in arid and semiarid regions of the country. The project is aimed at making of biodiesel from cottonseed oil using sodium hydroxide (NaOH as catalyst by catalysed transesterification process. The physical properties such as density, viscosity, flash point, kinematic viscosity, pour point were found out for biodiesel. and by load test IP, FC, IMEP, Mechanical efficiency, brake thermal efficiency, indicated thermal efficiency were found out for Cottonseed Biodiesel and its blends. The same characteristic study was carried out for the diesel fuel for obtaining the base line data for analysis. We consider the aim of obtaining compared to the, measures of performance for diesel biodiesel and its blends. The results are analysed to optimise best operating conditions for maximum performance for various loads.

Key words: Biodiesel, cottonseed oil, sodium hydroxide, Mechanical efficiency, brake thermal efficiency, indicated thermal efficiency

1.INTRODUCTION:

India depends on mostly on import of fossil fuels to satisfy energy demand, and with population growth and economic development the demand will continue to increase. India is one of the largest petrol consuming and importing countries. India imports about 70% of its petroleum demands. The current yearly consumption of diesel oil in India is approximately 40 million tonnes constituting about 40% of the total petro product consumption. Fossil fuels are finite energy resources will eventually be exhausted. Furthermore, the use of fossil fuels has a severe impact on climate change.

In combination with the increasing global demand for renewable energy forms the need to secure energy supply in developing countries has created a demand for biomass energy. One of the most common energy systems is production of biodiesel through transesterification of non-petroleum based oils. Biodiesel can be used in unmodified diesel engines, either alone or blended with conventional petrol diesels. For developing countries, production of biodiesel could represent a way to achieve economic growth by increasing and securing energy supply, but also creating job opportunities and as a source of income for the farmers involved.

2.COTTONSEED OIL AS A SOURCE FOR PRODUCTON OF BIODIESEL

Cottonseed oil is a cooking oil extracted from the seeds of cotton plants of various species, mainly Gossypiumhirsutum and Gossypiumherbaceum, that are grown from cotton fibre, animal feed and oil. Cotton seed has a similar structure to other oilseeds such as sunflower seed, having an oil bearing kernel surrounded by a hard outer hull, in processing, the oil is extracted from the kernel.

Cottonseed oil appears generally clear with a light golden colour, the amount of colour depends on the amount of refining. It has a relatively high smoke point as a frying medium. Density ranges from 0.917 g/cm3 to 0.933 g/cm3. Like other long chain fatty acid oils, cottonseed oil has a smoke point of about 450 °F (232 °C) and is high in tocopherols, which also contribute its stability, giving products that contain it a long shelf life.

2.1. Biology of Cotton Plant

Cotton is a soft, fluffy staplefibre that grows in aboll, or protective case, around the seeds of cotton plants of the genusGossypiumin the family ofMalvaceae. The fibre is almost purecellulose. Under natural conditions, the cotton bolls will tend to increase the dispersal of the seeds.

The plant is ashrubnative to tropical and subtropical regions around the world, including the Americas, Africa, and India. The greatest diversity of wild cotton species is found in Mexico, followed by Australia and Africa. Cotton was independently domesticated in the Old and New Worlds.

Fig.1 Cotton Plant

Cotton is an important fibre crop of global significance and is grown in tropical and subtropical regions of more than eighty countries. Cotton is primarily cultivated for its lint or fibre, in other words, lint is the main product of cotton crop. Now, cotton seed oil is also widely used for human consumption. Thus, cotton has become a fibre cum oil yielding crop. It’s seeds also contains 20-25% protein. Hence, in future, cotton will become a source of fibre, oil and protein. There are four products of cotton plant viz. lint, seed, stalk and leaves. Out of these, lint is the main product and rest are by-products. The information on the utilization of cotton by products is very scanty and that too is not available in any single source.

