

Performance Optimization of internal combustion engine using weight reduction method

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ABSTRACT

The purpose of this paper is to enhance the performance of the single cylinder 4 stroke diesel engine using weight reduction approach. First of all the existing engine is tested as per the method mentioned in IS: 11170 for loop test at different speed and its optimized speed was found then after engine was critically studied for weight reduction possibility and accordingly modified and tested again following the similar method at different speed and its optimized speed was found. The performance of both the engines at their optimized speed was compared. From the result it is concluded that the modified engine shows better performance with reduction in cost however the modified engine needs strong base plate as foundation because of high speed.

Keywords: I C Engine, IS:11170, Weight reduction, Loop test, Optimized Speed

1. Introduction

Rajkot is one of the leading center and hub for manufacturing & assembling of various auto parts and all types of engines. Engines are manufactured for various applications in the field of irrigation, small capacity generator set and agriculture. The selected engine is having the specific use in the field of agriculture. The Indian standard for this product is IS: 11170:1985 which is specific for the diesel engine used in the agriculture field having brake power in the range from 1kW to 19kW. Therefore, in general the engines assembled by them are to be tested as per the specifications of IS: 11170:1985. Due to the recent export policy form by the government of India this industry is facing the strong competition in the international market due to cost and performance aspect. This paper presents detail study & performance enhancement of the specific model having specifications as 3.7kW(5hp) rated output at 1800 rpm.

Performance enhancement in the diesel engine is not a new concept. Lot of work has been done for the enhancement of performance in diesel engine. The various authors have studied and suggested various methods for achieving the same object. Some have altered the fuel and have used the various blends of biodiesel for performance enhancement. While some have modified the various design parameters like Compression Ratio, Fuel Injection Pressure, Fuel Injection timing and operating parameters like various cetane no, Varying load and speed of the engine and the weight reduction of engine. The weight reduction is the one of the prominent methods of engine for achieving performance enhancement which needs more attention.

Liang Y U [1] had evaluate the impact of the combustion pressure, timing of combustion, duration of combustion and heat release on the performance of the engine however the author had taken the jetpropha as a fuel but same results can be used for the diesel also. Yack up Incingur [2] had evaluate the effect of Fuel Cetane No and Injection pressure on diesel engine performance. Increase in engine torque by 5% and power ou put by 4% when CN was increased from 46 to 54.5. However, when increasing CN above 54.5 no significant increase in engine performance was observed. N.Ravikumar [3] in his research had studied the effect of compression ratio & EGR on performance, combustion and emission of D.I. Injection Diesel engine. The Author had evaluated that while conducting an experiment on single cylinder variable compression diesel engine with different compression ratios, percentage of EGR and loads to estimate performance, combustion and emission characteristics of the engine, it was found that with the increase in CR the brake thermal efficiency increases and SFC decreases. With raise in % of EGR the percentage increase in BTE was up to 13.5%. S. Semin [4] had Conducted the experiment on I C Engine. The author had evaluated the IP, IHP, BP & BHP for various speeds and fixed load. The Author had concluded that with the increase in the speed the value of

IHP in general increase, the value of BHP had also increase with the speed, The value of SFC also increase with the speed but at 220 bar FIP it remains constant upto 1000 rpm and then it again increases. The highest SFC was observed at 180 bar FIP but most economic SFC is observed at 200 bar FIP. When the engine speed was more than 1000 rpm the best FIP was 200 bar and at same FIP at different speeds the engine was found more stable, however SFC was higher than that of FIP 220 bar. For higher speed high FIP gives more power however increase in FIP will increase FC for the engine.

2. Details of Experimental set up

2.1 Testing Setup Schematic Diagram



2.2 Experimental Setup:

Fig shows a schematic representation of Diesel engine testing facility used for studying engine performance characteristics. 3.7kW (5hp) high speed direct injection engine was selected for the present study which is widely used in agriculture, generator set and irrigation purpose. The detailed specification of the engine is shown in Table-1. The engine was coupled to a hydraulic dynamometer to control engine speed and load. Control panel gave the measurement of load, speed and fuel consumption digitally. K type thermocouple connected to the digital display unit was used for measurement of exhaust gas temperature. The inlet and outlet temperature of cooling water was measured by thermometers attached to corresponding passages. Engine was started & run for 30 min time to attain steady state conditions. Observations in respect of performance characteristics were taken at different load conditions & different speed i.e. No Load, 20%, 40%, 60%, 80% & 100% with a speed ranging from 1500 rpm to 2400 rpm. The speed of the engine can be changed by loosening or tightening the governor spring. Data were collected for the engine torque, engine power, Brake Specific Fuel Consumption (BSFC), Brake thermal efficiency & Exhaust gas temperature. Then modified engine was tested keeping all the conditions same except the speed which was ranging from 2000 rpm to 2600 rpm. The specifications of the modified engine are given in Table-1.

