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Air Engine

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Abstract: *This The Air Driven Engine is an eco-friendly engine which operates with compressed air. An Air Driven Engine uses the expansion of compressed air to drive the pistons of an engine An Air Driven Engine is a pneumatic actuator that creates useful work by expanding compressed air. There is no mixing of fuel with air as there is no combustion. An Air Driven Engine makes use of Compressed Air Technology for its operation The Compressed Air Technology is quite simple. If we compress normal air into a cylinder the air would hold some energy within it. This energy can be utilized for useful purposes. When this compressed air expands, the energy is released to do work. So, this energy in compressed air can also be utilized to displace a piston.*

Keywords: Air Driven Engine, Compressed air, Piston, pneumatic actuator

I. INTRODUCTION

At first glance the idea of running an engine on air seems to be too good to be true. Actually, if we can make use of air as an aid for running an engine it is a fantastic idea. As we all know, air is all around us, it never runs out, it is non-polluting and it is free.

An Air Driven Engine makes use of Compressed Air Technology for its operation. Compressed Air Technology is now widely preferred for research by different industries for developing different drives for different purposes. The Compressed Air Technology is quite simple. If we compress normal air into a cylinder the air would hold some energy within it. This energy can be utilized for useful purposes. When this compressed air expands, the energy is released to do work.

So, this energy in compressed air can also be utilized to displace a piston. This is the basic working principle of the Air Driven Engine. It uses the expansion of compressed air to drive the pistons of the engine. So, an Air Driven Engine is basically a pneumatic actuator that creates useful work by expanding compressed air. This work provided by the air is utilized to supply power to the crankshaft of the engine.

In the case of an Air Driven Engine, there is no combustion taking place within the engine. So it is non-polluting and less dangerous. It requires lighter metal only since it does not have to withstand elevated temperatures. As there is no combustion taking place, there is no need for mixing fuel and air. Here compressed air is the fuel and it is directly fed into the piston cylinder arrangement. It simply expands inside the cylinder and does useful work on the piston. This work done on the piston provides sufficient power to the crankshaft.

II. OBJECTIVE

The search engines Google Scholar, Scopus, and Science Direct were used to identify the most important articles relevant to this review. The combination of keywords Air Driven Engine, Compressed air, Piston, pneumatic actuator was used. The last search took place on May 20, 2022. Figure 1, illustrates the process of identifying and selecting relevant research articles.

The first stage involves searching for articles according to their titles and abstracts. Afterward, existing articles are sortedin order to select the appropriate ones that meet the following three basic criteria, namely: a) the subject should be related to Air engine, b) the working of air engine, and c) the subject should be related to automation. References in the list also led to the identification of additional papers. The final number of papers left in the database is 106 after exclusion from the database. In the second stage, abstracts from these papers are screened, which resulted in 90 potential articles being shortlisted. Then, the articles are read through to determine if they are relevant or not. 78 articles were deemed relevant at the end of the process.

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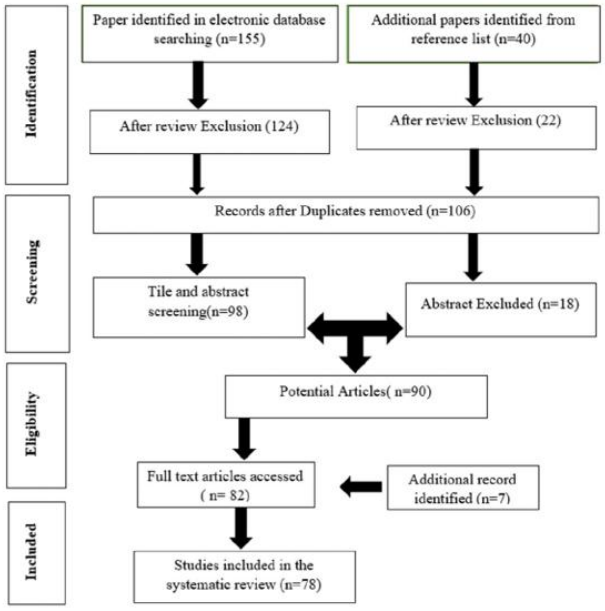

Figure 1. Flow chart for research paper identification and selection strategy

III. Literature Review

Compressed Air technology: Air can be compressed into small volumes and can be stored in suitable containers at high pressures. Such air compressed into containers is associated with an amount of energy. When the stored compressed air is released freely it expands thereby releasing the energy associated with it. This energy released can be utilized to provide useful work.