Cottonseed contains hull and kernel. The hull produces fibre and linters. The kernel contains oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols etc. Cottonseed oil is extracted from cottonseed kernel. Cottonseed oil, also termed as "Heart Oil", is among the most unsaturated edible oils. It need not be as fully hydrogenated for many for cooking purposes as is required in case of some of the more polyunsaturated oils. Refined and deodorised cottonseed oil is considered as one of the purest cooking medium available. An additional benefit that accrues from Cottonseed Oil is its high level of antioxidants.

Fig .2 Cotton Seeds

3.2 Geographical Distribution and Ecological Preference of Cotton Plant

Cotton is an important fibre crop of global significance and is grown in tropical and subtropical regions of more than eighty countries. Cotton is primarily cultivated for its lint or fibre, in other words, lint is the main product of cotton crop. Now, cotton seed oil is also widely used for human consumption. Thus, cotton has become a fibre cum oil yielding crop. It's seeds also contains 20-25% protein. Hence, in future, cotton will become a source of fibre, oil and protein. There are four products of cotton plant viz. lint, seed, stalk and leaves. Out of these, lint is the main product and rest are by-products. The information on the utilization of cotton by products is very scanty and that too is not available in any single source.

3.PREPARATION, BLENDING ANDCHARACTERISATION OF BIODIESEL:

3.1 Transesterification Process

Transesterification is the process by which Biodiesel is produced the catalyst for this reaction is KOH or NaOH. Three mol of methanol react with one mol of triglyceride which produces mixture of fatty esters and glycerine. The industrial-scale processes for transesterification of vegetable oils were developed in the early 1940s to improve the separation of glycerine during soap production.

The primary input is assumed to be the oil that has been extracted from Cottonseed. To accomplish the transesterification reaction described above, the oil, methanol and catalyst are mixed together in a stirrer reactor. 55-60°C temperatures will cause the reaction to reach the equilibrium more rapidly; in most cases the temperature is kept below the normal boiling point methanol (65°C) so the reactor does not need to be pressurized. The fatty acid methyl esters are attractive as alternative diesel fuels.

As shown in the reaction, three moles of methanol react with the one mole of triglycerine. In practice, most producers will use more than 100% excess methanol (6:1 molar ratio) to force the reaction equilibrium towards a complete conversion of the oil to the biodiesel. The reaction is slowed by mass transfer limitations since at the start of the reaction the methanol is only slightly soluble in the oil and later on, the glycerine is not soluble in the methyl esters.

