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Estimation of Run Time Parameters of Compressed Air Engine Prototype

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Abstract: As the world is hard pressed with the energy and fuel crises, compounded by pollution of all kinds, any technologies that bring out the solutions to this problem is considered as a bounty. In one of such new technologies, is the development of a new engine called as compressed air engine which does not require any of the conventional fuels like diesel, petrol, CNG, LPG, hydrogen etc. This paper describes the modeling of the prototype of compressed air engine. Different experimental investigations have been performed over this model to identify the variations in different parameters like torqe, rpm with respect to the input pressure. Early cost analysis shows that it's very cost effective and the operational cost is ten times less than that of petrol or diesel. However, the performance characteristics like brake power, mechanical efficiency have been found to be within the acceptable limit.

Keywords: compressed air engine, experimental investigation, torqe, rpm, mechanical efficiency.

Introduction

Fossil fuels (i.e., petroleum, diesel, natural gas and coal), which meet most of the world's energy demand today, are being depleted rapidly. Also, their combustion products are causing global problems, such as the greenhouse effect, ozone layer depletion, acid rains and pollution, which are posing great danger for our environment. These factors are leading automobile manufacturers to develop cars fuelled by alternative energies. One possible alternative is the air powered car. Air, which is abundantly available and is free from pollution, can be compressed to higher pressures at a very low cost, is one of the main motive since atmospheric pollution can be permanently removed. In one of such new technologies, is the development of a new engine called as compressed air driven engine, which does not require any of the known fuels like petrol, diesel, CNG, LPG, hydrogen etc. this works using only compressed air. This replaces all types of to date known fuels and also permanently solves the problem of pollution, since its exhaust is clean and cool air, which is measured practically as low as 5℃. A prototype, a horizontal, double acting single cylinder low speed engine was modified to run on compressed air. This evolutionary engine is the first of its kind in India and second of this kind in the world. However some of the modifications are very unique, which makes it a very unique engine. Extensive research is in progress to eliminate all the problems of design. Air motors, pneumatic actuators and other various such pneumatic equipment's are in use. Compressed air was also used in some of the vehicle for boosting the initial torque Turbo charging has become one of the popular techniques to enhance power and improve the efficiencies of the automotive engines. It was also under study to develop a reciprocating automotive engine that completely runs on compressed air. There are at least two ongoing projects (In France, by MDI and in S. Korea) that are developing a new type of car that will run only on compressed air. Similar attempt has been made to make an engine and to test on compressed air.

FAZELI et al. [1] have experimented and concluded on strategy for hybrid engines. A novel compression strategy for air hybrid engines is proposed utilizing two storage tanks which increases the efficiency of regenerative braking of air hybrid vehicles significantly by increasing the stored air mass and, consequently, the storing pressure in the tank. The experimental results show at least 70% improvement in storing pressure and 125% improvement in energy storing capability in the regenerative braking process using the double-storage system.CHUNG et al.[2] Currently in Taiwan, there are more than 13 million motorcycles, mostly driven by internal combustion engines, and the pollutants, carbon monoxide (CO) and unburnt hydrocarbons (HC), generated by motorcycle are responsible for more than 10% of the air pollutants released to the atmosphere. The studies show that the internal combustion engines of motorcycles may generate up to two times more pollutants than those of automobiles. In order to improve the air pollution condition and eliminate the pollutants exhausting, this paper presents a new idea of using compressed air as the power sources for motorcycles. Instead of an internal combustion engine, this motorcycle is equipped with an air motor, which transforms the energy of the compressed air into mechanical motion energy. A prototype is built with a fuzzy logic speed controller and tested on the real road. The experiment data shows that the speed error is within 1 km/h and the efficiency is above 70% for this system when the speed is over 20 km/h. NAYAK et al.[3] have given a review on

compressed air vehicle. Diesel and Petrol engine are frequently used by automobiles industries. In view of above, the need of some alternative fuel has been arises which lead to the development of CAVs (Compressed Air Vehicle). Applications of such compressed air driven engine are in small motor cars. SZABLOWSKI et al. [4] have presented a dynamic analysis of the compressed air energy storage in the car. The analysis was used to determine those processes most relevant to achieving highest possible efficiency. A review of the state of the art is presented. Simple technical-economic analysis of usage those kind of cars is also performed and discussed by taking Polish local conditions from an electricity market. Main advantages as well as drawback of the compressed air cars are pointed out.BASBOUS et al. [5] have experimented and concluded on hybrid pneumatic combustion engine. This paper presents an evaluation of an optimized Hybrid Pneumatic-Combustion Engine (HPCE) concept that permits reducing fuel consumption for electricity production in non-interconnected remote areas, originally equipped with hybrid Wind–Diesel System (WDS).The evaluation of the concept is based on ideal thermodynamic cycle modeling. MANISH et al. [6] have experimented and concluded on compressed air engine.

