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OVERVIEW OF THE PROJECT:

- Work of previous semester:

STEP 1

Duration: 1 month

Searching of different types of engine and procurement of best suitable engine

STEP 2

Duration: 1 month

Gathering various research paper and measuring dimensions of various parts of engine

STEP 3

Duration: 2 month

Design of parts of engine, creating simulation and final report

- Work of current semester:

STEP 4

Duration: 15 days

Making Plan for manufacturing one working model of Pneumatic Engine

STEP 5

Duration: 15 days

Decision making for various components of the system

STEP 6

Duration: 1 month

Procurement of the components

STEP 7

Duration: 1 month

Manufacturing of Pneumatic Engine

STEP 8

Duration: 1 month

Testing of the Pneumatic Engine

CHAPTER 1
INTRODUCTION

We all know that air is all around us, it will never runs out, it is non-polluting and it has no cost.

An Air powered Engine makes use of Compression of Air for its operation. Compressed Air Technology is now widely used for research by different industries . If we compress normal air then 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 be used to move a piston of engine. This is the working principle of the Air powered Engine. It uses the expansion of compressed air to move the pistons of the engine. So an Air Driven Engine is basically a pneumatic system that creates useful work by expansion of compressed air.

In this way we will use compressed air as our alternative fuel in engine and as there is no combustion taking place so there is no pollution occurred due to it.

In our previous semester work, we have performed modeling, literature review and simulation work. In that modeling work had been done in CREO parametric 2.0. And simulation work had been done in VISUAL BASICS.

From that simulation work, we have found out theoretical efficiency and that was coming around 27%.

Now in this current semester we are going to make actual model of pneumatic engine and will try to establish actual system like this. With this model we will introduce one new concept to drive the engine.

Here we are going to use air as a fuel. To be precise we can say that we need compressed air. Air is free and on earth anywhere we can get it without any cost. But nothings come for free. As we have to use compressed air in the running of the engine.

If we can find some better way to compress the air at that time our project will be very much worthy. So our project needs some extra effort in field like material science and fluid mechanics. Like if we can find out material which have more strength than plastic and lighter in weight than plastic, in that condition we can make piston –cylinder assembly with the help of that material which will require low force of compressed air. Hence pressure required to be compressed air will be lesser.

So, be ready to use some new technology

. CHAPTER 2
DECISION MAKING

- **Which** components are required?
- **Why** only that component is required?
- **How much cost** of the components?
- Is any component can be interchanged to increase efficiency?

To do this decision making we have used **WHY- WHY analysis** theory in horizontal form. That we have learned in Product design and value engineering.

Decision making is very big term and even today it is very crucial term for most of the industries. In our project, we have to make decision to select the appropriate component as well as to prefer safer side on both the hand cost as well as time reduction. As one time consuming but smart and step by step work will reduce the chances of rejection. So during the entire project work we have given major focus on decision making.

Decision making of various system components and why they are required is described from the next page:

Decision making of Solenoid Control Valve:

Why we need solenoid control valve in our project?

If somebody saying that we have to use solenoid control valve in our project. So, first question in everyone's mind is why solenoid? One smart answer to this question is that in our project we will not supply air continuously to the engine. We have to maintain gap between suction and expansion stroke.

This means that first of all we have to supply air to the engine and after that some fraction of second must be given to air to expand itself in the system.

To do that we need some mechanism such that it breaks up inlet of compressor at our desired time and do our task.

That can be accomplished by solenoid valve and in the previous semester work we have decided that we are going to use solenoid control valve in our project.

Solenoid valve:-

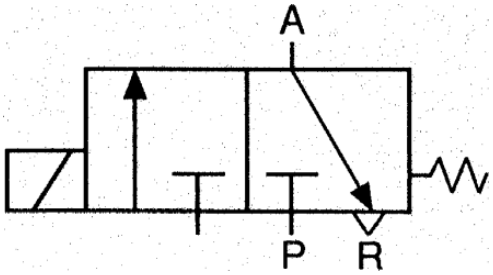
A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves 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.

So, from above description it is clear that solenoid valve is best suitable device for this purpose.

Another major question is that if we are going to use solenoid valve than there is one long list of solenoid valve. So, **which type of solenoid valve is most suitable to us?**

In previous semester we have decided that we will use 3/2 solenoid control valve.