The following reactions takes place while doing the transesterification process

O ‖

CH2 – O – C – R2

|

| O O CH2 – OH | ‖

‖ | CH – O – C – R2 + 3CH3OH ⟶ 3CH3 – O – C – R + CH – OH |

| | O CH2 – OH | ‖

CH2 – O – C – R3

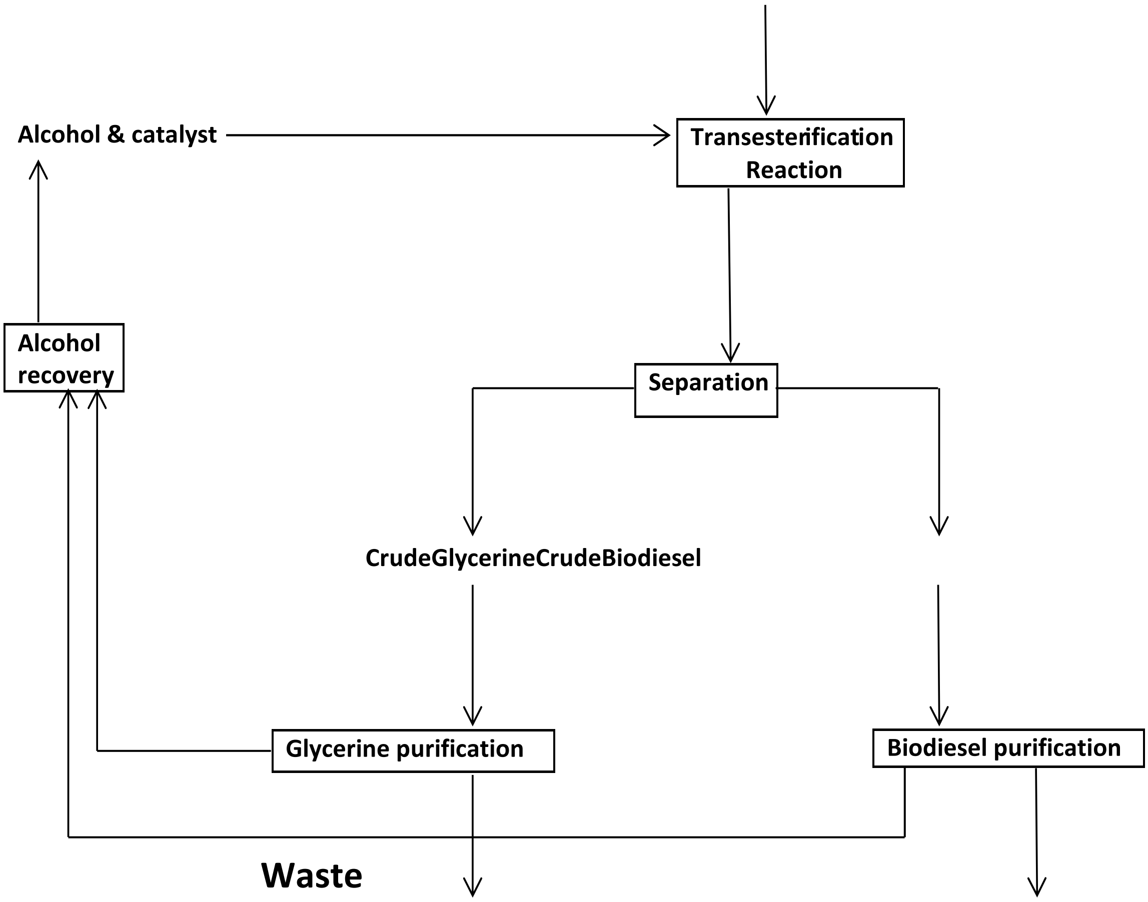
(Triglyceride) (Methanol) (Methyl Ester) (Glycerine)

Since the catalyst tends to concentrate in the glycerine, it can become unavailable for the reaction without agitation. A common approach to overcome this issue is to conduct the transesterification in two stages. First, the oil is combined with 75% to 90% of methanol and the catalyst and this reaction is allowed to react to equilibrium. Then, the glycerine that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for a second reaction period. At the conclusion of this second reaction period, the remaining glycerine is separated and the biodiesel is ready for further processing. The glycerine separation and accomplished by gravity settling or with a centrifuge.

After the Biodiesel is separated from the glycerol, it contains 3% to 6% methanol and usually some soap. If the soap level is low enough (300 to 500 ppm), the methanol can be removed by vaporisation and this methanol will usually be dry enough to directly recycle back to the reaction. Methanol tends to act as a co-solvent for soap in the biodiesel, so at higher soap levels the soap will precipitate as a viscous sludge when methanol is removed.

3.2. Preparation of Bio Diesel

Vegetable oil



Glycerine Refined Biodiesel

3.2.1 Filtering

The extracted cottonseed oil may contain solid impurities. These impurities may react with the chemical compounds used in transesterification process and form unwanted products. These solid impurities are removed by filtering process. The oil is to be heated to a temperature of 30°C, so that oil passes through the holes of oil filter.

3.2.2. Preheating the oil

Heat the oil first to remove water content if any. Waste oil will probably contain water, which can slow down the reaction and cause specification. Less the water content better is the oil state. Raise the temperature to 100°C, hold it there and allow the water to boil off. Run the agitator to avoid steam pockets forming below the oil and exploding, splashing hot oil. Or drain the oil puddles out from the bottom as they form and save any oil that comes with the water later. When the boiling slows raise the temperature to 130°C for 10 minutes to remove any water present in it. Regular source of water does not need to have the water boiled off, in which boiling means extra energy and time.

