SIMULATION OF VARIOUS ENGINE PARAMETERS OF PPCI ENGINE FOR NOx CONTROL

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ABSTRACT

The paper presents the investigation of the Kirloskar Engine using 1D simulation software Ricardo WAVE. The main objective of this work is to predict the emission model of PPCI engine to get lower emission. Compression ratio, Nozzle diameter and the number of injector holes was chosen as parameters for this investigation. Experimental investigation of effect of fuel injection parameters is quite time consuming process. Hence Ricardo Wave, an engine simulation software was chosen for simulation purpose. Kirloskar TV1 diesel engine was chosen as a test engine for modelling. The engine datum were fed in the Ricardo software and simulation model was created. The typical Ricardo engine simulation involves Building a single cylinder model, Running WAVE and creating time plots, making Sweep plots in Wave Post. After simulation, based on the results for the given input, the combination of input parameters were chosen to get lower NOx emissions. An attempt was made to get desired number of holes, Nozzle diameter and Compression ratio for lower NOx emissions by simulation using Ricardo software. The advantage of going for Ricardo engine simulation is that it's less costly and time saving as compared with experiments. The simulation was performed in full load conditions. In addition to NOx emission, CO emission, Soot emissions are also discussed.

Keywords: PPCI, WAVE, Nozzle diameter, Compression ratio, NO, CO.

I.INTRODUCTION

In recent years there were a lot of developments in the field of internal combustion engines. The awareness of air pollution introduced strict emission regulations on engine there by limiting the optimization of engine performance thus demanding alternate ways to increase the efficiency. Recently more research works has been carried out on alternate fuels and methods than the usual fuels and engine type. The technologies like Homogeneous charge compression ignition engine, variable compression ratio engine, Gasoline direct injection engine hydrogen engine etc. found their way on the development. One of the areas which researchers are more focused on is duel fuels engines because of their high efficiencies and capability of handling multiple fuels. On the other hand, there has been an enormous increase in the number of vehicles. This has started dictating the demand for fuel.

It is investigated that the injector nozzle hole size and number included 340 × 3 (340 μm diameter holes with 3 holes in the nozzle), 240 × 5, 200 × 7, The results verified that the brake specific fuel consumption (BSFC), carbon dioxide (CO_2) and nitrogen oxides (NO_x) emission increased, smoke opacity (SO), hydrocarbon (HC) and carbon monoxide (CO) emissions reduced due to the fuel properties and combustion characteristics of biodiesel. However, the increased INHN caused a decrease in BSFC at the use of high percentage biodiesel–diesel blends (B50 and B100), SO and the emissions of CO, HC. The emissions of CO_2 and NO_x increased.

It has been proposed that further reduction in compression ratio beyond current levels would be beneficial to engine out emissions and specific power, and could be facilitated by developments in cold-start technology. The results of a study using this single-cylinder facility to evaluate the effect of reducing compression ratio from 18.4 to 16.0 are presented. It was found that, although there was a small CO and HC penalty, either reducing the compression ratio or retarding the injection timing greatly reduced NO_x and soot emissions when both pre-mixed and diffusion–combustion phases were present. This effect was less significant when the combustion was solely premixed [2].

This simulation was done in different nozzle diameter 0.12 mm and 0.2 mm performed at the ambient temperature 500 K and 700 K with different injection pressure 40 MPa, 70 MPa and 140 MPa. Results show that high pressure influence droplet diameter become smaller and the penetration length longer with the high injection pressure apply. Smaller nozzle diameter gives a shorter length of the breakup. It is necessary for nozzle diameter and ambient temperature condition to improve the formation of spray. High injection pressure is most effective in improvement of formation spray under higher ambient temperature and smaller nozzle diameter. [3]

