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Experimental Investigation on Four Stroke Single Cylinder Petrol Engine Using Water Cooling

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Abstract: In internal combustion engines, water injection, also known as anti-detonate injection, is spraying water into the cylinder or incoming fuel-air mixture to cool the combustion chambers of the engine, allowing for greater compression ratios and largely eliminating the problem of engine knocking (detonation). This effectively reduces the air intake temperature in the combustion chamber, meaning that performance gains can be obtained when used in conjunction with a supercharger, turbocharger, altered spark ignition timing, and other modifications.

The reduction of the air intake temperature allows for a more aggressive ignition timing to be employed, which increases the power output of the engine. Depending on the engine, improvements in power and fuel efficiency can also be obtained solely by injecting water. Water injection may also be used to reduce carbon monoxide emissions.

Keywords— Brake power, indicated power, emissions, detonation, cooling.

I. INTRODUCTION

The Electronic fuel injector consists of a small tank, pump, microcontroller unit, engine set up and fuel injector. The microcontroller unit is used to setting the fuel injection period. The fuel pump is used to suction the fuel in to deliver the fuel injector. The 12 volt fuel injector is used to inject the fuel in to the cylinder. This 12v fuel injector is controlled by the microcontroller unit.

The injector consists of the nozzle, nozzle valve, spring and body. The fuel is forced under pressure by the fuel injection pump. The fuel lifts the nozzle valve because of the pressure, and then the fuel is sprayed through the nozzle hole. The nozzle valve is returned to its seat by the spring. Some amount of oil which is not injected passes through the nozzle valve and reaches the tank through the leak-off pipe.

Water has a very high heat of vaporization. As water at the ambient temperature injected into the engine, heat is transferred from the hot cylinder head/ intake air into the water. This causes it to evaporate, cooling the intake charge. A cooler intake charge means it is more dense (higher volumetric efficiency) and also will have a lower tendency to knock. However the water will displace some air, negating the denser intake charge from the lower temperature. Knocking is generally more of a problem in forced induction engines rather than naturally aspirated so this can be a useful aid in its prevention. On electronic ignition systems the ignition timing is generally retarded to prevent knock from occurring but with water injection it can be advanced closer to Maximum Brake Torque (MBT) timing for additional power.

II. EXPERIMENTAL SETUP

A. Working Principle

The Pressurized fuel is given to the input supply of this fuel injector. The 12 volt pump is used to suction the water from the water tank and is given to the fuel injector. The fuel injector is controlled by the microcontroller unit. The fuel and air is supplied from the carburetor already used in the petrol engine. The 12v power supply is given to the fuel injector coil. The coil gets energized to open the nozzle hole so that the pressurized water sprayed by the injector nozzle. Engine power production, referred to as brake mean effective pressure (BMEP), is measured by taking the average effective pressure of the cylinders as they progress through intake, compression, ignition, and exhaust strokes. Added power comes as a result of greater pressure, but a higher temperature inside the cylinder accompanies greater pressure. These higher temperatures can lead to detonation, referred to as engine knock, or pre-ignition, both of which are cases where the fuel-air mixture burns in an undesirable manner and can be destructive to an engine. To combat knock and pre-ignition as power increases, a richer air-to-fuel ratio is normally required. If the addition of extra fuel doesn't provide enough knock protection, then a higher-octane fuel, which is more resistant to knock and pre-ignition, may be used. However, once the knock limit of a higher-octane fuel is reached, can anything be done? This is where a water injection system

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presents an appealing option