3.2.3. Preparing Sodium Methoxide

Generally the amount of methanol needed is 25% Cottonseed oil by mass. The densities if these two oils are fairly close. Different oils can have different densities depending on the type of oil it originally was. The methanol is mixed into a solution with the NaOH creating sodium methoxide in an exothermic reaction. Keep all utensils the NaOH comes as dry as possible.

3.2.4 Heating and Mixing

Pre-Heating Cottonseed oil about 50-60°C. A full speed magnetic stirrer which is coupled to an electric motor works as a mixing device. Too much agitation is causing the splashing and bubbles through the vortexing and reduces mix efficiency. There should be a vortex appearing just above the surface. Add the sodium methoxide to the solution while stirring about 50 minutes.

The reaction is often completed in 30 minutes, but longer is better. The transesterification process separates the methyl esters from the glycerine. The CH3O of methanol then caps off the ester chains from NaOH stabilize the glycerine.

3.2.5. Settling and Separation

The Cottonseed oil will be floating on top while the denser glycerine will have settled in the bottom of the container forming a hard gelatinous mass. An alternative method is to allow the reactants to settle for at least an hour after mixing while keeping the mixture above 38°C, which keeps the glycerine semi-liquid. Then slowly decant the bio diesel. This can be done by draining the reactants out of the bottom of the container through a transparent-hose. The semi-liquid glycerine has dark brown colour and the bio-diesel is straw yellow colour.

3.2.6. Glycerine

The glycerine from oil is brown and turns to a solid below 38°C. Glycerine from oil often stays a liquid at lower temperatures. Reclaimed glycerine is composed after being vented for three weeks to allow residual methanol to evaporate off or after heating it to boil off any methanol content. The excess methanol can be recovered for re-use when boiled off if and run the vapour through a condenser.

3.2.7. Washing and Drying

However, some alcohol, catalyst and remain suspended throughout the bio-diesel after the transesterification is complete. Water in bio-diesel can lead to biological growth as the fuel degrades. Unreacted methanol in the bio-diesel fuel can result in fire or explosion and can corrode engine components. The catalyst can also attack other engine components. Because the methanol and catalyst are chemical bases, unwashed bio-diesel is caustic and may damage diesel engine components.

Soap is not a fuel and reduces fuel lubricity and cause engine coking and other deposits. In the small batch-scale described above, it is not feasible to reclaim the methanol. When making significant quantities of bio-diesel, reclaim the unreacted methanol represents a significant quantities of bio-diesel, reclaim the unreacted methanol represents a significant cost saving and methanol is a pollutant in its own right. The bio-diesel from this stage can be used to fuel the tanks of vehicles. It is used to let it settle for a while about two days, allowing the majority of the soap residues to settle before running the bio-diesel through a filtration system then into the vehicles fuel tank. A simple way of washing is using a PVC container with a valve 100mm from bottom. Fill with water until it is halfway between the container bottom and the valve, then fill up with the bio-diesel to be washed

After a gentle stirring followed by 12-24 hours of settling, the oil and water will separate, the cleaned oil can be decanted out the valve, leaving the denser soap water to be drained off from the bottom. This process might have to be repeated two or three times to be remove close to 100% of soaps. The second and third washings can be done with water alone. After the third washing any remaining water gets removed reheating the oil slowly, the water and other impurities sink to the bottom. Transesterification and washed bio-diesel will become clearer over times as any remaining soaps drop out of the solution.

3.2.8 Calorific Value

Calorific value is an important parameter in the selection of the fuel. The calorific value of biodiesel is generally lower than of diesel. This can be determined by Bomb calorimeter

Table 1 Properties of Fuels

Fuel Property	Diesel	Cottonseed
Viscosity at 40°C (Cst)	0.278	2.192
Flash Point (°C)	44	178
Fire Point (°C)	49	185
Density(kg/m3)	800	850
Calorific Value (KJ/Kg)	43000	39648

4. EXPERIMENTALPROCEDURE:

The chapter deals with load test carried out for both Diesel and Biodiesel under same conditions to evaluate the performance of the both oils by using Kirloskar engine. The Kirloskar engine specifications are given below

