An Experimental Investigation on Compressed Air Engine

Lalit Patel[1] DR.Ratnesh Shukla[2]
[1]Research Scholar [2]Professor
[1,2]Department of Mechanical Engineering
[1]Rai University, Ahmedabad, India [2]Goverment Engineering College, Bharuch, India

Abstract— Now a days, the serious environmental issues, such as greenhouse effect, ozone layer depletion and fog and haze, have drawn considerable attention. Burning of fossil fuels pollutes the environment seriously, and consume enormous non-renewable energy so Today the whole world is in search of alternative fuel. To avoid such environmental problems, renewable energy has been applied to automobiles. In this paper, an air-powered engine of a renewable energy vehicle is introduced. a physical model of compressed air engine (CAE) is established with modified came from existing 4 stroke petrol engine. . To obtain performance on the CAE, a setup is prepared with dynamometer. The output torque, break power and fuel consumption are obtained through experimental study. The results show that the prototype of CAE has a good economic performance at constant pressure 6 kg/cm2 provide max 0.779 kW power output with varying load 0.5 kg to 2.5 kg. This research can be referred to in the optimization of air-powered engine.

Key words: Compressed air engine, Experiment, Performance, zero pollution, Compressed air fuel (CAF), eco-friendly engine

I. Introduction

The burning of fossil fuels has been recognized as the main cause of serious environmental issues, including the greenhouse effect, ozone layer depletion and acid rain [1]. Renewable fuels, such as wind, solar, compressed air, etc., are used as obvious solutions [2]. With respect to environmental protection, Shafiee and Topal believe that oil and gas reserves may be diminished in 2042; this enhances the competition in the field of renewable energy vehicles [3]. Because of its low cost, safe maintenance, easy access, recyclability, higher energy storage density and long lifespan, compressed air energy storage will be an advanced and rapidly developing field in the future. The flow characteristics of compressed air in equipment have been studied [4] to [6]. Most applications of compressed air engines focus on auxiliary systems or systems that assist IC engines [7,8,9]. Only a few studies or industrial projects have focused on the application of a compressed air engine as the main power system [10].This study focuses on the experimental investigation of a compressed air engine to be installed in vehicles as a main power system. These results can be used to evaluate practical applications of compressed air engines and possible solutions in improving the efficiency and extending the duration time. Compressed air engines have been studied and used for decades in the form of power motors, known as pneumatic power tools or air motors. These power tools and air motors can operate in hazardous environment with flammable or acid gases where conventional electrical power tools are inapplicable. These pneumatic power tools or motors can be categorized as piston- and vane-types, and they can operate at high rotation speed with specified functions such as dental equipment. However, pneumatic power tools operating at a high rotation speed require a high air flow rate, which limits the duration of operation if no air compressor is connected. Therefore, a pneumatic power tool or air motor with moderate air consumption is critical for sustainable applications [11].To use pneumatic/air motors as a power system to drive motor vehicles, the power output and air consumption are critical factors when evaluating the feasibility of such an engine system. Vane-type air motors typically require a higher air flow rate than piston-type air motors because they require continuous compressed air pushing the vane [12]. To simplify the analysis, this study on a single-cylinder 4 stroke petrol engine converted to 2 stroke air engine and investigates its power output.

II. Engine Required

Table 1 lists the specifications of the IC engine, which was modified in the current study as a single-cylinder piston-type compressed air engine. The 4-stroke operation of the IC engine was changed to 2-stroke operation for application as a compressed air engine.

	Honda Sleek
Engine displacement	97.2 cc
Engine type	air cooled ,4 stroke
Number of cylinder	1
Valves per cylinder	2
Max power	7.0 ps @8000 rpm
Max torque	7.5 nm
Bore*Stroke	50 mm*49.5 mm
Fuel type	petrol
Starter	kick
Number of speed gear	4

Table 1: Engine Specifications

III. Experimental Method

Before the experiments, the 97.2 cc IC engine was modified and connected to a compressed air tank. The cam profile was modified to be conjugate to change the engine from 4-stoke to 2-stroke operation. After the engine was installed, the intake and exhaust valves were examined for possible leakage under high-air-pressure operation. The leakage of the intake valve was thus close to the flow rate in the experiments, and it seriously affected the performance of the compressed air engine. The exhaust valve leakage was examined when the engine was locked in the intake process, and no leakage was observed. For load testing of air engine, it is connected with the rope break dynamometer with brake drum, spring balance, belt and holding frame. Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, alternator, differential, water pump, and other auxiliary components such as power steering pump, muffled exhaust system, etc. Brake refers to a device which was used to load an engine and hold it at a desired RPM. During testing, the output torque and rotational speed were measured to determine the brake horsepower. Horsepower was originally measured and calculated by use of a brake drum connected to the engine's output shaft. Brake power is the power produced by the engine as measured by the brake drum. For specific air consumption, mass flow rate is calculated by use of weighing balance for particular time period.

