Study of Impact of Spark Timing and Compression Ratio on Performance of SI Engine

Indira Priyadarsini, M. V. S. Murali Krishna, E. Nirmala Devi

***Abstract:** The improvement of performance characteristics of gasoline engine study is needed as automobile series of development has been changing rapidly. This 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 compression ratio 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 ST of 20^0 to 30^0 BTDC and CR of 3.5 to 9. The results have shown that performance parameters: brake thermal efficiency and volumetric efficiency increased for advanced timing. Specific fuel consumption and exhaust gas temperature decreased with earlier timing before top dead centre. The peak pressure increases with increasing spark advance. The increased compression ratio results increased BTE and EGT increased and then decreased. BSFC decreased with increased compression ratio. The engine for tests used was variable compression ratio engine with adjustable dome head with wheel. The setup is running at constant speed of 3000rpm with water cooling system. The purpose of spark advance mechanism is to assure that under every condition of engine operation, ignition takes place at the most favourable instant in time. Increasing the compression ratio below detonating values to improve on the performance is another choice of variable.*

***Index Terms:** Compression Ratio, Four Stroke, Performance, Spark Timing.*

I. INTRODUCTION

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. 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, load, temperatures and conditions.

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There exists a particular spark timing which gives maximum engine torque at fixed speed, and mixture composition and flow rate [1]. 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 [2]. 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 [3]. The performance and emissions of the engine with 8 compression ratio was evaluated at 22^0,27^0,32^0 ignition advances of BTDC. The AVL Digas 444 type emission analyzer uses for CO, HC, CO2 and NOx for emission measurement [4]. Syed Yousufuddin *et.al* carried out tests with the spark timing adjusted to the maximum brake torque timing in various equivalence ratios and engine speeds for gasoline and natural gas operations. the natural gas operation causes an increase of about 6.2% brake special fuel consumption, 22% water temperature difference between outlet and inlet engine, 3% exhaust valve seat temperature, 2.3% brake thermal efficiency and a decrease of around 20.1% maximum brake torque, 6.8% exhaust gas temperature and 19% lubricating oil temperature when compared to gasoline operation [5]. Ioannis Gravalos *et.al* [6] studied the effect of using alternative fuels in spark ignition engine and evaluated performance characteristics. Liu Shenghua studied methanol blended engine performance. A 3-cylinder port fuel injection engine was adopted to study engine power, torque, fuel economy, emissions including regulated and non-regulated pollutants and cold start performance with the fuel of low fraction methanol in gasoline. Without any retrofit of the engine, experiments show that the engine power and torque will decrease with the increase fraction of methanol in the fuel blends under wide open throttle (WOT) conditions [7]. Jovan Ž is proposed unconventional piston movement which makes engine easy to provide variable compression ratio, variable displacement and combustion during constant volume [8]. The addition of methanol increases the octane rating of fuel; hence it enables the gasoline engine to operate at higher compression ratios. Blending alternative fuels with gasoline have significance effect on performance [9].

A high compression ratio is desirable because it allows an engine to extract more mechanical energy from a given mass of air-fuel mixture due to its higher thermal efficiency. The higher efficiency is created because higher compression ratios permit the same combustion temperature to be reached with less fuel, while giving a longer expansion cycle, creating more mechanical power output and lowering the exhaust temperature. Higher compression ratios will however make gasoline engines subject to engine knocking.

II. METHODOLOGY

The schematic diagram of experimental set–up used for investigations is shown in Fig.1. It is a four – stroke, single cylinder, variable compression ratio (3:1 to 8:1), water cooled SI engine (brake power 2.5 kW with constant speed of 3000rpm). The setup consists engine connected to eddy current type dynamometer for measuring its torque, load control and brake power. Dynamometer has been loaded by a rheostat. The air consumption box type flow meter unit is been used to measure the air flow of the engine in addition to the instrumentation for measuring the engine performance. Compression ratio of engine is varied with changing the clearance volume by adjustment of cylinder head. It is provided with necessary equipment and instruments for combustion pressure and crank angle measurements. These signals are interfaced with computer through engine indicator for pθ, PV plots and engine indicated power, Provision is also made for interfacing air flow, fuel flow, temperatures and load measurements with computer. The setup enables study of petrol engine for indicated power, brake power, thermal efficiency, volumetric efficiency, fuel consumption, air fuel ratio, heat balance etc. and to obtain the pθ diagram, PV plot and performance curves at various operating points. There are many factors that influence proper ignition timing for a given engine. These include the timing of the intake valve(s) or fuel injector(s), the type of ignition system used, the type and condition of the spark plugs, the contents and impurities of the fuel, fuel temperature and pressure, engine speed and load, air and engine temperature, turbo boost pressure or intake air pressure, the components used in the ignition system, and the settings of the ignition system components. Usually, any major engine changes or upgrades will require a change to the ignition timing settings of the engine.

