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PERFORMANCE OF FOUR STROKE DIESEL ENGINE, FOCUSING COMBUSTION MODELING AND CYCLE ANALYSIS

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ABSTRACT

In the world, now a day use of various transportation vehicles are drastically increase and also increase the consumption of crude oil so it is very important to improve the fuel consumption and emission in particular area of automobile. Now in the recent Era the diesel engine is most preferable for a transportation system. And the diesel as a fuel is better than another fuel so diesel is more used as a fuel. So it's a challenge for researcher to reduce fuel consumption and increase break power and reduce the exhaust emission. If experimentally investigate the data, it is very laborious, time consuming and expensive. Also cannot detail micro level research study of the engine. For achieving and full fill above concept it is very important to do the combustion modeling and IC engine cycle analysis to detail micro level research study of the combustion process. Here, effort has been made for combustion modeling and simulation of two cylinder four stroke diesel engines and finds the pressure–volume diagram and other relevant combustion diagram with equations and find the various better results for improving the combustion efficiency and brake power in twin cylinder diesel engine. In present study also investigate experimentally performance parameters of diesel cycle with the use of data logger. With the help of data logger it is found that most of the efficiency, brake power, specific fuel consumption, and pressure–volume diagram of each load at each crank angle of diesel cycle. So it is found that from the above study of combustion of diesel engine that modeling is more important for the prediction of combustion behavior characteristic and for the better performance of engine.

I. THEORY OF MODELING

The modeling of I.C engines is a multi-disciplinary subject that involves chemical thermodynamics, fluid mechanics, Turbulence, heat transfer, combustion & numerical methods. I.C engine is a main power plant of transportation systems and are responsible for a substantial fraction of fuel consumption. The scarcity of oil resources and the ever-increasing standards on air pollution & emissions have decide to need for improved, more efficient and less pollution I.C engine. Improvement on engine design has been achieved by traditional method based on extensive experience. The advent of computers & possibility of performing "numerical" experiment may provide a new way of designing I.C engine. In fact, stronger interaction between engine modelers, designers & experimenters may results in improved engine design in the not too-distance future. In model, engine behavior is described with a mathematical model. The optimization does not occur in the real engine but rather is a model, which takes into account all effects relevant for the concrete table of optimization. [1] According to J.B.Heywood engine combustion modeling is a physically based description of the engine combustion process which predicts the mass burning rate and flame geometry as function of engine design & operating variable. The modeling of engine processes continues to develop as our basic understanding of the physics and chemistry of the phenomena of interest steadying expands and as the capability of computers to solve complex equations continues to increase. Modeling activities can make major contributions to engine engineering at different levels of generality or detail, corresponding to different stages of model development.

The aims of modeling I.C engine processes are:

(1) To predict engine performance without having to conduct tests.

(2) To deduce the performance parameters that can be difficult to measure in tests.[2,3]

It is obviously an advantage if engine performance can be predicated without going to the trouble of first building an engine then incrementing it, testing it and finally analyzing the results. Modeling should lead to saving of both time and money. The models have been classified as zero-dimensional, single-zone to multi-zone and multi-dimensional models. Zero-dimensional and multi-dimensional models have been called as phenomenological or thermodynamic and detailed models; respectively. Multi-dimensional models are based on the numerical solution of a set of governing coupled partial-differential equations, which are integrated in fine (2 or 3 dimensional) geometric grids in the combustion chamber space. Although these models are capable of providing detailed information about both spatial and temporal resolution of the quantities of interest, they require large amounts of computer time and storage capacity. Thus, if it is desired to examine the effects of all parameters on combustion and pollutant emissions more practical methods such as thermodynamic models could be used. Thermodynamic models are based upon a combination of fundamental theory, similarity considerations, direct and indirect experimental data correlations based on various sources. They are widely used to compute whole engine cycles, engine parameters and exhaust emissions, because of their quicker and cheaper application abilities, for generating the information required to support engine design and development studies. The thermodynamic models may be subdivided into two groups such as zero-dimensional single-zone (ZDSZ) and quasi-dimensional multi-zone models (QDMZ).[4,5]

In ZDSZ models, combustion process is modeled simply by assuming it as an empirical heat addition process. Using these models, engine cycles, engine performance parameters and emissions of exhaust gases can be calculated easily and various useful results can be obtained. The QDMZ models are formulated by employing simplified quasi steady equations describing the individual processes that occur in the engine cylinder such as fuel injection, fuel atomization, air entertainment, fuel-air mixing, combustion and heat transfer. In these models, charge in the cylinder is divided into several zones during various processes, especially for combustion process. [6,7]