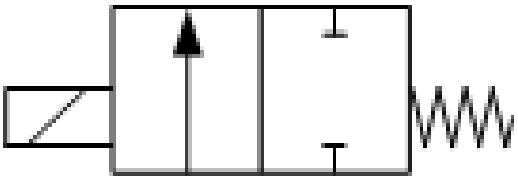


In that we have decided that at the time of suction stroke we will give compressed air to the engine and during expansion stroke that air will bypass and again send back to the tank.

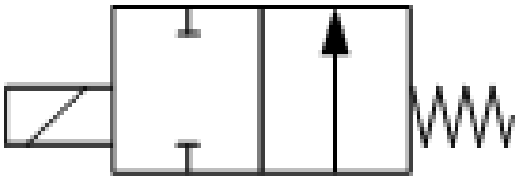
But cost of 3/2 solenoid valve is too high than 2/2 solenoid valve so go for another option in current semester.

We have found out that if valve itself capable enough to stop air supplied to the engine during expansion phase than why we should use bypass option.

So we have decided that we will go for 2/2 solenoid control valve.



2/2 way
Normally Closed



2/2 way
Normally Open

❖ **Function of 2/2 solenoid valve:**

1) Direct operated (direct acting) solenoid valves

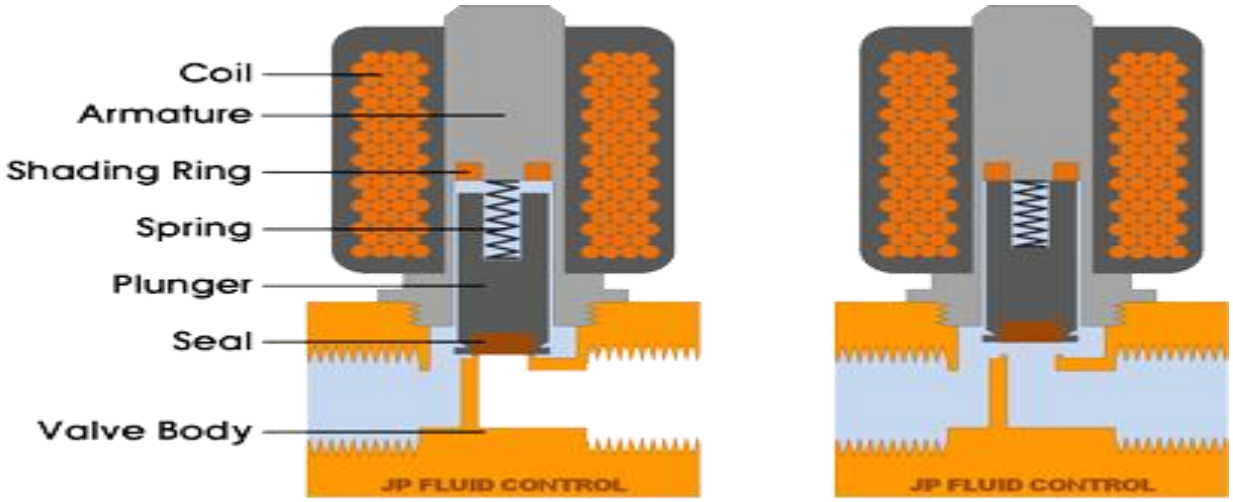


Fig.2.1 Normally closed condition and energized condition of solenoid valve is shown in above figure.

Direct operated (direct acting) solenoid valves have the most simple working principle. The medium flows through a small orifice which can be closed off by a plunger with a rubber gasket on the bottom. A small spring holds the plunger down to close the valve. The plunger is made of a ferromagnetic material. An electric coil is positioned around the plunger. As soon as the coil is electrical energized, a magnetic field is created which pulls the plunger up towards the centre of the coil. This opens the orifice so that the medium can flow through. This is called a Normally Closed (NC) valve. A Normally Open (NO) valve works the opposite way: it has a different construction so that the orifice is open when the solenoid is not powered. When the solenoid is actuated, the orifice will be closed. The maximum operating pressure and the flow rate are directly related to the orifice diameter and the magnetic force of the solenoid valve. This principle is therefore used for relatively small flow rates. Direct operated solenoid valves require no minimum operating pressure or pressure difference, so they can be used from 0 bars up to the maximum allowable pressure

