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Performances Analysis of a four stoke Petrol Engine –A Case Study

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ABSTRACT
Modern civilization utilizes I.C Engines in different areas such as aircraft, automobile, model engine, and motorcycle engine, marine propulsion, railway locomotive engine, spacecraft propulsion such as rocket engine, traction engine etc. Efficient running of engines are very much required for better utilization of fuels and lesser pollution. Thus, aim of this paper is to study the best performance condition of apractical ISUZU Engine. Detailed calculations regarding engine performance have been made and based on analysis of the test results maximum efficiency of 31.28 % was observed at 16.3:1 air:fuel ratio which is slightly lean mixture. This is the most economical running condition when other parameter like rpm is 1568 and BHP is 9.85. Maximum power was observed to be 12 HP at the A:F ratio of 12.3:1 which is slightly richer than the stochiometric mixture while rpm was 1234.

KEY WORDS: Petrol engine, engine performance, air fuel ratio, lean mixture and stochiometric mixture

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Nomenclature

BP	Brake Power	N	Speed of the turbine in RPM
A:F	Air fuel ratio	ɳ	Efficiency
T	Torque in Kgm	HP	Horse Power
IP	Indicated Power		

I. INTRODUCTION

Petrol Engineisan internal combustion engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine the expansion of the high-temperature and pressure gases produced by combustion applies direct force to some component of the engine, such as pistons. This force moves the component over a distance, generating useful mechanical energy.The effect of water injection on a spark ignition engine thermal balance and performance has been experimentally investigated on a four stroke four cylinder engine with LPG (liquid petroleum gas) as fuel [1]. The results showed that as the water injection level to the engine increased, the percentage of useful work increased, while the losses other than unaccounted losses decreased. Moreover, the specific fuel consumption decreased, while the engine thermal efficiency increased. A theoretical study of different strategies for waste heat recovery in an internal combustion engine run by internal combustion and electric motor was conducted to reduce specific fuel consumption [2]. The important applications of I.C. engines are road vehicles, locomotives, ships and aircraft, portable standby units for power generation in case of scarcity of electric power, extensively used in farm tractors, lawn movers, concrete mixing devices and motor boats etc.Thus, aim of this paper is to study the best performance condition of a practical ISUZU Engine.

II. MATERIALS AND METHODS

The schematic diagram and the original image of the experimental set up used for the present study is shown in Fig. 1 and Fig. 2respectively. The test has been carried out at I/C Engine lab. in Department of Mechanical Engineering, Durgapur Institute of Advanced Technology and Management, Durgapur. The test rig has been developed and supplied by M/s.

Technical Teaching (D) Equipment, Bangalore, India. The specifications of the said Engine [are given below:

Brake Horse Power	: 10HP
No of cylinder	: 4
Compression ratio	: 8.5:1
Bore Diameter	: 84mm
Stroke length	: 82mm
Types of cooling	: water cooling
Air drum orifice diameter	: 24mm
Speed	: 1500rpm
Load arm	: 320mm
Maker	: ISUZU

The test rig mainly consists of a digital temperature indicator to measure different temperatures sensed by thermocouples, a digital rpm indicator to measure the speed, a burette with 3-way manifold to measure the fuel consumption and a differential U tube manometer with suitable orifice to measure air intake.

The Engine and Hydraulic Dynamometer are mounted on a 3" M.S. Channel Frame and further mounted on anti-vibromounts. Panel board of the engine is used to fix the starter, ammeter (analogue to battery). Also panel board is used to fix burette with 3-way cock, digital temperature indicator with selector switch, digital rpm indicator and Utube manometer.