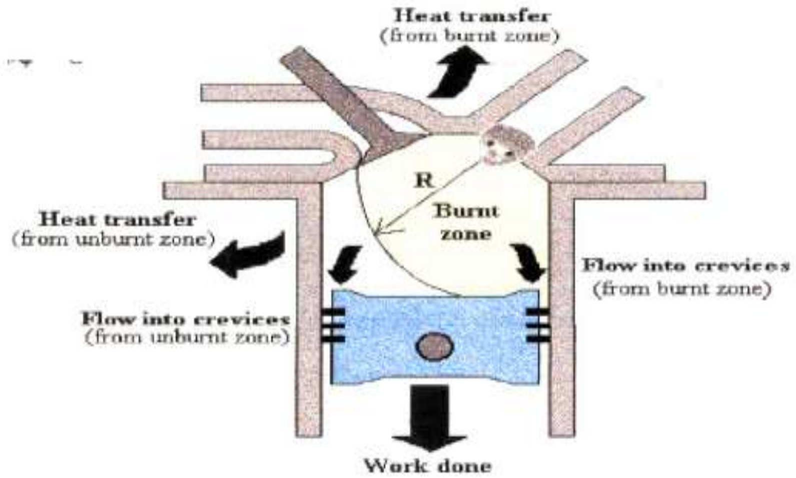

Fig: 1 Two Zone Quasi One Dimensional Thermodynamic Model

Other type is Linguistic model &Mathematical model. In linguistic model rule-based method built upon empirically grounded rules, which can't be grasped by mathematical eq^{n}s. In mathematical model which is resting on mathematical formulism also parametric models & Non-parametric models. Parametric models are represented by compact mathematical formulism for the description of system behavior which rest upon physical & chemical laws & show only relatively few parameters that are to be experimentally determined. These models are typically described by means of a set of partial or normal differential equations and non-parametric models are represented by tables that record the system behavior at specific test input signals with the help of suitable mathematical method, e.g. Fourier transformation the behavior of the system can be calculated at only input signal.[8,9]

The system of ordinary differential equations that is obtained from the first law of thermodynamics and the other basic thermodynamic relations are solved for pressure, temperature and mass in the zones. Although these models are not very detailed, they are used widely as routine simulation exercises and extensive parametric studies of engine operating and emission characteristics. In QDMZ models, the engine cycle and engine characteristics have been computed generally from compression stroke to expansion stoke and indicated engine characteristics have been given from the cycle calculation. In the some research paper two zone quasi one dimensional model is proposed for modeling of combustion process of an I.C. engine as it is readily incorporated complete engine models, is useful for parametric studies associated with engine and tries to predict burn rate information. In two zones quasi one dimensional model, turbulence is eliminated which makes method simple and adaptable from the point of view of programming. The prediction of performance with the help of this model is very much nearer to the actual and available data. [10,11, 12]

II. EXPERIMENTAL PROCEDURE

The experimental was carried out on twin cylinder four stroke vertical water cooled diesel engine made by kirloskar oil engine ltd (TV2/DM 17/DM20 TYPE) with a bore 87.5 mm and stroke 110 mm. the engine is rated for 10.3 (14 hp) and 1800 rpm with a centrifugal governor to control the speed . The engine was connected with an electric dynamometer is used to measure the power output. The engine is instrumented to measure the parameter like fuel consumption, load speed of engine, cooling water temperature, inlet air and exhaust gas temperature. The engine test carried out with constant speed of 1800 rpm and load vary with no load to the maximum load condition. At each operating points variations measured were taken for engine.[13,14]

Table 1: Engine Specification

Engine type : Multi cylinder vertical water cooled self-governed constant speed diesel engine	
Injection pressure = 200bar	I.V.O = 4.5° BTDC
Piston diameter = 87.5 mm	I.V.C = 35.5° ABDC
Compression ratio = 17.5:1	E.V.O = 35.5° BBDC
Power = 10.3 kw = 14 HP	E.V.C = 4.5° ATDC
Lubrication oil = 20w/40.	Injection timing = 26° BTDC
Lubrication oil required = 7 litrs	A/F ratio = 14.89 : 1

