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Performance Test on Single Cylinder Four Stroke Compression Ignition Engine by Varying Nozzle Diameters at Various Pressures

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ABSTRACT

The engine ratings usually indicate the highest power at which manufacturer expect their products to give satisfactory of power, economy, reliability, and durability under service conditions. Maximum torque and the speed at which it is achieved. The performance and emission characteristics of diesel engines depend on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, the shape of the combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl etc. In the present investigation, the experiment conducted by varying nozzle flow area (i.e. the number of nozzle holes × nozzle hole diameter) and fuel injection pressure at different loads. For these two kinds of nozzles (with nozzle flow areas of 3 × 0.28 mm, and 4 × 0.24 mm respectively) are selected. In the present work Diesel fuel has to investigate in a constant speed, CI diesel engine with variable fuel injection pressures (170, 180) and by varying nozzle holes. The main objective of this project is to investigate the effect of injection pressures and the nozzle holes on the performance of the engine by using diesel on a single cylinder four stroke CI Diesel engine. In the present investigation, two kinds of nozzles (with nozzle flow areas of 3 × 0.28 mm, and 4 × 0.24 mm respectively) are selected and fuel injection pressures (170, 180) are varying.

Keywords: *Brake Power (B.P), Frictional Power (FP), Indicated Power (I.P) Brake Specific Fuel Consumption (B.S.F.C), Total Fuel Consumption (T.F.C), Volumetric efficiency (η_{vol}), Brake thermal efficiency (η_{bth}), Indicated thermal efficiency (η_{ith}), Mechanical efficiency (η_{mech}).*

1. INTRODUCTION

The details of the diesel engine design vary significantly over the engine performance and size range. In particular, different combustion chamber geometries and fuel injection characteristics are required to deal effectively with major diesel engine design problem achieving sufficiently rapid fuel-air mixing rates to complete the fuel burning process in the time available. A wide variety of inlet port geometries, cylinder head, and piston shapes, and fuel-injection patterns are used to accomplish this over the diesel size range. The engine ratings usually indicate the highest power at which manufacturer expect their products to give satisfactory of power, economy, reliability, and durability under service conditions. The importance of the diesel engine performance parameters is geometrical properties, the term of efficiency and other related engine performance parameters. The engine efficiencies are indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, volumetric efficiency and relative efficiency in the diesel engine geometries design written that diesel engine compression ratio is maximum cylinder volume or the displaced volume or swept and clearance volume divided by minimum cylinder volume. And the power delivered by the diesel engine and absorbed by the dynamometer is the product of torque and angular speed.

2. EXPERIMENTAL SETUP & PROCEDURE

Before starting the engine, the fuel injector is separated from the fuel system. it is clamped on the fuel injection pressure tested and operates the tester pump. Observe the pressure reading from the dial. At which the injector starts spraying. In order to achieve the required pressure by adjusting the screw provided at the top of the injector. This procedure is repeated for obtaining the various required pressures.

As first said, diesel alone is allowed to run the engine for about 30 min, so that it gets warmed up and steady running conditions are attained. Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated.

The various steps involved in the setting of the experiments are explained below

- The Experiments were carried out after installation of the engine
- The injection pressure is set at 170 bars for the entire test.
- Precautions were taken, before starting the experiment.
- Always the engine was started with no load condition
- The engine was started at no load condition and allowed to work for at least 10 minutes to stabilize.
- The readings such as fuel consumption, spring balance reading, cooling water flow rate, manometer reading etc., were taken as per the observation table.
- The load on the engine was increased by 20% of FULL Load using the engine controls and the readings were taken as shown in the tables.
- Step 3 was repeated for different loads from no load to full load by varying injector pressures (such as 170bar and 180 bars).
- After completion of the test, the load on the engine was completely relieved and then the engine was stopped.
- The results were calculated as follows.

The above experiment is repeated for various loads on the engine. The experimental procedure is similar as foresaid. While starting the engine, the fuel tank is filled in required fuel proportions up to its capacity. The engine is allowed to run for 20 min, for steady-state conditions, before the load is performed. The engine is run by pure diesel at various injection pressures (170 bars and 180 bars) for, 3hole nozzle&4-hole nozzle and the corresponding observations are noted. The test is carried out on the KIRLOSKER Engine for the following nozzles: 1.for 3-hole nozzle, 2.for 4-hole nozzle.

