OPTIMIZATION OF IGNITION LOCATION FOR MAXIMUM EFFICIENCY IN A MULTIFUEL SPARK IGNITION ENGINES

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Abstract
Internal combustion engines are the backbone of transportation worldwide. Those engines are majorly categorized as spark ignition(SI) engine and compression ignition(CI) engines. However the source of SI or CI engine is fossil fuel and according to WTO report these sources are depleting day by day. So, research is focused on alternative fuels and their working efficiency. In regards to this, there are lot of different fuels developed and tested as well for their performance in the engine. To achieve the maximum output from the same amount of fuel consumed in engine, there must be selection of optimum compression ratio according to the fuel. In addition to this there is one more technique called as variable spark plug location as per load, speed and fuel involved at a particular instance. Different authors worked on the variation of spark plug location (Witze,1982, Wentworth,1974) which are along radial distance from centre location. There is no attempt made previously where the spark plug can be travelled axially settling at optimum CR. The movement of spark plug has been achieved by its connection to a stepper motor and a belt and pulley type power transmission system. The system has been designed in such a way that the clearance height available for movement is 12mm and the revolutions of the stepper motor have been programmed such that the linear movement of the spark plug is ranging to be 7-8mm. This height for movement has been decided such that the parameters would vary sharply and would produce significant variation. The engine parameters that will be measured are the torque, brake power, fuel consumption, brake thermal efficiency and brake specific fuel consumption. The results of these experiments will be discussed more in manuscript.

Keywords: spark ignition engine, variable spark location, multifuels, brake power.

1. INTRODUCTION

IC engines are types of engine which produces power using the combustion of petrol or such fuels. In the combustion chamber, now , conventionally considering SI engines which uses petrol as the fuel is combusted by the spark plug ignition method, fuel is ignited in the combustion chamber when both the intake and exhaust valves are closed, by sparking of the air-fuel mixture in the chamber using spark plug. Engine performance is enhanced by the use of turbochargers, supercharger, spark plug gap reduction, etc. Turbochargers and Superchargers enhance the engine performance by increasing the air intake and optimizing the air-fuel mixture. As per the power requirements. Due to the specified spark plug location horizontal and vertically, the point of flame initiation is determined. This point of flame initiation controls the flame propagation. We aim to change the dynamics of flame propagation by varying the spark plug location vertically, we would change the dynamics of fame propagation thus reducing the time by a minute factor. Hence, improving the engine performance in real time.

2. AIMS AND OBJECTIVE

In this project we aim to test the various engine parameters at varying spark plug location which is being varied vertically so as to be closer or farther from the piston and valves.

Objectives of the project:

- To construct a fully functional test setup for the testing of engine parameters.
- To construct a proper engine head modification so as to allow proper vertical variation of spark plug location vertically.
- To take observatory reading of all the variations observed.

3. SCOPE

The main scope of our project is that research has been done extensively in the field of improvement of performance in IC engines. But, never before has the spark location been varied vertically. This project has the scope of engine modifications and engine improvisations and can be applied extensively in engine manufacturing and design sector.

4. EXPERIMENTAL SET-UP

In this project the experimental setup mainly consists of a rope brake dynamometer based engine power measuring system. The engine power is measured using the dynamometers. The spark plug location variation is achieved by the rotary action of the spark plug in its housing causing it to move ahead due to the action of threading. The pitch of the thread is 1.25mm, hence for every rotation the spark plug moves further 1.25 mm into the engine head, closer to the piston. This rotary motion is given to the spark plug using a shaft connected to the spark plug which is then rotated using a belt and pulley transmission system which uses a stepper motor for the required rotary motion. The speed of the shaft of the engine at various locations is measured by a tachometer.

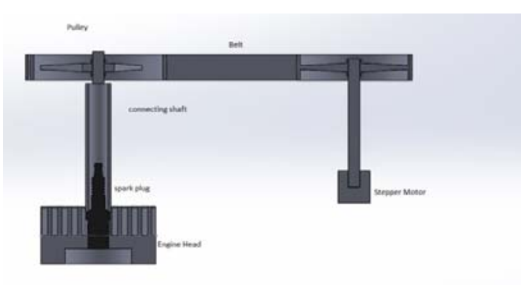

Figure. Schematic of the system

TESTING METHODOLOGY

- The testing has been done on this setup extensively using petrol and kerosene fuels.
- The engine has been tested for brake power, brake thermal efficiency, brake specific fuel consumption, mass flow rate and torque.
- The readings have been taken at 3000 rpm and at 2750 rpm.
- The readings have been taken at spark locations of 0mm, 1.25mm, 2.5mm, 3.75mm, 5mm, 6.25mm and 7.5mm towards the piston.