Table-1 Specification of the 4 stroke single cylinder water cooled engine

Sr No	Description	Present Engine	Modified engine
1	Rated Power	3.7kW at 1800 rpm	3.7kW at 2600 rpm
2	Different Speed	1500,1800,2000 &2200rpm	2000,2200,2400 &2600 rpm
3	Bore	85 mm	76 mm
4	Stroke	80 mm	78 mm
5	Mechanical efficiency (Taken from reference standard)	80%	80%
6	Altitude	140 m	140m
7	Nominal Compression Ratio	16.5:1	16.5:1
8	Specific Gravity	0.83	0.83
9	Calorific value	10500Kcal/Kg	10500Kcal/Kg
10	Oil Specification	Yantrol-32	Yantrol-32
11	Cooling	Water	Water

2.3 Experimental Procedure:

First the existing engine i.e. 3.7kW(5 hp) 1800 rpm was tested in existing set up. The engine was started and after achieving the stable condition the engine was put on the full load and after that the following tests were conducted on engine.

2.3.1 Performance Test: The engine the engine was put at rated full load for continuously 6 hrs and 110% overload of the rated load for 1 hrs and all the parameters were measured at the interval of 1 hr each. This test was followed by the loop test.

2.3.2 Loop test: In this test the engine was started and put on the no load for half an hour than the load was increased to 20% of full load and the reading were taken this way there was an increment of 20% after each half an hour with the final increment was of 10% i.e the readings were taken in 110% load condition.

The same tests were carried out on modified engine and same parameters were noted down. The modification done on the existing engine are listed in article 2.4 given below.

2.4 Modification done in the engine:

- 1) The weight of the flywheel was reduced by 10 Kg, therefore the weight is reduced from 19 Kg to 9 Kg.
- 2) The bore (Inside Cylinder diameter) was reduced from 85 mm to 76 mm.
- 3) The stroke is reduced from 80 mm to 78 mm.

3. Performance investigation of existing and modified engine

3.1 Performance Investigation of Existing engine at different speed:

% of Load	1500 rpm		1800 rpm		2000 rpm		2200 rpm	
	FC	$\eta_{\beta th}$	FC	$\eta_{\beta th}$	FC	$\eta_{\beta th}$	FC	$\eta_{\beta th}$
N.L.	359	----	398.4	---	481.94	----	553.33	-----
20%	403.789	20.81	445.97	17.88	489.84	16.05	563.77	13.16
40%	564	30.24	585.88	28.35	579.1	28.31	664	25.02
60%	694.88	36.33	711.42	33.80	747	33.21	889.29	27.66
80%	878.82	37.55	905.45	35.45	853.72	33.78	905.45	35.94
100%	1106.67	36.72	1045	38.26	1114.93	36.55	1082.60	37.53
110%	1334	32.38	1141	38.24	1167.19	37.78	1176.37	37.39

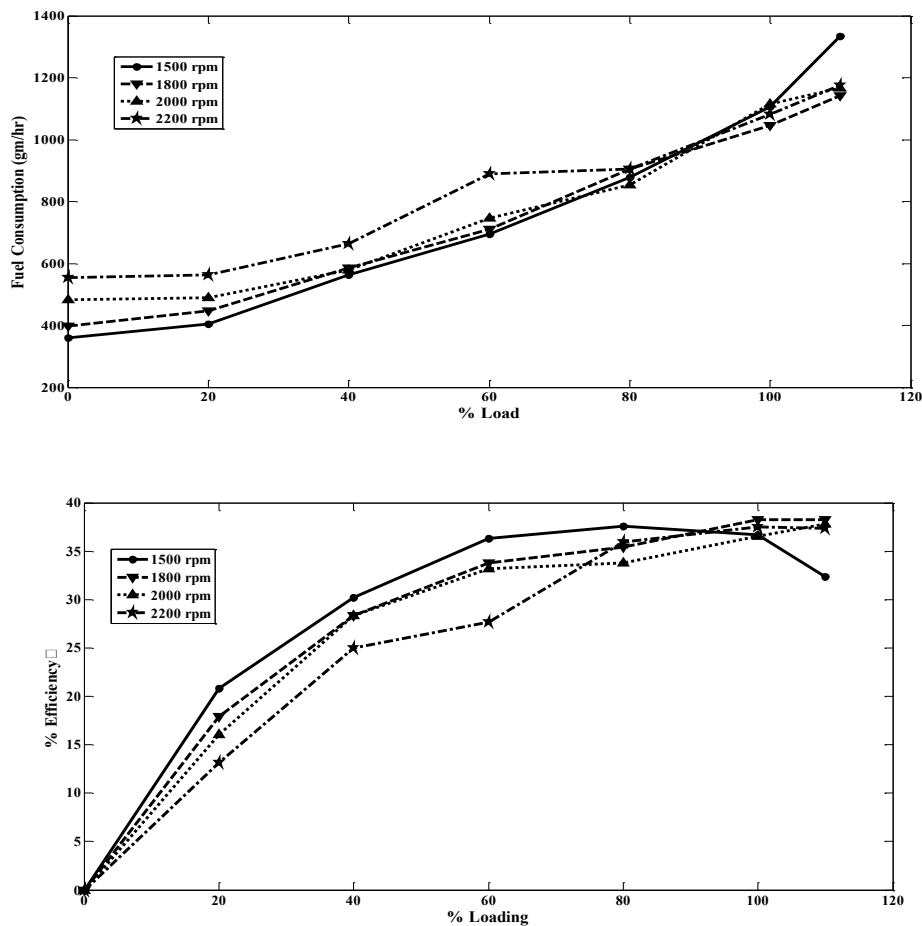
3.2 Performance Investigation of Modified engine at different speed:

% of Load	2000 rpm		2200 rpm		2400 rpm		2600 rpm	
	FC	$\eta_{\beta th}$	FC	$\eta_{\beta th}$	FC	$\eta_{\beta th}$	FC	H βth
N.L.	373.5	---	422.03	----	434.30	----	481.94	-----
20%	403.78	21.39	459.69	19.03	498	16.67	481.94	17.00
40%	585.88	29.50	585.88	28.92	622.5	26.69	609.79	26.70
60%	807.57	31.68	830	29.36	747	32.91	766.15	31.80

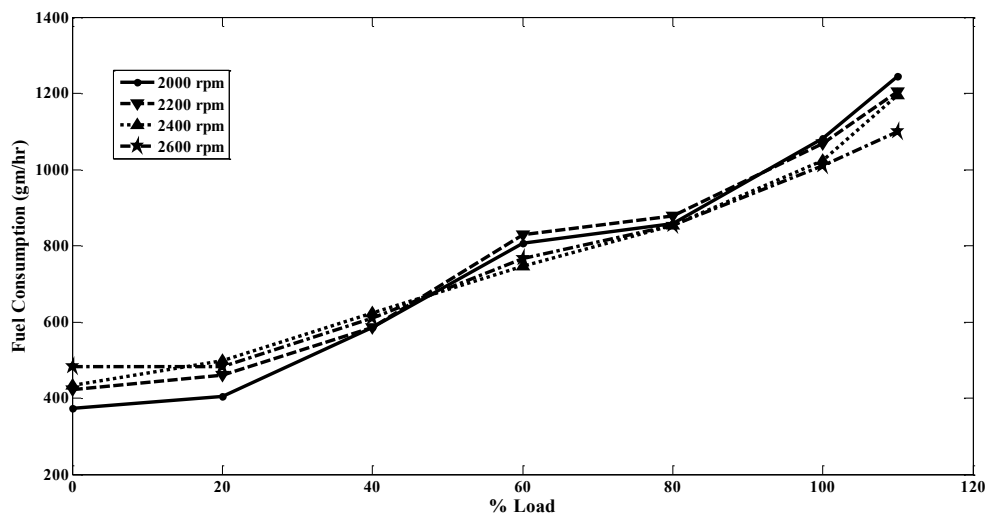
80%	858.62	38.70	878.82	36.80	853.71	37.62	853.71	37.62
100%	1082.61	36.83	1067.14	37.36	1023.29	38.66	1009.46	39.50
110%	1245	34.34	1204.83	35.49	1195.2	36.05	1098.52	39.02

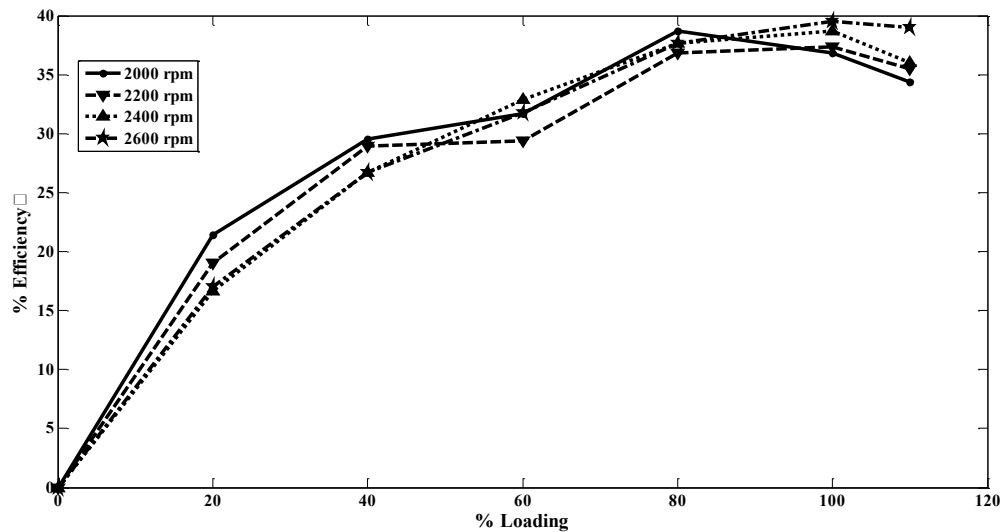
4. Fuel consumption and efficiency graph