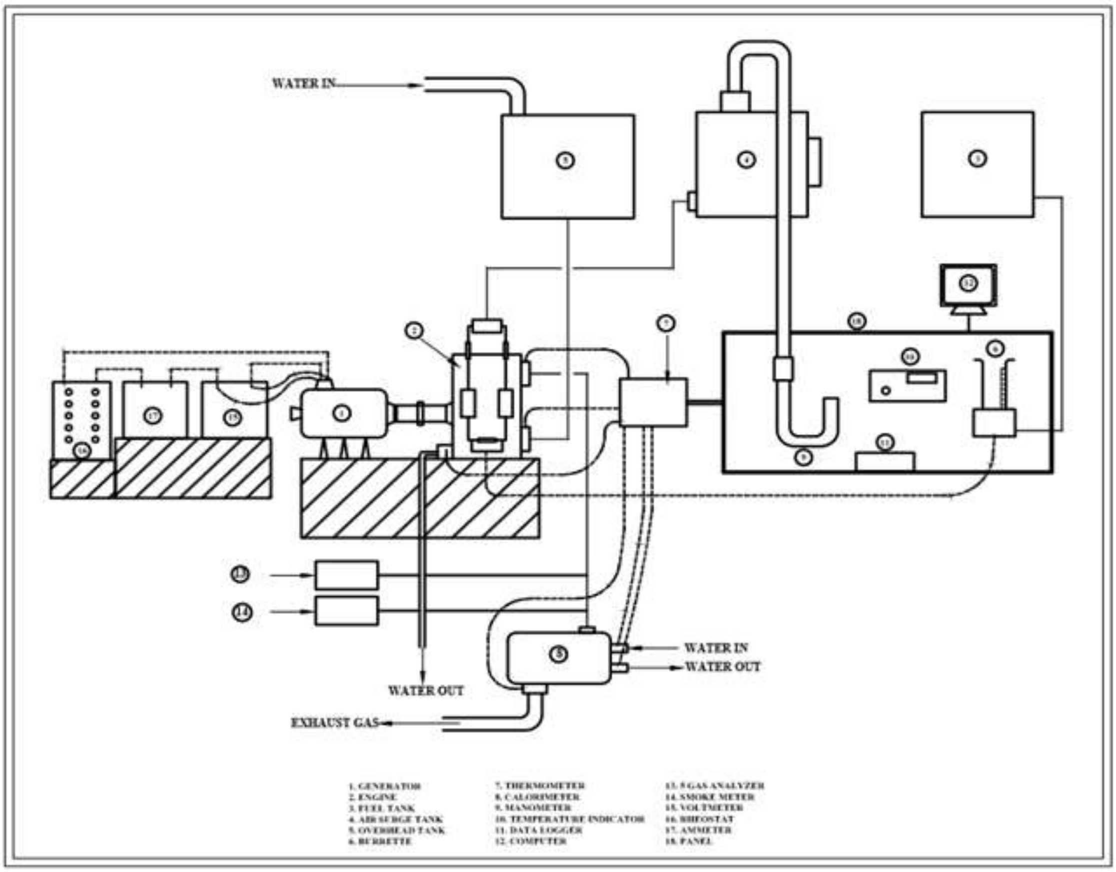

Fig 2: The Block Diagram of Experimental Set-Up

III. RESULT AND DISCUSSION

3.1 Brake Power Vs Volumetric Efficiency

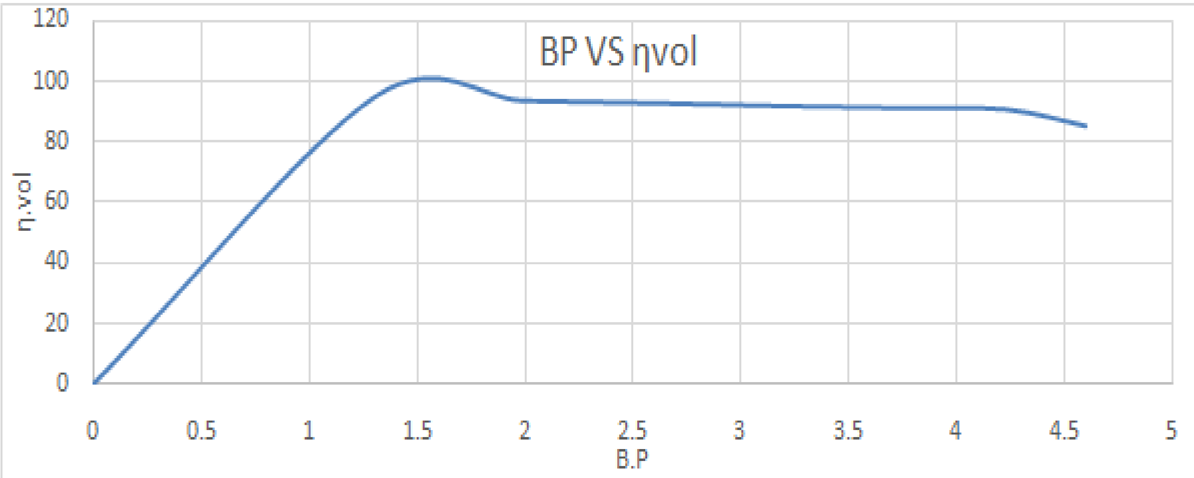

Fig 3: Comparisons of Brake Power (BP) V/S Volumetric Efficiency

It can observe from the above graph; when the brake power is increase volumetric efficiency is increase after it reached at rated power 4.2kw the volumetric efficiency is decrease so at rated power the volumetric efficiency is 90.55 %. At higher operating load the combustion temperature is very higher and engine speed is also very high so less charge of air is admitted in the combustion chamber so after rated power volumetric efficiency is decrease.

