OPEN ACCESS
Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

# Evaluating Parameters Affecting the Performance of the Spark Ignition Engine

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**DOI:** 10.36348/sjet.2021.v06i08.003 | **Received:** 01.07.2021 | **Accepted:** 04.08.2021 | **Published:** 17.08.2021

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## Abstract

An experiment work has been carried out to evaluate the parameters affecting a one cylinder engine (spark ignition engine) at two throttle positions (1/2 throttle and full throttle) for two stroke engine and at three throttle positions (1/2 throttle, 2/3 throttle and full throttle) for four stroke engine. Parameters such as brake power, BMEP, Brake thermal efficiency and specific fuel consumption where considered at varying speeds (780, 1560, 2340, 3120 and 3900rpm) and (1000, 1200, 1400, 1600 and 1800rpm) for two stroke and four stroke respectively. The results obtained showed that the brake power, brake mean effective pressure and brake thermal efficiency increases while the torque, specific fuel consumption and volumetric efficiency decreases as the engine speed increases when considering the three throttle positions. The volumetric efficiency and brake power of the two stroke engine for the half throttle positions at 4680rpm for two stroke were 0.229 and 7.545kw respectively compared to the full throttle positions which were 0.299 and 7.662kw respectively. The volumetric efficiency and brake power of the four stroke engine for the half throttle positions at 1800rpm for two stroke were 0.180 and 5.598kw respectively compared to the 2/3 and full throttle positions which were 0.1803, 8.2073kw and 0.1803, 9.2026kw respectively.

**Keywords:** Parameters Affecting Spark Ignition Engine.



## 1. INTRODUCTION

The mechanical effort in engine devices such as the heat engine is by the conversion of heat into work and can be classified internal combustion engines: In this case, combustion of the fuel with oxygen of the air occurs within the cylinder of the engine. The internal combustion engines group includes engines employing mixtures of combustible gases and air, known as gas engines, those using lighter liquid fuel or spirit known as petrol engines and those using heavier liquid fuels, known as oil compression ignition or diesel engines. External combustion type: In this case, combustion of fuel takes place outside the cylinder as in the case of steam engines where the heat of combustion is employed to generate steam which is used to move a piston in a cylinder. Other examples of external combustion engines are hot air engines, steam turbine and closed cycle gas turbine. These engines are generally used for driving locomotives, ships, generation of electric power and others. For the purpose of this study, the internal combustion concentrating on a single cylinder was considered using the air-fuel mixture. Internal combustion engines are mechanical devices that use controlled explosions (combustions) of petrol and air mixtures to rotate wheels. The reciprocating (back and forth) engine explodes the mixture of air and fuel in a cylinder that forces the contained piston to move. This movement of the piston is transmitted through the connecting rod to a rotating device called the crankshaft. The piston slides back and forth due to high gas pressure developed in the cylinder. The thrust on the piston is transmitted by the connecting rod to a crankshaft and the angular position of the piston transmits this power to the flywheel and the flywheel uses some of the power to return the piston to the top of the cylinder. The back and forth movement of the piston is known as the reciprocating movement of the piston. The rotary engine is simple with fewer parts, which costs less and substitutes a rotary member for the reciprocating piston and is easily balanced. One of its designs is the Wankel engine. The Wankel engine is a fascinating beast that features a very clever rearrangement of the four elements of the Otto cycle. Most rotary engines have certain disadvantages like sealing problems, higher fuel consumption and it does not last long. Hence it is not widely used compared with the reciprocating engines. Generally the internal combustion engine gives a high thermal efficiency and higher power output and has special importance in the field of land transportation (motor vehicle), industries and locomotives. The wankel reciprocating engine design diagram is presented in the Figures.