3. CALCULATIONS AND GRAPHS

The parameters that are determined at different loads are as fallows

a. Brake Power, B.P = $\frac{2\pi NT}{60\times1000}$.... KW
   Where, N=speed in rpm T=torque N-m Brake Power, B.P= kW

b. T.F.C = $\frac{10 \text{ x } 0.85 \text{ x } 3600}{\text{t x } 1000}$Kg/h
   Where, T.F.C =Total Fuel Consumption, Kg/h Specific gravity of diesel=0.85
   t=Time taken for 10 cc fuel, seconds T.F.C =------- Kg/h

c. Brake Specific Fuel Consumption, bsfc= $\frac{\text{T.F.C}}{\text{B.P}}$ Kg/kwh
   Brake Specific Fuel Consumption, bsfc=_ _ _ _ _ _ _ Kg/kwh

d. Heat Input = T.F.C X C.V kW
   Where, C.V=Calorific Value of Fuel, kJ/kg k

e. Frictional Power, F.P = ---------kW (from the graph by William's line method)

f. Indicated Power =B.P + F.P
   Indicated Power =_ _ _ _ _ _ kW

g. Mechanical efficiency = $\frac{\text{B.P}}{\text{I.P}}$x 100 %
   Mechanical Efficiency, η_{mech} =_ _ _ _ _ _ %

h. Brake thermal efficiency = $\frac{\text{B.P}}{\text{Heat Input}}$ x 100 %

i. Indicated thermal efficiency = $\frac{\text{I.P}}{\text{Heat Input}}$ x 100 %

j. Volumetric efficiency, η_{vol} = $\frac{\text{Va}}{\text{Vth}}$ x 100 %
   $\text{Va} = \text{Cd} \times \text{Ao}\sqrt{(2 \times \text{g} \times \text{Ha}} = \dots \text{m}^3/_{\text{sec}}$ Vth = $\frac{\pi\times D^2\times Ls\times N}{4\times2\times60} = \cdots \dots \dots . \text{m}^3/_{\text{sec}}$

Table: 1 Performance Test Results of Diesel Engine at 170 bars for 3 hole Nozzle

LOAD W	SPRING BAL.S	W1	SPEED	H1	H2	H1 ~ H2	ha	TIME For 10cc	B.P	TFC	I.P	F.P	HEAT INPUT	BSFC	ISFC	Va $\times 10^{-3}$	Vth $\times 10$	ma $\times 10$	η_m	η_v
kg	kg	N	Rpm	mm	mm		Meter of water	Sec	kW	kg/hr	kW	kW	kW	kg/Kw-hr	Kg/kw-hr	m^3/sec	m^3/s	Kg /sec	%	%
0	0.1	0.981	1440	36	17	53	45.68	90	0.027	0.3308	1.472	1.5	3.987	12.25	0.216	5.828	6.635	6.76	1.8	87.8
2	0.1	18.639	1424	36	17	53	45.68	80	0.527	0.372	2.027	1.5	4.484	0.705	0.183	5.828	6.651	6.76	25.9	88.8
4	0.1	38.25	1415	35	18	53	45.68	65	1.062	0.458	2.562	1.5	5.521	0.431	0.178	5.828	6.519	6.76	41.45	89.4
6	0.1	57.87	1402	35	18	53	45.68	60	1.593	0.496	3.093	1.5	5.979	0.311	0.160	5.828	6.459	6.76	51.5	90.2
8	0.1	77.49	1400	35	18	53	45.68	65	2.13	0.458	3.63	1.5	5.521	0.215	0.126	5.828	6.450	6.76	58.67	90.3
10	0.1	97.11	1405	35	18	53	45.68	65	2.679	0.458	4.179	1.5	2.679	0.170	0.109	5.828	6.473	6.76	63.14	90

Table: 2 Performance Test Results of the Diesel Engine at 180bar for 3hole nozzle

