

The Fourth Most Utility: - Compressed Air Engine



Mudit sharma, Abhishek kumar singh, Abhishek, Rahul kumar, Raman sohal

Abstract: *this paper describes the working of compressed air engine which is regarded as the fourth most utility after electricity, natural gas and water. Compression, storage, and release of air are termed as compressed air technology (CAT)As we know that the pollution caused by combustion of fuel is polluting the environment. Compressed air engine basically replaces the combustion of fuel with compressed air technology. Here air is compressed in small volume and stored in container. Since the air is at high temperature, it contains some amount of energy. This energy can be used to do some useful work (such as displacing the piston). The piston transmits the energy to crank which in turn rotates the wheels. Many other advantages of compressed air engine are there such as it is less costly, simple mechanism, easy to maintenance, explosion free. It can also be used for doing various operations in industries such as drive for conveyors, fluid pumps for small displacement.*

Keywords: *efficiency of CAT, load testing, pneumatic piston, 5-way-2position, rotary compressor, solenoid valve.*

I. INTRODUCTION

The engine that is worked via air was first applied to the field of transportation inside the mid-nineteenth century. 2 centuries before Dennis Papin thought of the idea of exploitation compacted gas. Makarska motors were first used by Tramway Delaware port on Gregorian schedule month thirteen, 1879, to control their armada of trains. it's arranged in port, France. Robert Hardie had presented a substitution strategy of warming that will expand the differ of the motor that assisted with stretching out in separation in 1892. Charles B Hodges will be recognized as a genuine dad of gas thought because of he didn't design exclusively vehicles that pass by gas anyway even have significant mechanical accomplishment with it. After the work of twelve years of looks into and advancements

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* Correspondence Author

Mudit Sharma*, Assistant Professor, Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India.

Abhishek kumar singh, UG Students of Department of Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India

Abhishek, UG Students of Department of Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India

Rahul kumar, UG Students of Department of Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India

Raman shoal, UG Students of Department of Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India

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French architect by calling Guy Negre has conjointly planned low utilization and low contamination making a motor for urban individuals' driving that sudden spikes in demand for compacted air technology(CAT). In the year 2008, India's biggest maker organization TATA was conjointly pronounced that it would present the world's first modern vehicle which can run on gas^[1].

II. LITERATURE REVIEW

In previous research work of pneumatic piston as shown above, it clearly indicates that due to position of pneumatic piston there will be power loss, energy loss which directly reduces the efficiency of the compressed air engine, so we are trying to increase this lost efficiency by giving the robust structure to the pneumatic piston with the help of piston chain arrangement.

Now coming on to the “cost benefit analysis” part, it is evident that using of multi-way solenoid valve is beneficial but with the help of cost benefit analysis tool we come to our conclusion that instead of using multi-way solenoid valve we can use 5-way solenoid valve which consequently decrease

RESEARCHER	RESEACHES
VISHWAJEET SINGH* et al [JULY-2017]	The specialist performed experiment on the compressed air engine whereas they incorporate the inversion of single slider crank chain i.e. oscillating cylinder engine (piston position). Further they used multi-way solenoid valve which the way for inlet and exhaust of compressed air.
GAURAV KUMAR* et al [November-2015]	The specialist did experiment on the compressed air engine whereas they incorporate the inversion of single slider crank chain i.e. pendulum pump or bull engine (piston position). Further they used multi-way solenoid valve which the way for inlet and exhaust of compressed air.
QIHUI YU* et al [JUNE-2015]	The researcher did an experiment on CAE (compressed air engine) where they got the output torque, power and efficiency are obtained when the supply pressure is 2MPa, the maximum output power is 1.92 KW, the maximum output torque is 56.55 N-m and the maximum efficiency is 25%. They use engine specification as; <ul style="list-style-type: none"> • BORE dia; 85 mm • Stroke;88mm • Displacement; 0.5L • intake port diameter; 12mm • compression ratio; 10

cost benefit analysis part, hence in nutshell cost of the arrangement decreases.



III. COMPONENTS

A. DC BATTERY

All vehicles, in today's world operate using 12volt, direct current (DC), electric system. These batteries consist of 6cell.



Fig:3.1 DC BATTERY

B. MINI COMPRESSOR

It is a device that is used to compress the air, this compressor compresses the air upto 150psi. Air is compressed in small volume and stores in cylinder tank. Compressed air is having high pressure and contains some amount of energy within it.