Fig. 1:

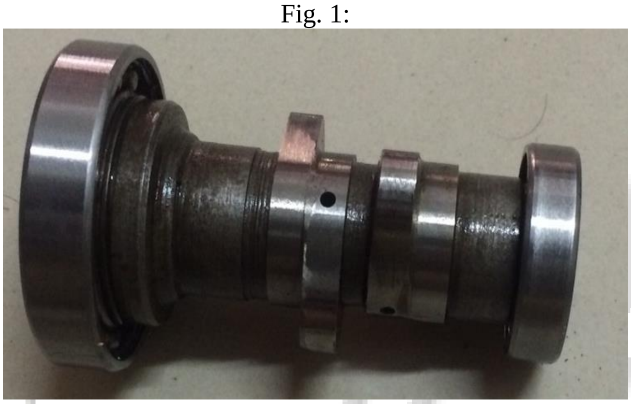

Fig. 2:

Fig. 3: Experimental Set Up For Air Engine with Modified Cam

IV. Results & Discussion

The observation were noted at constant pressure 6 kg/cm2 with varying load condition.

No.	W in kg	Speed in rpm	Initial weight of cylinder in kg	Final weight of cylinder in kg	Mass flow rate(kg/min)	Break power (KW)	specific air consumption (kg/kw*mim)
1	0.5	880	60.100	59.840	0.26	0.339	0.766
2	1	622	58.750	58.460	0.29	0.479	0.605
3	1.5	480	57.530	57.210	0.32	0.554	0.577
4	2	450	56.300	55.920	0.38	0.693	0.548
5	2.5	415	55.320	54.900	0.42	0.799	0.525

Table 2: Observation Table

From above graph, Figure 2, it is concluded that brake power is increases with increase in load at particular inlet pressure. Reason for that brake power is a function of torque and torque is directly proportional to load.

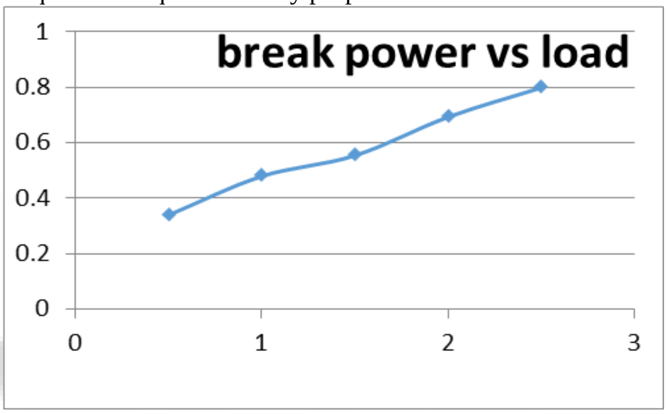

Fig. 2: Variations in B.P with Load

From above graph, Figure 3 it is concluded that mass flow rate is Increases with increase in load at particular inlet pressure.

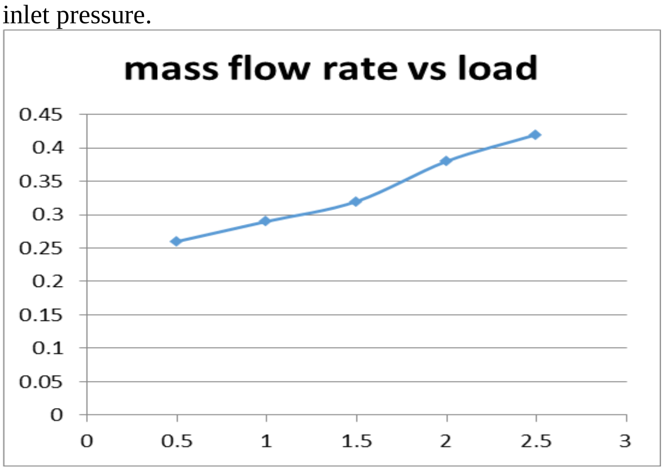

Fig. 3: Variations in mass flow rate with Load

From Figure 4, shows that speed is increases with increase in specific air consumption at particular inlet pressure.

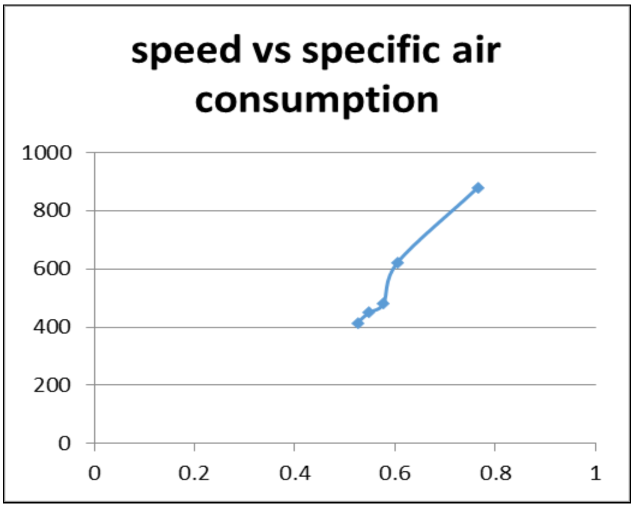

Fig. 4: Variations in speed with specific air consumption

Figure 5, depicts the break power at different speed at particular inlet pressure. Here at constant pressure 6 kg/cm2, break power is decreases with increase in speed.