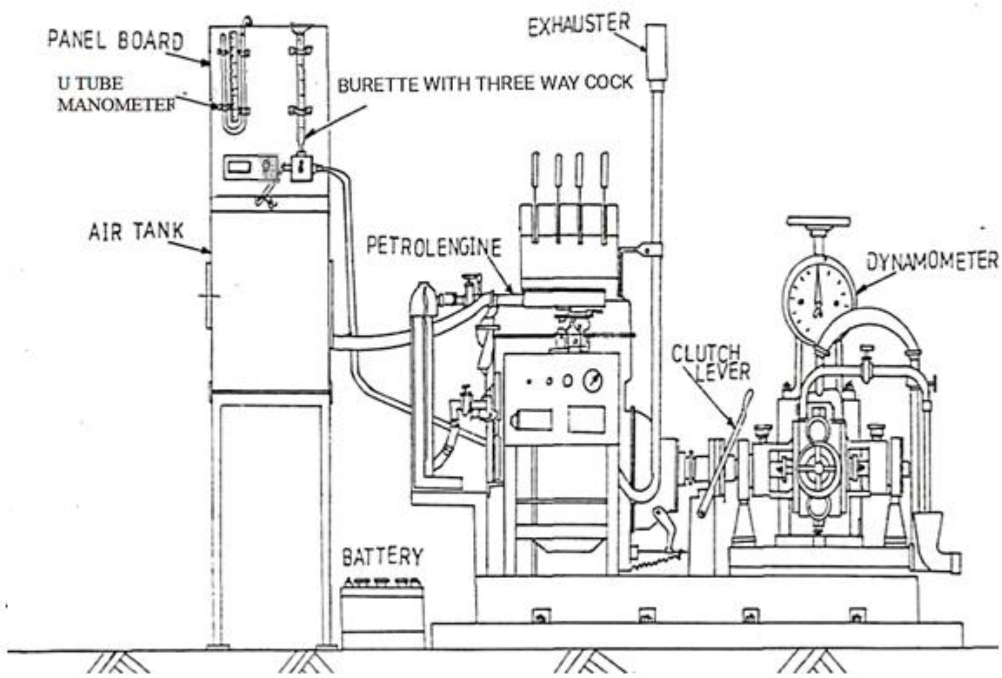

Fig 1Schematic diagram of the experimental test rig of Petrol Engine (ISUZU Engine)

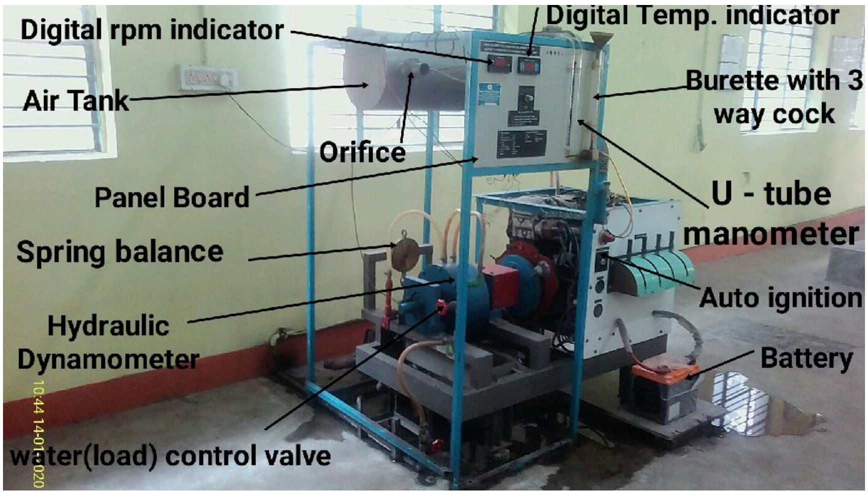

Fig2 Original image of ISUZU Engine

3.1 Analysis of engine performance

The engine performance is indicated by the term efficiency η. The heat energy which is converted to power is called indicated power, IP it is utilized to drive the piston. The useful energy available at the shaft is called brake power BP. The fuel consumption characteristics of an engine are generally expressed in terms of specific consumption in kg of fuel per kilowatt-hour. It is an important parameter that reflects how good the engine performance is. The relationship between speed, power developed and specific fuel consumption determines the performance of an engine.

3.1.1 Important Formulae Used

Power and Mechanical Efficiency

The power developed by an engine and measured at the output shaft is called the brake power (*BP*) and is given by,

$$BP = \frac{2\pi NT}{60}$$

Volumetric Efficiency

It is defined as the ratio of the mass of air inducted into the engine cylinder during the suction stroke to the mass of the air corresponding to the swept volume of the engine at atmospheric pressure and temperature.

$$\text{Volumetric efficiency } (\eta_v) = \frac{Mass\ of\ charge\ actually\ sucked\ in}{Mass\ of\ charge\ corresponding\ to\ the\ cylinder\ intake\ P\ and\ T\ conditions}$$

Fuel-Air Ratio (*F*/*A*)

Fuel-air ratio of the mixture affects the combustion phenomenon in that it determines the flame propagation velocity, the heat release in the combustion chamber, the maximum temperature and the completeness of combustion.