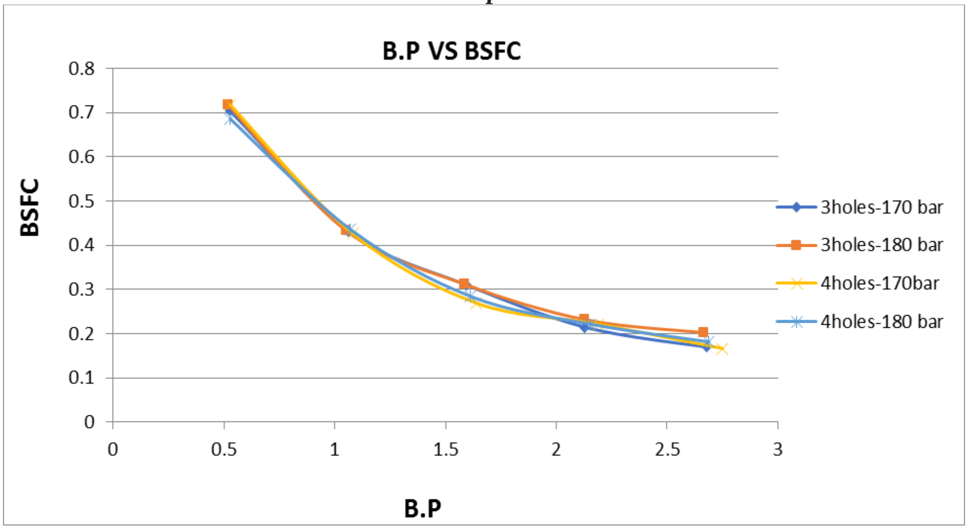
LOAD W	SPRING BAL.S	W1	SPEED	H1	H2	H1 ~ H2	ha	TIME For 10cc	B.P	TFC	I.P	F.P	HEAT INPUT	BSFC	ISFC	Va $\times 10^{-3}$	Vth $\times 10$	ma $\times 10^{-}$	η_m	η_v
kg	kg	N	Rpm	mm	mm		Meter of water	Sec	kW	kg/hr	kW	kW	kW	kg/Kw-hr	Kg/kw-hr	m^3/sec	m^3/s	Kg /sec	%	%
0	0.1	0.981	1429	35	20	55	47.41	93.95	0.0275	18.79	1.4725	1.5	3.809	11.49	0.214	5.989	6.58	6.947	1.8	90.9
2	0.1	18.639	1418	33	22	55	47.41	80	0.518	0.372	2.018	1.5	4.484	0.718	0.184	5.989	6.53	6.947	25.66	91.6
4	0.1	38.25	1402	35	20	55	47.41	65	1.053	0.457	2.553	1.5	5.509	0.433	0.226	5.989	6.45	6.947	41.2	92.7
6	0.1	57.87	1398	35	20	55	47.41	60	1.586	0.496	3.088	1.5	5.979	0.312	0.160	5.989	6.44	6.947	51.4	92.9
8	0.1	77.49	1400	36	19	55	47.41	60	2.130	0.496	3.63	1.5	5.979	0.232	0.136	5.989	6.45	6.947	58.6	92.8
10	0.1	97.11	1398	36	20	55	47.41	55	2.665	0.541	4.165	1.5	6.522	0.203	0.129	5.989	6.44	6.947	63.9	92.9

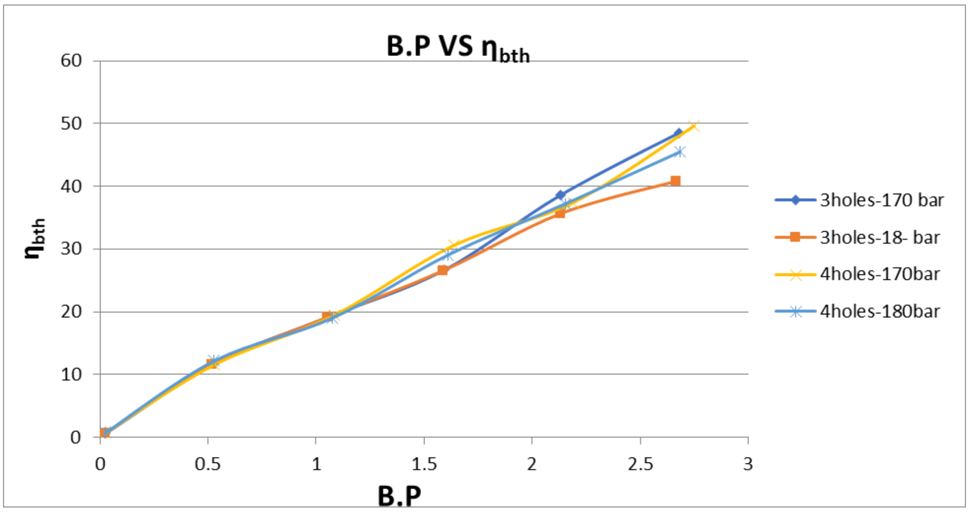
Table: 3 Performance Test Results of Diesel Engine at 170 bar for 4 hole Nozzle