3.2 Brake Power Vs Mechanical Efficiency

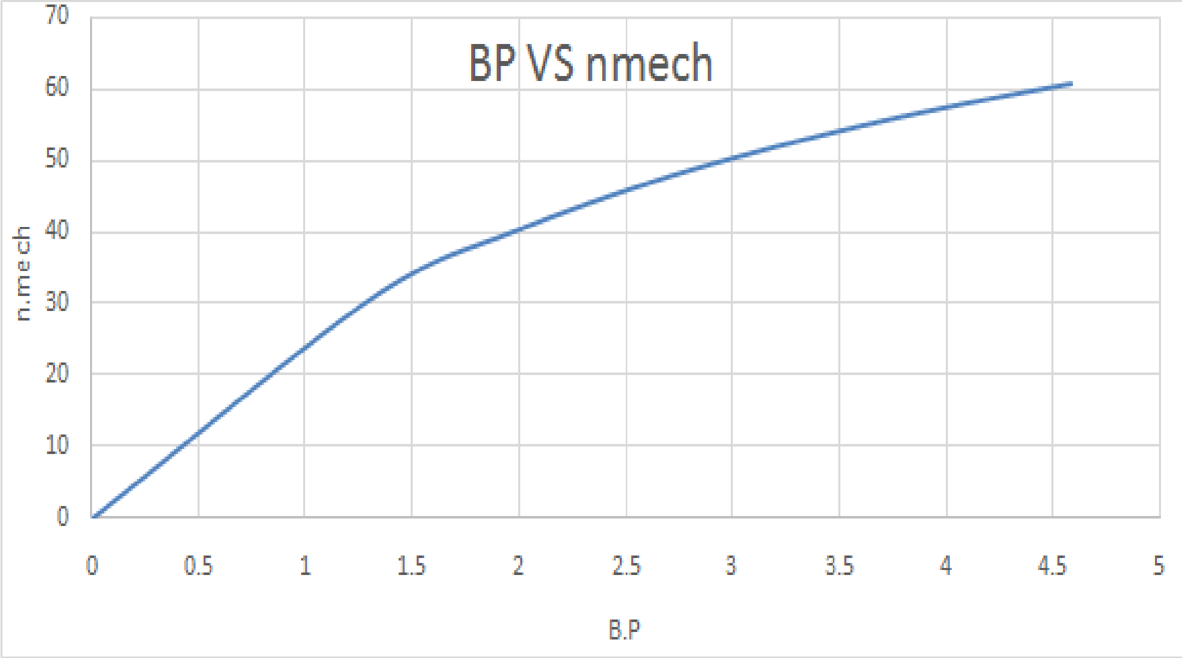

Fig 4: Comparisons Of Brake Power (BP) V/S Mechanical Efficiency

It can found from the above graph; when the brake power is increase mechanical efficiency is increase after it reached at rated power 4.2kw the mechanical efficiency is 58.85 %. At higher operating temperature the lubricant oil temperature also it is high so that viscosity will decrease and friction will also decease.