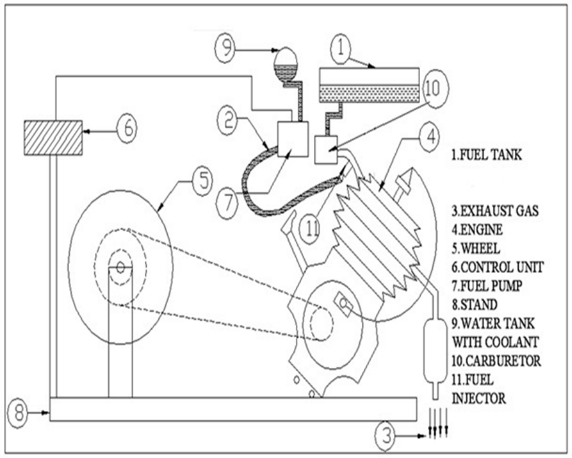

Fig. 1 layout of setup

At normal condition (room temperature)

$$H_2O \longrightarrow H^+ + OH^-$$

In combustion chamber (temp1500-2000 ^{0}c)

$$H_2O \longrightarrow H_2 + (1/2)\ O_2$$
$$CO + \ (1/2O_2) \longrightarrow CO_2$$

(Exhaust gas)

Figure: 2 Experimental setup

III. EXPERIMENTAL RESULTS

The obtained results with the use of water injection system the mechanical efficiency increases, fuel consumption and frictional power decreases as per the following observations tabulated as given below.

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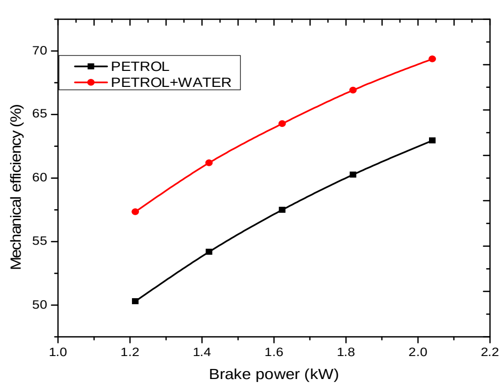
TABLE: 3.1 READINGS FOR PETROL

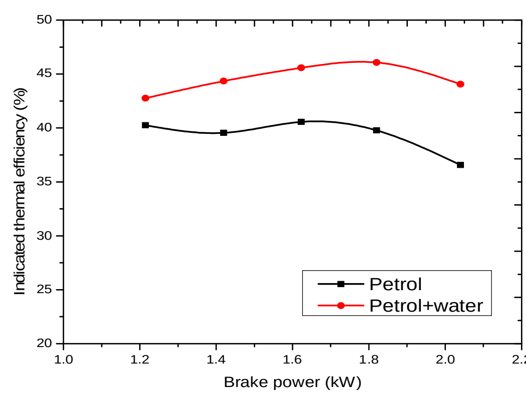
Speed	Time	Mass flow rate of fuel	BP	FP	IP	Mechanical efficiency	B_{the}	I_{the}	BSFC	ISFC	Heat flow rate
RPM	Sec	kg/sec	Kw	kW	kW	%	%	%	kg/kW-h	kg/kW-h	kW
3000	115	0.000125	1.21	1.2	2.41	50.3	20.21	40.25	0.37	0.186	0.068
3500	104	0.000138	1.42	1.2	2.62	54.19	21.37	39.55	0.35	0.19	0.075
4000	99	0.000145	1.62	1.2	2.82	57.49	23.25	40.56	0.32	0.185	0.079
4500	91	0.000158	1.82	1.2	3.02	60.26	23.96	39.77	0.31	0.188	0.086
5000	78	0.000185	2.04	1.2	3.24	62.96	23.02	36.56	0.32	0.205	0.099