Specific Fuel Consumption

Specific fuel consumption is defined as the amount of fuel consumed for each unit of power developed per hour. It is a clear indication of the efficiency withwhich the engine develops power from fuel.

$$\text{Specific fuel consumption } (sfc) = \frac{Fuel\ consumption\ per\ unit\ time}{Power}$$

Table1:Experimentaland calculated data

No of observation	RPM	Manometric Head(mm)	Water thrust Kg	BHP	Mass of fuel Kg	η_{Bth}	Actual volm^3 /hr	Swept vol m^3 /hr	$\eta_{vol(\%)}$	A:F
1	685	35	6.4	2.02	1.4	8.85	24.35	37.62	64.75	21.02
2	925	42	8.4	3.53	1.6	13.03	26.67	50.68	52.62	19.31
3	1164	41	15	7.84	3.2	14.65	26.03	63.77	40.83	9.52
4	1568	41	14	9.85	1.9	31.28	26.03	85.79	30.32	16.3
5	1234	54	21.4	11.87	2.9	24.24	67.37	67.38	45.3	12.27

Table-1 exhibits the experimental data and calculated performance data.

4.1 Results and discussions

Experimental results obtained on five different loads in form of water thrust of the Petrolengine are discussed in the following paragraphs:

4.1.1 Variation of efficiency with variation of air fuel ratio

The Fig 3 describes the variation of efficiency(η) with the variation of air fuel ratio(A: F). Initially efficiency increases linearly as the A:F ratio increases and maximum efficiency of 31.28 % was observed at 16.3:1 (A:F) which is slightly lean mixture. This Air : Fuel ratio (16.3:1) is very important from point of fuel economy and also, less pollution. Complete combustion of fuel is possible at this air fuel ratio when other parameter like rpm is 1568 and BHP is 9.85.

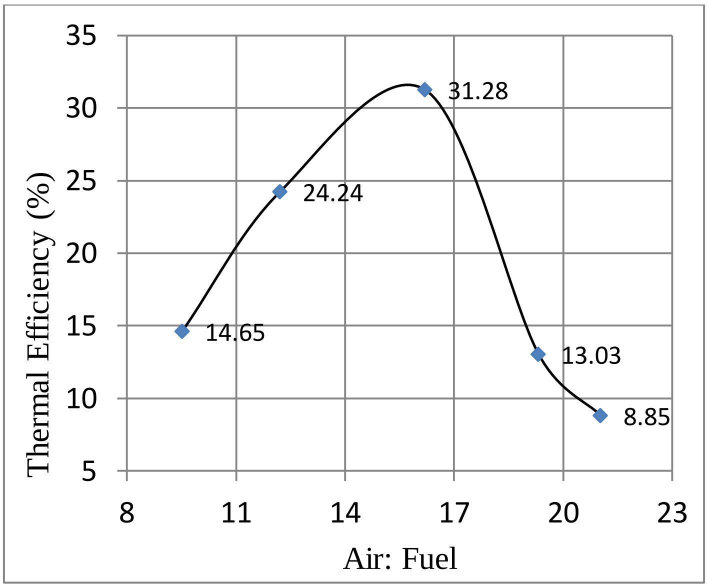

Fig 3Variation of efficiency(η) with the variation of air fuel ratio

4.1.2Variation of power output with variation of air fuel ratio :