The compression, storage and release of the air together are termed as the Compressed Air Technology. This technology has been utilized in different pneumatic systems. This technology has been undergoing several years of research to improve its applications. Compressed air is regarded as the fourth utility, after electricity, natural gas, and water. Compressed air can be used in or for:

- Pneumatics, the use of pressurized gases to do work.
- vehicular transportation using a compressed air vehicle
- scuba diving
- To inflate buoyancy devices.
- Cooling using a vortex tube. Gas dusters for cleaning electronic components that cannot be cleaned with water.
- air brake (rail) systems
- air brake (road vehicle) systems
- starting of diesel engines (an alternative to electric starting)
- compressed air breathers (such as Suisse Air)
- pneumatic air guns
- pneumatic screwdrivers

Two Stroke Engine: A two-stroke engine is an internal combustion engine that completes the thermodynamic in two movements of the piston compared to twice that number for a four-stroke engine. This increased efficiency is accomplished by using the beginning of the compression stroke and the end of the combustion stroke to perform simultaneously the intake and exhaust (or scavenging) functions. In this way two-stroke engines often provide strikingly high specific power. Gasoline (spark ignition) versions are particularly useful in lightweight (portable) applications such as chainsaws and the concept is also used in diesel compression ignition engines in large and non-weight sensitive applications such as ships and locomotives.

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All functions are controlled solely by the piston covering and uncovering the ports as it moves up and down in the cylinder. A fundamental difference from typical four-stroke engines is that the crankcase is sealed and forms part of the induction process in gasoline and hot bulb engines. Diesel engines have mostly a roots blower or piston pump for scavenging.

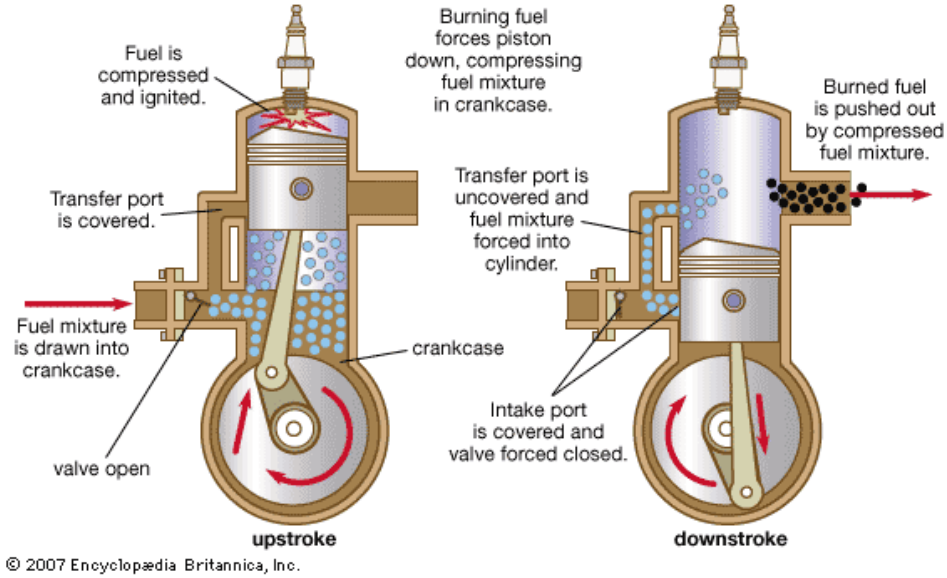

Figure 2. Working of two stroke engines.

There are no traditional valves in a two-stroke engine. In a two-stroke the engines fires once every revolution. This makes the engine highly efficient and lightweight compared to four-stroke systems. Rather than entering through valves, the fuel/air mixture enters through an intake port and exhaust exits out of an exhaust port. In place of traditional valves, the two-stroke engine uses the piston's position to force out exhaust or suck in fuel mixture.