TABLE: 3.2 READINGS FOR PETROL AND WATER

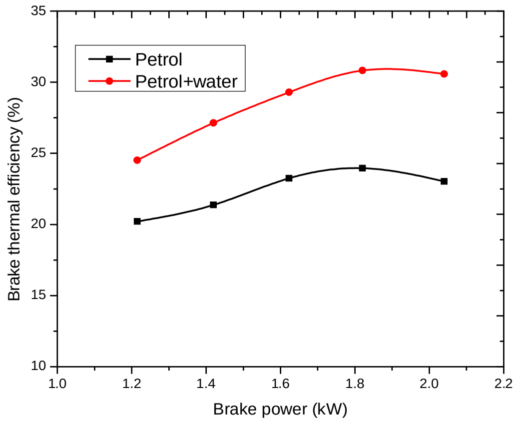
Speed	Time	Mass flow rate of fuel	BP	FP	IP	Mechanical efficiency	B_{the}	I_{the}	BSFC	ISFC	Heat flow rate
RPM	Sec	kg/sec	kW	kW	kW	%	%	%	kg/kW-h	kg/k-Wh	kW
3000	140	0.000102	1.21	0.9	2.11	57.34	24.52	42.76	0.30	0.175	0.055
3500	132	0.000109	1.42	0.9	2.32	61.20	27.14	44.34	0.27	0.169	0.058
4000	125	0.000115	1.62	0.9	2.52	64.28	29.29	45.57	0.256	0.164	0.063
4500	117	0.000123	1.82	0.9	2.72	66.91	30.82	46.07	0.24	0.162	0.066
5000	103	0.000139	2.04	0.9	2.94	69.38	30.57	44.06	0.24	0.170	0.072



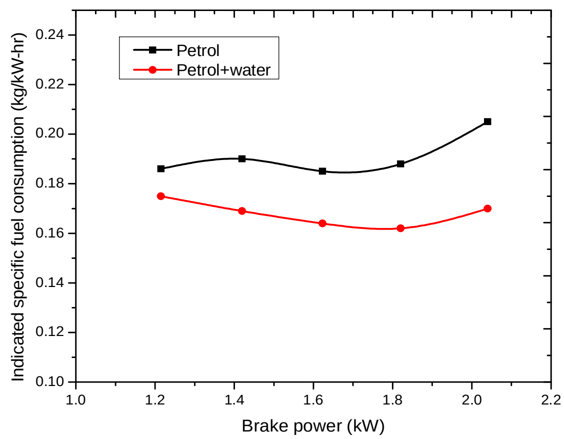
Graph 1 Brake power v_s mechanical efficiency



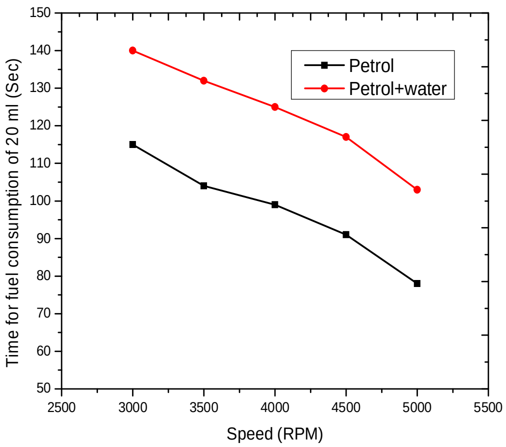
Graph.2 Brake power v_s indicated thermal efficiency



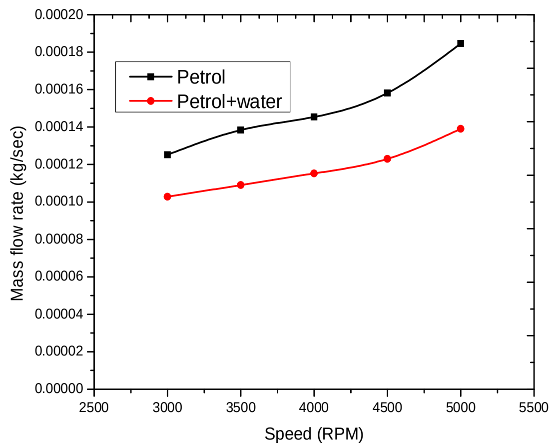
Graph .3 Brake power v_s brake thermal efficiency