This paper is reports on the review of compressed air engine (bikes/moped) can be run on the compressed air with a few modifications that are the main objective of the study. Main advantage of this engine is that no hydrocarbon fuel required means no combustion process is take place for the design and development of single cylinder engine, which can be run by the compressed air. LAL and NAG [7] has done the design and analysis of a single stroke compressed air engine. This paper contains design and dynamic analysis of a light weight single stroke compressed air engine it does not required any of the fossil fuels like petrol, diesel, CNG, LPG, hydrogen etc. to run engine and no power is required to start up engine only compressed air valve is to be opened. It works on compressed pressure air and hence is pollution free and 100% eco-friendly. HUA-LU et al. [8] have done research and they performed model simulation on hybrid pneumatic engine. In this study, they develop a model pneumatic hybrid motorcycle system and simulate its acceleration and mileage (km/L) performance. The results show that the pneumatic hybrid motorcycle can improve efficiency with an appropriate control strategy for driving operation .HUANG et al. [9] have experimented on compressed air driven piston engine and gave a report on its performance. The experiments in this study used a test bench to examine the power performance and pressure/temperature variations of the compressed air engine at pressures ranging from 5 to 9 bar (absolute pressure).YADAV, BHARAT et al. [11] have studied and fabricated a compressed air engine. This paper is based on the design of a proto type, a horizontal, single cylinder low speed engine was modified to run on compressed air. Since this engine runs only on high pressure compressed air, the exhaust of which is undoubtedly only air, making it a zero pollution engine. This paper is on the performance and efficiency of pneumatic engine with respect to other engines. In this study, we develop a model pneumatic hybrid motorcycle system and simulate its acceleration and mileage (km/L) performance. ZHANG et al**.** [12] have studied the performance and design criteria of air powered multistage turbines are studied thermodynamically in this paper. In-house code is developed in the C++ environment and the characteristics of four-stage turbines with inter-heating are analysed in terms of maximum thermal efficiency, maximum exergy efficiency and maximum work output over the inlet temperature range of 293 K–793 K with inlet pressure of 70 bar. Kumar et al. [13] have given a statement on gas expansion, a new structure of reciprocating air-powered engine is proposed. It can convert the reciprocal motion of piston into one-way rotary motion of the output shaft and provide engine power. According to the pneumatic transmission system dynamics, the mathematical model of the air-powered engine is established and simulated.

Working Principle of the Compressed Air Engine

At first the compressor switch was switched on the compressor to provide compressed air to the flow regulating valve. From the flow regulating valve compressed air is supplied to the directional control valve and limiting switches. The pneumatic pipes are connected with limit switch, dc valve, pneumatic cylinder, FRL and with compressor. There are 7 pneumatic pipes are used to run the machine. Four pipes are connected with 2 limit switches. Two pipes are connected with pneumatic cylinder. These two piper further connected with 5/2 direction control valve(two output pots).the limit switch inlet port pipes are connected with FRL and output pipes are connected with 5/2 direction control valve. These two pipes are used to control the spool .another last one pipe is connected with FRL and main inlet of the 5/2 direction control valve. Air supplied from compressor passes to FRL unit. The pressure is maintained according to requirement. Always air pressure maintained at the inlet of DC valve and at the limit switch. When one limit switch pressed according to the movement of the cam arrangement, the air passes through the limit switch and it changes the spool position inside the DC valve. Thus the direction of the air flow changes. The air flows from opposite direction and piston moves is opposite direction from its previous. This process occurs for 180 degree movement of crank. The after half rotation of crank the other limit switch pressed by the cam arrangement and it changes the spool direction again. Thus again the direction of piston movement changes and thus the cycle goes on and piston reciprocates inside the pneumatic cylinder. The cam arrangement is made by making 2 elevated portions on the cylindrical portion of the dynamo. The elevated portions are calibrated and made according to the dwell period. The dwell angle of the machine is 20 degree. According to the angel the elevated portions are made. According to the above circuit diagram the arrangement are made and conducted the experiment.in the circuit diagram two limit switches are used to control the piston movement and reciprocate it at a very faster rate. The reciprocating to rotary motion and the crank rotates in 360 degree. Then torque generated and power trance mission occurs from crank to the gears ant finally from gears to the chain spiked and to the wheel.