CI ENGINE BASE MODELLING

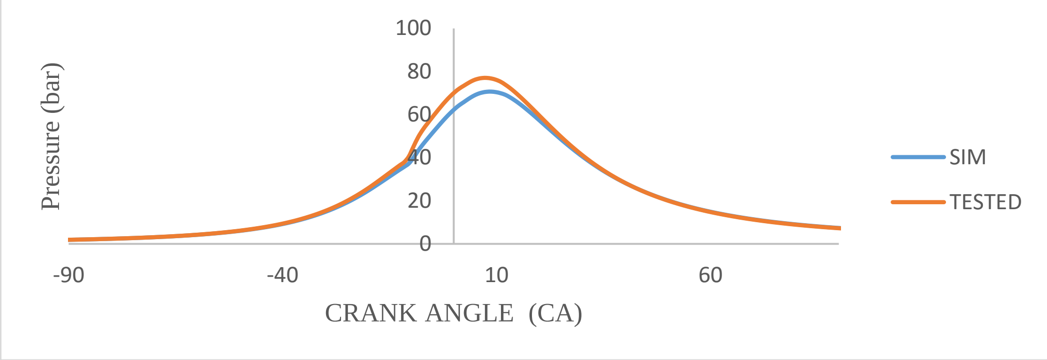

Fig 1 . Validation curve

2.1 Methodology

Initially engine variables established that influences the NOx and other emissions. Then among them a suitable variable is selected. In this work design variables like Compression ratio, nozzle diameter, no of holes are selected. Then the simulation is done using Ricardo wave. After that results are analyzed.

2.2 Process Flow

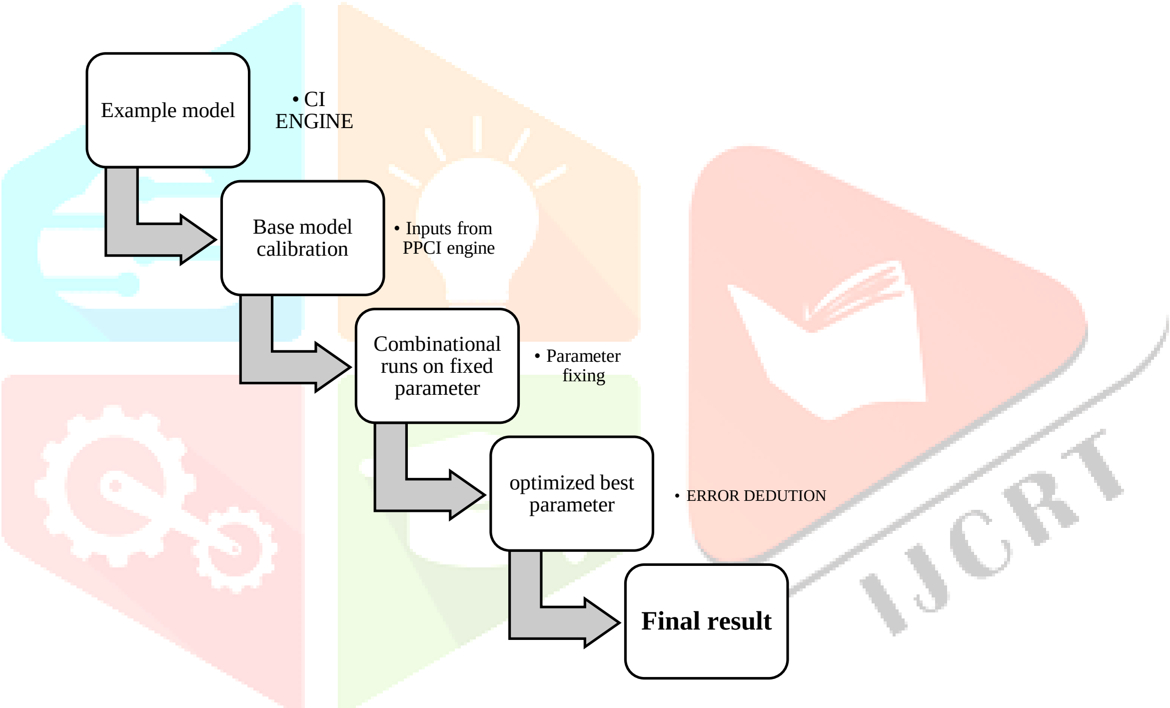

Fig 2. Process flow diagram

III.METHODOLOGY FOR OPTIMIZATION OF PARAMETERS

3.1 SELECTION OF FACTORS

In-cylinder temperature and availability of oxygen during combustion are the two important factors affecting the formation of NOx. The variation in Nozzle diameter, injector hole number and compression ratio has a considerable effect on combustion temperature and contributing in NOx emission. So, Nozzle Diameter, compression ratio and Number of injector holes were selected as a factors for the present investigation.