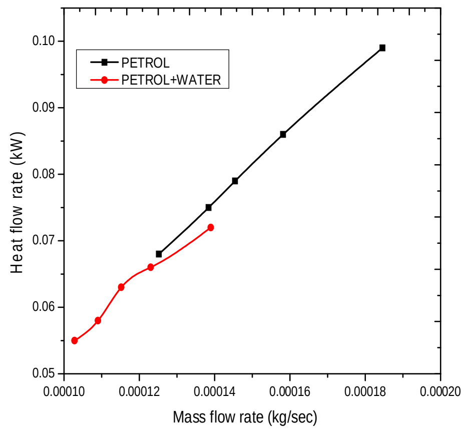
Graph.4 Brake power v_s indicated specific fuel consumption



Graph. 5 Speed v_s time for fuel consumption of 20ml



Graph. 6 Speed v_s mass flow rate



Graph.7 mass flow rate v_s heat flow rate

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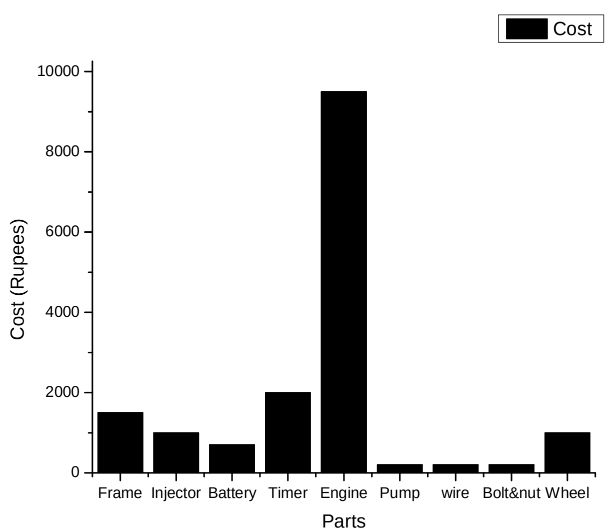
IV. COST ESTIMATION

Sl. No.	PARTS	Qty.	Material	Amount (Rs)
i.	Frame Stand	1	Mild Steel	1500
ii.	Fuel Injector	1	Aluminum	1000
iii.	Battery	1	Lead Acid	700
iv.	Timer unit	1	Electronics	2000
v.	Engine	1	100 Cc	9500
vi	Fuel Pump	1	Electro-Magnetic	200
viii.	Connecting wire	1 meter	Copper	200
ix.	Bolt and Nut	-	M.S	200
x	Wheel Arrangement	1	-	1000

TOTAL= Rs 16,300/-



Graph.8 Parts v_s cost

V. CONCLUSION

An attempt is made in the present work to experimentally study the performance of a single cylinder four stroke petrol engine using water injection system. Emissions were also tested.

The experimental tests were conducted for the proposed water injection petrol engine by varying speed. The results yielded from the experiments have shown that mechanical efficiency of the engine with petrol is 50.31% at 3000 rpm and it is improved to 57.31% at 3000 rpm when used petrol and water injection. The emission of CO was also reduced by the reaction of water and CO changes to CO_2.

The indicated thermal efficiency (ITE) improved when water was injected in the compression stroke. The ITE improvement was only through range of water injection timing and this range mainly depends on the water quantity the range of water injection timing which ensures an improvement in the ITE was increased as the water quantity increased, but this conclusion is restricted by present operating conditions and engine specifications.

The reduction of NOx emissions was most strongly dependent on the water injection timing and quantity. The maximum reduction in the NOx emissions reached. Water injector nozzle with a pintle type nozzle was used to water sprays inside the combustion chamber. This simultaneously reduces much more NOx emissions it is important to supply water effectively into the burning zone.

VI. SCOPE OF FUTURE WORK

It can be modified and developed in near future on the basis of a six stroke engine, though there are some inherent problems like low durability, high manufacturing cost which are mainly due to some modifications made in the design of camshaft.

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