Reeds are vital to a two-stroke system. The reeds are placed between the intake manifold and the carburettor, open and close to allow the fuel / air mixture to enter the case of the engine and trap it, and ensure the proper exchange of gasses in the engine. This procedure might sound complex, but it is, in fact, extremely effective and easy to understand.

The whole cycle can be explained as follows:

1) As the piston moves from bottom dead centre to top dead centre it creates a vacuum to draw the fuel / air mixture through the carburettor and past the reed valve assembly.

2) The piston moves down from top dead centre to bottom dead centre. The reed closes, causing the pressure to build in the cylinder. The movement of the piston uncovers the intake port and pressurized the fuel / air mixture.

3) The piston now moves up from bottom dead centre to top dead centre, effectively ending a cycle and starting another. The spark plug ignites the compressed mixture, sending piston back down.

4) At this point the piston uncovers the exhaust port, allowing the spent gasses to escape. As it continues to bottom dead centre, it uncovers the intake port and allows the fuel / air mixture through the carburettor and past the reed valve assembly.

Solenoid Valve: A solenoid valve is an electromechanical valve for use with liquid or gas. The valve is controlled by an electric current through a solenoid coil. Solenoid valves may have two or more ports: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically. A direct acting valve has only a small flow circuit, shown within section E of this diagram. This diaphragm piloted valve multiplies this small flow by using it to control the flow through a much larger orifice.

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Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened or closed while the valve is not activated.

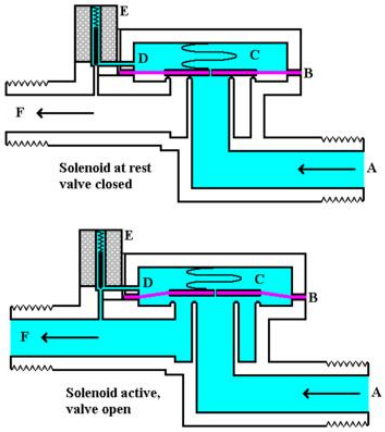

Figure 3. Working of solenoid valve.

A-Inputside
B-Diaphragm
C-Pressurechambe
D-Pressurereliefconduit
E-Solenoid
F- Output side

The diagram above shows the design of a basic valve. At the top figure is the valve in its closed state. The water under pressure enters at **A**. **B** is an elastic diaphragm and above it is a weak spring pushing it down. The function of this spring is irrelevant for now as the valve would stay closed even without it. The diaphragm has a pinhole through its centre which allows a very small amount of water to flow through it. This water fills the cavity **C**on the other side of the diaphragm so that pressure is equal on both sides of the diaphragm. While the pressure is the same on both sides of the diaphragm, the force is greater on the upper side which forces the valve shut against the incoming pressure. In the figure, the surface being acted upon is greater on the upper side which results in greater force. On the upper side the pressure is acting on the entire surface of the diaphragm while on the lower side it is only acting on the incoming pipe. This result in the valve being securely shut to any flow and, the greater the input pressure, the greater the shutting force will be.

In the previous configuration the small conduit **D** was blocked by a pin which is the armature of the solenoid **E** and which is pushed down by a spring. If the solenoid is activated by drawing the pin upwards via magnetic force from the solenoid current, the water in chamber **C** will flow through this conduit **D** to the output side of the valve. The pressure in chamber **C** will drop and the incoming pressure will lift the diaphragm thus opening the main valve. Water now flows directly from **A** to **F**.

When the solenoid is again deactivated and the conduit **D** is closed again, the spring needs very little force to push the diaphragm down again and the main valve closes. In practice there is often no separate spring, the elastomer diaphragm is moulded so that it functions as its own spring, preferring to be in the closed shape.

From this explanation it can be seen that this type of valve relies on a differential of pressure between input and output as the pressure at the input must always be greater than the pressure at the output for it to work. If the pressure at the output, for any reason, rise above that of the input then the valve would open regardless of the state of the solenoid and pilot valve.

