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Thermodynamic Analysis of Petrol and Diesel Engines

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Abstract: *This study presents the thermodynamic performance characteristics; fuel power (FP), brake thermal efficiency (BTE), brake power (BP) and Specific fuel consumption (SFC) of petrol and diesel fuel. The experiments were conducted in two stages: constant load and constant speed.In constant load,the load is held constant and the speed is varied, and readings were taken, while in constant speed,the speed is held constant and the load is varied, and readings were taken. These tests were performed on cortina petrol engine testbed and diesel engine testbed for the petrol and diesel fuel respectively.Both engines are four stroke,four cylinder engines. The result showed that petrol engine requires more brake power than the diesel engine,however,the petrol engine has a lower fuel economy than the diesel engine.Thus, petrol engines are generally employed in light duty vehicles such as motorcycles, carsetc while the diesel engines are generally employed in heavy duty vehicles like trucks and earth moving equipment.*

Keywords: *Petrol(gasoline), diesel, pperformanceparameters, dieselengines, petrol engines.*

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I. Introduction

In today's growing and competitive automotive sector,Internal combustion engine which comprises the spark ignition and the compressor ignition engines have played a substantial role. They are the main propulsion systems for ground transport, both in on-road and off-road applications: vehicles, boats, ships, airplanes, and trains.

Basically, the spark ignition engines and compression engines use petrol and diesel fuel respectively and both engines differ in how they supply and ignite the fuel. In a spark ignition engine, the fuel is mixed with air and then inducted into the cylinder during the intake process. After the piston compresses the fuel-air mixture, the spark ignites it, causing combustion. In a diesel engine, only air is inducted into the engine and then compressed. Diesel engines then spray the fuel into the hot compressed air at a suitable, measured rate, causing it to ignite.

Due to their different performance characteristics, it is necessary to employ the type of engine that is best suited for a purpose.Consideringthis, the thermodynamics analysis of both engines is imperative to determine the performance characteristics -power output,fuel consumption, efficiency-of the engines.A lot of experimental investigation of this study have been done by various researchers such as Boby*et al* (2014), Abhishek *et a*l (2015),Bhasker and Siddeswararao (2014).

Several works carried out in petrol and diesel engines includes:

In Boby*et al.* (2014) "Experimental investigation of diesel engine using gasoline as an additive", they found out that the effective power output increased at the level of 4-9% and fuel consumption decreased by approximately 6% when gasoline was mixed with the diesel fuel. Also, it was observed that increasing the gasoline volume fraction decreased the fuel density,kinematic viscosity and surface tension. Furthermore, the diesel auto ignition temperature was visibly low when compared with that of a gasoline fuel and the flashpoint of gasoline was lower than diesel due to volatility of gasoline was more. (Flashpoint of a substance is the lowest temperature at which it can vaporize to form an ignitable mixture in air). Gasoline blending increased the ignition delay and the formation of a more homogenous mixture.These combustion characteristics caused the simultaneous reduction of NO_2 and soot emission.

In a Similar work done by Bhaskar and Siddeswararao(2014),however they blended Diesel fuel with 50% Honne oil and tested the blend at various injection pressures. It was found out that as injection pressure increased,the brake specific consumption decreased. They attributed this to good atomization of the blended fuel at higher injection pressure which helped in faster rate of heat release.Also, in an experiment to determine the brake thermal efficiency at various loads,they observed that the brake thermal efficiency values at full load were 18.13%,19.53% and 23.02% for diesel fuel at 180,200 and 220bar respectively.

Abhishek*et al* (2015) in "effects of compression ratio on the performance of diesel engine at different loads." experiment,discovered that the least fuel consumption was at compression ratio of 18.The lower compression ratios than 18 resulted in high fuel consumptions. At the lower sides of the compression ratios,fuel consumption was high due to incomplete combustion of fuel.The maximum fuel consumption was measured at compression ratio of 14. Furthermore,it was observed that as compression ratio of the engine increased,the brake specific fuel consumption decreased(improved). out of the four compression ratios selected for the study, compression ratio 18 recorded the lowest brake specific fuel consumption.This was due to a higher compression ratio,brake power increased.It was also seen that when the load increased at any compression ratio the specific fuel consumption decreased,and also when the compression ratio was increased,a decrease in specific fuel consumption was observed with the lowest value occurring at compression ratio 18 and at 12kg load.

Furthermore, Abhishek observed during comparison of brake power with load,that when the load was increased at any compression ratio,the brake power increased, and statistical data showed that brake power increased from 0.97KW at 3.31kg load to 3.44,3.48,3.45.3.46KW for compression ratio 14,15,161 and 18 respectively at 12Kg load.Similar,the brake mean effective pressure increased when the load increased.