2) Indirect Operated (Servo or Pilot Operated)

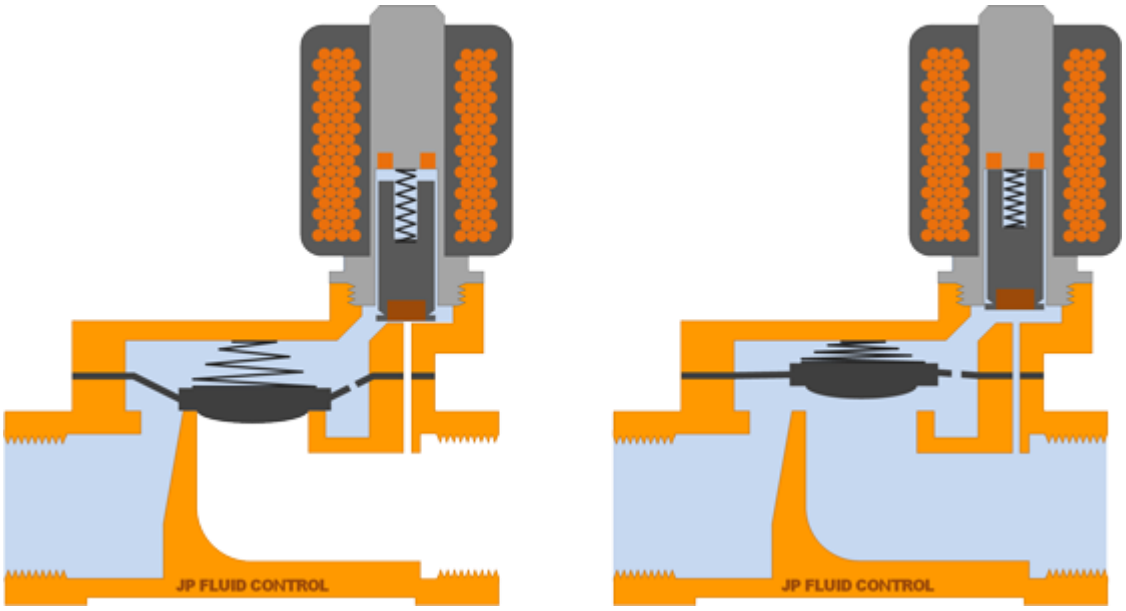


Fig.2.2 Normally closed condition and energized condition of solenoid valve is shown in above figure.

Indirect operated solenoid valves (also called servo operated, or pilot operated) use the differential pressure of the medium over the valve ports to open and close. Usually these valves need a minimum pressure differential of around 0.5 bars. The inlet and outlet are separated by a rubber membrane, also called **diaphragm**. The membrane has a small hole so that the medium can flow to the upper compartment. The pressure and supporting spring above the membrane will ensure that the valve remains closed. The chamber above the membrane is connected by a small channel to the low pressure port. This connection is blocked in the closed position by a solenoid. The diameter of this "pilot" orifice is larger than the diameter of the hole in the membrane. When the solenoid is energized, the pilot orifice is opened, which causes the pressure above the membrane to drop. Because of the pressure difference on both sides of the membrane, the membrane will be lifted and the medium can flow from inlet port to outlet port. The extra pressure chamber above the membrane acts like an amplifier, so with a small solenoid still a large flow rate can be controlled. Indirect solenoid valves can be used only for one flow direction. Indirect operated solenoid valves are used in applications with a sufficient pressure

differential and a high desired flow rate, such as for example irrigation systems, showers or car wash systems. Indirect valves are also known as servo controlled valves.

Air Flow is Crucial in Delivering the Best Performance

Each solenoid is rated for flow in liters per minute or by a flow coefficient or flow factor. The rated airflow of the solenoid valve must meet the bulk handling valve manufacturer's requirements of air demand to the air cylinder. If purchasing solenoids locally make sure the air flow and other ratings are a perfect match to the solenoid specified by the valve manufacturer. Using a lower flow solenoid valve will cause performance problems such as chattering and slow actuation of the blade.

The valve, which we have used, is diaphragm type 2/2 solenoid control valve in our project.