In some solenoid valves the solenoid acts directly on the main valve. Others use a small, complete solenoid valve, known as a pilot, to actuate a larger valve. While the second type is actually a solenoid valve combined with a pneumatically actuated valve, they are sold and packaged as a single unit referred to as a solenoid valve. Piloted valves require much less power to control, but they are noticeably slower. Piloted solenoids usually need full power at all times to open and stay open, where a direct acting solenoid may only need full power for a short period of time to open it, and only low power to hold it.

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Solenoid valves are used in fluid power pneumatic and hydraulic systems, to control cylinders, fluid power motors or larger industrial valves. Automatic irrigation sprinkler systems also use solenoid valves with an automatic controller. Domestic washing machines and dishwashers use solenoid valves to control water entry to the machine. In the paintball industry, solenoid valves are usually referred to simply as "solenoids." They are commonly used to control a larger valve used to control the propellant (usually compressed air or CO_2). In the industry, "solenoid" may also refer to an electromechanical solenoid commonly used to actuate a sear.
Besides controlling the flow of air and fluids solenoids are used in pharmacology experiments, especially for patch-clamp, which can control the application of agonist or antagonist.

Air Compressor: An air compressor is a device that converts electrical power or gas into kinetic energy by pressurizing and compressing air, which is then released in quick bursts. There are numerous methods of air compression, divided into either positive-displacement or non-positive displacement types.
Positive-displacement air compressors work by forcing air into a chamber whose volume is reduced to affect the compression. Piston-type air compressors use this principle by pumping air into an air chamber through the use of the constant motion of pistons. They use unidirectional valves to guide air into a chamber, where the air is compressed. Rotary screw compressors also use positive-displacement compression by matching two helical screws that, when turned, guide air into a chamber, the volume of which is reduced as the screws turn. Vane compressors use a slotted rotor with varied blade placement to guide air into a chamber and compress the volume.
Non-positive-displacement air compressors include centrifugal compressors. These devices use centrifugal force generated by a spinning impeller to accelerate and then decelerate captured air, which pressurizes it.
The air compressors seen by the public are used in 5 main applications:

- To supply a high-pressure clean air to fill gas cylinders, to supply a moderate-pressure clean air to supply air to a submerged surface supplied diver
- To supply a large amount of moderate-pressure air to power pneumatic tools
- For filling tires
- To produce large volumes of moderate-pressure air for macroscopic industrial processes (such as oxidation for petroleum coking or cement plant bag house purge systems).

Most air compressors are either reciprocating piston type or rotary vane or rotary screw. Centrifugal compressors are common in very large applications. There are two main types of air compressor's pumps: Oil lube and oilless. The oilless system has more technical development, but they are more expensive, louder and last less than the oiled lube pumps. But the air delivered has better quality. The best choice depends of the application that the user needs.

Infrared Pair: The infrared pair mainly consists of an infrared emitter and an infrared sensor. The infrared emitter emits the infrared rays to the infrared sensor. The sensor senses the infrared rays which are emitted by the emitter. Both the emitter and the sensor are LEDs of same rating. They are placed in correct position face to face and are aligned in a straight line. They are also placed close together and are enclosed by a covering with an opening for the rays to pass. This helps to increase the accuracy of the sensing of the sensor to its maximum.

Figure 4. IR pair.

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IV. COMPONENTS USED

The major components of our Air Driven Engine consist of:

1. The engine
2. The solenoid valve
3. The valve actuation system
4. The pipe system
5. The pressure gauge system

The Engine: The basic engine that we have used in the project is a normal two stroke petrol engine. The details of the engine are as follows:
Make: Bajaj M80
Displacement: 78.04cc.
No. of cylinders: 1

Figure 5. Engine.

We only needed a simple piston-cylinder arrangement with an outlet and an exhaust. But as we know a normal two stroke engine contained several ports and it also had the spark plug which we didn't require. So, several modifications had to be done on the engine to suit our purpose.
The modifications comprised of:

- Closing the transfer port
- Closing the inlet port
- Removing the spark plug from the cylinder head
- Providing an inlet at the place of the spark plug
- Providing a suitable connector at the cylinder head

The transfer port was to be sealed to provide maximum sealing of the piston-cylinder arrangement so that the chances of escape of air from the cylinder can be avoided. We made use of m-seal and araldite to seal off the transfer port. First a fine quantity of m-seal was filled in the transfer port fully except for a small clearance to apply araldite. Then the m-seal was allowed to solidify. After that araldite was applied in another layer and was allowed to solidify. Thus, the transfer port was closed with the help of the adhesives.

