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"Performance Evaluation of Computerised Multi Fuel Research Engine Using Variable Compression Ratio (VCR)"

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Abstract: During this century, one of the major problem faced by the world is global environment problem. The result of combustion of petroleum fuel is one of the main reason which leads to global environment problem. This in turn leads to global warming, acid rains, climate change and ozone layer depletion. Diesel is one of the most widely used petroleum fuel. Diesel engines are preferred over other engines due to their higher efficiency. The importance of diesel engines for human application is growing day by day. The engine operating parameters also play a key role in tuning the engine conforming to better performance and emission standards. Emissions from automobiles have a major contribution to the air pollution which has a hazardous effect on the environment. The need to reduce these emissions is necessary in present day. The alarming situation in front of the engineers worldwide is to reduce the ever increasing environmental pollution due to emission of vehicles. This study is aimed to investigate performance of Diesel Engine at varying loads and compression ratio and to find the best possible combination of load and compression ratio at which efficiency is maximum and emissions are minimum. The experiments were conducted on widely used Diesel Engine without major modifications. All the tests were conducted at steady state and constant speed by varying the load. Also the emissions from the engine were studied by performing the tests.
Keywords: Multifuel, diesel engine, VCR, efficiency, brake power, Indicated power budgeting, Resource Planning

Introduction

As the time passes, it is believed that the petroleum products and crude oil will not be enough and will be costly. Various researches are going on for the improvement of fuel economy of engines. However as the demand and availability for petrol and diesel is somewhat unbalanced and there is a need to balance since that is mainly happened due to enormous increase in number of vehicles. If the same situation continues then the scenario will be more disastrous and petrol and diesel will be more costly and limited. With increased use and the depletion of fossil fuels, today more emphasis is given on the alternate fuels. There is an essential need of alternate fuels in a way or other. Improving Internal Combustion (IC) engine efficiency is a prime concern today. A lot of engineering research has gone into the improvement of the thermal efficiency of the (IC) engines, so as to get more work from the same amount of fuel burnt. Most of the energy produced by these engines is wasted as heat. In addition to friction losses and losses to the exhaust, there are other operating performance parameters that affect the thermal efficiency. These include the fuel lower calorific value, QLV, compression ratio, and ratio of specific heats, γ. Today intensive search for the alternative fuels for both spark ignition (SI) and compression ignition (CI) engines. The biggest problem associated with engines is harmful exhaust emission. Each emission (NOx, CO, HC) is the outcome of chemical reactions and hence depends upon temperature and reactant concentration. These pollutants have an adverse effect on public health and environment.

Description of Experimental Setup

Multi fuel research engine is new technology advancement in the field of internal combustion engines. The working mode of the engine can be changed from CI to SI and vice versa by changing the head of the engine. These engines has provided with a special arrangement to change the compression ratio without stopping the engine. The arrangement is „tilting block arrangement‟ by which the cylinder block volume can be changed with the help of mechanical arrangement.

The setup consists of single cylinder, four stroke, Multi-fuel, research engine connected to eddy current type dynamometer for loading. The operation mode of the engine can be changed from diesel to ECU Petrol or from ECU Petrol to Diesel mode by following some procedural steps. In both modes the compression ratio can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.

In Diesel mode fuel injection point and pressure can be manipulated for research tests. In Petrol mode fuel injection time, fuel injection angle, ignition angle can be programmed with open ECU at each operating point based on RPM and throttle position. It helps in optimizing engine performance throughout its operating range. Air temp, coolant temp, Throttle position and trigger sensor are connected to Open ECU which control ignition coil, fuel injector, fuel pump and idle air. Set up is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements.

The set-up has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. Rota meters provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement.

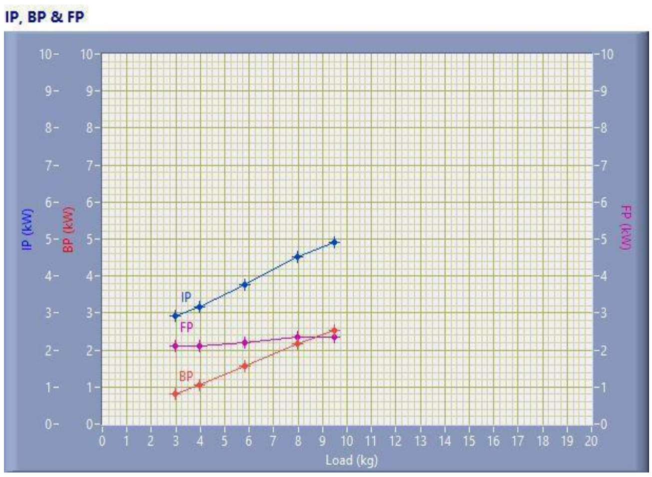
The setup enables study of VCR engine performance for Brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption. Lab view based Engine Performance Analysis software package "Enginesoft_9.0" is provided for on line performance evaluation.