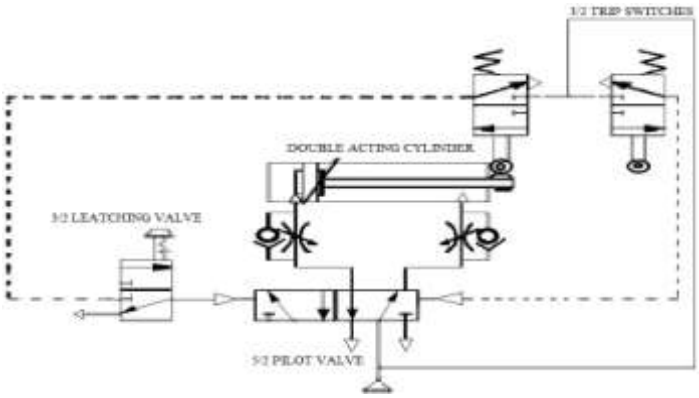

Figure 1: Circuit diagram of the engine.

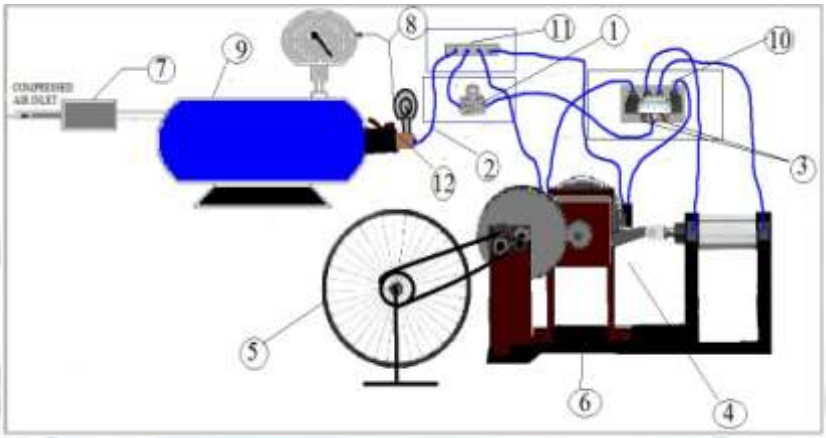

Figure 2 Schematic diagram of air driven engine

Development of the Prototype

The prototype has been developed according to the circuit diagram [Fig. 1]. The different parts are (1) Flow control valve/acceleration control valve, (2) Inlet tube, (3) Exhaust port, (4) Engine, (5) Wheel, (6) Stand, (7) Non return valve, (8) Pressure gauge, (9) Air tank, (10) Direction control valve, (11) Air distributer, (12) Pressure control liver.

The limit switches are fitted with the engine. The limit switch used in experiment is 5/2 Poppet valve with Roller lever (Normally closed).it has Poppet seating arrangement.Its operating pressure limit is 10 bar and inlet and outlet port diameter is 6mm.the inlet ports are connect with supply of compressed air. The supply was controlled by FRL unit. The outlet ports were connected with the direction control valve. The FRL can supply and regulate the pressure of air up to 20 bar. The direction control valve operating pressure was 10 bar. The direction control valve was 5/2 dc valve. One main inlet was connect main pressure line and other 2 ports are connected with the limit switch outlet pipes. The rest 2 ports of dc valve was connected with pneumatic cylinder 2ports.the pneumatic cylinder has stroke length of 50mm and bore diameter of 50 mm. The operating pressure is 10 bar. it has cushioning effect on both end of the cylinder. Rest all the components of the air engine were connected through pipes with pneumatic trainer kit. .The experiment is conducted at different pressure and at different rpm with varying the lode.

Figure 3 Prototype of the Compressed Air Engine

Results and Discussion

Table 1 Values of RPM at different Pressure

Pressure (In bar)	RPM			Average RPM
	1st observation	2nd observation	3rd observation	
0.5	95	92	95	94
0.75	100	102	103	101.67
1	150	143	148	147
1.25	168	169	170	169
1.5	195	191	193	193
1.75	225	222	220	222.34
2	301	296	293	296.67

