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Optimization of Four Stroke c.i. Engine Performance by using Statistical Techniques (Mathematical Method)

P.Vignesh, P.Madan, D.Mohankumar, Naveenchandran.P

Abstract-The concern for a clean environment, high oil prices and strict emission standards in research was the driving force behind the internal combustion engine. Popular direct injection engine nutrition with its compact size, low fuel consumption and low emission level. Here is the mathematically using the various statistical methods.

Keywords-IC Engine, Mathematical modeling, Wiebe function, Miyamoto model

***Index Terms**: About four key words or phrases in alphabetical order, separated by commas.*

1. INTRODUCTION

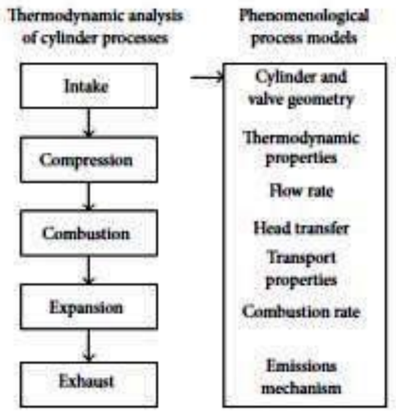
Engine performance prediction and optimization is widely used in automotive industry to minimize design iterations to reduce the product development cycle. Various mathematical simulation tools zero dimensional, one dimensional [5-8], three dimensional are utilized in the initial development stages of an engine to optimize the design parameters. Based on this preliminary design inputs the engine hardware is made and tested and tuned to get the targeted results. Mathematical modeling and simulation has dramatically reduced the product development cost and time. Simulation tools are also combined with other simulation software's called co-simulation to optimize the final vehicle target[1-4]. (HIL, SIL)

MATHEMATICAL MODELLING

1.1 MODEL STEUP [1], [8], [12]

Mechanical model is constructed by defining entries. The default input contains mechanical and boundary conditions. Therefore, all dimensions of intake and exclusion channels are measured and added. Similarly[9-11], the indices of internal mechanical geometries, the hole, the strokes, the long wire extension, the offset piston pin and the compression ratio are attached to the simulation model. The initial conditions, such as upper temperatures and wall temperatures, were set for the default values provided in the software. Since then, our systems have no tools to measure them. Since actual mechanical measurements are available, they can be replaced with more accuracy.

By using gas law, pressure and temperature and mechanical engineering, the number of cylinders on each crack angle can be determined from the beginning of the compression from the beginning of the injecting of the fuel.



Structure of thermodynamic based simulation of ICE operating cycle.

Fig: 1 – Thermodynamic Flowchart of ICE

Models, performance and emissions analysis of these blocks are reasonable, with brief explanations. Performance is generally more effective at controlling flow in the combustion zone. Fast combustion engines provide higher turbulence levels. In terms of more turbulent conditions, the reliability of events, but the thermal efficiency is determined by the heat transfer rate. These models include subsamples to predict some of these trade-offs[12-16].

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* Correspondence Author

Mr.P.Vignesh*, Assistant Professor, Mechanical Department, Indira Institute of Engineering and Technology, Pandur, Thiruvallur, Tamil Nadu, India.

Mr.P.Madan, PG Scholar, Mechanical Department, Bharath Institute of Higher Education and Research, Tambaram, Chennai, Tamil Nadu, India.

Mr.D.Mohan Kumar, Assistant Professor Automobile Department, Bharath Institute of Higher Education and Research, Tambaram, Chennai, Tamil Nadu, India.

Dr.NaveenChandran, Professor & Head of Department, Automobile Department, Bharath Institute of Higher Education and Research, Tambaram, Chennai, Tamil Nadu, India.