Fig:3.2 MINI COMPRESSOR

C. PRESSURE CONTROL VALVE

Pressure control valves are used to regulate the pressure (according to the use) to certain amount in order to keep the component safe. They are found in almost every fluid system component.



Fig:3.3 PRESSURE CONTROL VALVE

D. SOLENOID VALVE

5/2 way is a five port; 2 position valve will allow fluid or air into one end of a double acting device as well as allowing the other end vent to exhaust.

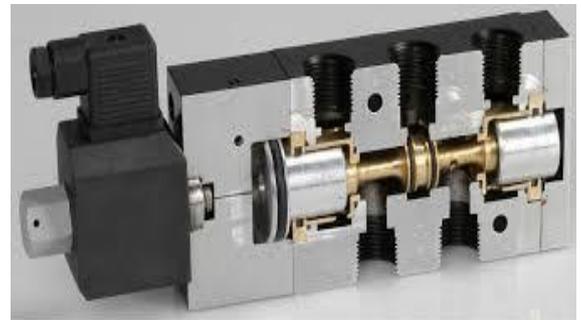


Fig:3.4 5/2WAY SOLENOID VALVE

E. TIMER

We use 555 timer IC as an integrated circuit (chip). It is used in a variety of machines to set the time period for which the component works. It is used to provide time delays, as an oscillator, and as a flip-flop element.



Fig:3.5 555 TIMER IC

F. PNEUMATIC PISTON

Pneumatic piston is used to provide linear motion. This linear motion takes place by the help of compressed air. Since compressed air contain energy within it, it exerts force on the piston and the piston moves linearly. This linear motion can be further converted in rotary or reciprocating motion.



Fig:3.6 RESCIPROCATING PISTON

G. CRANK SHAFT

Crankshafts are used to convert the linear motion of the connecting rod into rotary motion. Crankshafts are commonly used in IC engines and consist of a series of cranks and crankpins to which the connecting rods are attached.



Fig:3.7 CRANK SHAFT

IV. TECHNOLOGY OF COMPRESSED AIR

Primary goal of compressed air in vehicle is to reduce the consumption of energy without deteriorating its work output which consequently increases the engine efficiency to far great extent, secondly to foster urban life style through paving the way for eco-friendly environment

ADIABATIC PROCESS: in this process there is no heat interaction between system and surrounding, in a nut shell there is no heat loss from the air which lead to pressure rise, which means maximum value requirement increases.

ISOTHERMAL PROCESS: In this process temperature remain constant through-out the process in a nut shell air temperature remain constant, which means work requirement decreases to least value

However according to chart mention below, which shows that isotherm expansion($T=C$) is larger as compared to adiabatic expansion($Q=C$).

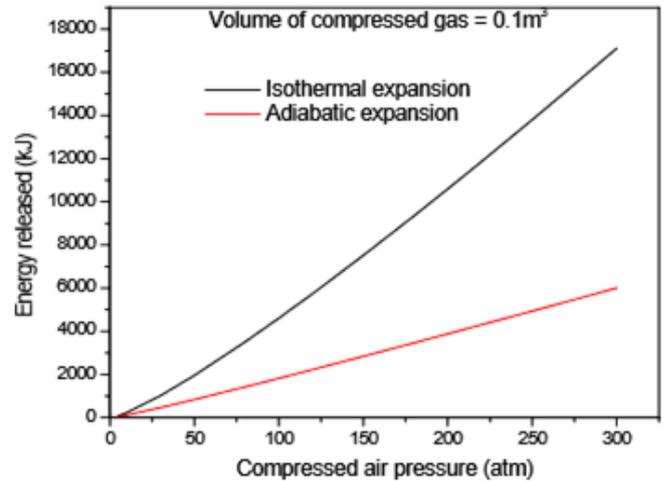


Fig:4.1 VARIATION OF PRESSURE AND ENERGY RELEASED

The engine is completely depending on compressed air, not by combustion, hence the matter of dangerous and harmful gases which accustomed embark from the Ic engine is completely eradicated by this gas technology which consequently paved the way for a cleaner environment.^[2]

V. WORKING

The compressed air engine is working on air alone without any combustion of fuel inside the cylinder takes place. In this we use compressed air stored in the compressor tank at 150psi. The air is fed through an air injector into a solenoid valve. The solenoid valve is of 5/2. In 5 port solenoid valve there is 2 port at the top which is called as inlet port for pneumatic cylinder in addition there is 3 port at the bottom which include 2-exhaust port for pneumatic piston and 1-inlet port for compressed air.^[3]