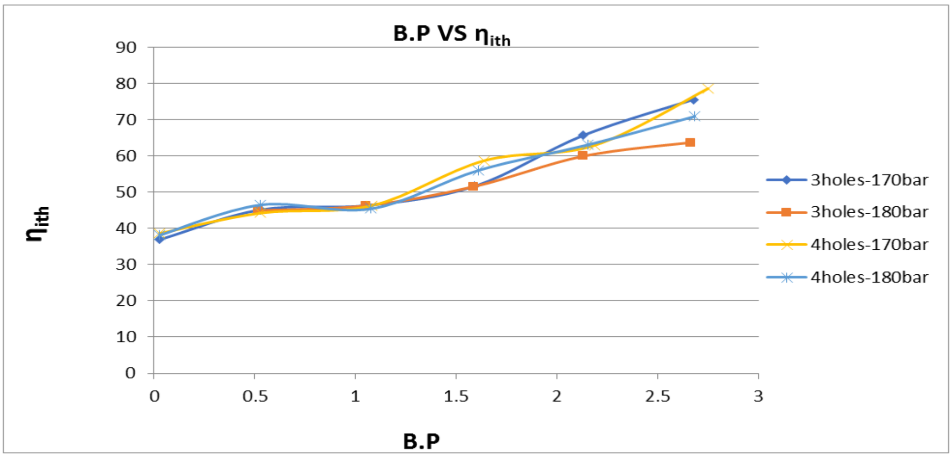
LOAD W	SPRING BAL. S	W1	SPEED	H1	H2	H1 ~ H2	ha	TIME For 10cc	B.P	TFC	I.P	F.P	HEAT INPUT	BSFC	ISFC	Va $\times 10^{-3}$	Vth $\times 10^{-}$	ma $\times 10^{-}$	η_m	η_v
kg	kg	N	Rpm	mm	mm		Meter of water	Sec	kW	kg/hr	kW	kW	kW	kg/Kw-hr	Kg/kw-hr	m^3/sec	m^3/s	Kg /sec	%	%
0	0.1	0.981	1433	36	19	55	47.41	94.2	0.0275	0.316	1.4725	1.5	3.809	11.49	0.214	5.93	6.602	6.88	1.8	89.82
2	0.1	18.639	1420	36	18	54	46.55	78.15	0.529	0.38	2.029	1.5	4.580	0.718	0.187	5.88	6.542	6.82	26.07	89.88
4	0.1	38.25	1416	36	18	54	46.55	64.4	1.083	0.462	2.583	1.5	5.569	0.426	0.178	5.88	6.524	6.82	41.92	90.12
6	0.1	57.87	1416	36	18	54	46.55	67	1.638	0.443	3.3148	1.5	5.34	0.27	0.141	5.88	6.524	6.82	52.19	90.12
8	0.1	77.49	1413	35	20	55	47.41	61.7	2.189	0.486	3.689	1.5	5.85	0.222	0.131	5.93	6.510	6.88	59.33	91.09
10	0.1	97.11	1416	35	20	55	47.411	64.5	2.750	0.4601	4.25	1.5	5.546	0.167	0.108	5.93	6.524	6.88	64.7	90.89