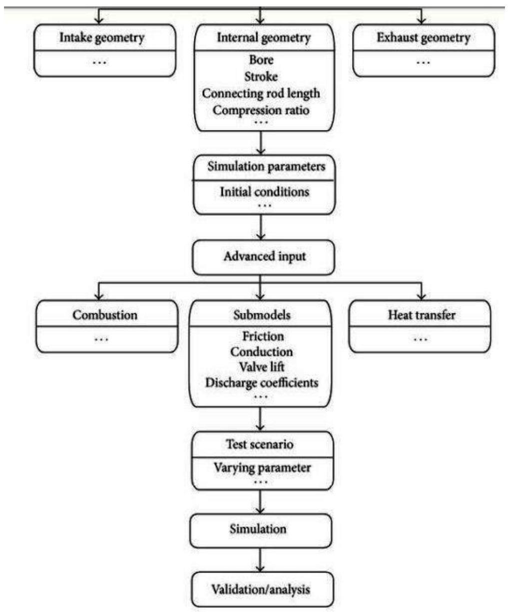

Fig: 2 Flowchart of Engine Development Process

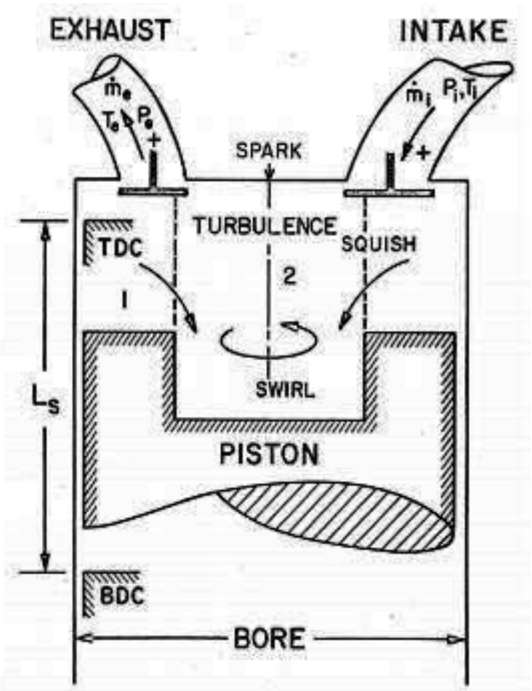

Fig: 3 Combustion Chamber Parameter

Sophisticated thermal driven models of performance are achieved including these submodels. Such models can customize and customize the direction of many major designs. Different designs are applied to the bone exhausting quality, it is believed that some treatments should include useful for realistic models of treatment[22-28].

1.2 HEAT TRANSFER [8]

In-cylinder heat transfer model has been developed for more than 20 years and as a result its focus is very low.

Heat transfer takes place between a cylinder and a thin layer of solid wall gas. This level of heat boundary layer, which shows a major change with the most significant gradient of gas temperature wall. Formally, heat transfer gradients and gases are given by thermal conductivity. However, because the gradient shift to outer boundary level. Depending on the features, it is affected by the transmission speed through the weak flow. The presence of the wall has a profound effect on the distribution of gases, because the average velocity and turmoil will disappear between the walls. Therefore[17-21], heat transfer heat at any place is a function of the boundary layer and the boundary layer of the moment.

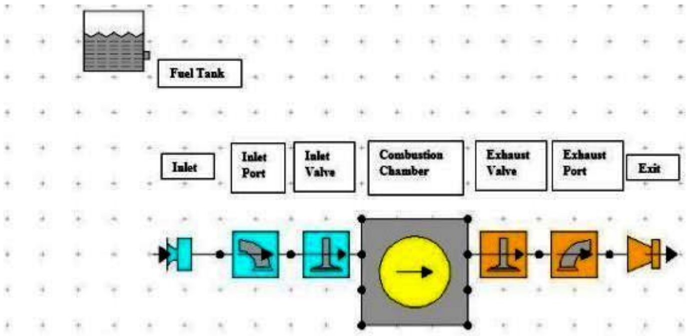

Fig: 4 – One Dimensional model of C.I. Engine

The figure 4, below shows the base components of the engine in simulation software. The following components are:

- Fuel tank
- Inlet
- Inlet port
- Inlet valve
- Combustion chamber
- Exhaust valve
- Exhaust port
- Exit