Ubwa*et al* (2014) experiment on cortina petrol engine to determine the performance of the engine using different ethanol blend on petrol engine fuel.They observed that at the engine speed of 1050RPM a peak in brake thermal efficiency of (petrol with 5% mixture of alcohol) was reached,then the brake thermal efficiency sharply declined as the speed increased and then reached a minimum at 1350RPM.
Also, at speed of 750RPM, specific fuel consumption of petrol fuel was maximum. when the engine speed was increased to 1050RPM,the specific fuel consumption of petrol fuel decreased slightly.However, when the engine speed was increased further to 1350RPM,the specific fuel consumption of petrol increased slightly. A sharp drop was observed when the engine speed was taken to 1700rpm.

II. Methodology

The test procedures for derivations of the performance parameters were conducted using cortina petrol and diesel engines test bed found in both Department of Mechanical Engineering laboratory,University of Nigeria Nsukka,Enugu State and University of Ibadan, Oyo State under the supervision of Engr, M.N Eke and Mr.Kalu.Detailed description of both engines is shown below:

Table 1: Engine specification of Cortina Petrol and Diesel Engine Test bed.

Engine	Petrol	Diesel
Type	Ford	Perkins 4:108
Engine Number	711F-9450-AB	108US7258
Bore	83mm	79.73mm
Stroke	92.95mm	88.90mm
Swept Volume	1.76litres	1.76litres
Maximum Speed	3,000rpm	3000rpm
Diameter of exhaust pipe	1.5inches	1.5inches
Length of Exhaust pipe	36inches	36inches

The test begins with setting the four stroke cortina petrol and diesel engine test bed to an idle speedstarting from 1000rpm.The engines was allowed to run at this speed for some time to warn it up to a uniform temperature.

However,the experimentation was done in two stages for both engines (petrol and diesel)namely: constant load(variable speed) and constant speed(variable load)test.

Constant load experiment:

In the constant load experiment,the engine was throttled to the first desired speed(1000rpm), measured with the aid of a tachometer and the engine was allowed to run for some time at this speed. The air manometric reading,inlet and exit temperature of the cooling water as well as the exhaust temperatures,and the time for $50cm^3$ and $25cm^3$ of petrol and diesel fuel consumed were taken respectively. Load was applied to the engine at the dynamometer and on the spring balance for diesel and petrol engines respectively. The chosen loads were held at the point while other readings were being taken. The above steps were repeated for different speed of 1200rpm,1400rpm,1800rpm,200rpm etc.

Constant speed experiment:

In constant speed test,the speed is made the constant parameter and it follows similar pattern as the constant load test,however the speed is held constant and the load is varied, and readings were taken.Then the various loads were unloaded, and both engines were switched off.

III. Results and Discussion

Brake power

Fig 4.1 shows the variation of brake power with engine speed for both petrol and diesel engine test beds.It was observed that a petrol engine requires a higher amount of brake power than a diesel engine.This can be seen in the speed of combustion of both engines which inturn depends on the mixing of the fuel and air.In petrol engine,air and petrol are initially pre-mixed before compression,which allows the petrol engine to have a much higher speed than the diesel engine,thus producing more brake power but severely reduces their compression ratio and thus their efficiency.