3.3 Brake Power Vs Brake Thermal Efficiency

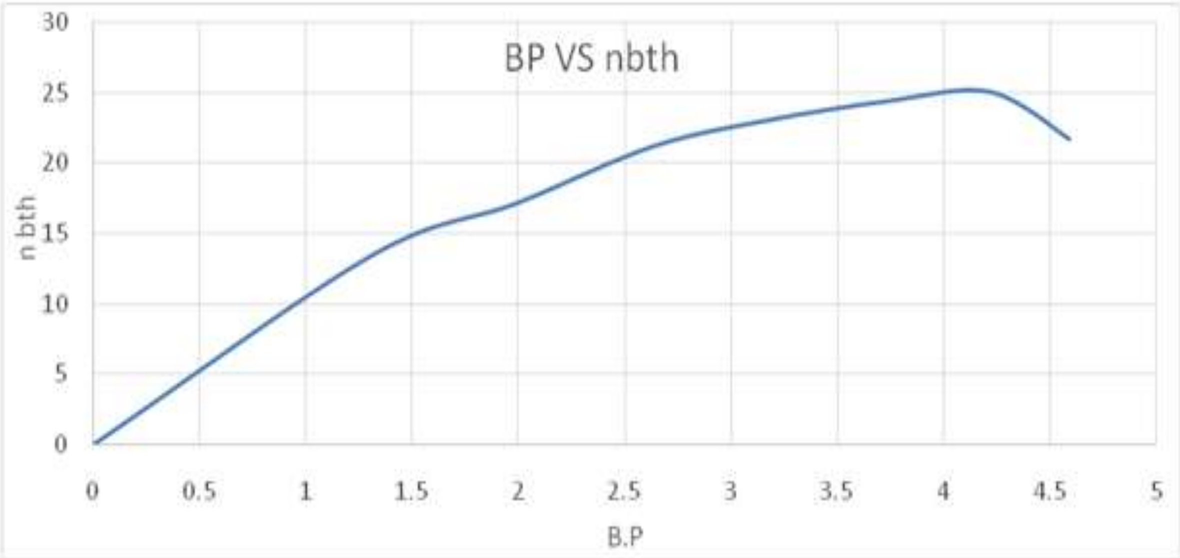

Fig 5: Comparisons Of Brake Power (BP) V/S Brake Thermal Efficiency

It can found from the above graph; when the brake power is increase brake thermal efficiency is increase after it reached at rated power 4.2kw the brake thermal efficiency is 25.08 %. At higher load condition the mixture can lean so the brake thermal efficiency is increase due to lower S.F.C , when at overload condition the mixture become a very rich and incomplete combustion will take place so the efficiency decrease.

3.3 Brake Power Vs Specific Fuel Consumption

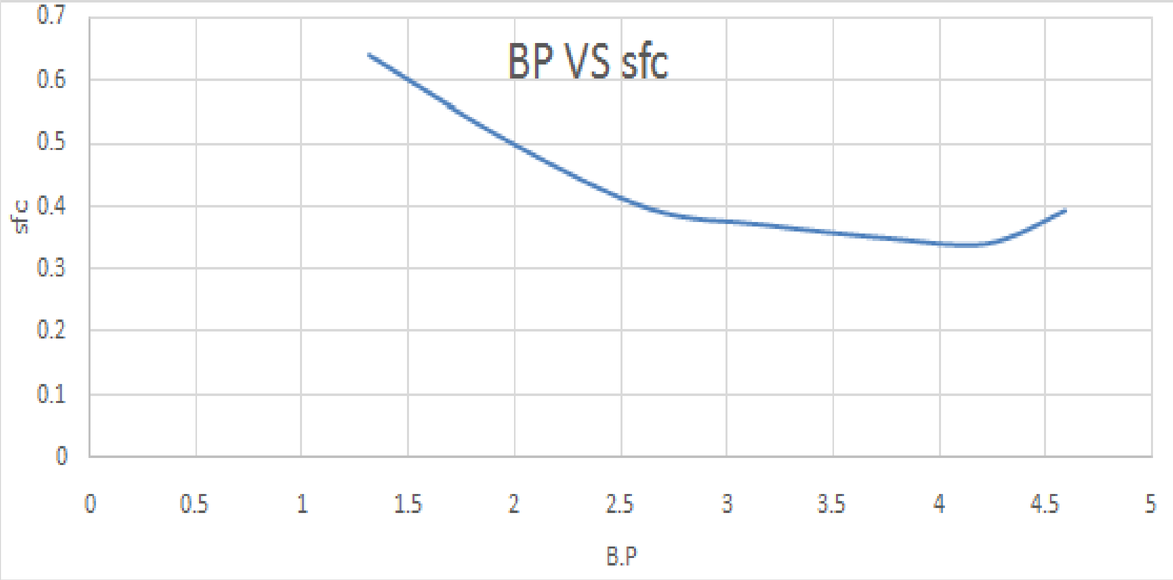

Fig 6: Comparisons of Brake Power Vs Specific Fuel Consumption

It can found from the above graph; when the brake power is increase specific fuel consumption is decrease after it reached at rated power 4.2kw, specific fuel consumption the is 0.344kg/kwhr . After rated power the SFC is now increase. At rated power optimum use of air and fuel so best SFC found among all load condition.