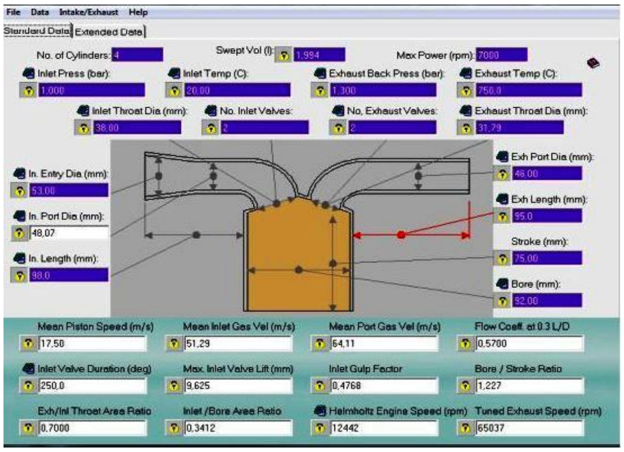

Fig: 5 – Lotus Engine Simulation Combustion chamber tool

1.3 Wiebe function [11]

Using continuous mathematical functions to assess the combustion rate and performance of internal combustion engines provides fast and low cost technology. These functions are usually variable variable's variable distribution derivatives and the most famous Wiebe function[29-34].

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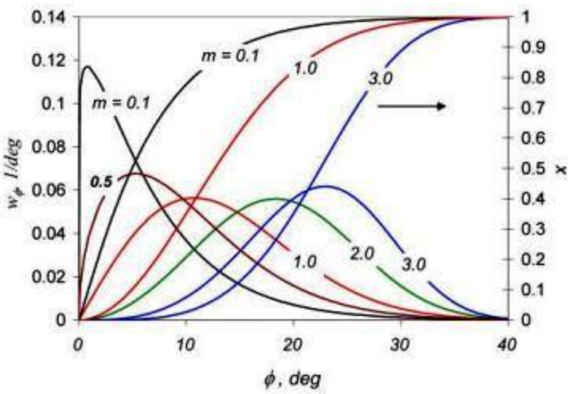
In an actual combustion system, the internal combustion engine can run parallel to the formation of intermediate types, including chain reactions and independent radicals and atoms. This is called the interactive network of the website. Due to its highly reactive and functional center, chemical chemistry plays an important role in the reaction and is necessary for the way of communication. To start a conversation, you need a special complex active center (the primary center) and you can create it by providing heating or electricity for the center air composite and fuel.During the combustion process, a large number of active centers will be present near the main reactive species molecules. Molecules that burn the final product and more active centers can trigger new reaction cycles. This scheme eliminates blockage of the center of the chain resulting from collision of free radicals or free atoms with a third object (any other group of atoms, atoms or molecules or their walls). As it burns, the concentration of the reagent gradually decreases and the reaction rate correspondingly decreases[35-38].



Graph 1 – Wiebe Burn Characteristics

1.4 Miyamoto model

They tried to establish a relationship between some Wiebe parameters regarding thermodynamic efficiency, noise and smoke discharges. A sample of thermal output rate comprised of two Wiebe functions. They are the amount of energy released in the pre-mixing and spread conditions of their respective fuel. Other parameters are defined by Wiebe, the index associated with the P code and the index d for the spread. Miyomoto and many others. Continuous tests were conducted in direct injection diesel and indirect injections. Engine adjustment parameters such as brake average pressure (b.m.e.p), needle time and ignition time are related to the remaining adjustment parameters.

The figure 6, 7 below shows the data input given in the simulation software where the type of fuel, Fuel system, bore, stroke, etc. are entered.

Label	
Fuel System	Direct Injecti
Fuel Type	Diesel
Calorific Value (kJ/kg)	42700.0
Density (kg/litre)	0.8400
H/C Ratio Fuel (molar)	1.9000
O/C Ratio Fuel (molar)	0.0000
Molecular Mass (kg/k.mol)	170.000
Maldistribution Factor	1.000
Conversion Tool	

Fig: 6 – Data Input Window for Fuel system

Label	default cylinder
Bore (mm)	80.0000
Stroke (mm)	110.0000
Cyl Swept Volume (l)	0.55292
Total Swept Volume (l)	0.55292
Con-rod Length (mm)	230.00
Pin Off-Set (mm)	0.00
Compression Ratio	16.00
Clearance Volume (l)	0.036861
Phase (ATDC)	0.00
Combustion Model	
Open Cycle HT	
Closed Cycle HT	
Surface Areas	
Surface Temperatures	
Scavenge-Cylinder	

Fig:7 – Data Input Window for Engine Geometry

Single zone model assumes the charge as homogeneous and single wiebe heat release model is widely used to model SI combustion. Here we use two wiebe model as we are simulating a Direct Injection Diesel Engine[37-41].