Level	1	2	3
COMPRESSION RATIO	17.5	18.5	20.5
NOZZLE DIAMETER	0.12	0.16	0.2

NO OF HOLES	3	5	7

Table 1. Levels of factors

SI NO	COMBINATION OF LEVELS		
	COMPRESSION RATIO	NOZZLE DIAMETER	NO OF HOLES
1	17.5	0.12	3
2	17.5	0.16	5
3	17.5	0.2	7
4	18.5	0.12	5
5	18.5	0.16	7
6	18.5	0.2	3
7	20.5	0.12	7
8	20.5	0.16	3
9	20.5	0.2	5

Table 2. Different Combination of levels

IV.RESULTS AND DISCUSSION

4.1 Combustion characteristics:

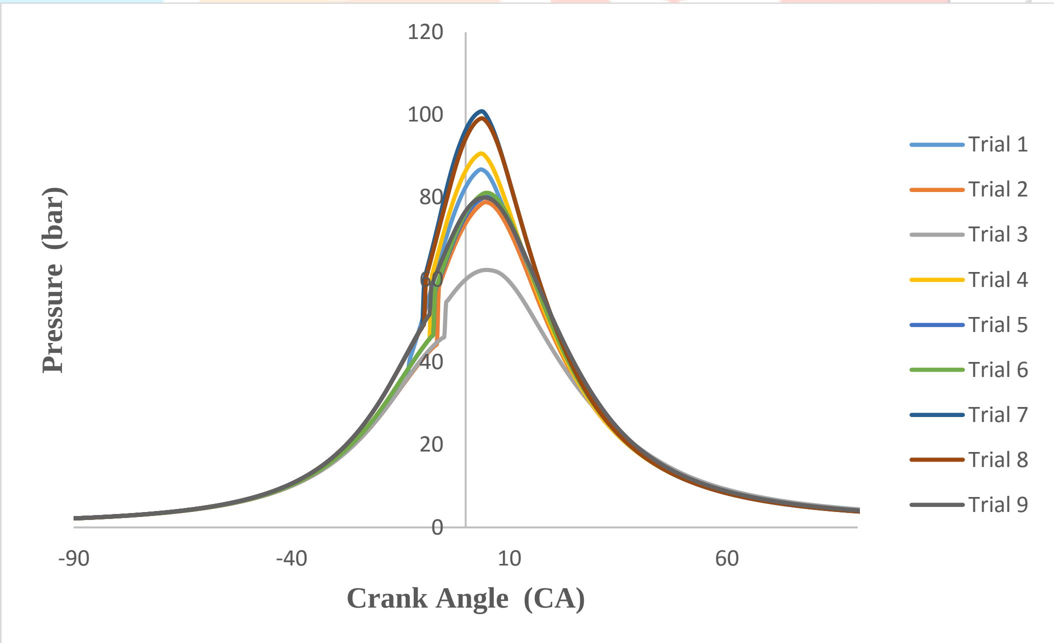

Fig 3 : In cylinder pressure

In the above mentioned graph the maximum pressure is attained at the levels of 7 and 8. Here the pressure is increased with the increase of both compression ratio and the no of holes. So that the pressure is increase with the increase of temperature. This is due to the more of fuel get injected in to the cylinder and also due to the increased penetration length. Here trial 3 shows an optimum pressure rise.

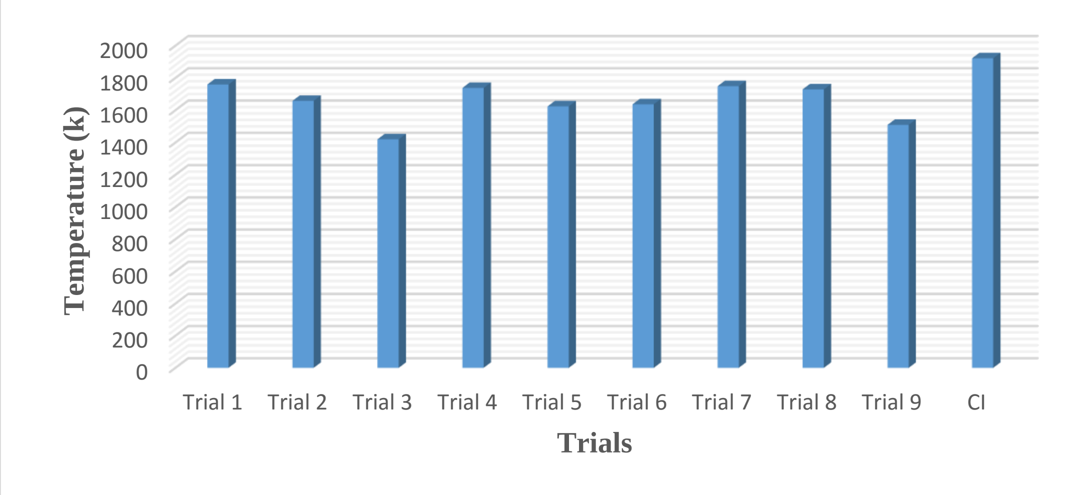

Fig 4: Incylinder Temperature

In the above mentioned graph, the temperature is decreases with the increase of nozzle diameter and the decrease of the no of holes.it is due to the less amount of fuel injected into the cylinder so the combustion temperature is also get decreased. The best optimum level is 3 and 9.