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Figure 6. Cylinder block.

The inlet port also was required to be closed to avoid mild chances of leakage. It was much easier to close the inlet port. The inlet port contains a Reed valve at its start. This valve is basically a non-return valve. So, if we screw it tightly there wouldn't be chances of escape of air through the inlet port. This was carried out to close the inlet port.

There is no combustion taking place in an Air Driven Engine. So naturally there is no need for the spark plug. So the spark plug is removed from its respective position that is on the top of cylinder head. It would be great if we provide the inlet for compressed air at the position of the spark plug as it is better to let the air enter from the top of the piston. So, the connector which is used to connect the pipe from the compressed air tank has to be fixed at the position of the spark plug. The connector contains an R1/2 thread of BSPT standard. So, we tapped the same thread on the cylinder head at the position of the spark plug. Then the suitable connector was fixed on the cylinder head.

Figure 7. Cylinder head.

Solenoid Valve: A solenoid valve is an electromechanical valve for use with liquid or gas. The valve is controlled by an electric current through a solenoid coil. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas.

For controlling the air flow in and out of the engine we use a 3/2 pilot operated normally closed valve. The symbol of the 3/2 valve is as shown:

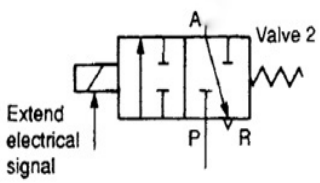

Figure 8. Valve symbol.

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The specifications of the valve are the following:

- Orifice: 12mm.
- Operating pressure range: 2-10bar
- Flow rate: 3000Litres/minute
- Coil width: 32mm.
- Voltage: 24V DC
- Duty cycle: Continuous

The 3/2 solenoid valve utilized in our project is shown in the following picture:

Figure 9. The solenoid valve.

The construction and the working of the 3/2 solenoid valve can be explained with the help of the following diagram:

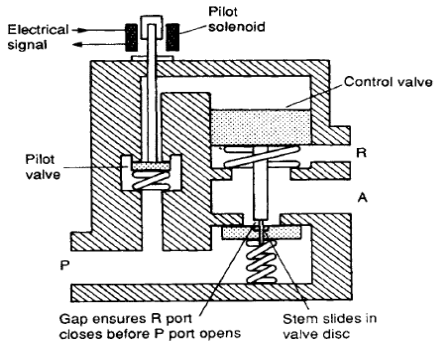

Figure 4.17 *Construction of a pilot-operated 3/2 valve*

Figure 10. Construction and working.

The figure shows the operation of a pilot operated 3/2 pneumatic valve. The solenoid operates the small pilot valve directly. Because this valve has a small area, a low operating force is requiring. The pilot valve applies line pressure to the top of the control valve causing it to move down, closing the exhaust port. When it contacts the main valve disc there are two forces acting on the valve stem. The pilot valve applies a downwards force of P×D, where P is the line pressure and D is the area of the control valve. Line pressure also applies an upwards force P×E to the stem, where E is the area of the main valve. The area of the control valve, D, is greater than area of the main valve E, so the downwards force is the larger and the valve opens.

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When the solenoid de-energizes, the space above the control valve is vented. Line and spring pressure on the main valve causes the valve stem to rise again.

Electronic Circuit: The electronic circuit mainly consists of the following components namely

1. Power supply
2. Power supply connector
3. Voltage regulator
4. Resistors
5. Voltage divider
6. Infrared emitter connector
7. Infrared sensor connector
8. Transistor
9. Valve connector
10. Comparator

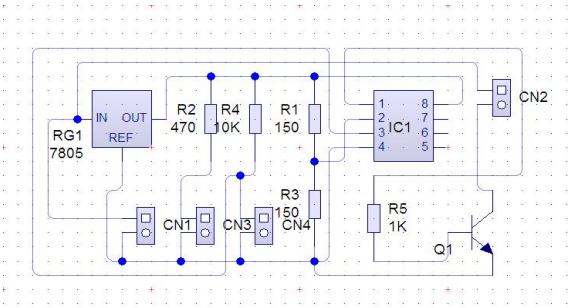

Figure 11. Circuit.