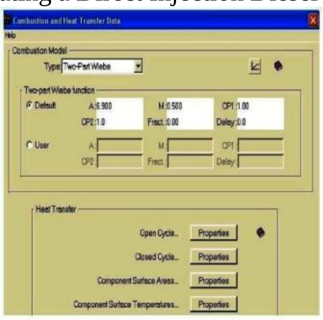


Fig: 8 – Data Input Window for Combustion and Heat Transfer Data

Heat transfer by convection from gas to the cylinder walls or from the cylinder walls to the gas is considered over the entire cycle. Heat transfer by radiation is additionally considered, during combustion as the temperature of burning zone is significant[42-48].

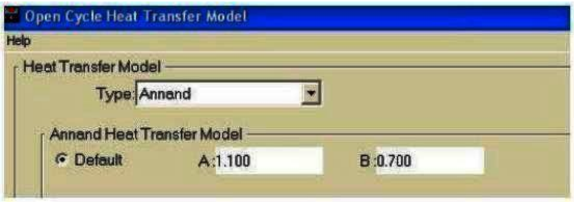


Fig: 9 – Heat Transfer Input Window

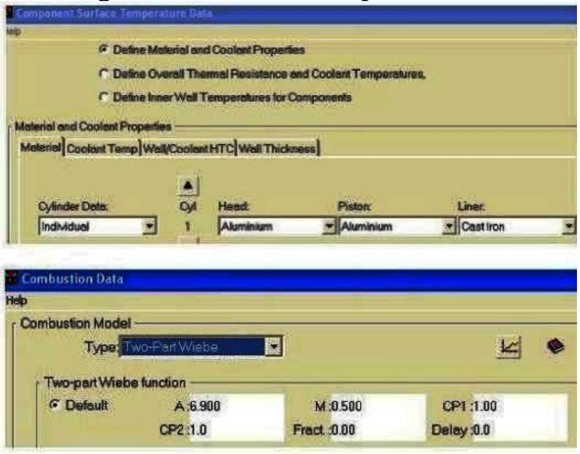


Fig: 10 – Heat Transfer Input Window

The figures above shows the data input given into the simulation software.

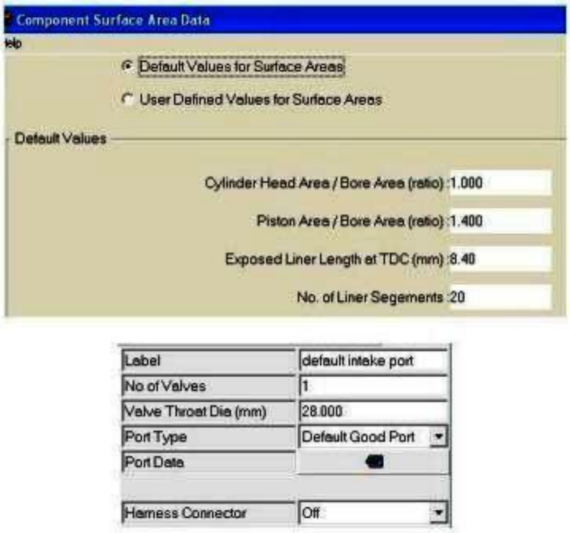


Fig: 11 – Intake Valve Data Input Window

Figure 12 shows the port flow coefficient values for different valve lift values. We have accepted the default values provided for a single cylinder diesel engine, because to measure the actual data, a flow test rig is needed.

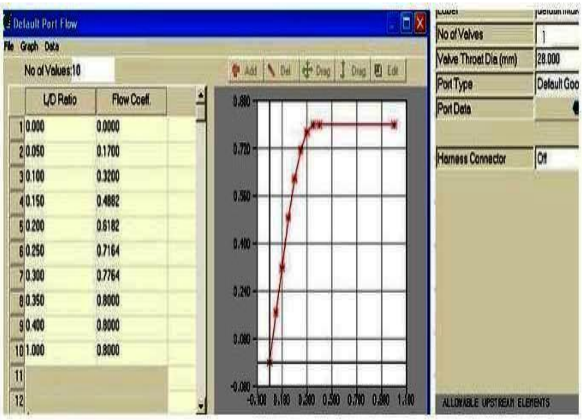


Fig: 12 –Data Input Window for Intake Port Flow Coefficient

Figure 13 shows the valve event display with firing order in the cylinder with its required data. The graph shows the Pressure variance during the cycle of combustion.