3.4. Heat Balance Sheet at Rated Power

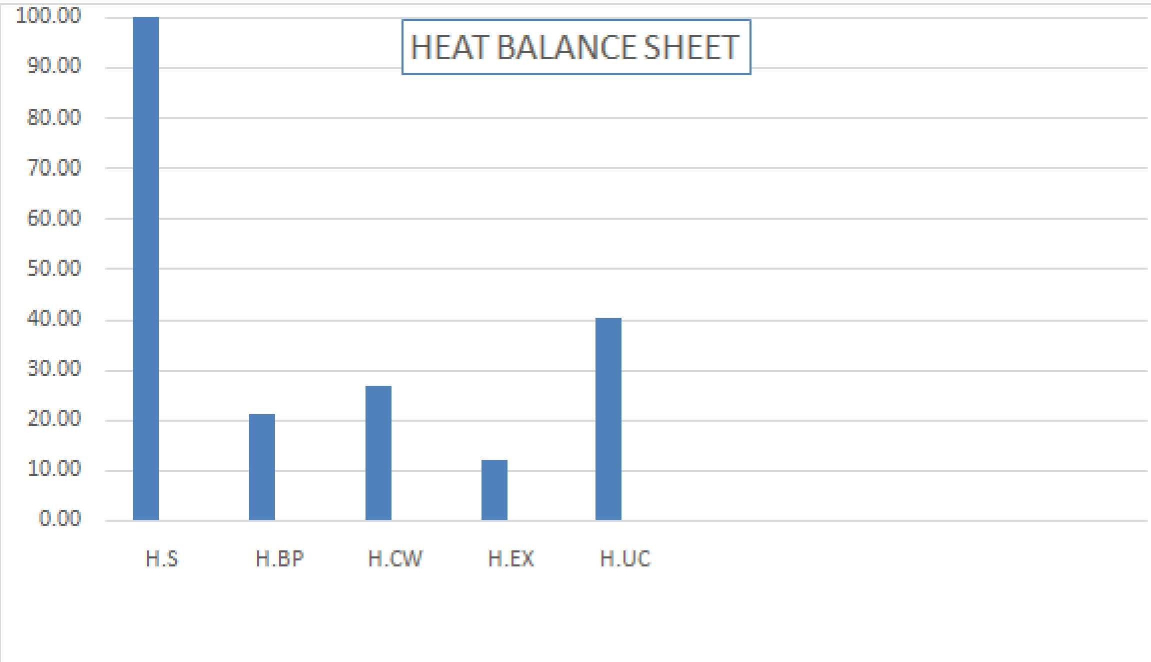

Fig 7: HEAT BALANCE SHEET AT RATED POWER

From the above figure it is found that at rated power 4.2 kw. When100 % heat supply by fuel. 21.02 % Equivalent heat use brake power, 26.78 % heat carried as a loss by jacket cooling water, 12 % heat carried as a loss through exhaust gases. , 40.17 % heat lost by radiation and unaccountable losses.