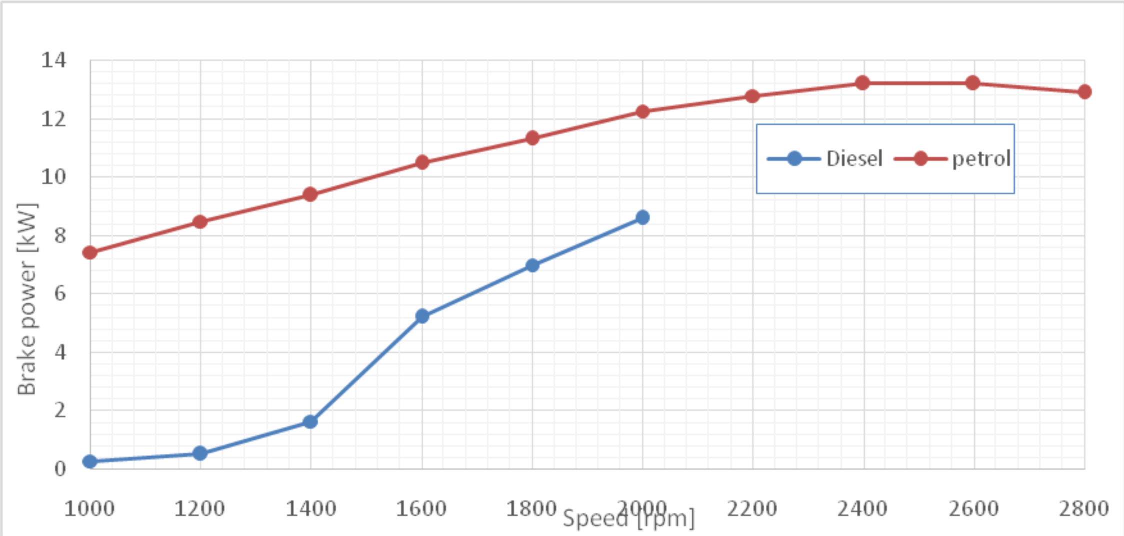

Figure 4.1: Graph of brake pover against Speed

Specific fuel consumption

The effect of variation of engine indicated speed with fuel consumption is shown in fig 4.2. From the Fig.it can be seen that the fuel consumption of diesel engine is relatively higher that that of the petrol engine.This is because the diesel fuel has higher specific gravity and viscosity and thus lower volume flow rate than the petrol fuel.This result is evident with the law that shows the rate of fuel delivery to engine speed was greatly affected by the density,specific gravity,and viscosity of fuel.(stone,R.1992)

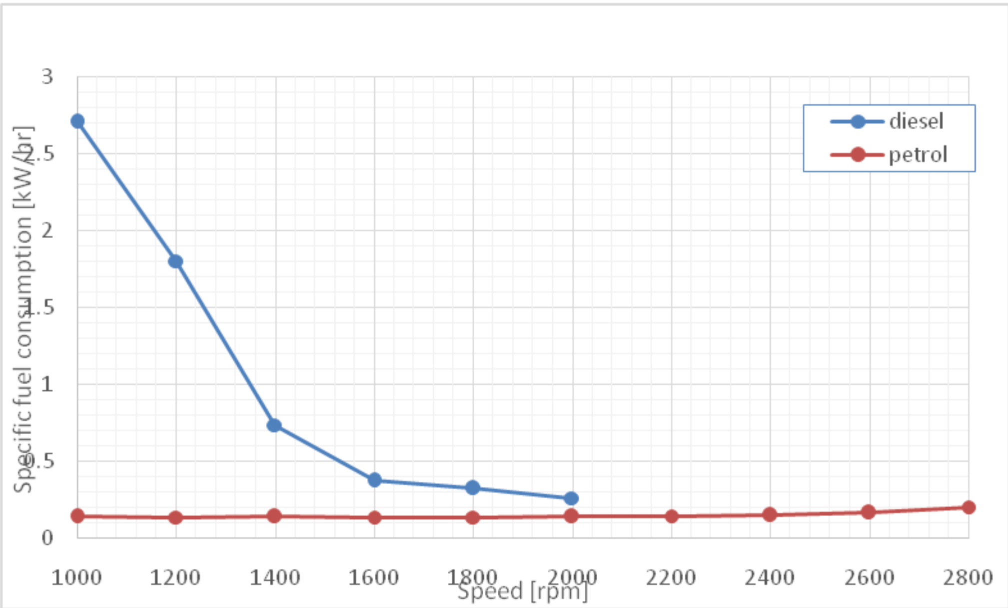

Figure 4.2: Graph of specific fuel consumption against Speed

Brake thermal efficiency

Figure 4.3 shows the rate at which the brake thermal efficiency varies with indicated speed. From the figure,It would be seen that the efficiency of the petrol engine varies slightly as the speed increases,whereas the efficiency of the diesel engine varies very well as the speed increases and also the brake thermal efficiency of the petrol engine is higher than that of the dieselengine, this was due to a better combustion of the petrol than the diesel fuel.Thus we can say that the brake thermal efficiency is proportional to combustion efficiency.(Baglione,2007).