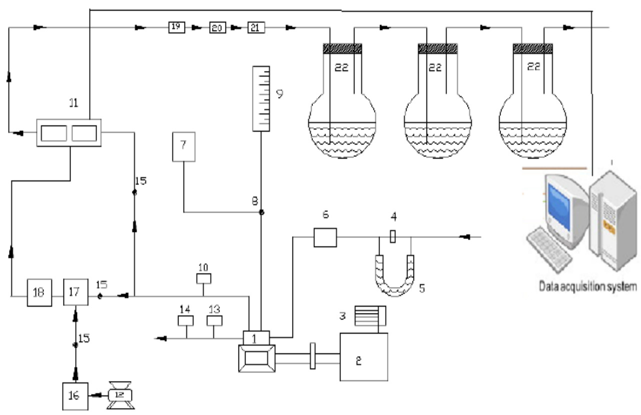

Fig. 1 Schematic Diagram of experimental set–up for four–stroke SI engine

1.Engine, 2.Eddy current dynamometer, 3. Loading arrangement, 4. Orifice meter, 5. U-tube water monometer, 6. Air box, 7. Fuel tank, 8. Three-way valve, 9. Burette,10. Exhaust gas temperature indicator, 11 CO analyzer, 12. Air compressor, 13. Outlet jacket water temperature indicator, 14. Outlet jacket water flow meter,15. Directional valve, 16. Rotometer, 17. Air chamber and 18. Catalyst chamber 19. Filter, 20. Rotometer, 21. Heater, 22. Round bottom flasks containing DNPH solution

Table 1. Specifications of engine used for Experiment

Engine Specifications	
Bore	70 mm
Stroke	66.7 mm
Rated output	2.5 kW
Speed	3000 rpm
Spark ignition timing	25 º BTDC
Compression ratio	3:1 to 9:1
Specific fuel consumption	475 gm/ kW h
Lubricating oil	SAE-40
Make	Greaves Limited

Fig. 2 Photographic View of Experiment

III. RESULTS AND DISCUSSIONS

The performance parameters with different ignition timings(25^0,26^0,27^0,28^0,29^0) BTDC for Conventional engine with pure gasoline operating at compression ratio of 3 to 9:1 and speed 3000 rpm is evaluated.

3.1 Performance Analysis

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.. Fig.3 The brake thermal efficiency increases with increasing spark timing between 25^0 to 29^0 BTDC.Better optimum thermal efficiency for petrol engine is obtained higher at compression ratio of 8:1 and spark timing 28^0 BTDC is a result of complete combustion due to proper air-fuel mixing,

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higher calorific value and thus it shows least brake specific fuel consumption. Lower calorific value of gasoline need higher fuel supply for producing same power at given 3000 rpm.

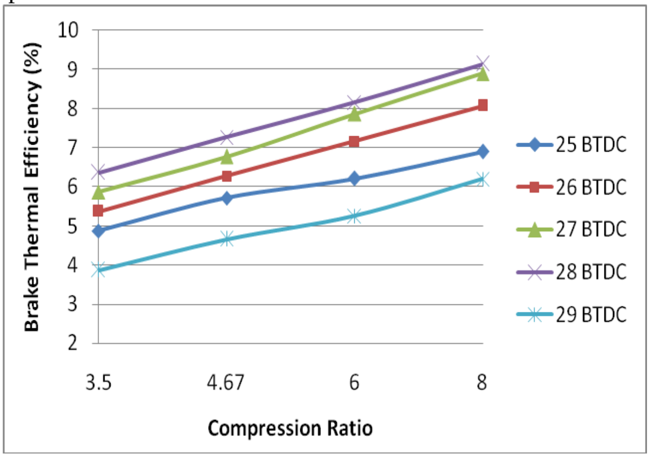

Fig. 3 Compression ratio Vs Brake thermal efficiency

Volumetric efficiency: Fig. 4 shows the effect of ignition timing on the volumetric efficiency. It can be noticed that advancing the spark timing increases the volumetric efficiency and the engine has a higher volumetric efficiency as compared to the variable compression ratio.