4.1 Engine Specifications

The specifications of experimental engine are given below

Type : Single cylinder vertical

Configuration : Direct injection 4-Stroke diesel engine

Rated power : 5HP

Rated speed : 1500 RPM

Fuel used : High speed diesel CLASS-'A' IS-1460

Lubricating oil : HD SAE 40 above 20°C

4.2. Engine Description

The engine is Kirloskar make, 4-stroke, single cylinder, vertical and cranking type diesel engine. Eddy current dynamometer is coupled to engine and is provided with resistance back load. Burette with 3-way cock is arranged for measuring fuel supply. The engine is also provided with air tank orifice plate and manometer for air intake measurement and exhaust gas calorimeter, thermos

4.3. Experimental Setup and Procedure

The experiment work is carried out by checking the level of oil in fuel tank, cooling water supply to the engine and exhaust gas calorimeter. Before starting the engine without any load on the engine the engine is started by hand cranking. By using the test rig the experiment is conducted for pure diesel, bio-diesel & blends. The resistance back load is switched on and the back loads are varied from no load to full load by selecting the switches on resistance back load. The speed is adjusted to rated speed at each load. The voltmeter reading, the ammeter reading and the time for 5cc fuel consumption and brake power, frictional power is determined by producing straight portion of the curve to meet the negative B.P axis. The performance parameters like FC, SFC, IP, IMEP, ηBth%, ηIth%, and ηmech% were calculated and tabulated in tables and calculations are shown. The performance of various blends, biodiesel with diesel fuel is compared by means of the graphs.

5.RESULTS AND DISCUSSIONS:

In this chapter the results of the experimental values and plotted graphs between load vs brake thermal efficiency, load vs BSFC, load vs FC, BP vs FC and load vs indicated thermal efficiency and variations are shown in the graphs for different fuels of pure diesel, biodiesel and its blends.

Also the economical speed of the diesel, biodiesel and its blends are found.

5.1 Comparison Graphs for Performance of Diesel, Biodiesel and Blends

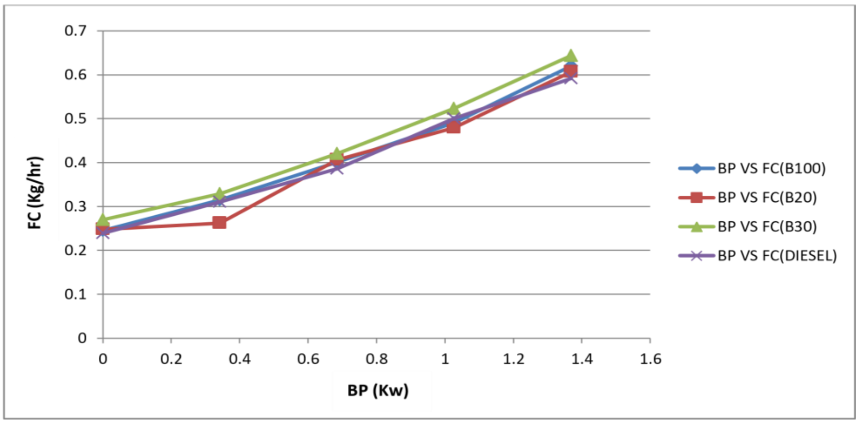


Fig 2 BP Vs FC

It is clear that while compared to pure diesel, B100 and B30 the fuel consumption of B20 is less with increase in the load.

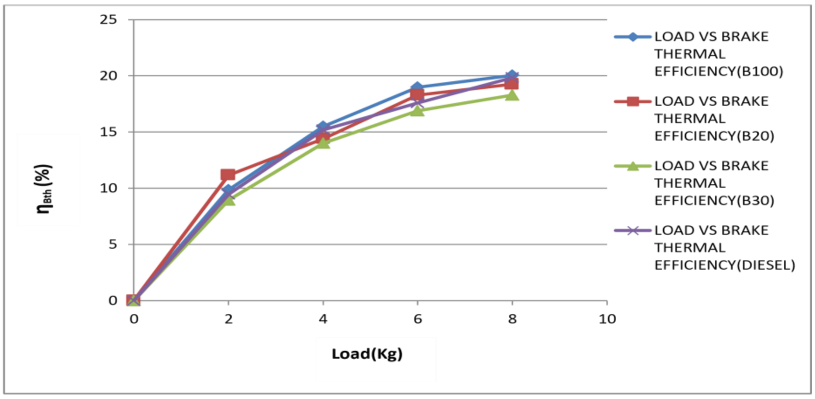


Fig 3 Load Vs η_{Bth}

The B20 has the highest brake thermal efficiency when compared to all the other blends and pure diesel.