Table: 4 Performance Test Results of Diesel Engine at 180 bar for 4 hole Nozzle

LOAD W	SPRING BAL. S	W1	SPEED	H1	H2	H1 ~ H2	ha	TIME For 10cc	B.P	TFC	I.P	F.P	HEAT INPUT	BSFC	ISFC	Va $\times 10^{-3}$	Vth $\times 10$	ma $\times 10^{-}$	η_m	η_v
kg	kg	N	Rpm	mm	mm		Meter of water	Sec	kW	kg/hr	kW	kW	kW	kg/Kw-hr	Kg/kw-hr	m^3/sec	m^3/s	Kg /sec	%	%
0	0.1	0.981	1440	36	17	53	45.68	90	0.027	0.3308	1.472	1.5	3.987	11.42	0.217	5.88	6.584	6.824	1.9	89.35
2	0.1	18.639	1424	36	17	53	45.68	80	0.527	0.372	2.027	1.5	4.484	0.686	0.178	5.88	6.547	6.824	26.18	89.85
4	0.1	38.25	1415	35	18	53	45.68	65	1.062	0.458	2.562	1.5	5.521	0.436	0.182	5.88	6.492	6.824	41.79	90.61
6	0.1	57.87	1402	35	18	53	45.68	65	1.593	0.496	3.093	1.5	5.979	0.285	0.147	5.88	6.418	6.824	51.79	91.66
8	0.1	77.49	1400	35	18	53	45.68	69	2.13	0.458	3.63	1.5	5.521	0.222	0.131	5.88	6.404	6.824	58.94	91.86
10	0.1	97.11	1405	35	18	53	45.68	65	2.679	0.458	4.179	1.5	2.679	0.182	0.116	5.88	6.381	6.824	64.07	92.19







4. RESULTS AND DISCUSSION

The engine is run by pure diesel various injection pressures (170 and 180) for 3hole and 4hole nozzles. The performance tests are conducted at 1500 rpm with the loading of 20, 40, 60,80and 100 percent of maximum load. The performance characteristics are compared with 3hole and 4hole nozzle at various injection pressures and at different loads. The basic performance parameters such as Specific fuel consumption, Brake thermal efficiency are calculated and presented against load for all attempts as shown in table 1-4

Brake Specific Fuel Consumption

The variation of brake specific fuel consumption with respect to load for 3 holes and 4 holes at various injection pressure at different loads is shown in table 1-4. The injector was set for different opening pressures namely 170 and 180 for 3 holes and 4 holes and the engine was tested. It may be observed that the brake specific fuel consumption is decreasing in the 180,170 bar order for 3holes and 4 holes nozzle. And it is also observed that the brake specific fuel consumption is decreasing with increase in injection pressure this is because of good atomization at higher injection pressure and nozzle spray area which helps in a faster rate of heat release.

Brake Thermal Efficiency

The variation of brake thermal efficiency with respect to B.P for the 3-hole nozzle, 4-hole nozzles at various injection pressures at different loads is shown in table1-4. For all the readings of 3-hole nozzles, 4-hole nozzles, at various injection pressures the brake thermal efficiency increases with respect to various loads. The brake thermal efficiency values at full load are of 48.52%, 40.8% for 3-hole nozzle at 170, 180 bar and the brake thermal efficiency values at full load are 49.63%, 45.49%, for 4-hole nozzle at 170, 180 bars. Maximum brake thermal efficiency is obtained at 170 bars for the 3-hole nozzle.

Indicated Thermal Efficiency

The variation of indicated thermal efficiency with respected to load for 3hole nozzles, 4hole nozzle, at various injection pressures at different loads is shown in table1-4 for all the readings of 3 holes, a 4holes nozzle at various injection pressure the indicated thermal efficiency increases with respect to various loads. The indicated thermal efficiency values at full load are 75.69%, 63.8% for 3holes at 170,180 and the indicated thermal efficiency values at full load are of64.7%, and 71.0% for 4hloles nozzle at 170,180bar.

Mechanical Efficiency

Mechanical efficiency indicates how good an engine is inverting the indicated power in table1-4 shows that the Mechanical efficiency increased for all injection pressures at 170,180 for 3 hole compared to 4 holes. The mechanical efficiency is approximately same at all pressures for 3hole & 4hole nozzles. Maximum efficiency is obtained for 4hole at 170bar is 64.7%

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