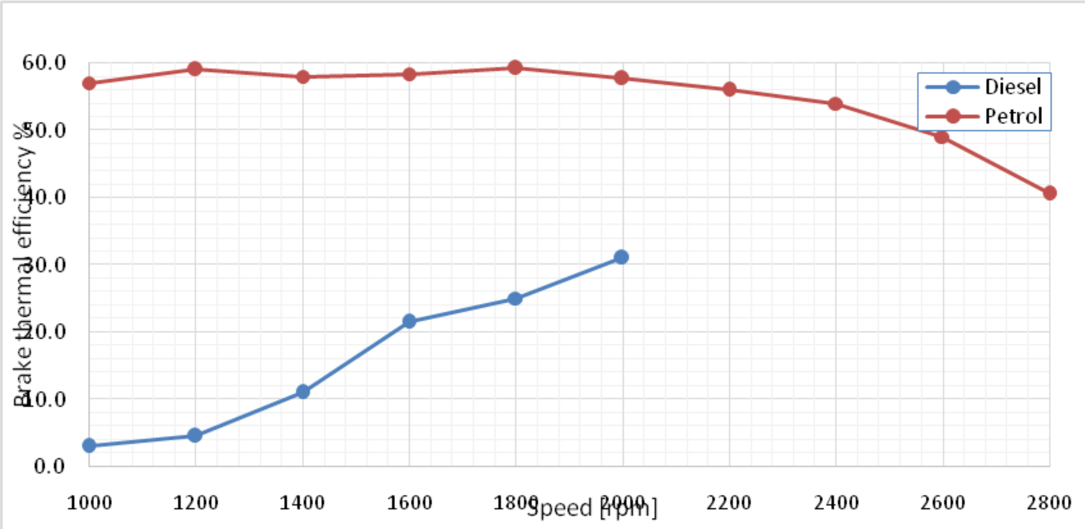

Figure 4.3: Graph of Brake thermal efficiency against speed

Volumetric efficiency

The plot of volumetric efficiency against speed for constant load is shown. In figure 4. 4.It would be observed from the figure that diesel engine has a higher volumetric efficiency than the petrol engine,this is due to the diesel engine has a higher compression ratio than the petrol engine.And the higher the compression ratio,the more volumetric efficient is the engine.This is strongly backed up by the results calculated purely from geometric of the mechanical part that the compression ratio of petrol and diesel engine ranges from 10:1to 9:1,and 14:1 to 25:1 respectively.(Horst,O.H.1999)

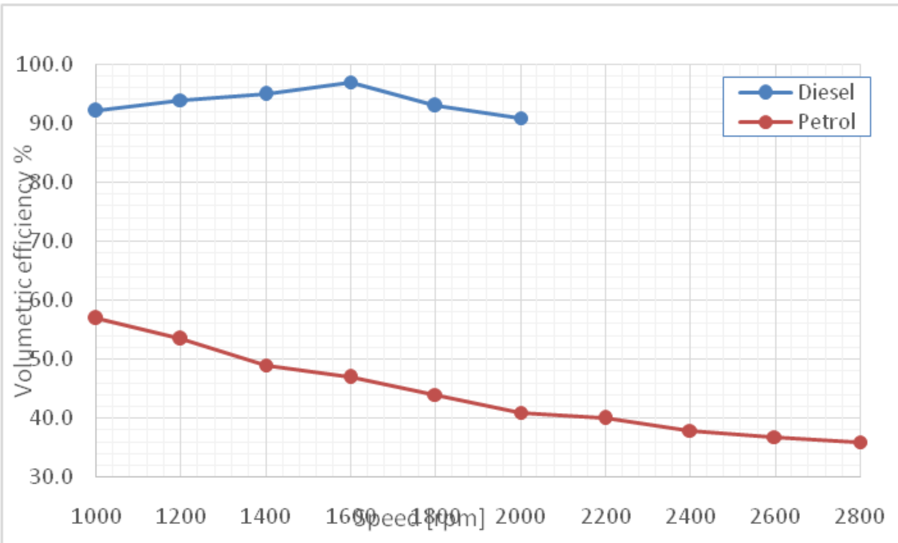

Figure 4.4: Graph of Volumetric efficiency against Speed

Mass flow rate

Figure 4.5 shows the rate of mass flow with engine speed.From the figure,it would be observed that the mass flow rates of both engines increase with increasing speed.With the diesel fuel having higher mass flow rate than the petrol fuel at speed of 200rpm, this was due to that diesel engine has lower power to weight ratio than the petrol engine,thus more weight(mass)of diesel will flow in a given cross sectional area than the petrol.This can also be seen in their densities, where the density of a diesel fuel is greater than that of a petrol fuel,and mass flow rate depends on density.