Experimentation

Before testing all the wiring and piping connections are needed to be checked for any errors. If error occurs, there is a need to correct it before starting the engine. Check for the fuel in the tank and if the fuel pipe line is working or not. Ensure sufficient fuel is in the tank before starting the engine. Start the engine with the help of ignition key and on the loading unit. Slowly increase the load at a constant speed.

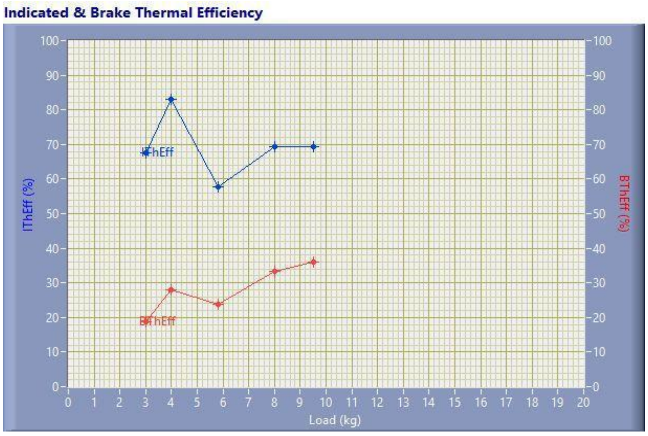
The trials were conducted on computerized multifuel research engine with eddy current dynamometer to evaluate the performance of the system. The performances parameters were compared with VCR and without VCR for same engine output conditions. A rota-meter is fitted for volumetric flow rate measurement. Digital Temperature Indicator is used to measure the temperature of exhaust gas. A Bourdon's pressure gauge is used to measure the pressure and it is mounted on exhaust manifold. Digital control panel is provided to acquire data such as torque, fuel, air, water flow of engine and calorimeter. Thermocouples are provided at the intake, exhaust manifold and other test points along the EGR route. An AVL smoke-meter is used to measure the smoke opacity of the exhaust gas. A five gas analyzer is used to measure the exhaust pollutants such as O_2, CO, CO_2, HC and NOx."

Graphs
The following results were obtained during testing of an engine



Graph (I): Load Vs BP, IP, FP (Testing)

Graph (II): Load Vs Air, Fuel Flow (Testing)



Graph (III): Load Vs $I_{th\ eff}$, $B_{th\ eff}$(Testing)

Result & Discussion

- At C.R. 12 (compression ratio), as load increases from 0 to 12 kg, specific fuel consumption decreases from 0.95 Kg/Kw-hr to 0.33 Kg/Kw-hr. Also mechanical efficiency increases from 22.23% to 59.13% and brake thermal efficiency increases from 8.99% to 25.68%.
- At C.R. 14, as load increases from 0 to 12 kg, specific fuel consumption decreases from 0.78 Kg/Kw-hr to 0.34 Kg/Kw-hr. Also mechanical efficiency increases from 23.09% to 61.92% and brake thermal efficiency increases from 10.93% to 25.03%.
- At C.R. 16, as load increases from 0 to 12 kg, specific fuel consumption decreases from 0.65 Kg/Kw-hr to 0.34 Kg/Kw-hr. Also mechanical efficiency increases from 24.77% to 61.74% and brake thermal efficiency increases from 13.13% to 25.47%.
- At C.R. 18, as load increases from 0 to 15 kg, specific fuel consumption decreases from 0.67 Kg/Kw-hr to 0.37 Kg/Kw-hr. Also mechanical efficiency increases from 28.40% to 61.21% and brake thermal efficiency increases from 12.89% to 22.98%

Conclusion

The performance of an engine was evaluated on the basis of the following parameters:

- Specific Fuel Consumption.
- Brake and Indicated Mean Effective Pressure.
- Specific Power Output.
- Specific Weight.
- Exhaust Smoke and Other Emissions.