4.1 Fuel Consumption and Efficiency Graph of existing engine at different speed

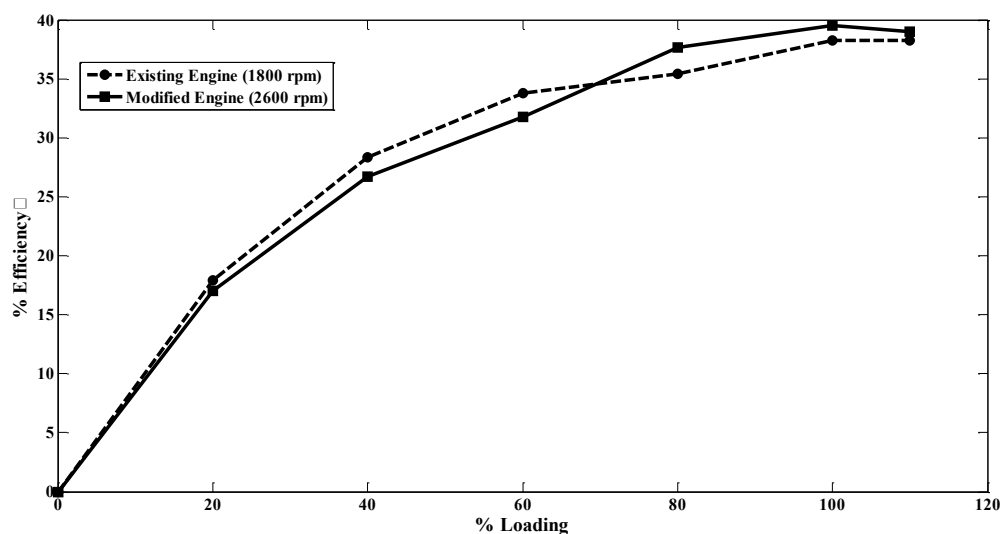


4.2 Fuel Consumption and Efficiency Graph of modified engine at different speed





4.2 Efficiency Comparison of Existing engine and modified engine at their optimized speed.



5. Result and discussion:

5.1 Speed optimization of existing engine:

After comparing the performance of existing engine at different speed it can be concluded that the performance of engine at 1500 and 1800 rpm is good but it is not up to the mark at remaining two speeds i.e., 2000 and 2200 rpm. From 20% to 80% Load condition engine has the lowest FC i.e., best thermal efficiency at 1500 rpm and also has the good efficiency at 1800 rpm. However, in most application engine is bound to run between 80% to 100% load in this zone existing engine has best thermal efficiency at 1800 rpm. Therefore, the optimized speed for existing engine is 1800 rpm.

5.2 Speed optimization of modified engine:

While comparing the performance of modified engine at different speed it can be observed that the under low load condition engine gives better result at lower speed i.e., at 2000 and 2200 rpm. But at high load condition i.e., 80% onwards the engine gives better performance at higher speed i.e., 2400 and 2600 rpm. The best performance of engine at 100% and 110% Load condition is observed at 2600 rpm. Further severe vibration of engine is observed at 2800 rpm. Therefore, the optimized speed for existing engine is 2600 rpm.

5.3 Comparison of existing engine and modified engine at their optimized speed:

It can be observed from the graph that up to 60% load condition the existing engine has better thermal efficiency while at 70% load condition the efficiency of both engines is equal. However, from 70% load condition onwards modified engine gives better thermal efficiency as compared to existing engine.

6. Conclusion:

From the result table and graphs drawn it can be concluded that the optimized speed for the existing engine is 1800 rpm as at high load condition the engine gives the lowest FC at this speed. Further it can also be concluded that the optimized speed for the modified engine is 2600 rpm as further increase in the speed of the engine results in a severe vibration. By Comparison of both engines at their optimized speed it can be observed that in high load condition the modified engine gives the better thermal efficiency by 2% in comparison to existing engine.

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