Sensitivity and Effect of Variable Ignition Timing and Engine Speed on the Performance of a Spark Ignition Engine

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Abstract— The combustion process in a spark ignition engine is a progressive reaction, and thus certain factors such as the timing of ignition, combustion duration, the end of combustion etc. have considerable effect on performance of an engine. The work enhanced the importance of design variables of I.C. engine for better performance with fewer emissions. The spark timing and compression ratio are the two important design variables to deal with for effective performance of engine. This paper presents the effects of spark timing and RPM on the performance of a four stroke single-cylinder spark ignition engine. The study evaluated results of research in the area of spark ignition engine and is assessed by studying its performance characteristics relative to find the optimum. Experiments were conducted at different combustion start at 10, 14, 18, 22, 26, 30, 34, 38 degrees BTDC and for engine speed of 500, 1500, 3400 and 5000rpm. The performance of a spark ignition engine is investigated under different values of ignition advance. By varying the ignition timing i.e. related to top dead centre, the results of some characteristics such as power, torque, thermal efficiency, pressure, and brake specific flue consumption are obtained and compared.

Key words: Variable Ignition Timing, Spark Ignition Engine

I. INTRODUCTION

The performance of spark ignition engines is a function of many factors. One of the most important ones is ignition timing. It is one of the most important parameters for optimizing efficiency and emissions, permitting combustion engines to conform to future emission targets and standards. Since the advent of Otto’s first four stroke engine, the development of the spark ignition engine has achieved a high level of success. In the early years, increasing engine power and engine working reliability were the principal aims for engine designers. In recent years, however, ignition timing has brought increased attention to development of advanced SI engines for maximizing performance.

Ignition timing, in a spark ignition engine, is the process of setting the time that an ignition will occur in the combustion chamber (during the compression stroke) relative to piston position and crankshaft angular velocity. Setting the correct ignition timing is crucial in the performance and exhaust emissions of an engine. The objective of the present work is to evaluate whether variable ignition timing can be effect on exhaust emission and engine performance of an SI engine. Produce and deliver a high-voltage spark from a low voltage supply source (the battery). This spark must be distributed to each combustion chamber as the piston nears top dead centre on the compression stroke of the piston. Control and even alter when the spark occurs in the cylinder to meet different engine demands. Deliver a spark that has enough voltage and energy to ensure combustion of the fuel mixture. Be able to reliably accomplish these goals throughout a variety of rpm. Method For achieving this goal, at a different speed range, the ignition timing has been changed in the range of 10° BTDC to 38° BTDC and for optimize operation, ignition timing has been designed at wide-open throttle and at last, the performance characteristics such as power, torque, thermal efficiency, pressure, and brake specific flue consumption are obtained and compared are obtained and discussed.

There exists a particular spark timing which gives maximum engine torque at fixed speed, and mixture composition and flow rate. Sparks occurring too soon or too late in the engine cycle are often responsible for excessive vibrations and even engine damage. The ignition timing affects many variables including engine longevity, fuel economy, and engine power. Modern engines that are controlled in real time by an engine control unit use a computer to control the timing throughout the engine's RPM and load range. Setting the correct ignition timing is crucial in the performance and exhaust emissions of an engine. The performance of spark ignition engines is a function of many factors. One of the most important ones is ignition timing. Also it is one of the most important parameters for optimizing efficiency and emissions, permitting combustion engines to conform to future emission targets and standards.

II. METHODOLOGY

GT-POWER is the market leading engine simulation software, used by every major engine manufacturer for the design and development of their engines. It is applicable to all sizes and types of engines, and its installed base includes a highly diverse group of car, truck, motorcycle, motor sport, marine, locomotive, power generation, mining and construction, agricultural, and lawn and garden equipment manufacturers.