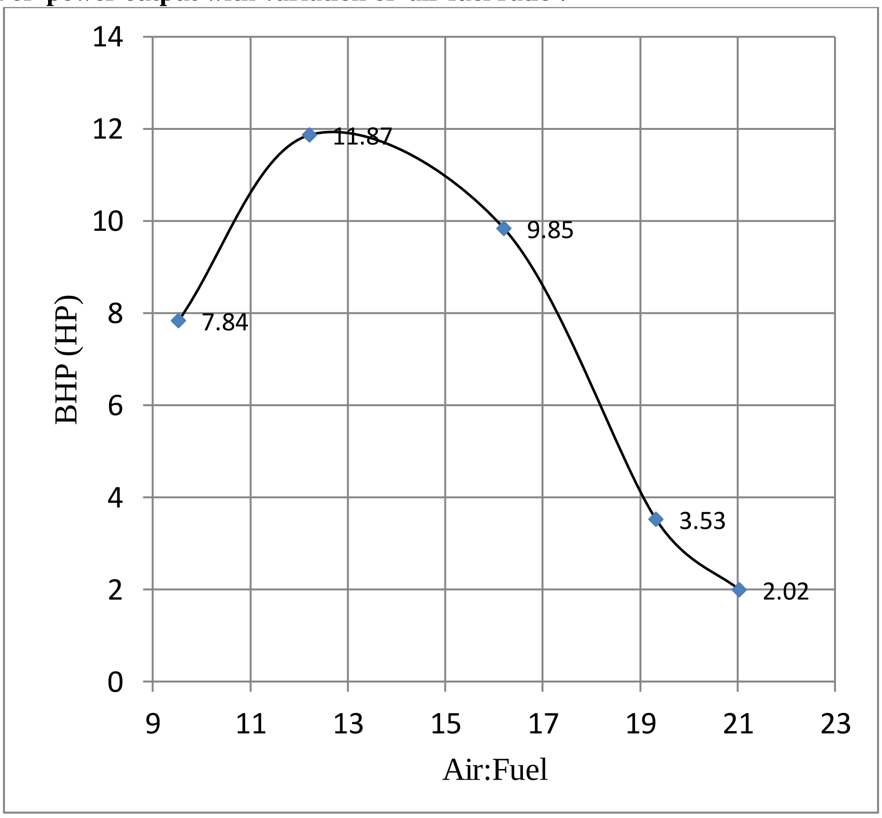

Fig 4Variation of power output (HP) with the variation of air fuel ratio(A:F)

The Fig 4 describes the variation of power output(HP) with the variation of air fuel ratio(A:F). The A:F ratio at which an engine operates has a considerable influence on its power output. Initially when A:F mixture is rich i.e. Air is less compared to stoichiometric Air:Fuel ratio very less oxygen is available for sufficient combustion and hence, engine produces less power. After that power output increases with increases in A:F ratio due to availability of more oxygen for burning. Maximum power was observed to be 12 HP at the A:F ratio 12.3:1 which is slightly richer than the stochiometric mixture.The oxygen available in the limited air inside the cylinder is fully utilized for combustion. Dissociation is less as CO is already present in the product of combustion and thereby, power is highest at rich mixture.Therefore to get maximum power from the engine it should be run at 12.3:1 A:F ratio.