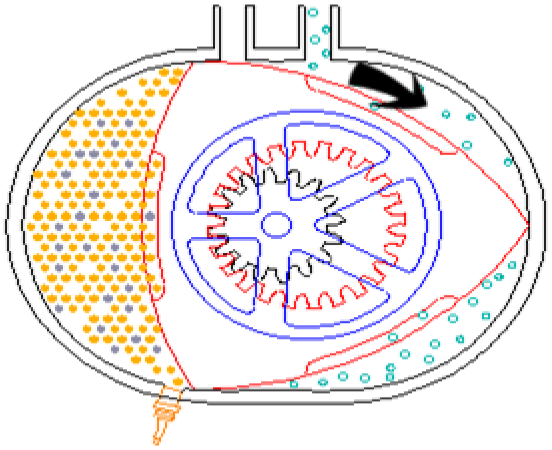

**Fig-1: Wankel Engine**

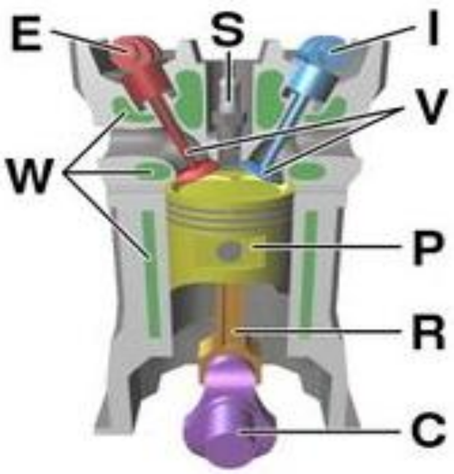


**Fig-2: Reciprocating Engine**

**Principle of Spark Ignition Engine**

The spark ignition engine requires an amount of air-fuel mixture to affect combustion in the cylinder**.** The composition depends on the speed and load on the engine. This is compressed by an upward movement of the piston towards the spark plug which initiates a spark to ignite the combustible mixture burning most part of it which leads to the expansion of gases. The pressure development forces the piston to the bottom of the stroke and the force generated is transmitted to the crankshaft through the connecting rod and made to turn one half of the revolution at the bottom dead centre. This causes the motion of the flywheel attached to the crankshaft rotating at high speed to produce a mechanical used motion. However, there are several types of operating cycles but the most commonly used are the two stroke and four stroke cycles. The four stroke cycle is completed in two revolutions of the crank shaft. The induction/intake stroke; compression stroke; power stroke and exhaust stroke. While the two stroke cycle has the steps occurring in the four stroke cycle but it is completed in just one revolution unlike the four strokes that needs 2 revolutions to complete its cycle. This is described by the position of the piston in the cylinder in terms of extremity. When the piston is at the top of the cylinder, it is known as the top dead centre (TDC). When it is at the lower side of the cylinder, it is known as the bottom dead centre (BDC). The aim of this study is to evaluate the parameters affecting the performance of a one cylinder spark ignition engine that operates as a two stroke and four stroke engines. The parameters to be evaluated include: Indicated power, brake power, friction power, mechanical efficiency, brake thermal efficiency, specific fuel consumption, brake Mean Effective Pressure (BMEP), volumetric efficiency. These will be determined from the data obtained from the experiments to be carried out.

## 2. REVIEW OF LITERATURE

The Incentive for the development of practical engine has been wide spread throughout history and most engines are being applied in transportation. The internal combustion engine in the 18$^{th}$ century is as a result of greater scientific understanding and a search by scientist for the substitute in coal power generation. The most readily available fuel for the earliest engine was developed by Huygens (1980) and Papin (1960) was gunpowder and coal. Gunpowder and coal which burns more rapidly than coal became the earliest internal combustion engine. Though an extensive literature of experimental findings on investigation carried out on internal combustion engines abounds in the work of various authors. It was later concluded that the engine had no practical application because of failure to produce adequate power output. It was not until the end of the 18$^{th}$ century that a practical internal combustion engine was developed. Robert Steele an Englishman invented such an engine in 1794. But the operation of this engine was extremely clumsy. Air was pumped into the cylinder forcing the heavy piston halfway up its stroke; liquid fuel was then let in and was ignited by the cylinder heated cylinder head. The resulting combustion and heating of gases drove the piston further up its stroke than required and after expansion, the gases were cooled and forced to contract thereby lowering the piston. An investigation carried out showed that the engine was too tedious because the engine was done manually. (Heywood, 1988). However in 1857, two Italians named; Barsanti and Matteuci built a free piston engine which illustrated the motion of the piston controlled by gas pressure. The piston was capable of sliding back and forth in a reciprocating motion during combustion in the cylinder. At the bottom stroke, it engages a ratchet connected to the shaft on a repeated process, the same work done by Heywood showed that the engine was going to fail because of low power generation. 1860: Belgian Jean Joseph Etienne Lenoir (1822–1900) produced a gas-fired internal combustion engine similar in appearance to a horizontal double-acting steam beam engine, with cylinders, pistons, connecting rods, and flywheel in which the gas essentially took the place of the steam. This was the first internal combustion engine to be produced in numbers. It was built in such a way that there was no compression and on the intake stroke, the air and gas was ignited by an electric spark. Due to this effect, the fuel consumption was very high and a conclusion was made that the engine could not establish a high power output due to low fuel economy. 1861 The earliest confirmed patent of the 4-cycle engine, by Alphonse Beau de Rochas. A year earlier, Christian Reithmann made an engine which may have been the same, but it's unknown since he didn't clearly patent it. 1862: German inventor Nikolaus Otto was the first to build and sell the engine.

The time and process temperature has a way of influencing the pyrolysis reactions, affecting product yield and composition, but in cases where input selection is required, it may be achieved using modified atmospheres and catalysts [1, 2]. Study conducted in recent time observed zeolites as being suitable as catalysts for such process as cracking of the oil to obtain compounds with boiling points in the range of gasoline [3]. Other study conducted using gasoline have been achieved using alcohol which is a practical way of improving the octane number (ON) of conventional gasoline [4], this could often be useful in motor sports. The latent heat of vaporization of ethanol is 2.5 times higher than that of gasoline, allowing an increase in the volumetric efficiency of the engine [5] by lowering its intake mixture temperature. Ethanol has a high octane number and contains oxygen, therefore, its mixture with gasoline reduces the tendency to "knock" and promotes the reduction of emissions of some exhaust gases [6]. Oztop et al. [7] evaluated the performance and emissions of exhaust gases of an SI engine fuelled with a mixture of gasoline and pyrolysis distillates from tire wastes. The authors concluded that this new fuel could partially replace gasoline blends by up to 60% without significant changes in engine performance and exhaust emissions. Suiuay et al. [8] evaluated the performance and emissions of exhaust gases of an SI engine fuelled with a mixture of gasoline and pyrolysis bio-oil distillates from the hard resin of Yang (gasoline-like fuel (GLF)). The authors concluded that the GLF showed better results than gasoline for torque, brake thermal efficiency, and brake specific fuel consumption; GLF had lower emissions of CO and unburned hydrocarbons (UHC) and higher emissions of NOx. The use of ternary mixtures of gasoline and two different biofuels has been tested by different authors with the purpose of achieving optimal combustion conditions by combining fuels with different chemical composition and fuel properties [9, 10].