5. OBSERVATIONS

FOR PETROL

FOR 3000RPM

Position (mm)	Load(kg)	Time(sec) for 1cc
0	3.1	4.79
1.25	3.22	4.73
2.5	3.3	4.7
3.75	3.38	4.71
5	3.455	4.73
6.25	3.563	4.7
7.5	3.66	4.73

FOR 2750RPM

Position (mm)	Load(kg)	Time(sec) for 1cc
0	2.3	5.48
1.25	2.31	5.41
2.5	2.43	5.43
3.75	2.58	5.39
5	2.65	5.34
6.25	2.82	5.4
7.5	2.9	5.42

FOR KEROSENE

AT 3000RPM

Position (mm)	Load(kg)	Time(sec) for 1cc
0	2.9	6.07
1.25	2.98	5.78
2.5	3.1	5.35
3.75	3.21	5.49
5	3.2	5.47
6.25	3.3	5.68
7.5	3.35	5.53

AT 2750RPM

Position (mm)	Load(kg)	Time(sec) for 1cc
0	1.9	6.69
1.25	1.98	6.39
2.5	2.1	6.22
3.75	2.18	6.51
5	2.28	6.63
6.25	2.35	6.57
7.5	2.39	6.39

6. CALCULATIONS

Calculation for Petrol

For 3000rpm

For reading 1 (Position 0);

W= 3.1kg ; t = 4.79 sec

Mass flow rate = $m_f = \frac{1}{t} \times \frac{0.71}{10^3} = \frac{1}{4.79} \times \frac{0.71}{10^3} =$ 0.00014 kg/sec

Torque = T = W× $R = 3.1\times 10 \times 0.075 =$ 2.325 Nm

Brake Power = $\frac{2\times\pi\times N\times X\times R}{60\times10^3} = \frac{2\times\pi\times3000\times2.325}{60\times10^3} =$ 0.73 KW

Efficiency = $\eta = \frac{BP}{\text{mf}\times44000} = \frac{0.73}{0.00014\times44000} =$ 11.2%

Brake Specific Fuel Consumption = BSFC = $\frac{mf\times3600}{BP} = \frac{0.00014\times3600}{0.73} = 0.6904$ kg/KWhr

For 2750rpm
For reading 1 (Position 0)
W= 2.3kg ; t = 5.48 sec

Mass flow rate = $m_f = \frac{1}{t} \times \frac{0.71}{10^3} = \frac{1}{5.48} \times \frac{0.71}{10^3} =$ 0.000129kg/sec

Torque = T = W× $R = 2.3\times 10 \times 0.075 =$ 1.725 Nm

Brake Power = $\frac{2\times\pi\times N\times X\times R}{60\times10^3} = \frac{2\times\pi\times2750\times1.725}{60\times10^3} =$ 0.49 KW

Efficiency = $\eta = \frac{BP}{\text{mf}\times44000} = \frac{0.49}{0.000129\times44000} =$ 8.63%

Brake Specific Fuel Consumption = BSFC = $\frac{mf\times3600}{BP} = \frac{0.000129\times3600}{0.49} = 0.9477$ kg/KWhr

Calculation for Kerosene

For 3000rpm

For reading 1 (Position 0)

W= 2.9kg ; t = 6.07 sec

Mass flow rate = $m_f = \frac{1}{t} \times \frac{0.71}{10^3} = \frac{1}{6.07} \times \frac{0.71}{10^3} =$ 0.000117kg/sec

Torque = T = W× $R = 2.9\times 10 \times 0.075 =$ 2.175 Nm

Brake Power = $\frac{2\times\pi\times N\times X\times R}{60\times10^3} = \frac{2\times\pi\times3000\times2.175}{60\times10^3} =$ 0.683 KW

Efficiency = $\eta = \frac{BP}{\text{mf}\times44000} = \frac{0.683}{0.000117\times44000} =$ 16.6%

Brake Specific Fuel Consumption = BSFC = $\frac{mf\times3600}{BP} = \frac{0.000117\times3600}{0.683} = 0.617$ kg/KWhr