CASE-1 (solenoid valve is de-energized)

The plunger will be at initial position and one of the inlet port at this condition remain open which paved the way for compressed air and consequently piston move from the bottom dead center(BDC) to top dead center(TDC).^[4]

CASE-2(solenoid valve is energized)

Then plunger move towards opposite direction due to virtue of conductor which result in opening of another port and closing the earlier one. Now compressed air goes to that port which is open and eventually piston moved from top dead center to bottom dead center, because former compressed air now tends to move out from one of the exhaust port.^[4]

CASE-3(solenoid valve de-energized)

In this case pneumatic piston move from bottom dead center to top dead center and former compressed air leaves the piston through another exhaust port.^[4]

WORKING

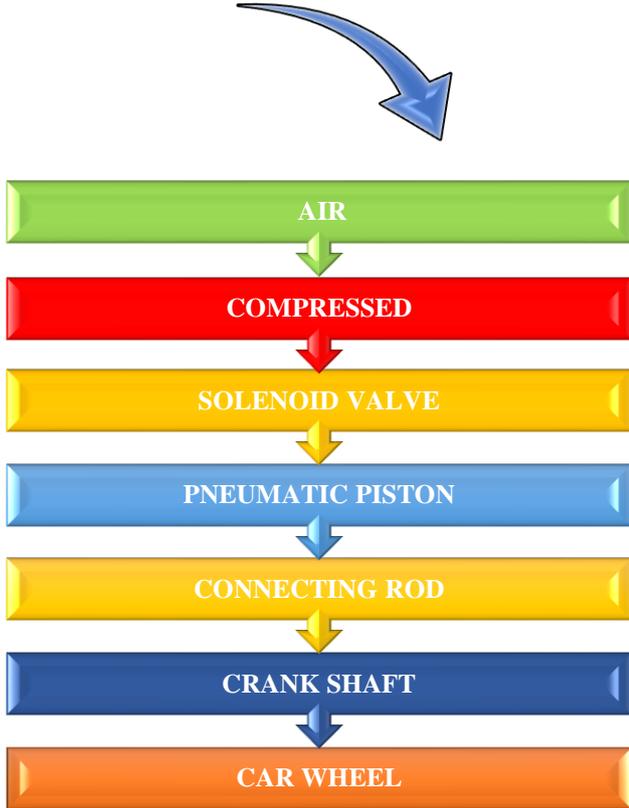


Fig5.1: WORKING

HOW COMPRESSED AIR CAN RUN AN ENGINE

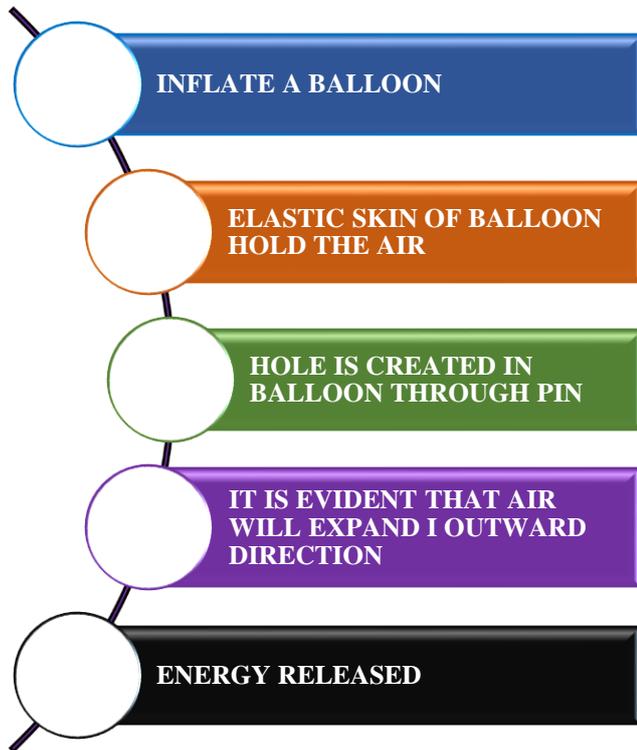


Fig5.2: COMPRESSED AIR CAN RUN AN ENGINE

Block diagram

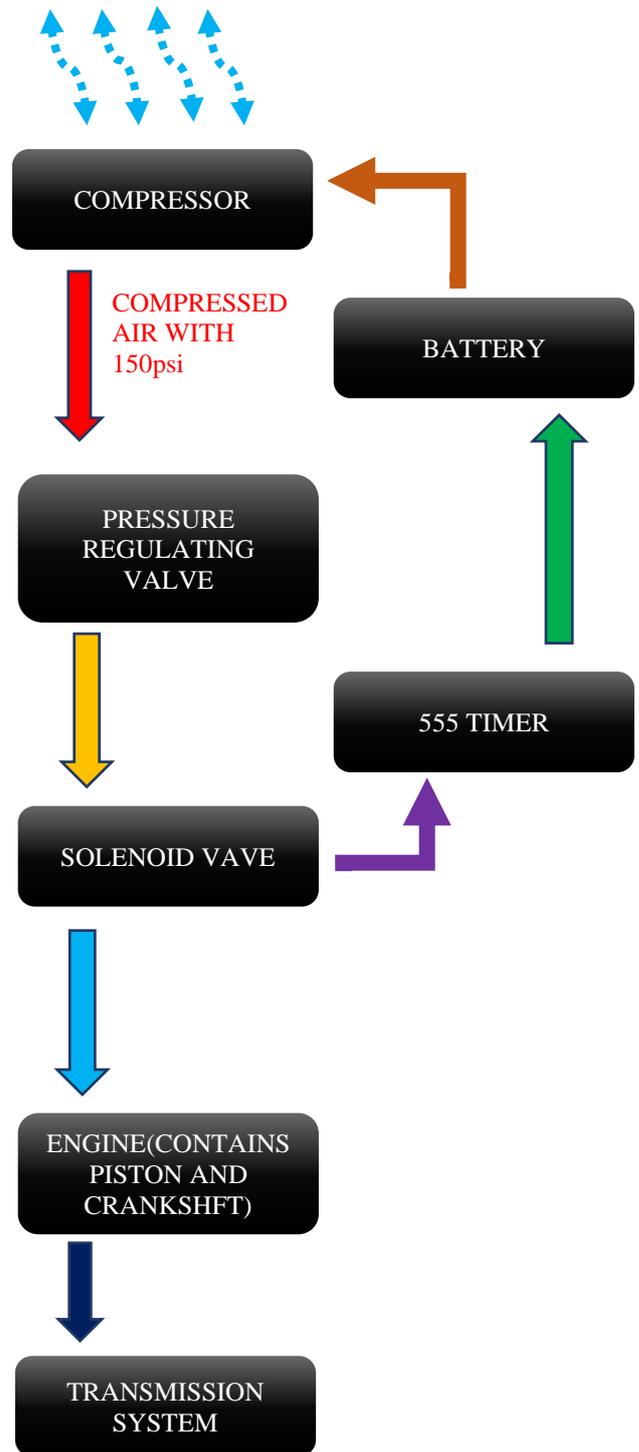


Fig5.3: BLOCK DIAGRAM