GT-POWER contains the industry’s most comprehensive and advanced set of models for engine performance analysis, providing the breadth of features required to allow the engineer to analyse a number of engine configurations and performance characteristics, including:

- Torque and power curves, airflow, vol. efficiency, fuel consumption, emissions
- Steady state or full transient analysis, under any driving scenario
- Turbocharged, supercharged, turbo compound, e-boost, pneumatic assist
- SI, DI, HCCI and multi-mode combustion, multi-fuel, and multi-pulse injection
- Infinitely variable valve timing and lift (VVT and VVL)
- Acoustic analysis of intake and exhaust systems
- Manifold and cylinder component thermal analysis, with included FE solver

– Controls system modelling, via built-in controls library or Simulink coupling

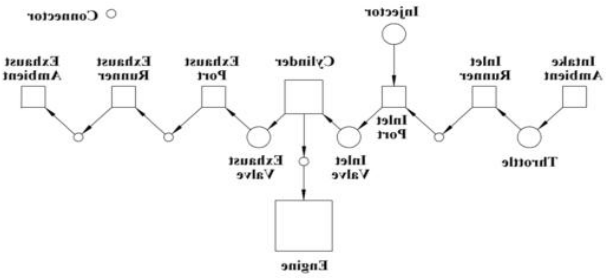

Fig. 1: Engine model for GT- Power Soft wear

Number of Cylinder	1
Number of Stroke	4
Cylinder Bore (mm)	75
Stroke (mm)	77
Connecting Rod Length (mm)	175
Compression Ratio	10.5
Maximum Speed (rpm)	5000
Minimum Speed (rpm)	500
TDC Clearance Height	1
Spark Ignition Timing	10° to 38°

Table 1: Engine Specification

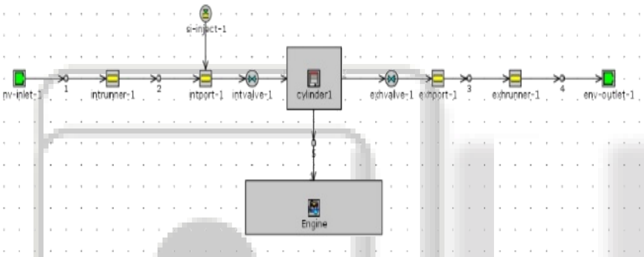

Fig. 2: Simulated model for single cylinder engine.

III. Performance Analysis

A. *Brake Thermal Efficiency*

Thermal efficiency of an engine is defined as the ratio of the output to that of the chemical energy input in the form of fuel supply it may be based on brake or indicated power. The brake thermal efficiency increases with the increase in the load. Here from graph 1, Brake efficiency is higher for engine speed 500, 1500, 3400 and 5000 with respect to 10, 14, 18 and 22, degrees Ignition advance angle respectively.

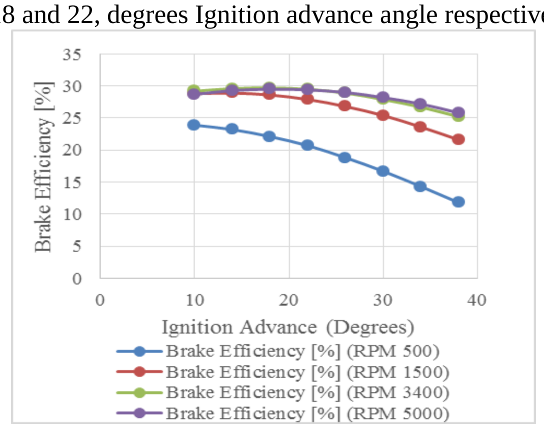

Fig. 3: Graph 1: Brake Efficiency Vs Ignition Advance

B. *Torque*

Variation of torque with ignition angle is similar to that of power. The variation of power generated and torque for different values of ignition angle is plotted. In graph 2, it is observed that torque increases with spark advance till a certain value, and maximum braking torque is achieved at spark advance of 10, 14, 18, and 22, degrees with respect to engine speed 500, 1500, 3400, and 5000 respectively. After this, with further increase in spark advance there is a decrease in the torque.