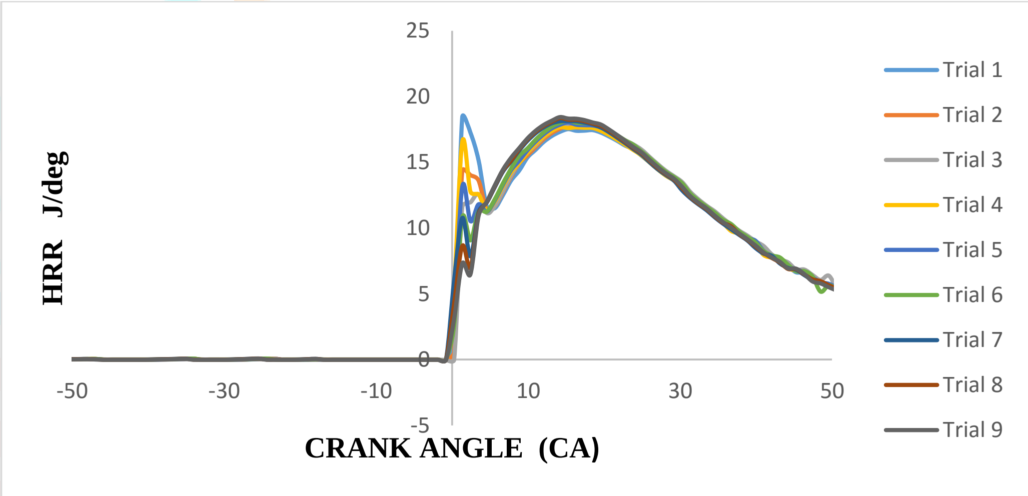

Fig 5. Heat release rate

In the above mentioned graph the heat release rate is increases with level of all parameters. The best optimum level is 3 and 8. This is due to the decrease of nozzle diameter and the no of holes .so that only a less amount of fuel injected into the cylinder results in the decrease of the temperature.

4.2 Emission characteristics:

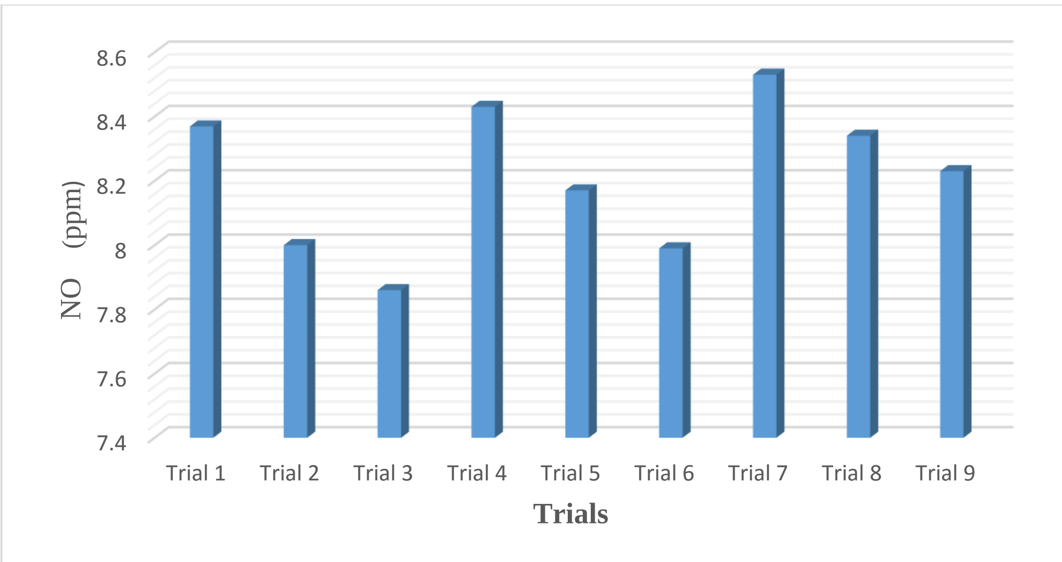

Fig 6. NO Concentration

In the above graph the NOx levels increases with the increase in the compression ratio. when compared to other the levels 3,6 shows considerable reduction in the emission. This is due to the reduction of compression ratio and the increased no of holes. The NO value obtained from CI base model is 468 ppm.