### 2.1 Fundamental Operation of the Four Stroke Otto Cycle

The four stroke cycle describes the operation in the S.I Engine which completes two revolutions of the crankshaft in one power stroke and operates as follows. Induction stroke: This begins with the piston at the top of its stroke and the inlet valve open. As the piston goes down, it draws the fuel air mixture into the cylinder past the inlet valve. During this operation the exhaust valve is usually closed. Compression stroke: When the piston has completed its downward stroke, the inlet valve closes, the revolving crankshaft then pushes the piston up again and the mixture now in the cylinder is compressed upward into the combustion chamber. At the top of the stroke, it is fully compressed. During this operation, the inlet and outlet valve are usually closed. Power stroke: At this point, a spark occurs between the electrodes of the sparking plug. This ignites the air-fuel mixture. The heat from this explosion causes a high pressure at the top of the cylinder which forces the piston downwards again. During this operation, both valves are still closed. Exhaust stroke: At the end of the downward stroke due to the sparking of the plug, the exhaust valve opens while the piston goes up again and the products of the combustion are pushed past the valve and out of the engine. This cycle is constantly repeated so long as the engine is running.

### 2.2. Spark Ignition Engine Cycles

The mixture or fuel and air used as the working fluid in an S.I engine is subject to chemical, thermal and mechanical changes during combustion in the engine. Assumptions are use to examine these changes and are corrected for the various points of difference. The air is assumed to be the entire working fluid and is called the air cycle.

### 2.3. The Air Standard Cycle

This is the theoretical cycle for the spark ignition cycle which involves four processes taking place simultaneously during combustion. Process 1 – 2: Isentropic compression, Process 2 – 3: Heat addition at constant volume, Process 3 – 4: Isentropic Expansion, Process 4 – 1: Heat rejection at constant volume.

The thermal efficiency

$$\eta = \frac{\sum Q}{Q_1} = \frac{Network}{Heat\ supplied}$$

Now since process 1 – 2 and 3 – 4 are isentropic, it can be shown that

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = \left(\frac{V_4}{V_3}\right)^{\gamma - 1} = \frac{T_3}{T_4} = r_v^{\gamma - 1}$$

Where $r_v$ is the compression ratio

Then $T_3 = T_4 r_v^{\gamma - 1}$

$$T_2 = T_1 r_v^{\gamma - 1}$$

Hence substituting into equation 1 we have

$$\eta = 1 - \frac{T_4 - T_1}{(T_4 - T_1)\, r_v^{\gamma-1}}$$
$$= 1 - \frac{1}{r_v^{\gamma-1}}$$

This shows that the thermal efficiency depends on only the compression ratio $r_v$.

### 2.4 Factors Affecting the Performance of the S.I. Engine

The air-standard Otto cycle showed that with an increase in compression ratio, the efficiency increases together with the brake thermal efficiency of the S.I Engines. However it has an upper limit to which the compression ratio can be applied noting that the liquid compressed in the cylinder is a mixture of air and fuel. The temperature of the combustible mixture increases during compression and if compression ratio is too high, it is possible for self-ignition to occur before spark ignition but if compression ratio is sufficiently low, it produces a much higher efficiency for which the engine can withstand and pre-ignition is avoided. Other factors may include the rise in pressure obtainable during combustion and also, the normal method of achieving the appropriate mixture and fuel is by means of the carburetor although much advanced means have come into play like the injector system. But the carburetor satisfies the requirement that a rich mixture is required at full throttle to attain maximum power at very low throttle setting and with weak mixtures a lower power output is attained.

## 3. PERFORMANCE CRITERIA

Engine performance is an indication of the degree of success with which it does its assigned job i.e., conversion of chemical energy contained in the fuel into the useful mechanical work. In evaluation of engine performance certain basic parameters are chosen and the effects of various operating conditions, design concepts and modifications on these parameters are studied. The basic performance parameters are Power and mechanical efficiency, mean effective pressure and torque, specific output, volumetric efficiency, air-fuel –ratio, specific fuel consumption, thermal efficiency and heat balance, exhaust smoke and other emissions, specific weight.

### 3.1. Power and Mechanical Efficiency

This is the relationship between bp and ip

$$\text{ME} = \frac{\text{bp}}{\text{ip}}$$

E.g. at one speed the bhp of an engine is 116, the ihp is 135, the M.E. is 116/135 – 0.86 or percent. This means that 86 percent of the ihp is delivered by the engine. The remaining 15 percent is lost as fhp. The mechanical efficiency is indicative of the mechanical losses in a machine. It depends upon the operating conditions especially speed, power output and lubrication.