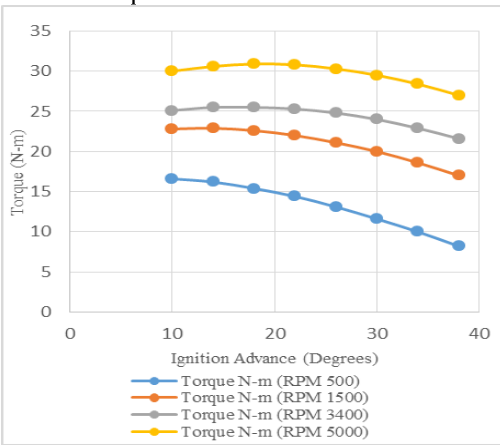

Fig. 4: Graph 2: Torque Vs Ignition Advance

C. *Brake Specific Fuel Consumption*

BSFC tend to improve with increase of ignition timing before top dead centre. It should be noted that when BMEP increase, BSFC follows inversely. There is an increase in power output till a certain extent. Also, since combustion process is advanced, the exhaust temperature decreases and loss of energy is reduced. Thus losses are reduced which gives more power for same amount fuel.

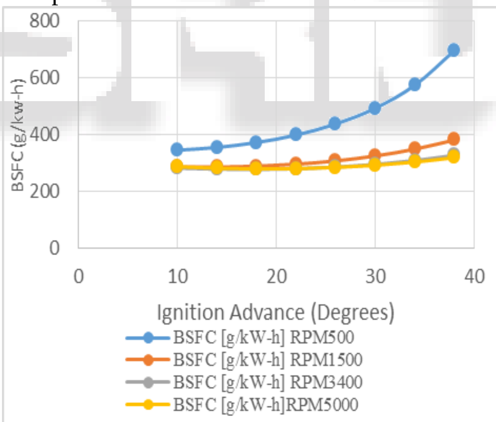

Fig. 5: Graph 3: BSFC Vs Ignition Advance

D. *Cylinder Pressure*

It is observed that maximum in-cylinder pressure increases with spark advance. When ignition is started at TDC, by the time maximum pressure is achieved by combustion process the piston has already crossed the TDC position and expansion process is started. Thus the maximum pressure that can be achieved is reduced .This reduces the mean effective pressure as a result of which the work done is decreased. With increase in spark advance, the duration between TDC and maximum combustion pressure is decreased and overall in-cylinder pressure increases.

E. *Brake Power*

For ideal engine, the maximum power will be generated when there will be instantaneous combustion at TDC. But since the combustion is progressive, maximum pressure is not achieved instantaneously, and thus, spark ignition angle is advanced to get maximum pressure. When ignition is started at TDC, expansion process is already started. Thus the work generated from expansion of that region is lost. Also, if ignition is started much before the TDC, the energy from combustion is utilized for opposing the compression movement of piston. From graph 4 it can be seen that the maximum power is produced when spark advance angle is 10, 14, and 18, 22 with respect to speed 500, 1500, 3400, and 5000 respectively.

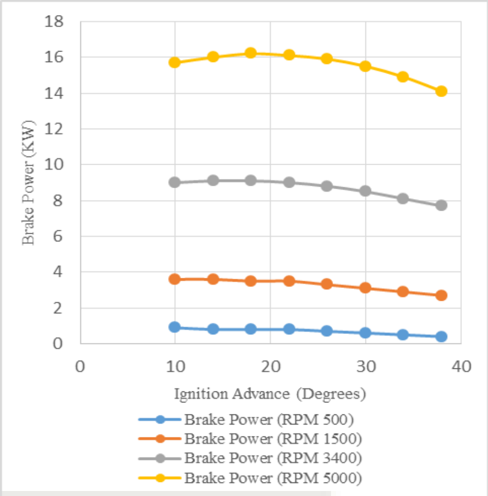

Fig. 6: Graph 4: Brake Power Vs Ignition Advance

IV. Conclusion

Increased fuel mileage, power, performance and reduction in emissions are just some of the benefits as the ignition timing can be advanced or retarded to prevent engine detonation. The aim of this paper was to study effects of ignition timing of a spark- ignition engine using variable spark timing (advancing) and speed on engine performance by GT-Power software. From all the reading and its respective graph we conclude that for better performance of engine Ignition advance BTDC 10, 14, 18, 22, is suitable for engine speed 500, 1500, 3400, 5000 RPM respectively for single cylinder 4- stroke engine. From the results, it can be concluded that the ignition angle can be a parameter to control the performance of the engine with relation to engine speed. Also selection of an ignition angle is based on optimum performance. It could be seen that high ignition advance gives maximum pressure in cylinder.

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