Power Supply: The power supply used here is a 24v supply. This voltage is provided by two batteries each of 24v and 2.5A rating. These batteries are connected in series.

Power Supply connectors: The circuit is provided with a connector which is a two-socket connector. The male connector is placed in the electronic circuit and the female connector is provided at the other end. The power supply connectors are soldered to the circuit.

Voltage Regulator: The voltage regulator used here is RG 7805. This voltage regulator has three terminals namely

- Reference
- Input
- Output

The reference terminal is grounded and the input terminal is provided with the supply. This circuit converts the 24v dc into 5v dc. All the components in this circuit only work on 5v. Thus, the 24v need to be stepped down to 5v in order to avoid burning of the circuit components. This 5v is taken out through the output terminal.

Resistors: The resistors are used to step down the current from the main supply. The main resistors used are the following.

- 100K
- 470
- 10K
- 1K
- 150*2

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Figure 11. Resistors.

The figure shows the 100K resistor. This component is connected before the voltage regulator to step down the high current of 24 v supply.

Voltage Dividers: The voltage dividers are used to divide the voltage according to the purpose. An equal number of resistors can be used to divide the circuit. Here two 150K resistors are used to divide the 5v to 2.5v dc to be supplied to the comparator.

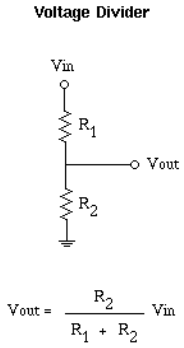

Figure 12. Voltage dividers.

Batteries: The batteries used here have a rating of 12v, 2.5A. The solenoid valve works only on 24v. Hence the batteries need to be connected in series to obtain 24v.

Figure 13. Batteries.

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V. WORKING OF CIRCUIT

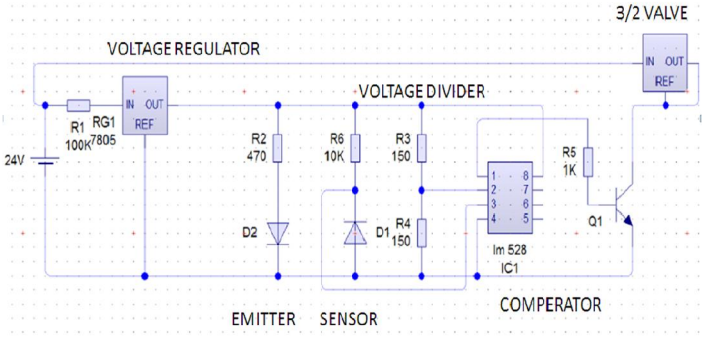

Figure 14. Circuit.

The supply voltage as shown in the figure is 24v dc. This high voltage is supplied to the voltage regulator. A 100K resister is used before the voltage regulator in order to reduce the high current to the circuit. The voltage regulator regulates the voltage and step down it to 5v dc, since all the components in the circuit works only on 5v dc. This 5v is given to all the components in the circuit. The emitter is provided with a 470-ohm resistor and the collector is provided with a 10K resistor which reduces the voltage further. A voltage divider is used in order to divide the 5v to 2.5v to provide it to the comparators. The transistor works as a switch.

The emitter is forward biased and the collector is reversed biased. The emitter sends infrared radiations continuously and this is sensed by the sensor. Thus, the circuit is short circuited. Hence low voltage is given to the comparator. When the power stroke region is reached the path gets cut off and as a result a high voltage is produced in the sensor circuit and this is given to the comparator. Comparator only provides the output when the input in the positive terminal is above 5v. Thus, during the power stroke region, the comparator is provided with a high voltage and thus it provides a high voltage at its output. This output is given to the transistor through a 1K resistor. The transistor acts as a switch. It conducts only when a high voltage is applied to it, and when this high voltage reaches it conducts it to the 3/2 solenoid valve.