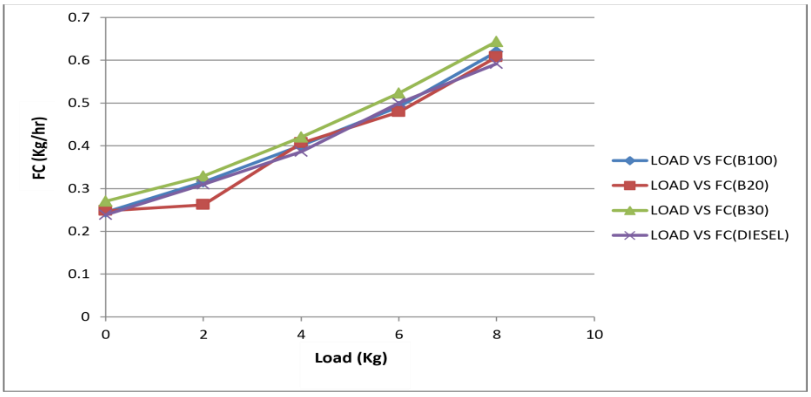


Fig 4 Load Vs FC

The fuel B20 has consumed less fuel compared to Pure Diesel, B100 and B30 as the load is increased.

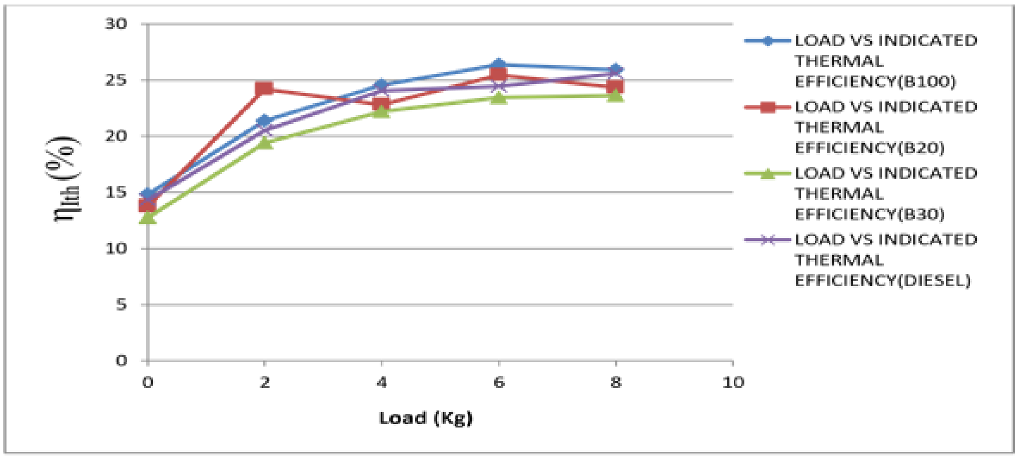


Fig.6 Load vs thermal efficiency

Indicated thermal efficiency of B20 is more than compared to other fuels Pure diesel, B30 and B100 for different loads