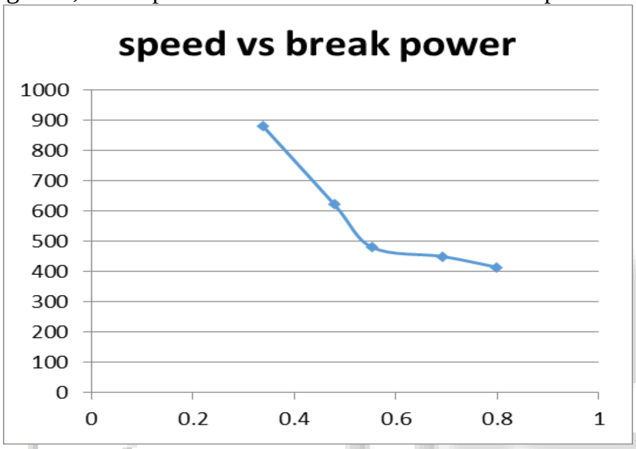

Fig. 5: Variations In Speed With Break Power

V. Conclusions

This study presents that the compressed air engine, which was modified from a commercially available IC engine, at constant pressure 6 kg/cm2 provide max 0.779 kW power output with varying load 0.5 kg to 2.5 kg . The performance of the CAE is mainly influenced by the rotation speed and supply pressure. Compressed air engine solves the both the problems of fuel crises as well as pollution.

References

[1] Veziroglu, T. N., Sahin, S. (2008). 21st century's energy: hydrogen energy system. Energy Conversion and Management, vol. 49, no. 7, p. 1820-1831,DOI:10.1016/j.enconman.2007.08.015.
[2] Li, Y., Chen, H., Zhang, X., Tan, C., Ding, Y. (2010). Renewable energy carriers: Hydrogen or liquid air/nitrogen?. Applied Thermal Engineering, vol. 30, no. 14-15,p.1985-1990, DOI:10.1016/j.applthermaleng.2010.04.033.
[3] Shafiee, S., Topal, E. (2009). When will fossil fuel reserves be diminished? Energy Policy, vol. 37, no.1, p.181-189, DOI:10.1016/j.enpol.2008.08.016.
[4] Bergant, A., Kruisbrink, A., Arregui, F. (2012).Dynamic behavior of air valves in a large-scale pipeline apparatus. Strojniški vestnik - Journal of Mechanical Engineering, vol. 58, no. 4. p. 225-237, DOI:10.5545/sv-jme.2011.032.
[5] Vukčević, V., Werner, A., Degiuli, N. (2012). Application of smoothed particle hydrodynamics method for simulating incompressible laminar flow. Transactions of Famena, vol. 36, no. 4, p. 1-13.
[6] Dudić, S.P., Ignjatović, I.M., Šešlija, D.D., Blogojević, V.A., Stojiljković, M.M. (2012). Leakage quantification of compressed air on pipes using thermovision. Thermal Science, vol. 16, Suppl. 2, p. 555-565, DOI:10.2298/TSCI120503191D.
[7] Papson, A.; Creutzig, F.; Schipper, L. Compressed air vehicles: Drive-cycle analysis of vehicle performance, environmental impacts, and economic costs. Transp. Res. Rec. J. Transp. Res. Board 2010, 2191, 67–74.
[8] Kang, H.; Tai, C.; Smith, E.; Wang, X.; Tsao, T.; Blumberg, P.; Stewart, J. Demonstration of Air-Power-Assist (APA) Engine Technology for Clean Combustion and Direct Energy Recovery in Heavy Duty Application. In Proceedings of SAE World Congress and Exhibition, Detroit, MI, USA, 14 April 2008; SAE International: Warrendale, PA, USA.
[9] Schechter, M. New Cycles for Automobile Engines. In Proceedings of International Congress and Exposition, Detroit, MI, USA, 1 March 1999; SAE International: Warrendale, PA, USA.
[10] Motor Development International (MDI) Web Page. AIRPod. Available online: http://www.mdi.lu/english/airpod.php (accessed on 27 August 2012).
[11] Chih-Yung Huang *, Cheng-Kang Hu, Chih-Jie Yu and Cheng-Kuo Sung (2013) Experimental Investigation on the Performance of a Compressed-Air Driven Piston Engine, Energies, 6, 1731-1745; doi:10.3390/en6031731, www.mdpi.com/journal/energies
[12] IDEX_Coporation Gast Airmotor Web Page. Gast Air andGearMotors.Availableonline:http://www.gastmfg.com/product_overview_air_motors.aspx (accessed on 8 March 2013).