The particular application of the engine decides the relative importance of these performance parameters. For the evaluation of an engine performance the following few more parameters were chosen and the effects of various operating conditions, design concepts and modifications on these parameters were studied.

- Power and Mechanical Efficiency.
- Volumetric Efficiency.
- Fuel-air Ratio.
- Thermal Efficiency and Heat Balance.

Test was carried out at different compression ratios of 12,14,16,18 at different torque of 3,6,9,11 N-m and The performance characteristics of engine such as Brake power (BP), Fuel flow rate was noted down. Also the remaining performance Characteristics like Indicated Power(IP) , Indicated Mean effective pressure, Specific fuel Consumption (SFC), Brake Thermal Efficiency, Indicated Thermal Efficiency, Mechanical Efficiency were determined.

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Table 1: Observations:

SR NO	*Speed (rpm)*	*Load (kg)*	*Comp Ratio*	*Air (mmWC)*	*Fuel (cc/min)*	*WaterFlow Engine (lph)*	*WaterFlow Cal (lph)*	*BMEP (bar)*	*IMEP (bar)*
1	1419	3.00	8.00	5.66	8.00	200	100	1.03	3.75
2	1405	3.97	8.00	8.10	7.00	200	100	1.37	4.08
3	1412	5.81	8.00	14.71	12.00	200	100	2.00	4.82
4	1426	8.00	8.00	22.36	12.00	200	100	2.76	5.75
5	1407	9.50	8.00	27.20	13.00	200	100	3.27	6.32

Table 2: Testing Results

SR NO	*Torque (Nm)*	*BP (kW)*	*FP (kW)*	*IP (kW)*	*Air Flow (kg/h)*	*Fuel Flow (kg/h)*	*SFC (kg/kWh)*	*Vol Eff. (%)*	*A/F Ratio*	*BTHE (%)*	*ITHE (%)*	*Mech Eff. (%)*
1	5.44	0.81	2.12	2.93	7.75	0.36	0.44	23.44	21.82	18.60	67.48	27.57
2	7.21	1.06	2.10	3.16	9.27	0.31	0.29	28.32	29.82	27.93	83.16	33.59
3	10.54	1.56	2.19	3.75	12.49	0.53	0.34	37.98	23.45	23.94	57.64	41.53
4	14.51	2.17	2.35	4.52	15.40	0.53	0.25	46.36	28.90	33.27	69.40	47.94
5	17.24	2.54	2.36	4.90	16.98	0.58	0.23	51.82	29.43	36.00	69.49	51.81

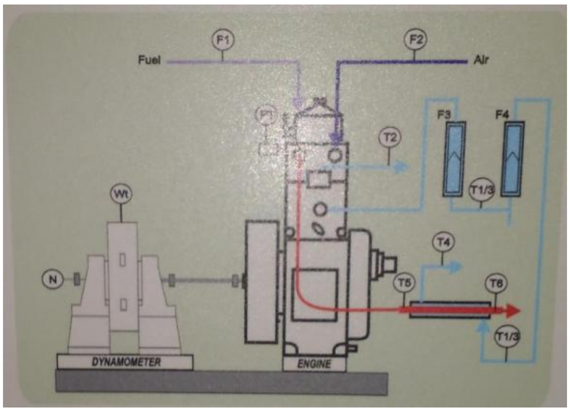

Figure 1: Line diagram of computerized Multifuel Research Engine Setup

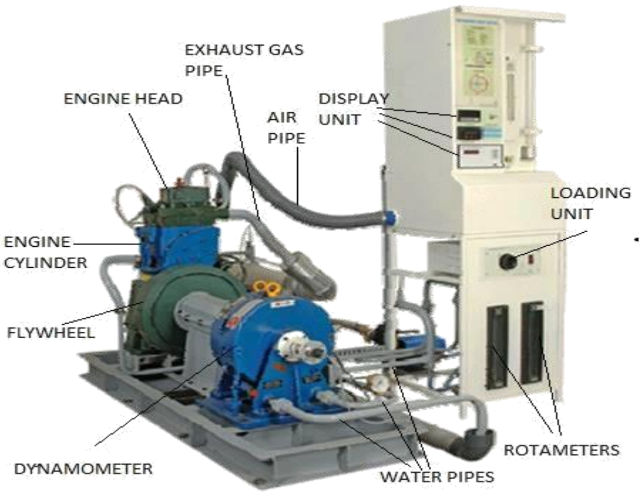

Figure 2: A 3D View of computerized Multifuel Research Engine Setup