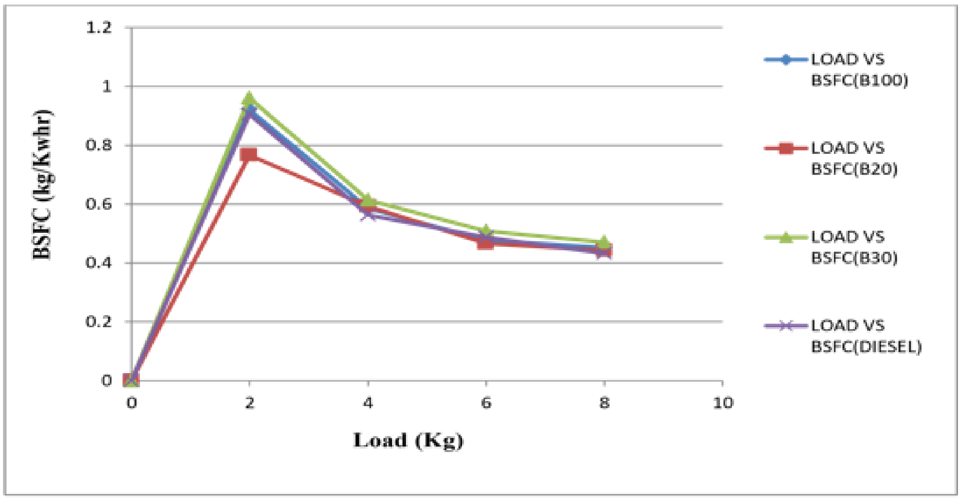


Fig .6 Load vs BSFC

The Brake specific fuel consumption is less for B20 as compared to Pure Diesel, B100 and B30 as the load increases

5.2Graphs for Economical Speed of Engine for Diesel, Biodiesel and Blends

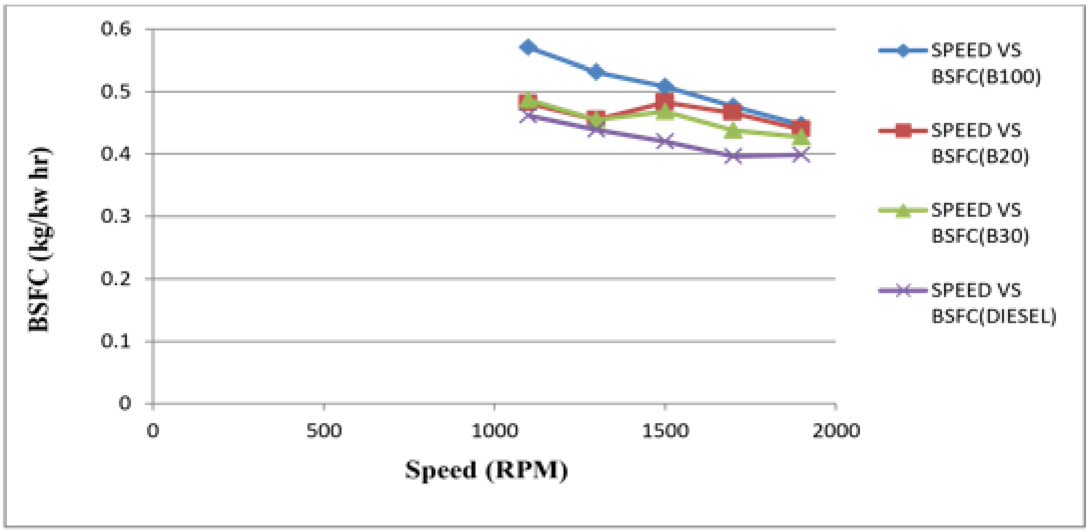


Fig .7 BSFC vs Speed

The speed of engine for B20 (20% Biodiesel) is more economical when compared to B30 (30% Biodiesel) and B100 (Pure Biodiesel)

6.CONCLUSION:

Thus from the study of literature that from the production of bio diesel from edible oils is more expensive than diesel fuels to this relative cost of edible oils. There is need to explore non-edible oils as alternative fuels for production of biodiesel. Non-edible oil like cottonseed oil is easily available in many regions of the world including India and it is cheaper compared to edible oils and diesel.

The catalytic transesterification triglycerides with the alcohols like methanol to form mono alkyl ester of long chain fatty acids.

Conventional diesel engines can be operated without much modification on biodiesel. It can be used as pure or mixture with hydro carbon based diesel fuels, these are known as blends.

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