The solenoid valve has three terminals namely

1. Reference terminal
2. Input terminal
3. Output terminal

The input terminal is connected to the supply and the output terminal and the reference terminal are shorted. The high voltage (5v) is given to the shorted circuit and thus the valve opens and the pressurized air is allowed to enter the cylinder of the engine. Thus, the engine works.

Pipe system: The pipe system is used to connect the components involved in the passage of the compressed air. It is used to connect the cylinder to the solenoid valve and the solenoid valve to the cylinder head.

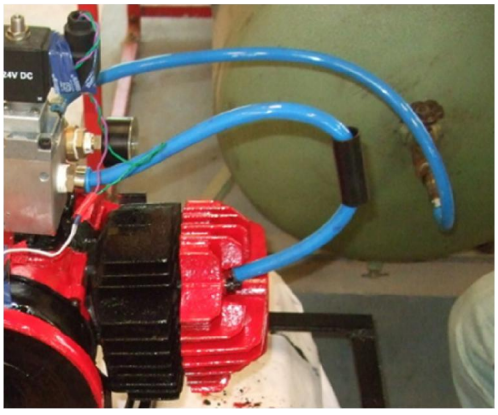

Figure 15. Pipe system.

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Here polyurethane pipes are used of diameter of 12mm and length of 1m. They are made of hard and flexible material so that they are able to pass the compressed air more efficiently and are highly flexible. These pipes are able to withstand high pressure and so are used to transport compressed air. They are perfectly suited to be inserted to the one touch male connector.

Pressure Gauge System: The pressure gauges are used to measure or display the pressure at the position at which the pressure gauge is installed. There are different ranges of the pressure gauges. 0 to 10 bar pressure gauges are used in this project. A t shaped female connector is used to install the pressure gauge in the system and it also holds the pressure gauge at position. The pressure gauge is connected to the inlet of the solenoid valve. This helps to measure the pressure inlet to the solenoid valve.

Figure 16. Pressure gauge system.

Working of Air Driven Engine: Our air engine works on the same principle of that of an internal combustion engine. The only difference between the two is that in an internal combustion engine; the explosion of fuel in the combustion chamber produces the energy to move the piston, while in an air engine the energy for moving piston is acquired from the supplied compressed air.

The complete assembly of our air engine consists of slightly modified ic engine, valve timing disc attached to the flywheel of the engine, sensor-controlled valve mechanism, piping system, gauge system, air compressor and air tank.

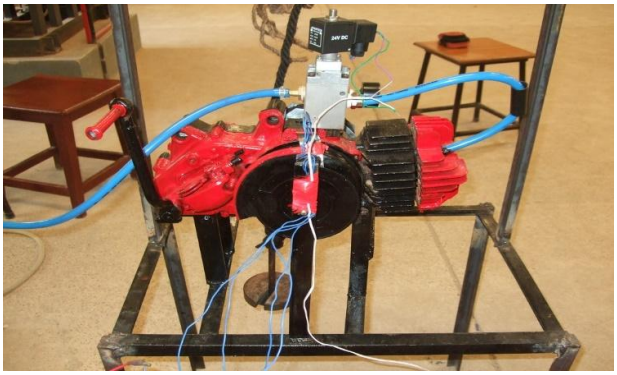

Figure 17. Working.

For the proper and continues working of the engine the timing with which the compressed air is supplied is of great importance. So, in order to make it precise we used sensor-controlled valve mechanism. The valve timing disc is made with utmost precision to precise operation of valve. For that the outer dead centre region (ODC) of the piston is found out and is

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marked on to the fixed valve timing disc. By the same method the point just before the exhaust port opening (EPO) is found out and marked on the disk with the help of a cross sectional change.