**Indicated power.** The total power developed by combustion of fuel in the combustion chamber is called indicated power.

$$\text{I.P} = \frac{n\, p_{mi}\, LANk\ x\ 10}{6}\ kw \qquad (3.1)$$

Where, n is the number of cylinders, $P_{mi}$ =Indicated mean effective pressure, bar, L is the Length of stroke, m, A is the area of piston, m and k is ½ for 4-stroke engine

**Brake power (B.P.).** The power developed by an engine at the output shaft is called the brake power.

$$\text{B.P.} = \frac{2\pi NT}{60\ x\ 1000}\ kW \qquad (3.2)$$

Where, N is the speed in r.p.m., and T is the torque in Nm. The difference between I.P. and B.P. is called frictional power, F.P.

$$\text{F.P.} = \text{I.P.} - \text{B.P.} \qquad (3.3)$$

The ratio of B.P. to I.P. is called mechanical efficiency

$$\text{Mechanical efficiency, ME} = \frac{\text{bp}}{\text{ip}} \qquad (3.4)$$

### 3.2. Mean effective pressure and torque

Mean effective pressure is defined as hypothetical pressure which is thought to be acting on the piston throughout the power stroke. If it is based on I.P. it is called indicated mean effective pressure ($I_{m.e.p}$ or $p_{mi}$,) and if based on B.P. it is called brake mean effective pressure ($B_{m.e.p}$ or $P_{mb}$). Similarly, frictional mean effective pressure ($F_{m.e.p}$ or $P_{mf}$) can be defined as

$$F_{m.e.p.} = I_{m.e.p} - B_{m.e.p} \quad (3.5)$$
$$B_{m.e.p} = 2bp/ALNn$$

The torque and mean effective pressure are related by the engine size.

Since the power (P) of an engine is dependent on its size and speed, therefore it is not possible to compare engine on the basis of either power or torque, Mean effective pressure is the true indication of the relative performance of different engines.

### 3.3. Specific output

It is defined as the brake output per unit of piston displacement and is given by:

$$\text{Specific output} = \text{Constant x } p_{mb} \text{ x r.p.m.} \quad (3.6)$$

For the same piston displacement and brake mean effective pressure ($P_{mb}$) an engine running at higher speed will give more output.

### 3.4. Volumetric efficiency

It is defined as the ratio of actual volume (reduced to N.T.P.) of the charge drawn in during the suction stroke to the swept volume of the piston. The average value of this efficiency is from 70 to 80 per cent but in case of supercharged engine it may be more than 100 per cent, if air at about atmospheric pressure is forced into the cylinder at a pressure greater than that of air surrounding the engine.

$$\eta_v = V / V_s \quad (3.7)$$

Where
V = volumetric of air induced
$V_s$ = swept volume

### 3.5. Fuel-air ratio

It is the ratio of the mass of fuel to the mass of air in the fuel-air mixture. Relative fuel air ratio" is defined as the ratio of the actual fuel air ratio to that of stoichiometric fuel-air ratio required to burn the fuel supplied.

### 3.6. Specific fuel consumption (s.f.c.)

It is the mass of fuel consumed per kW developed per hour, and is a criterion of economical power production.

i.e., $$\text{s.f.c.} = \frac{m_f}{B.P} \text{ kg/kWh.} \quad (3.8)$$

### 3.7. Thermal efficiency

Thermal efficiency: It is the ratio of indicated work done to energy supplied by the fuel.

If $m_f$ = Mass of fuel used in kg/sec., and
C = Calorific value of fuel (lower),

Then indicated thermal efficiency (based on I.P.),

$$\eta_{th\ (B)} \quad \frac{I.P.}{m_f \ \ x\ C} \quad (3.9)$$

and brake thermal efficiency (based on B.P.)

$$\eta_{th\ (B)} \quad \frac{B.P.}{m_f \ \ x\ C} \quad (3.10)$$

### 3.8. Basic Measurements

To evaluate the performance of an engine following basic measurements are usually under-taken: Speed, fuel consumption, air consumption, smoke density, exhaust gas analysis, brake power, indicated power and friction power, field volt, output current, heat going to cooling water, heat going to exhaust.

## 4. Data analysis for four stroke engine

The apparatus used for the experiment is a heat engine (one cylinder petrol engine) at full throttle and part throttle positions. The engine was developed on the principles of the four stroke Otto cycle which allows a limited quantity of fuel and an adequate combustion chamber space. The engine capacity is adequately large in addition to a small cylinder size and provides a consistent performance for a good thermal efficiency and power output at its speed and load variations. The engine speed can be operated up to 6000 rpm for spark ignition having a fixed compression ratio.

### 4.1. Engine Description

The S.I engine is a single cylinder, water-cooled, four stroke unit of 468.67cm$^3$ swept volume, having a bore of 84.98mm and a stroke of 82.49mm. The engine components consists of the cylinder, cylinder head and cam box, all bolted together to form one assembly. The cylinder housing is in turn fixed to the crank case which is made up of hardened phosphorus cast iron. An alloy steel connecting rod is coupled to the crankshaft supported by three white metal plain bearings. The piston is of aluminum alloy and is attached with three pressure rings and one oil ring. The combustion chamber is a thick disc providing good anti-knock properties and has the spark plug situated at the top between the inlet and outlet valves.

The lubricating system is of the wet sump type and the oil is pumped into the lubricating parts by means of a gear pump situated on the front cover of the engine. A relief valve is fitted to control the oil pressure. Attached to it is an oil heater of 0.5KW rating in the crankcase for increasing the oil temperature before the engine starts. An oil-water heat exchanger enables the temperature of the oil to be controlled at any desired value.