3.4 Combustion Graph from Data Logger

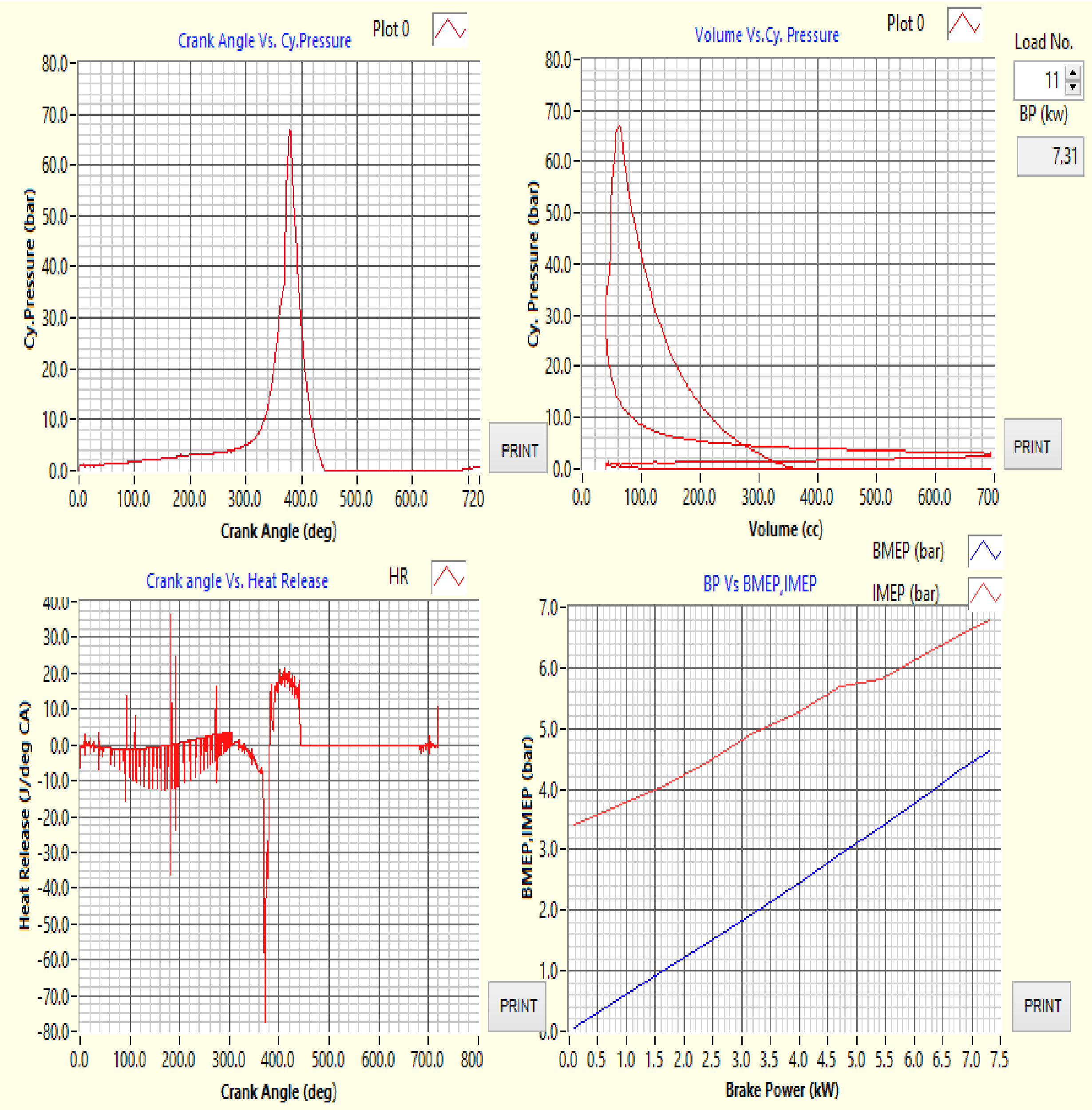

Fig 8: Combustion Graph from Data Logger

From the above combustion figures it can found that of the combustion process at each crank angle and find the pressure and volume at each crank angle and each load which was shows that combustion characteristics useful which will give the clue of improving combustion efficiency. The heat release is increase at combustion period at T.D.C. level of the piston and decrease at expansion at B.D.C condition of the piston. Also the brake mean effective pressure and indicated mean effective pressure is increase gradually with respect to brake power. These graphs are generated with the use of data logger.