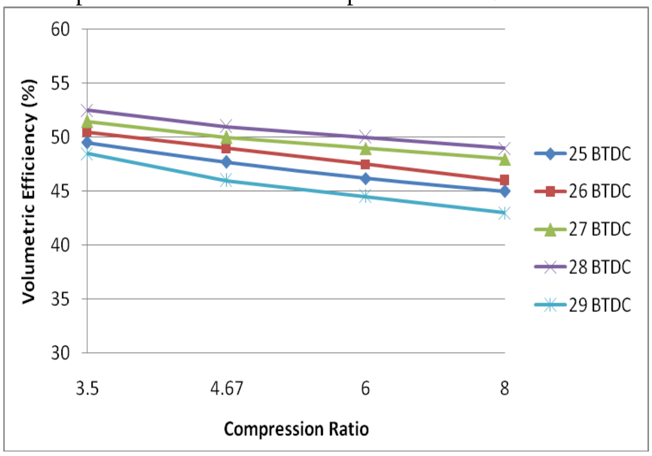

Fig. 4 compression ratio Vs volumetric efficiency

Exhaust gas temperature: Advancing the ignition timing decreases the exhaust temperature and increases the ignition timing the partial oxidation during compression stroke, whereas when the ignition timing is retarded then there is decrease in pressure and temperature peaks during combustion process as there is less time between ignition timing and TDC to complete chemical reaction, so large amount of fuel gets burn after TDC in expansion stroke which is known as post reaction. Post reaction mainly occurs between carbon monoxide and hydrocarbons in the exhaust system, therefore retarding the ignition timing is always associated with incomplete combustion and an increase in the exhaust temperature. Fig.5 shows the effect of ignition timing on exhaust gas temperature for conventional engine with pure gasoline it shows advancing the ignition timing reduces the exhaust gas temperature. The exhaust temperature decreases with increasing spark timing between 25^0 to 29^0 BTDC. The same trend of behavior is observed with the increasing compression ratio and the values for EGT increases with the increase in compression ratio. The exhaust temperature is also affected by spark timing. Retarding timing from MBT increases exhaust temperature; [1] both engine efficiency and heat loss to the combustion chamber walls are decreased. Retarded timing is sometimes used to reduce hydrocarbon emissions by increasing the fraction oxidized during expansion and exhaust due to the higher burned gas temperatures that result .Retarded timing may be used at engine idle to bring the ignition point closer to TC where conditions for avoiding misfire are more favorable.

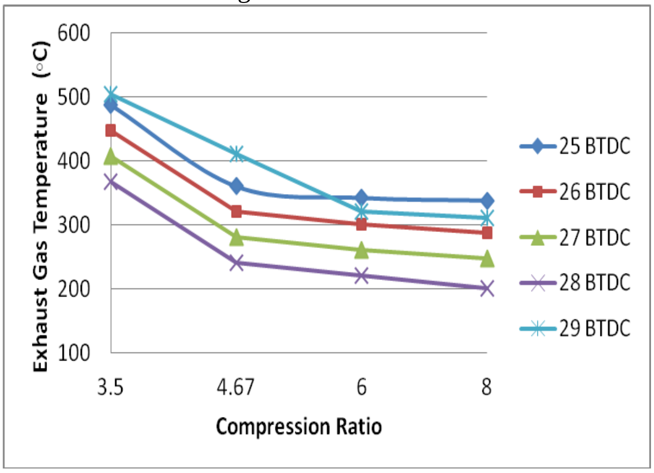

Fig. 5 Compression ratio Vs Exhaust gas temperature

IV. CONCLUSION

Increased fuel mileage, performance and reduction in emissions are just some of the benefits as the ignition timing can be advanced or retarded to prevent engine detonation. It is easy and accurate timing adjustments up to 15° results in better performances. The aim of this paper was effects of ignition timing of a spark- ignition engine using variable spark timing (advancing) and compression ratio at constant speed on engine performance by experimental. As for advanced ignition timing because of the compression affect that works against the expansion of the burning charge; hence more heat energy develops, and because the burn takes place in a smaller more confined effective area we will get higher pressures and therefore higher temperatures. It would results more heat rejection to the combustion chamber, valve faces, and cylinder walls with advanced timing. Higher compression ratios will however make gasoline engines subject to engine knocking if lower octane-rated fuel is used, also known as detonation. The overall results show that ignition timing can be used as an alternative way for predicting the performance of internal combustion engines. In this paper, the best results were obtained at 28°BTDC for compression ratio of 8:1 at 3000RPM.

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