The engine uses a carburetor and is fitted with a variable main jet that permits the mixture strength to be valued between limits. A fuel tank up to two gallons capacity with a metering equipment coupled to the engine. The engine is also coupled to a dynamometer that is mounted on a bedplate. It measures the output of the torque when the engine is running at different speeds up to 6000 rpm. A simple switch gear is used to enable the dynamometer operating as a motor to start the engine. A bank of resistance grids having a negligible temperature coefficient absorbs the energy developed by the dynamometer. Series of the bank switches enables the amount of resistance in the armature circuit to be varied, thus varying the load at different speeds on the dynamometer.

### 4.2 Experimental Procedure

To evaluate the parameters that affect the performance of the spark ignition engine, the throttle was set at half throttle position with a fixed compression ratio of 6:1 used throughout the experiment. The switch lever on the control box was raised and engine started with the dynamometer operating as an electric motor. When the engine is fired, the lever was dropped down cutting off power from the dynamometer which then acted as the load and absorbed the power developed by the engine. In this case the engine now drives the dynamometer. The initial speed of the engine was set at 1000 rpm and the data's recorded where brake load indicated by the spring balance, the manometer reading, time taken for the volume of petrol (17.5ml) to be consumed indicated by the stop watch, atmospheric pressure and temperature indicated by the barometer and thermometer respectively, the procedure was repeated for the other speeds at 200rpm intervals up to 1800rpm and also for 2/3 throttles positions and full throttle position.

## 4.3 RESULTS AND CALCULATIONS

**Table-1: Raw data for half throttle position.**

| SPEED (rev/min) | LOAD (kg) | MANOMETER READING (m) | TIME (s) | ATMOSPHERIC TEMP.( $^0$C) |
|---|---|---|---|---|
| 1000 | 8.7545 | 0.0122 | 60.0 | 29.0 |
| 1200 | 8.6411 | 0.0135 | 59.0 | 29.0 |
| 1400 | 8.4596 | 0.0148 | 57.0 | 29.0 |
| 1600 | 8.1421 | 0.0174 | 54.0 | 29.0 |
| 1800 | 7.8473 | 0.0177 | 49.8 | 29.0 |

At a speed of 1000rpm

$volume\ of\ fuel\ consumed = 17.5\,ml$

Mf $\quad = 2.1583 \times 10^{-4}$

(a) Brake power $(\boldsymbol{bp})$ = 2.876KW

(b) Brake Mean Effective Pressure (BMEP) =7.37bar

(c) Brake thermal efficiency $\boldsymbol{\eta_{bt}}$ = 30.49%

(d) Specific Fuel Consumption (SFC) = 0.27kg/kwh

(e) Volumetric efficiency $(\boldsymbol{\eta_v})$ $= 32.5\%$

**Table-2: Calculated data for half throttle position.**

| SPEED (rev/min) | TORQUE (Nm) | BRAKE POWER (KW) | BMEP | Mass Flow Rate(kg/s) | SFC (kg/kwk) | volumetric efficiency | B.T.E |
|---|---|---|---|---|---|---|---|
| 1000 | 27.499 | 2.880 | 7.38 | 0.00021 | 0.2697 | 0.3245 | 0.31 |
| 1200 | 27.143 | 3.466 | 8.74 | 0.00021 | 0.2277 | 0.2704 | 0.36 |
| 1400 | 26.572 | 4.101 | 9.99 | 0.00022 | 0.1994 | 0.2318 | 0.41 |
| 1600 | 25.575 | 4.761 | 11.0 | 0.00023 | 0.1812 | 0.2028 | 0.45 |
| 1800 | 24.649 | 5.598 | 11.9 | 0.00026 | 0.1672 | 0.1803 | 0.49 |

**Table-3: Raw data for 2/3 throttle position.**

| SPEED (rev/min) | LOAD (kg) | MANOMETER READING (m) | TIME (s) | ATMOSPHERIC TEMP.( $^0$C) |
|---|---|---|---|---|
| 1000 | 9.5708 | 0.0207 | 49.5 | 29.0 |
| 1200 | 9.7069 | 0.0247 | 43.8 | 29.0 |
| 1400 | 9.5708 | 0.0279 | 39.7 | 29.0 |
| 1600 | 9.2986 | 0.0332 | 38.2 | 29.0 |
| 1800 | 8.7316 | 0.0385 | 37.8 | 29.0 |

**Table-4: Calculated data for 2/3 throttle position.**

| SPEED (rev/min) | TORQUE (Nm) | BRAKE POWER (KW) | BMEP | Mass Flow Rate(kg/s) | SFC (kg/kwk) | volumetric efficiency | B.T.E |
|---|---|---|---|---|---|---|---|
| 1000 | 30.06 | 3.8165 | 8.069 | 0.0002616 | 0.2467 | 0.3245 | 0.3338 |
| 1200 | 29.54 | 5.0872 | 9.518 | 0.0002956 | 0.2092 | 0.2704 | 0.3937 |
| 1400 | 29.43 | 6.5228 | 11.061 | 0.0003261 | 0.1800 | 0.2318 | 0.4575 |
| 1600 | 29.20 | 7.6877 | 12.544 | 0.0003390 | 0.1587 | 0.2028 | 0.5189 |
| 1800 | 27.42 | 8.2073 | 13.252 | 0.0003425 | 0.1502 | 0.1803 | 0.5482 |