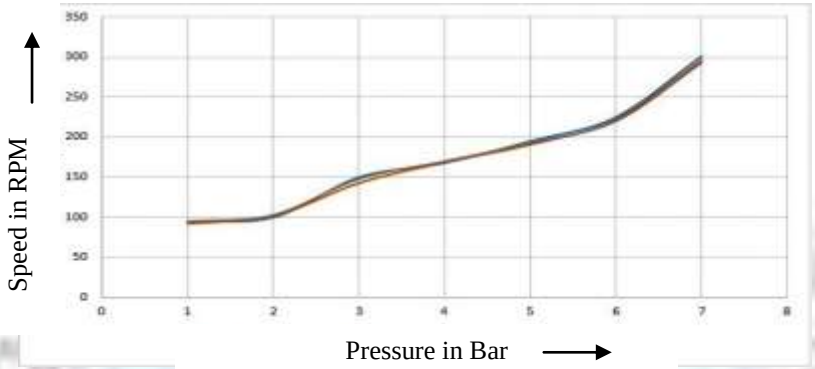

Figure 4 Variation of Speed with Pressure

Table 2 Power and Torque generated at different Pressures

Pressure in (Bar)	Power developed in (Watt)	Torque generated in (N-m)
0.5	13.42	1.423
0.75	21.81	2.042
1	42.71	2.718
1.25	57.41	3.244
1.5	84.33	4.172
1.75	111.09	4.757
2	169.66	6.302

Table 3 Brake Power at different RPM

Speed in (RPM)	Break power in (KW)
95	0.00425
102	0.0045
149	0.0075
169	0.0078
194	0.0086
223	0.0099
298	0.0133

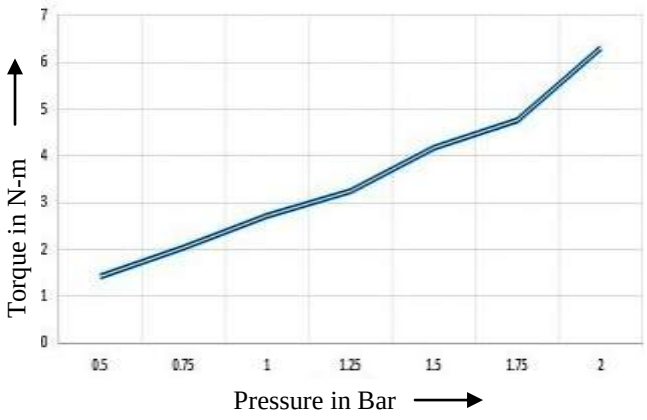

Figure 5 Variation of Torque with respect to Pressure

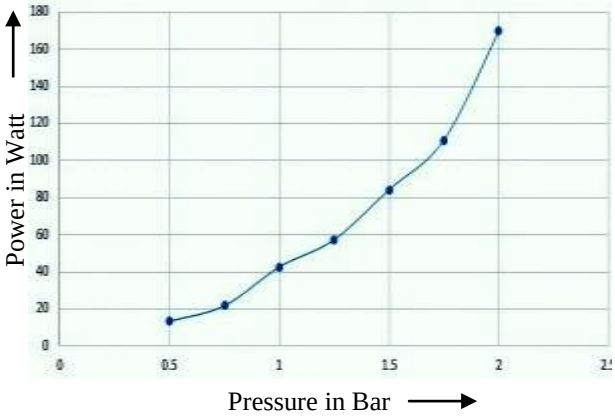

Figure 6 Variation of Power with respect to Pressure

The circuit diagram of the engine has been shown in Fig. 1. The schematic diagram and prototype have been shown in Fig. 2 and Fig. 3 respectively. Table 1 depicts the observed values of RPM and the average values of RPM against different pressures. Fig. 4 presents the variations of speed with pressure. The observations were noted by varying pressure and zero load condition. Table 2 presents the variations of power and torques against the pressures. Table 3 depicts the brake powers at different speed. Fig. 5 and Fig. 6 depict the variations of torques and powers with respect to the pressures respectively.

The speed of the engine is found to increase almost linearly with the increase in the pressures. Moreover, the torque and power generated also increase linearly with respect to the change in pressure.

Conclusion

Single cylinder pneumatic engine can be encouraged for its use as an alternate for an IC engine in future. Exhaust of gases is at very low temperature than conventional IC engine which solves problem of engine heating up to a great extent. Engine can be made up of lighter weight as heating of engine is reduced. Zero carbon emission can be achieved if air is compressed from the renewable source of energy like wind, flowing water, dams or tidal energy. This can be a major step towards pollution free environment. This concept can also be used in stationary applications where space is available and power is produced by single cylinder IC engine. This is a revolutionary engine design which is not only eco-friendly, pollution free, but also very economical. This addresses both the Problems of fuel crisis and pollution. However excessive research is needed to completely prove the technology for both its commercial and technical viability.

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