3.5 Combustion Graph from Modeling

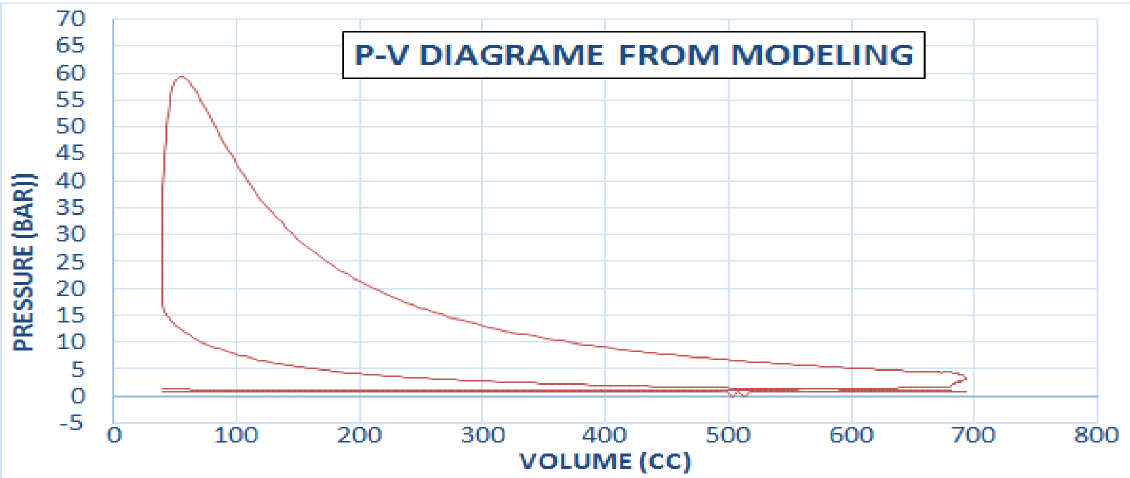

Fig 9: Pressure Vs Volume Graph from Modeling

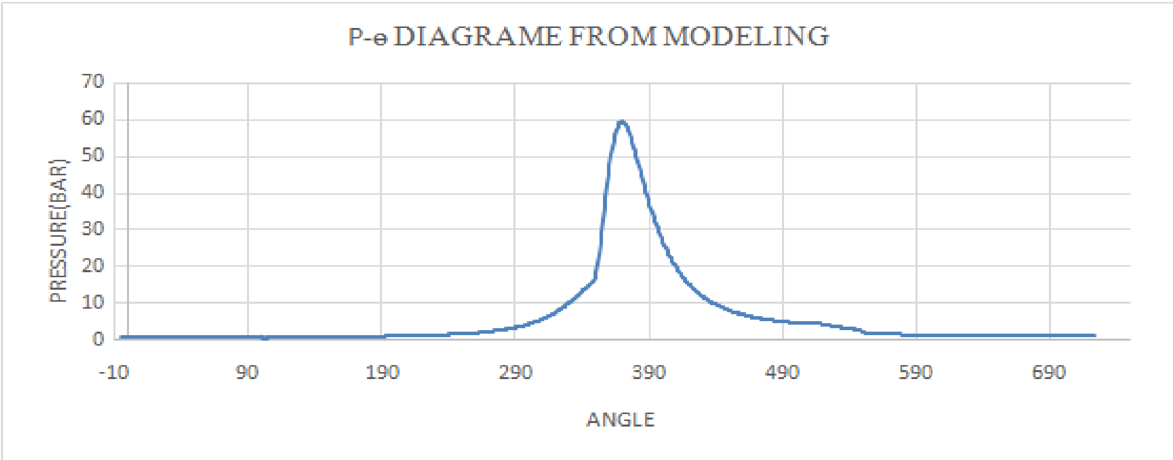

Fig 10: Pressure Vs Angle Graph from Modeling

These Figures are made by mat lab programming with the use of modeling equations and theory. From these graphs can find pressure and volume from the cycle analysis at each crank angle and can predict the performance of engine combustion from this graph without using experimental work and time consuming, laborious work during experiment.

IV. CONCLUSION

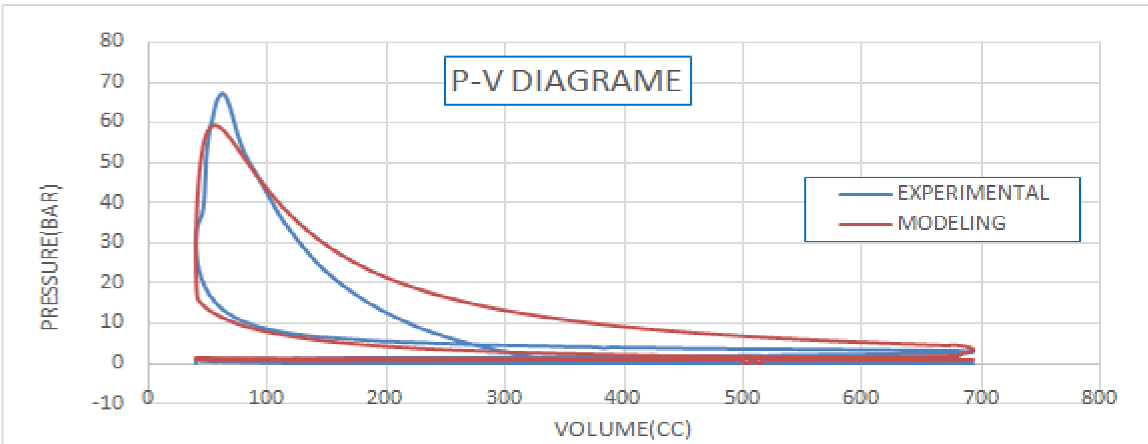

Fig 11: Comparison of Pressure Vs Volume Graph

With the use of data logger find the pressure-volume diagramed at each crank angle and this pressure-volume diagramed is compared with p-v diagramed of modeling shown in figure. From the above validation graph we found the variation in p-v diagramed .experimentally p-v diagram work done is less than the modeling p-v diagram this will be happened due to valve opening and closing in certain time. Also exact valve at TDC and BDC will not be open and close suddenly with zero time variation. The work done is improved by applying optimum advance angle & optimum compression ration required. Also we used some design change in combustion chamber area and design to increase the work done of the engine. From the experiment get the values of efficiency and SFC and heat balance sheet at the rated power of the engine. The volumetric efficiency is 90.55 %, the brake thermal efficiency is 25.08%, the mechanical efficiency is 58.85 %, and SFC is 0.344 kg /kwhr. Also getting the available brake power is 21.03 % and other energy is going in terms of losses.

V. SUGGESTIONS FOR FUTURE SCOPE OF WORK

Make mathematical model universal which is useful for different fuel (CNG, LPG, BIOGAS, BIOMASS, and BIODIESEL) and compare this mathematical model with experimental data. Apply different Batter TBC material on piston, piston head, and piston valve& liner and investigate emission & performance of engine. Make mathematical model of exhaust emission and investigate the exhaust pollution and find how to control the exhaust pollution. Use multidimensional and 3-dimensional mathematical modeling for the combustion chamber analysis. Also investigate vibration and noise condition at different system of the engine and found that what are the effect occur of different component of engine.

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