For 2750rpm
For reading 1 (Position 0)
W= 1.9kg ; t = 6.69 sec

Mass flow rate = $m_f = \frac{1}{t} \times \frac{0.71}{10^3} = \frac{1}{6.69} \times \frac{0.71}{10^3} =$ 0.000106kg/sec

Torque = T = W× $R = 1.9\times 10 \times 0.075 =$ 1.425 Nm

Brake Power = $\frac{2\times\pi\times N\times X\times R}{60\times10^3} = \frac{2\times\pi\times2750\times1.425}{60\times10^3} =$ 0.41 KW

Efficiency = $\eta = \frac{BP}{\text{mf}\times44000} = \frac{0.41}{0.000106\times44000} =$ 11.05%

Brake Specific Fuel Consumption = BSFC = $\frac{mf\times3600}{BP} = \frac{0.000106\times3600}{0.41} = 0.9307$ kg/KWhr

7. RESULTS

FOR PETROL

AT 3000RPM

Position	Load	Time	Mf	Torque	Efficiency	BP	BSFC
0	3.1	4.79	0.00014	2.325	0.112	0.73	0.6904
1.25	3.22	4.73	0.000153	2.415	0.1136	0.75	0.7344
2.5	3.3	4.7	0.000154	2.475	0.1163	0.777	0.7
3.75	3.38	4.71	0.00015	2.535	0.1206	0.796	0.6783
5	3.455	4.73	0.00015	2.591	0.1233	0.814	0.6634
6.25	3.563	4.7	0.000151	2.65	0.1263	0.8395	0.6475
7.5	3.66	4.73	0.00015	2.745	0.1307	0.8624	0.6262

AT 2750RPM

Position	Load	Time	mf	Torque	Efficiency	BP	BSFC
0	2.3	5.48	0.00013	1.725	0.0863	0.49	0.9477
1.25	2.31	5.41	0.00013	1.732	0.087	0.5	0.9432
2.5	2.43	5.43	0.00013	1.822	0.092	0.526	0.8892
3.75	2.58	5.39	0.00013	1.935	0.0963	0.559	0.85
5	2.65	5.34	0.00013	1.98	0.098	0.573	0.8356
6.25	2.82	5.4	0.00013	2.115	0.1058	0.6098	0.7733
7.5	2.9	5.42	0.00013	2.175	0.1086	0.6263	0.753

FOR KEROSENE

AT 3000RPM

Position	Load	Time	mf	Torque	Efficiency	BP	BSFC
0	2.9	6.07	0.00012	2.175	0.166	0.683	0.617
1.25	2.98	5.78	0.00012	2.235	0.164	0.702	0.6256
2.5	3.1	5.35	0.00013	2.325	0.158	0.73	0.65
3.75	3.21	5.49	0.00013	2.407	0.167	0.756	0.6142
5	3.2	5.47	0.00013	2.4	0.166	0.753	0.616
6.25	3.3	5.68	0.00013	2.475	0.17	0.777	0.58
7.5	3.35	5.53	0.00013	2.51	0.176	0.7893	0.583

AT 2750RPM

Position	Load	Time	mf	Torque	Efficiency	BP	BSFC
0	1.9	6.69	0.00011	1.425	0.1105	0.41	0.9307
1.25	1.98	6.39	0.00011	1.485	0.11	0.4276	0.9345
2.5	2.1	6.22	0.00011	1.575	0.1128	0.45	0.912
3.75	2.18	6.51	0.00011	1.636	0.1232	0.47	0.834
5	2.28	6.63	0.00011	1.71	0.13	0.49	0.78
6.25	2.35	6.57	0.00011	1.7625	0.134	0.507	0.766
7.5	2.39	6.39	0.00011	1.7925	0.132	0.5162	0.77

8.CONCLUSIONS

The conclusion of this project is that when the spark plug location is varied vertically towards the piston the engine parameters do vary. The parameters such as brake power, torque, BSFC, etc. increases with due variation. This paper shows the possibilities and innovation that is possible in IC engine improvisation and modification.

9.REFERENCES

Witze, P., "The Effect of Spark Location on Combustion in a Variable-Swirl Engine," SAE Technical Paper 820044, 1982, doi:10.4271/820044.

Wentworth, J., "Effects of Combustion Chamber Shape and Spark Location on Exhaust Nitric Oxide and Hydrocarbon Emissions," SAE Technical Paper 740529, 1974, doi:10.4271/740529.