For starting; the engine is cranked by the kicker. This will rotate the crankshaft along with the valve timing disk in the clockwise direction. During this rotation the ODC region of the disc cuts the IR beam first and followed by the EPO region. When the IR beam is first cut by ODC region, the circuit activates the solenoid valve by electric signal. At the moment the valve gets opened and allows the flow of compressed air into the cylinder from the tank through the piping system. The whole region from the point of ODC to EPO on the valve timing disk is opaque and does not allow the IR beam through it. So, all the way long the circuit maintains the solenoid valve open by supplying a continuous supply of electric current to the valve. At the same time the compressed air from the tank continues to fill in the cylinder there by pushing the piston further towards the bottom dead centre (BDC). But to increase the fuel efficiency the fuel supply should be cut-off before reaching the EPO. So, when the EPO region of the valve timing disc sweeps passed away from between the IR sensors, the IR beam will make connection again. This will cut the supply to the solenoid valve there by closing the valve. This will prevent the valve from being open at the same time of EPO; increasing efficiency.

When the disc rotates further, the valve remains closed throughout the area from the EPO to the ODC as the IR beam is closed. And this cycle continues.

VI. ADVANTAGES OF AIR DRIVEN ENGINE

1. less costly and more effective
2. The air engine is an emission-free piston engine that uses compressed air as a source of energy.
3. Simple in construction. The engine can be massively reduced in size
4. Easy to maintain and repair.
5. No fire hazard problem due to over loading. Air, on its own, is non-flammable.
6. Low manufacture and maintenance costs
7. Comparatively the operation cost is less.
8. Light in weight and easy to handle. The engine runs on cold or warm air, so can be made of lower strength light weight material such as aluminium, plastic, low friction Teflon or a combination
9. Compressed-air tanks can be disposed of or recycled with less pollution than batteries.
10. Compressed-air engines are unconstrained by the degradation problems associated with current battery systems.
11. The air tank may be refilled more often and, in less time, than batteries can be recharged, with re-filling rates comparable to liquid fuels.
12. Lighter vehicles cause less damage to roads
13. The price of filling air tanks is significantly cheaper than petrol, diesel or biofuel. If electricity is cheap, then compressing air will also be relatively cheap
14. Quick response is achieved.

VII. APPLICATIONS

DRIVE FOR CONVEYORS

Air driven engines can be used as drives for different types of conveyors such as Belt conveyors, Chain conveyors, Screw conveyors, etc, it is normally used for slow speed conveyors. Medium load can only be used.

Figure 18. Belt conveyer.

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JOB CLAMPING

In operations like carpentry job clamping generally requires low loading. Air Driven Engine can provide this low load clamping.

FLUID PUMPS

Air Driven Engine can also be utilized for small displacement pumps of low-pressure capacities.

AUTOMOBILES

The usage of the Air Driven Engine is possible for automobiles as two wheelers and light motor vehicles.

Figure 19. air car.

VIII. CONCLUSION

We were able to successfully complete the design and fabrication of the Air Driven Engine. By doing this project we gained the knowledge about pneumatic system and how automation can be effectively done with the help of pneumatic system. We were also able to gain practical knowledge about the basics of the normal IC engine and solenoid valves. The Air Driven Engine provides an effective method for power production and transmission. Even though its applications are limited currently, further research could provide wider applications.

IX. FUTURE SCOPE

- Design and fabrication of a new engine made of light metal will give better results.
- Usage of compressed air tanks for storage and supply will give it more scope in automobiles.
- Much like electrical vehicles, air powered vehicles would ultimately be powered through the electrical grid. This makes it easier to focus on reducing pollution from one source, as opposed to the millions of vehicles on the road. Transportation of the fuel would not be required due to drawing power off the electrical grid. This presents significant cost benefits. Pollution created during fuel transportation would be eliminated.
- Compressed-air vehicles operate to a thermodynamic process as air cools down when expanding and heats up when being compressed. As it is not possible in practice to use a theoretically ideal process, losses occur and improvements may involve reducing these, e.g., by using large heat exchangers in order to use heat from the ambient air and at the same time provide air cooling in the passenger compartment. At the other end, the heat produced during compression can be stored in water systems, physical or chemical systems and reused later.
- New engine designs; as shown in fig shows the improved variants of the air engine. With these types of engines; which is more efficient; air powered automobiles could gain a bright scope in future.

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Figure 20. Air Engine Variant.

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