**Table-5: Raw data for full throttle position.**

| SPEED (rev/min) | LOAD (kg) | MANOMETER READING (m) | TIME (s) | ATMOSPHERIC TEMP.( $^0$C) |
|---|---|---|---|---|
| 1000 | 9.8888 | 0.0225 | 43.0 | 29.0 |
| 1200 | 9.7524 | 0.0279 | 38.2 | 29.0 |
| 1400 | 9.7524 | 0.0371 | 35.6 | 29.0 |
| 1600 | 9.5256 | 0.0470 | 34.8 | 29.0 |
| 1800 | 8.7545 | 0.0559 | 33.8 | 29.0 |

**Table-6: Calculated data for full throttle position.**

| SPEED (rev/min) | TORQUE (Nm) | BRAKE POWER (KW) | BMEP | Mass Flow Rate(kg/s) | SFC (kg/kwk) | volumetric efficiency | B.T.E |
|---|---|---|---|---|---|---|---|
| 1000 | 31.05 | 4.5390 | 11.63 | 0.0003011 | 0.2388 | 0.3245 | 0.3448 |
| 1200 | 30.63 | 6.0472 | 15.5 | 0.0003390 | 0.2018 | 0.2704 | 0.4081 |
| 1400 | 30.63 | 7.5703 | 19.4 | 0.0003637 | 0.1729 | 0.2318 | 0.4762 |
| 1600 | 29.92 | 8.6448 | 22.16 | 0.0003721 | 0.1549 | 0.2028 | 0.5316 |
| 1800 | 27.49 | 9.2026 | 23.59 | 0.0003865 | 0.1512 | 0.1803 | 0.5447 |

**Table-7: Evaluated data for Brake Thermal Efficiency at the three throttle positions**

| SPEED (rev/min) | Half Throttle | 2/3 Throttle | Full Throttle |
|---|---|---|---|
| 1000 | 0.3054 | 0.3338 | 0.3448 |
| 1200 | 0.3617 | 0.3937 | 0.4081 |
| 1400 | 0.4131 | 0.4575 | 0.4762 |
| 1600 | 0.4544 | 0.5189 | 0.5316 |
| 1800 | 0.4927 | 0.5482 | 0.5447 |

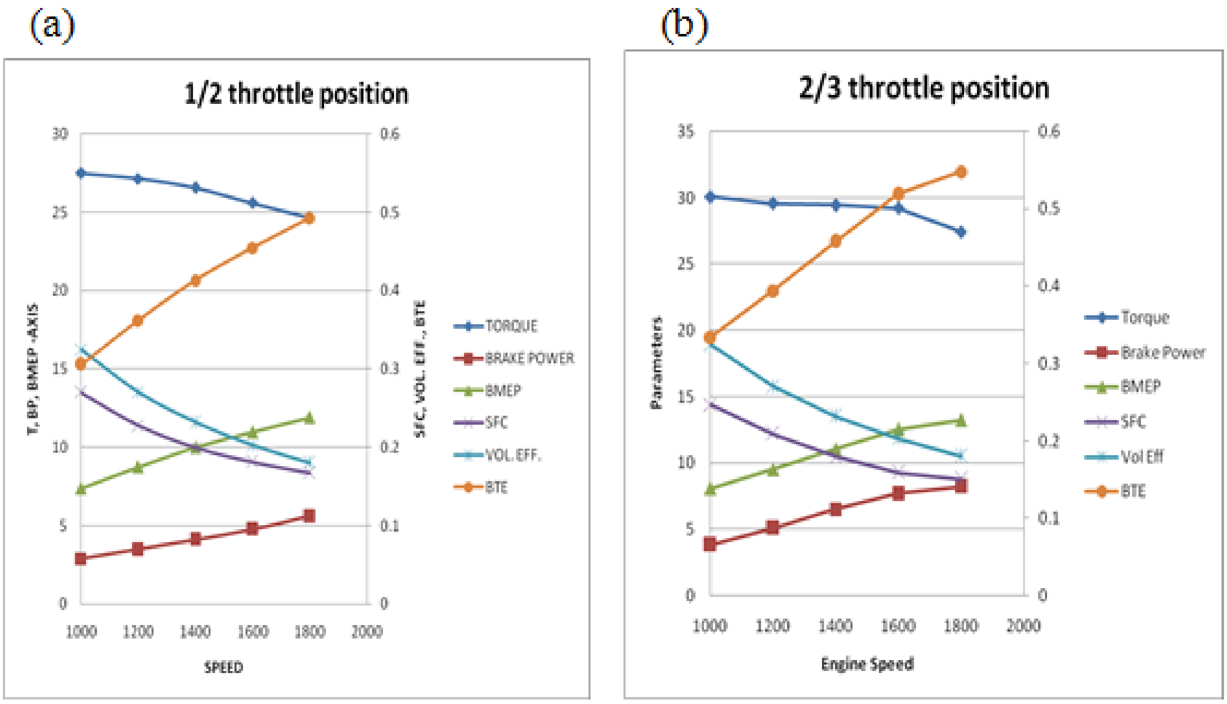


**Fig-3 (a): Input parameters vs engine speed for the ½ throttle position (b) Input parameters vs engine speed for the 2/3 throttle position**