VI. SPECIFICATION

Bore	20mm
Stroke	50mm
Intake port diameter	1/16inch
Exhaust port diameter	1/16inch

VII. CALCULATIONS: -

FORCE AND TORQUE CALCULATION: -

Friction force = $\mu * N$

$$\begin{aligned} &0.3 * 9.81 * 12 \\ &35.316 \text{ N} \end{aligned}$$

- T_R = resisting torque on wheel
- T_L = linear or translational torque
- T = net torque
- F_P = force on piston
- n = revolution per seconds
- ω = angular speed of CAE
- p_{in} = inlet pressure
- Q = airflow value under compressed condition

We know that,

$$T_L = (F * R) + I\alpha$$

Where, $\alpha = \frac{a}{R}$ & $I = \frac{MR^2}{2}$

$$T_L = (F * R) + \left(\frac{a}{R}\right) * \left(\frac{M * R^2}{2}\right)$$

$$T_L = \frac{3}{2} * F * R$$

$$T_L = \frac{3 * 35.31 * 50 * 10^{-3}}{2}$$

$$T_L = 2.648 \text{ N-m}$$

$$F_P = \frac{T_L}{R}$$

$$F_P = \frac{2.648 * 1000}{20}$$

$$F_P = 132.4125 \text{ N}$$

Pressure required to move object (P) = $\frac{F_P}{A}$

$$= \frac{132.4125 * 4 * 10^6}{\pi * 20 * 20}$$

$$\begin{aligned} &= 421482.078 \text{ N/mm}^2 \\ &= 4.21482 \text{ bar} \\ &= 61.13 \text{ psi (pounds-force per square inch)} \end{aligned}$$