4.1.3 Variation of volumetric efficiency with variation of Power output

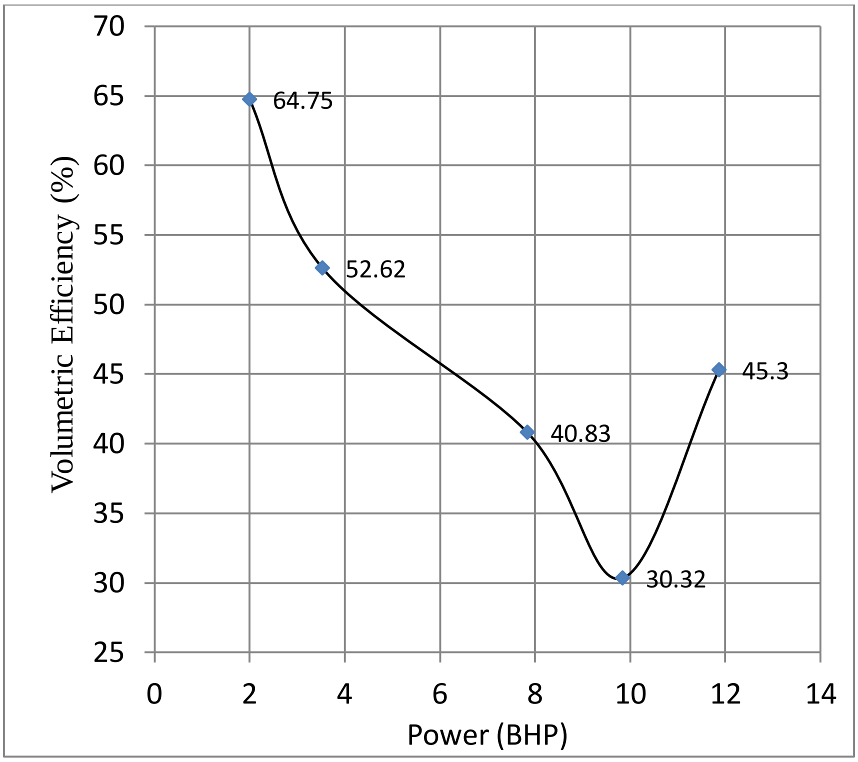

Fig 5 Volumetric efficiency versus power

Volumetric efficiency is a very important parameter for longevity and overall health of the engine. It also indicates the breathing ability of the engine. Here volumetric efficiency is maximum at brake power of 2 HP when rpm of engine is very low due to the fact that number of opening and closing of vlaves per unit time is less and hence, time involved in opening and closing is less. Operation of valves need some time to fully open the inlet. With increase in speed, the cycle time decreases and within the short span opening of valves are disturbed and cylinders are not fully filled with outside air and thereby, volumetric efficiency decreases. Moreover, at higher speed throttle valve of carburetor is fully open and hence at maximum power of 12 HP more air enter due to inertia of velocity and volumetric efficiency is medium (45.03 %). Therefore to get longevity of engine running at lower power is necessary and at urgency, maximum power is suitable.

4.1.4 Variation of Power output with variation of RPM

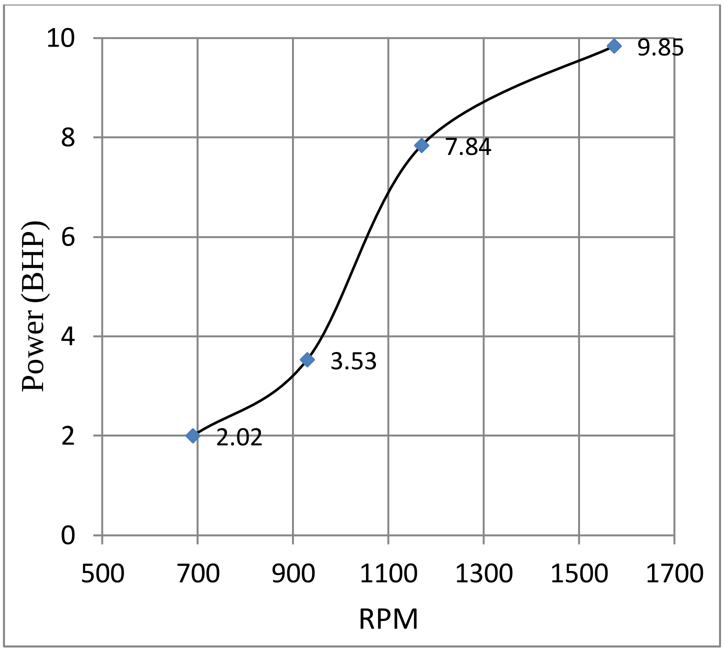

Fig 6 Power output with the variation of speeed (RPM)

The Fig 6 describes variation of power output with the variation of speeed(RPM). Brake power output of the engine is almost linearly proportional to speed of the engine. Number of cycles per unit time increases with increase in RPM. Hence, power output increases with the increase in rpm. Here we observed that highest brake power output(9.85HP) obtained when engine running at speed of 1568 RPM. Although, all engine have certain limit, where it gives highest power at a perticular speed. So, always engine should run within its speed limit. Otherwise it may damage any time.

III. CONCLUSION

Based on the present investigation the following conclusions are made:-

(i) Maximum efficiency of 31.28 % was observed at the A:F ratio 16.3:1 which is slightly lean mixture. This is the most economical running condition when other parameter like rpm is 1568 and BHP is 9.85.

(ii) Maximum power was observed to be 12 HP at the A:F ratio 12.3:1 which is slightly richer than the stochiometric mixture. The oxygen available in the limited air inside the cylinder is fully utilized for combustion. Dissociation is less as CO is already present in the product of combustion and thereby, power is highest at rich mixture.

(iii) Volumetric efficiency decreases linearly from 64.75% to 30.32% with increase in rpm. Operation of valves need some time to fully open the inlet. With increase in speed, the cycle time decreases and within the short span opening of valves are disturbed and cylinders are not fully filled with outside air and thereby, volumetric efficiency decreases. At higher speed throttle valve of carburetor is fully open and hence at maximum power of 12 HP more air enter due to inertia of velocity and volumetric efficiency is medium (45.03 %).

(iv) The BHP increases linearly with the increase in rpm. Number of cycles per unit time increases with increase in RPM. Hence, power increases with the increase in rpm.

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