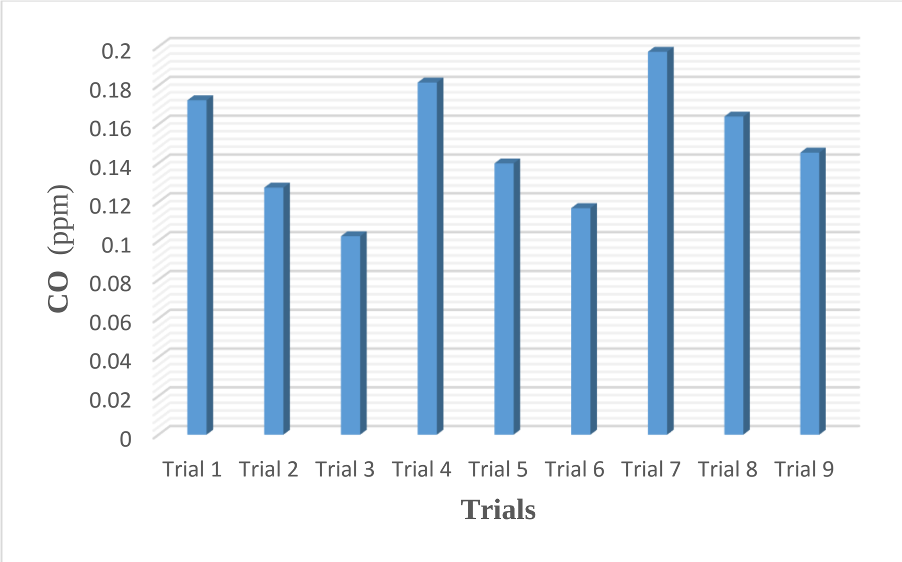

Fig 7. CO Concentration

In the above mentioned graph the CO levels decreases with decreasing in the size of hole diameter and the reduction of no of holes. So that only less amount fuel present inside the cylinder results in the reduction of emissions. The best optimum level is 3 and 6 which shows decreased amount emissions. In CI base model the value of CO is 342 ppm.

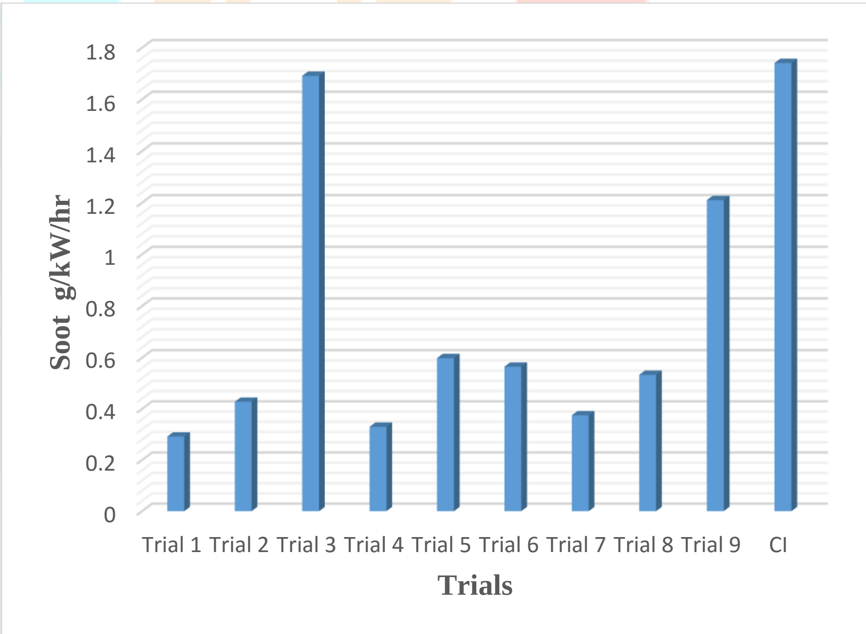

Fig 8. Soot Concentration

In the above graph the soot reach a maximum point in level 3 and CI.This is due to the increase in the no of holes and the nozzle hole diameter.The best optimum level is 1 and 4. Due to the increased no of holes and the diameter alows more fuel in the combustion chamber in the same reduction in the compression ratio results in an incomplete combustion.

V. CONCLUSION

The 1D wave PPCI model is constructed from the base CI engine and then it is calibrated and tested at various combinational levels of parameters which influences the NOx formation and other emissions. It is Concluded that the emission values acquired from the PPCI is model is very much lower when compared to the CI base model. By running various combinational runs level 3 shows an optimum value when compared to other levels which influences the NOx and other emission formations. This is due the increases of both number of holes (7) and the nozzle diameter (0.2) and also due to the reduction in the compression ratio that 17.5:1.

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