Power calculation: -

The power obtained at the output of the engine is calculated by: -

$$\text{Power} = \frac{T_L * n}{9550} \text{ kW}$$

OR

$$\text{Power} = \frac{T_L * n}{63025} \text{ H.P}$$

Efficiency calculation: -

Efficiency means the ratio of output energy to the input energy

$$\eta = \frac{\omega * T_L}{p_{in} * Q}$$

$$\eta = \frac{2 * \pi * n * T_L}{p_{in} * Q}$$

VIII. RESULT AND DISCUSSION

Pressure (psi)	Torque (N-m)	RPM	Power (kW)
85.3164	3.70	200	0.08
106.64	4.62	250	0.13

As we see in the above table and calculation, the minimum torque required to move the object is approximately 3N-m and the pressure is 61 psi. In our experiment, we saw the variation of speed with different pressure, at approx.85 psi and 106 psi the corresponding speed is 200 rpm and 250 rpm respectively and the maximum power output is 0.08KW and 0.13 respectively.

- The output torque falls with a rise in the rotation speed and ascends with increasing the supply pressure. The maximum torque can be obtained at the minimum rotation speed and the peak supply pressure. When the supply pressure 106 psi, the output torque is 4.7N-m.
- The energy efficiency decreases with a rise in the rotation speed and supply pressure. When the supply the pressure is 106 psi, the maximum efficiency obtained is 27%.

IX. CONCLUSION

In the present climate, we see the need for energy is at heightening, however essentially the traditional supply of energy is limited and not up to the mark. To satisfy the need of different sectors we have to think about some efficient technology, and (CAT)compressed air technology is that which leads to full fill the requirements of different sectors. This technology gives Zero pollution at the exhaust and uses minimum power and provide optimum output.



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After that, we tend to get each answer that we tend to expect from our surroundings as, by this technology its potential to unravel the surroundings drawback what we're facing today? after all, we can do something and everything that we wish. currently, we've got been to the moon. we tend to even have been into the area. If we've broken one thing no matter it ought to be currently simply it ought to be improved^[5].

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AUTHOR PROFILE



Mr. Mudit Sharma, B.Tech (ME) and M.Tech (National Institute of Technical Teachers Training & Research, Chandigarh) is presently serving as an Asst. Prof. in Dept. of Mech. in JEMTEC Greater Noida, having teaching experience. of over 10 Yrs. He has Publish more than 20 papers in Int. Journals. He has also guided more than 10 Undergraduate projects. His areas of research are Advanced Thermal Engineering, Automobile, and Production Technology.



Abhishek Kumar Singh, is a final year student of Bachelor of Technology specialized in Mechanical engineering from JEMTEC Greater Noida college. He aims to take the technology at the height of glory with their skills and knowledge without compromising the ecosystem (no pollution and sustainable development). He has contributed to publishing a review paper on "cooling load estimation of an auditorium" Published on International Journal Of Research in Engineering and Science.



Abhishek, is a final year student of Bachelor of Technology specialized in Mechanical engineering from JEMTEC Greater Noida college. He aims to take the technology at the height of glory with their skills and knowledge without compromising the ecosystem (no pollution and sustainable development). He has contributed to publishing a review paper on "cooling load estimation of an auditorium" Published on International Journal Of Research in Engineering and Science.



Rahul Kumar is a final year student of Bachelor of Technology specialized in Mechanical engineering from JEMTEC Greater Noida college. He aims to take the technology at the height of glory with their skills and knowledge without compromising the ecosystem (no pollution and sustainable development). He has contributed to publishing a review paper on "cooling load

estimation of an auditorium" Published on International Journal Of Research in Engineering and Science.



Raman shoal, is a final year student of Bachelor of Technology specialized in Mechanical engineering from JEMTEC Greater Noida college. He aims to take the technology at the height of glory with their skills and knowledge without compromising the ecosystem (no pollution and sustainable development). He has contributed to publishing a review paper on "cooling load estimation of an auditorium" Published on International Journal Of Research in Engineering and Science.