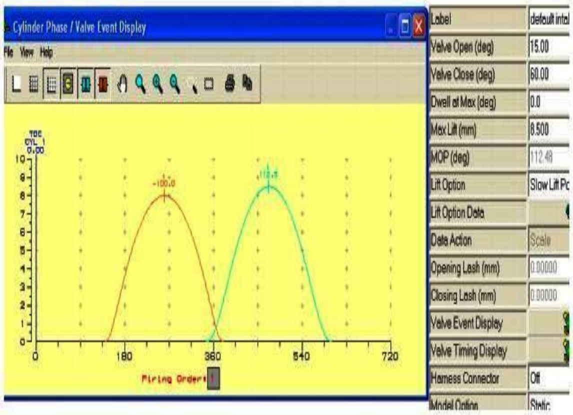


Fig: 13 – Valve Event Display

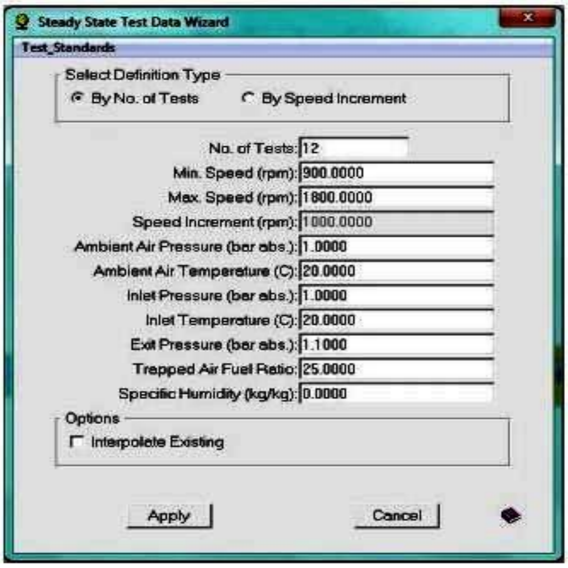
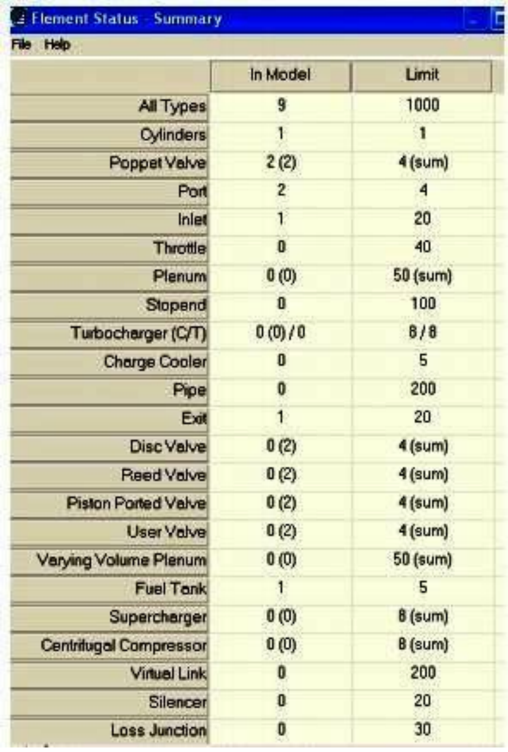


Fig: 14 – Steady State Test Input Data Window


Element Status - Summary
File Help

	In Model	Limit
All Types	9	1000
Cylinders	1	1
Poppet Valve	2 (2)	4 (sum)
Port	2	4
Inlet	1	20
Throttle	0	40
Plenum	0 (0)	50 (sum)
Stopend	0	100
Turbocharger (C/T)	0 (0) / 0	8 / 8
Charge Cooler	0	5
Pipe	0	200
Exit	1	20
Disc Valve	0 (2)	4 (sum)
Reed Valve	0 (2)	4 (sum)
Piston Ported Valve	0 (2)	4 (sum)
User Valve	0 (2)	4 (sum)
Varying Volume Plenum	0 (0)	50 (sum)
Fuel Tank	1	5
Supercharger	0 (0)	8 (sum)
Centrifugal Compressor	0 (0)	8 (sum)
Virtual Link	0	200
Silencer	0	20
Loss Junction	0	30

Fig: 15 – Summary of Engine Elements Inputs

The above figure shows the different element status at various stages of combustion, its values and requirements.