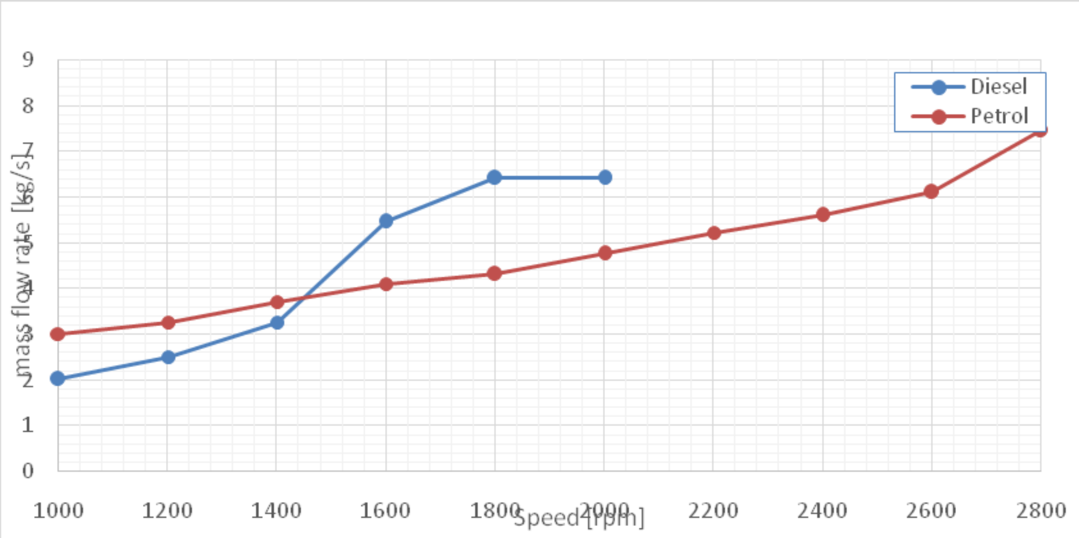

Figure 4.5: Graph of massflow rate against speed

Brake thermal efficiency against brake power

From figure 4.6, it would be observed that for a constant speed engine,the brake thermal efficiency is a linear function of the brake power,the curve increases to a maximum value for both engines.This display a maximum value values for the brake thermal efficiency of both engines,which are the conditions at which the engines are running at its best and with maximum economy.

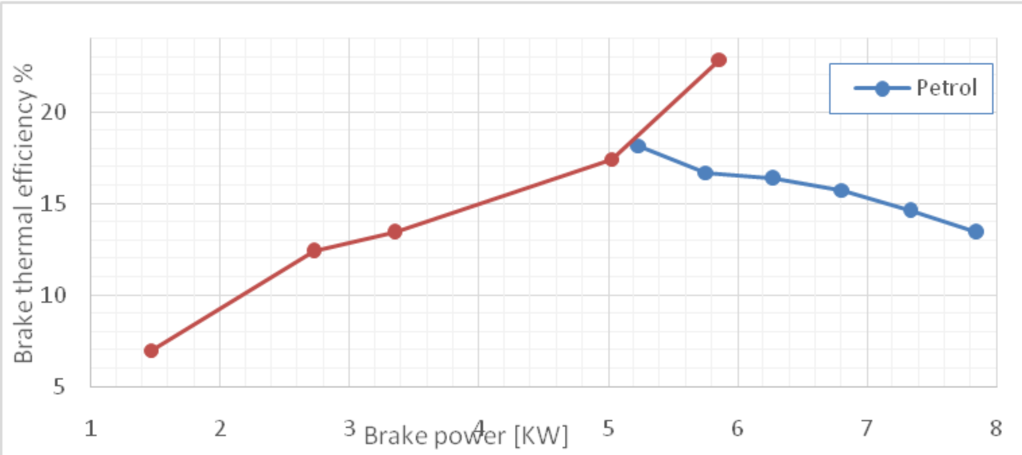

Figure4.6: Graph of brake thermal efficiency against brake power

IV. Conclusion

In this study, the analysis of the cortina petrol and the diesel engine test beds shows that the two fuels have different performance when they are tested.From this we can conclude that:

Petrol engines require more brake power than the diesel engine,this is due to that the petrol engine has a better combustion than the diesel fuel. However,the petrol engine has a lower fuel economy than the diesel engine,that is it is less volumetric efficient than the diesel engine.

It can also be concluded from the limited literature that the use of petrol reduces carbon deposit and wear of the key engine partscompared with the diesel fuel.This is attributed to lower soot formation of the petrol fuel,because it has a better combustion in air than the diesel fuel.Thus, diesel fuel causes more pollution than the diesel fuel.

The overall analysis shows that the two fuels petrol and diesel fuel are very important energy sources and their use depends on the purpose of the assignment they are being used for.Thus petrol engines are generally employed in light duty vehicles such as motorcycles,carsetc while the diesel engines are generally employed in heavy duty vehicles like trucks and earth moving equipments.

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