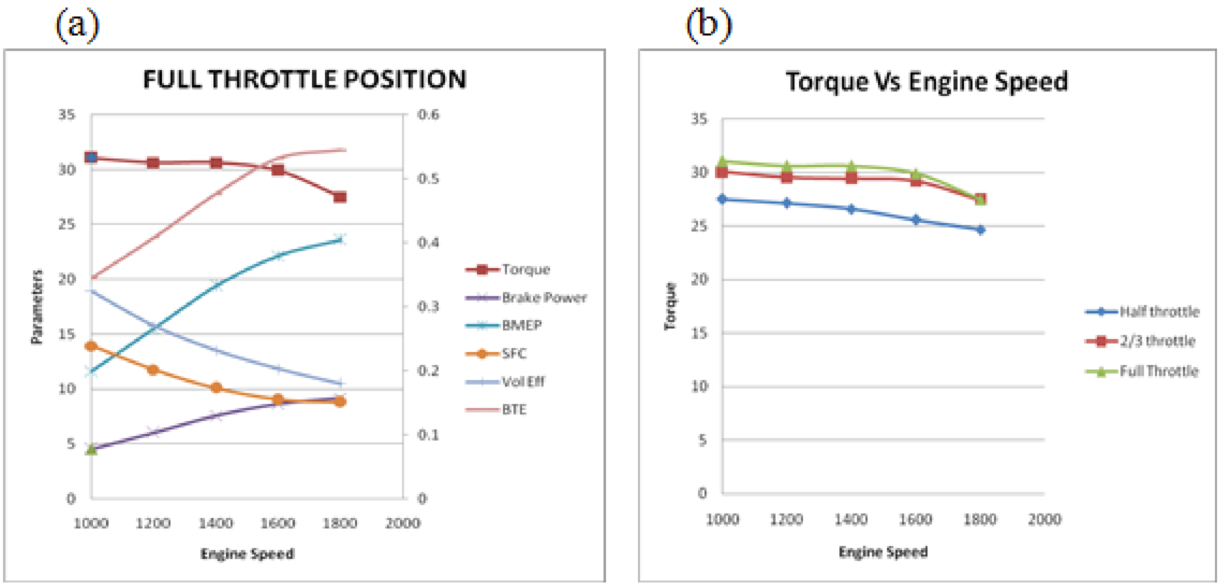


**Fig-4 (a): graph of input parameters plotted against the engine speed for the full throttle position (b) graph of torque vs engine speed for the three throttle positions**

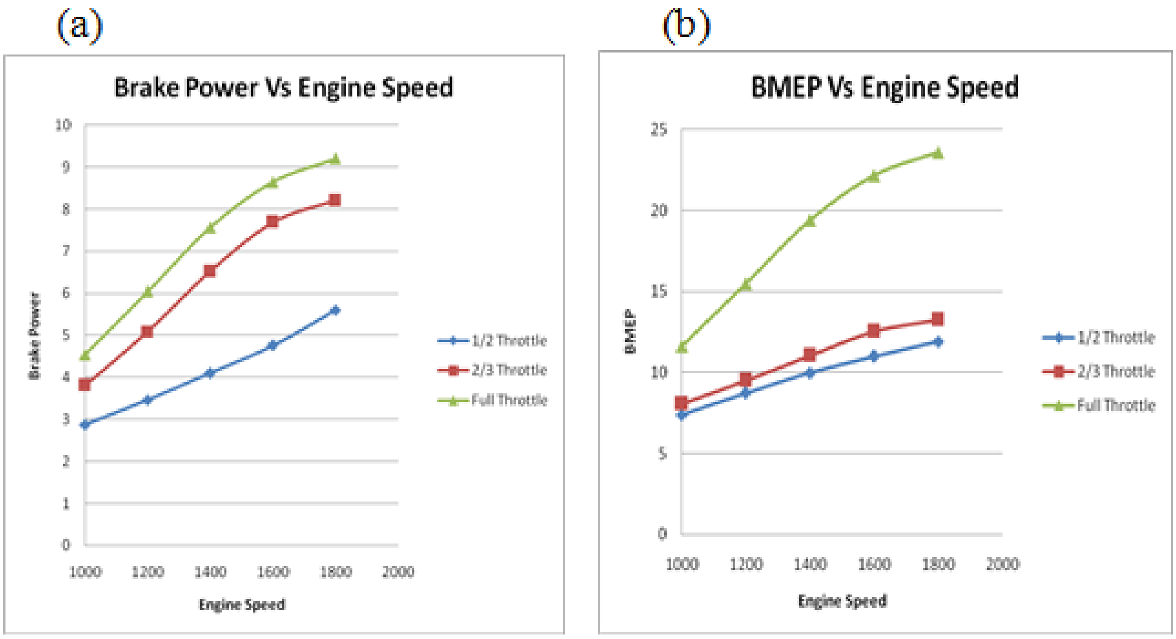


**Fig-5(a): Graph of brake power vs engine speed for the three throttle positions (b) graph of BMEP vs engine speed for the three throttle positions**