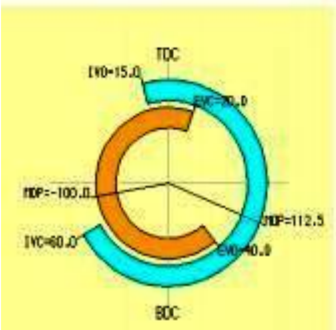


Fig: 16– Valve Timing Diagram of the Base Engine

The below mentioned figure 17, shows the tool provided in the software to estimate the FMEP values for a single cylinder CI engine. Various methods of obtaining FMEP values based on engine type, configurations are provided in the simulation tool. In the real scenario, the FMEP values needs to be collected by running the engine either in motoring mode and finding out the friction values by means of friction dynamometer.

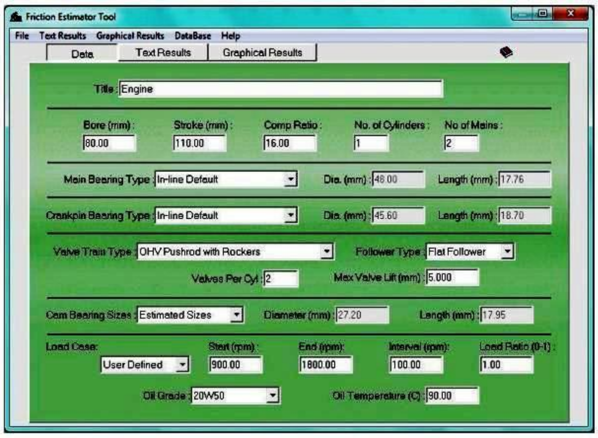
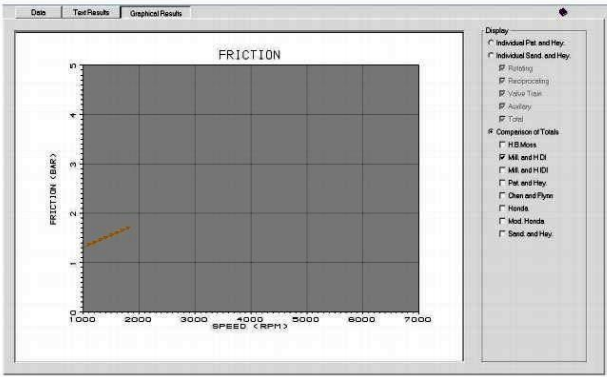
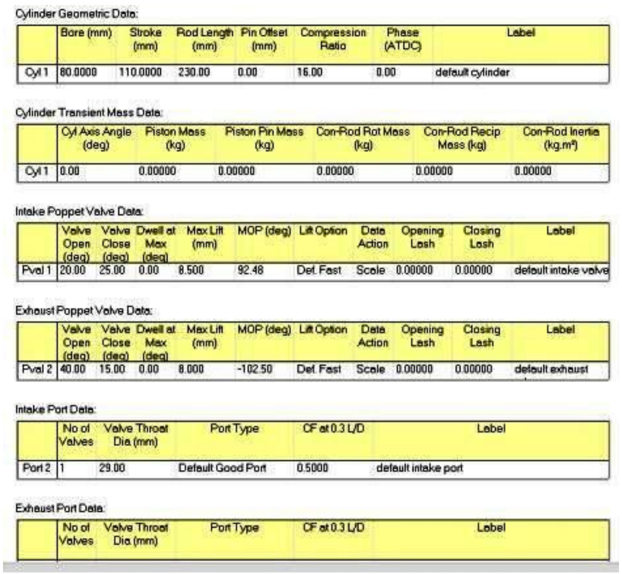


Fig: 17 – Friction Mean Effective Pressure Calculating Window



Graph: 2 FMEP plot


Cylinder Geometric Data:

	Bore (mm)	Stroke (mm)	Rod Length (mm)	Pin Offset (mm)	Compression Ratio	Phase (ATDC)	Label
Cyl 1	80.0000	110.0000	230.00	0.00	16.00	0.00	default cylinder

Cylinder Transient Mass Data:

	Cyl Axis Angle (deg)	Piston Mass (kg)	Piston Pin Mass (kg)	Con-Rod Rot Mass (kg)	Con-Rod Recip Mass (kg)	Con-Rod Inertia (kg.m²)
Cyl 1	0.00	0.00000	0.00000	0.00000	0.00000	0.00000

Intake Poppet Valve Data:

	Valve Open (deg)	Valve Close (deg)	Dwell at Max (deg)	Max Lift (mm)	MOP (deg)	Lift Option	Data Action	Opening Lash	Closing Lash	Label
Pval 1	20.00	25.00	0.00	8.500	92.48	Def. Fast	Scale	0.00000	0.00000	default intake valve

Exhaust Poppet Valve Data:

	Valve Open (deg)	Valve Close (deg)	Dwell at Max (deg)	Max Lift (mm)	MOP (deg)	Lift Option	Data Action	Opening Lash	Closing Lash	Label
Pval 2	40.00	15.00	0.00	8.000	-102.50	Def. Fast	Scale	0.00000	0.00000	default exhaust

Intake Port Data:

	No of Valves	Valve Throat Dia (mm)	Port Type	CF at 0.3 L/D	Label
Port 2	1	29.00	Default Good Port	0.5000	default intake port

Exhaust Port Data:

	No of Valves	Valve Throat Dia (mm)	Port Type	CF at 0.3 L/D	Label

Fig: 18 – Mathematical Data

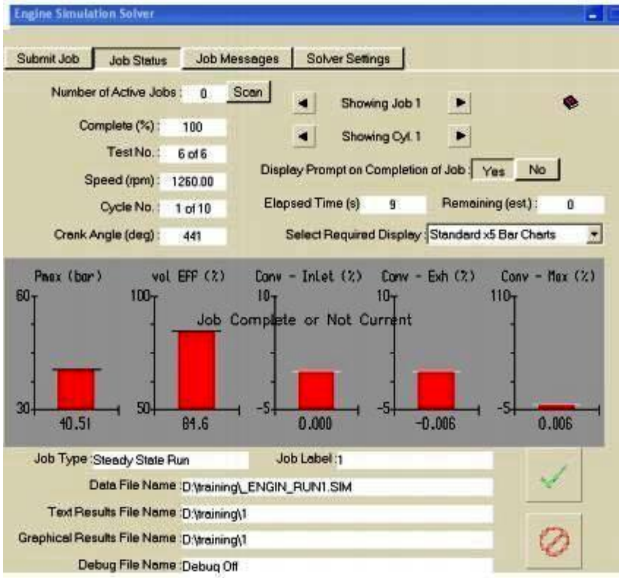


Fig: 19 – Simulation Solver of results

The above tabulation shows the input data is correct as no error is showing up and the result solver has accepted the input data's to run the simulation.

RESULT AND DISCUSSION

A method has been proposed to obtain a mathematical model of a four-stroke engine for hyle simulation of a motor control system. This technique is used to calculate motor parameters and empirical data functions for motor performance theory in real time.

The four-stroke diesel engine is considered to be a series of interactive elements such as cylinders, repair elbows and exhaust manifolds. Output parameters (angular shaft and rotor angle velocity and turbocharger intake and exhaust pressure) are different.

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AUTHORS PROFILE

Mr.P.Vignesh, Working as Assistant Professor In the department of Mechanical Engineering in Indira Institute of Engineering and Technology, Pandur, Thiruvallur, Tamil Nadu, India. Completed B.E Mechanical Engineering from Indira Institute of Engineering and Technology, Anna University -2015 and M.Tech Automobile engineering from Bharath Institute of Engineering and Technology – 2018. He had Life Time Membership from IAENG , UAMAE and He is acting as Reviewer and Editor Board member for IEEE and SCI Journals.

Mr.P.Madan, PG Scholar from Bharath Institute of Higher Education and Research Department of Mechanical Engineering. He Completed B.E Mechanical Engineering from St.Peter's College of Engineering and Technology, Anna University -2017.

Mr.D.Mohankumar, Assistant Professor from Bharath Institute of Higher Education and Research Department of Automobile Engineering. He Completed M.E (Engineering Design), in G.K.M College Engineering and Technology, Anna University – 2014.

Dr.P.Naveenchandran, Professor from Bharath Institute of Higher Education and Research Department of Automobile Engineering.