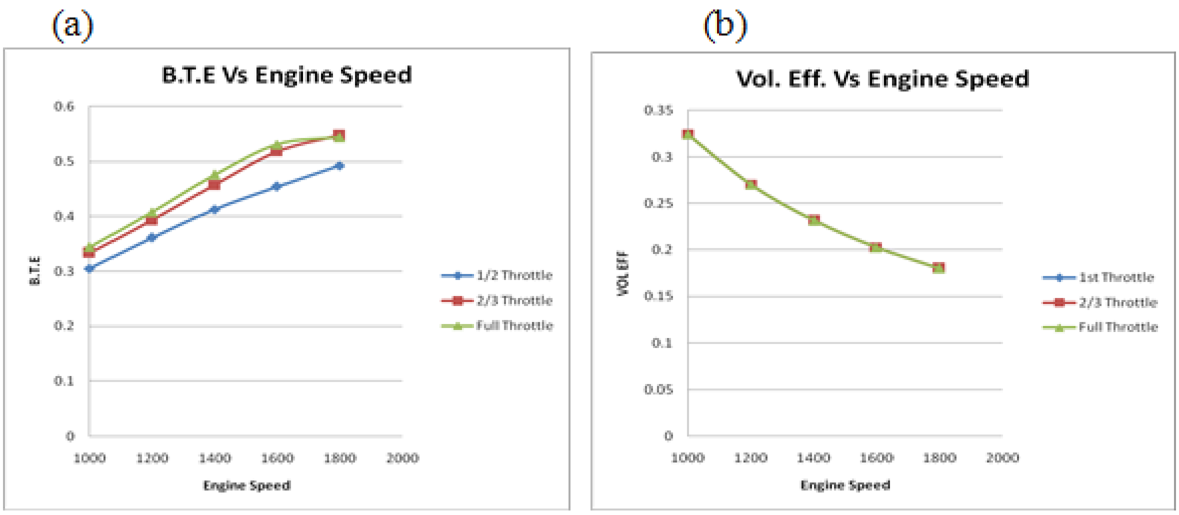


**Fig-6(a) graph of Brake Thermal Efficiency vs engine speed for the three throttle positions (b) graph of volumetric efficiency vs engine speed for the three throttle positions**

## 5. Data analysis for four stroke engine

The experiments carried out to evaluate the parameters demonstrates the effect each has on the engine performance and showing the relationship that exist between them. Three throttle positions (half, two-third, full) are varied with variation in speed during the experiment. The values obtained from the evaluation of the brake power shows the maximum power output attained on the engine as represented in Tables for half throttle position. This figure also represents the variation of the other parameters which are plotted against speed, and shows the typical curves obtained from the evaluation of the parameters. As the engine speed increases, the brake power also increases until it reaches its maximum value of 5.59KW at a speed of 1800rpm. This is also true for the 2/3 and full throttle positions as represented in the graphs of figure 4.1.2 and 4.1.3 respectively. Except that the maximum value attained at that speed is at 8.20KW and 9.20KW for 2/3 throttle and full throttle positions respectively. The Brake Mean Effective Pressure as represented on the same graph at half throttle position shows the pressure developed with an increase in engine speed. The pressure attained is 7.38 x $10^2$ $KN/m^2$ and then increased to a higher value of 11.9 $KN/m^2$ at the maximum speed. This is due to the pressure generated at the end of the exhaust stroke. The result also follows for the 2/3 and full throttle positions on Figs and Fig 5. The torque-speed relationships represented on the same graph at half throttle position shows that as the speed increases, the torque developed by the dynamometer acting as a load on the engine decreases. This resulted to friction lost on the engine, as the torque is proportional to the load. For the two-third and full throttle positions, the same result holds. The Specific Fuel Consumption shows the relationship with the engine speed as shown on the curve obtained in the graph at half throttle position. The SFC graph shows a decrease in value as the engine speed increases. At 1000rpm speed, the SFC value was 0.269kg/kwk and decreased to 0.167kwk for 1800rpm. The same characteristics was shown for both the 2/3 and full throttle positions. The brake thermal efficiency at half throttle position showed an increase as the speed of the engine was increase. At the 1000rpm speed it was 31% then it was later 49% at the highest speed. This is due to overheating in the combustion chamber at the optimum speed of 1800rpm. The 2/3 and full throttle positions also shows the same results. The volumetric efficiency showed very slight changes for the three throttle positions from the values calculated. The value of the volumetric efficiency decreases as the speed of the engine was increasing to its maximum value of 1800rpm. Since the engine is a single cylinder, the highest value would not be the same with and engine of multicylinders.

## CONCLUSION

It can be concluded that the engine parameters affecting the engine performance at the two throttle and three throttle positions for both two stroke and four stroke cycle engines respectively has effect on the engine. From the graph the trend shows that the brake power, brake mean effective pressure and brake thermal efficiency increases while torque, specific fuel consumption and volumetric efficiency decreases as the engine speed increases from 780rpm to 4680 for two stroke engine and also from 1000rpm to 1800rpm at intervals of 200rpm for four stroke cycle engine while considering the half throttle position, two-third throttle position and full throttle position. As it can be observed from the resulting graph for the half throttle position, a good volumetric efficiency and brake power output is attained. The maximum value attained is not exceeding the performance limit of the engine at its maximum speed. Hence the engine can perform effectively at this throttle position as compared to the full throttle position where the power output is higher than the actual rating of the engine. Based on the work of this project, the following are hereby recommended. The indicator pressure, one of the parameters affecting the performance of the engine can be evaluated with the provision of an electric indicator. A further work on the project can be carried out using a 4-6 cylinder engine so that a more elaborate result can be attained.

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