Specifications:
Type: 2/2 (DC24W)
Design: Diaphragm type
Medium: Air, Water, Inert Gas- Compressed air, lubricated
Operating pressure: 0.5 to 10 bar ambient temperature: 5˚ to 60˚ C
Actuation type: Electrical
Type of mounting: In-line installation
Power consumption: 5 W
Volts: 24 V DC

Fig.2.3. 2/2 normally closed solenoid valve

Task: To make a circuit that will actuates when sensor gives signal

Circuit making task is very crucial and time consuming task for us. Before making circuit we only know that we have to connect solenoid valve to the circuit only during suction stroke and during expansion stroke supply voltage to the solenoid vale must be disconnected. So for that we started making circuit with number of calculation and trial and error method. We have also taken help from one faculty member of Mechatronics Department to resolve our problem.

After that we came to one conclusion that for making circuit we need following electrical components.

1) RESISTOR
2) COMPARATOR
3) TRANSISTOR
4) VOLTAGE REGULATOR
5) VOLTAGE DIVIDER
6) INFRARED SENSOR AND EMITTER

Now for selecting appropriate components at appropriate place first of all, we have gathered information about all the components.

RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. In electronic circuits, resistors are used to limit current flow, to adjust signal levels, bias active elements, and terminate transmission lines among other uses. High-power resistors, that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits.

The electrical function of a resistor is specified by its resistance.

For selecting resistance we have used various theories related to resistor. They are mentioned below.

Ohm's law:

The behavior of an ideal resistor is dictated by the relationship specified by

$$V = I \cdot R.$$

Series and parallel resistors:

The total resistance of resistors connected in series is the sum of their individual resistance values.

$$R_{\text{eq}} = R_1 + R_2 + \cdots + R_n.$$

The total resistance of resistors connected in parallel is the reciprocal of the sum of the reciprocals of the individual resistors.

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}.$$

Color Code for Resistor:

COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE	
Black	0	0	0	1Ω		
Brown	1	1	1	10Ω	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 10%	(K)

SOLENOID CONTROL VALVE:

We have used normally closed 2/2 solenoid control valve which actuates at 24 v .This will cut off air supply whenever needed and allow supply of air whenever needed. So we need to do arrangements such that power supply of 24v has to be there and solenoid valve should actuate only at 24 v .Thus we have to create circuit in which when sensor senses power stroke then only 24 v will be supplied to solenoid control valve. So we have used various resistor, voltage regulator, transistor, etc.

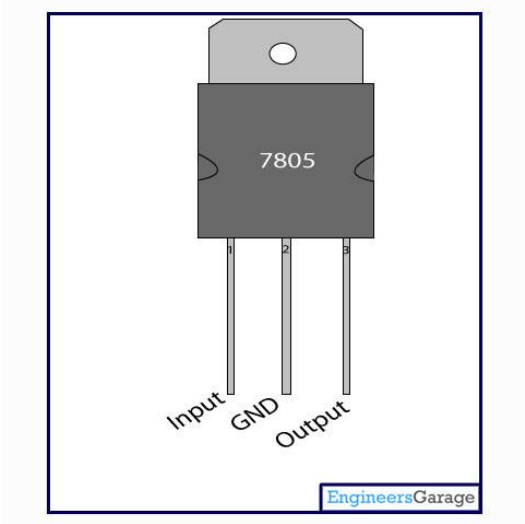
Battery:

We all know that,

In the **SERIES CONNECTION**, batteries of like voltage and Amp-Hr capacity are connected to increase the Voltage of the battery bank.

So, we have used two 12 v DC battery as we need 24v supply to actuate solenoid control valve to reduce the cost of the project. Because cost of one 12 V battery is 650 Rs. While that of for 24 V DC battery is around 3500 Rs.

VOLTAGE REGULATOR:



Pin Description:

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

At first we have to drop 24v to low voltage 5v as most of circuit parts works at 5v.

7805 is a **voltage regulator** integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The **voltage regulator IC** maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

So we have used RG 7805 voltage regulator.

.**TRANSISTOR**:

A transistor is a device that regulates current or voltage flow and acts as a switch or gate for electronic signals. Transistors consist of three layers of a semiconductor material, each capable of carrying a current.

A transistor consists of three layers of silicon or germanium semiconductor material. Impurities are added to each layer to create a specific electrical positive or negative charged behavior: There are essentially two basic types of point-contact transistors, the NPN transistor and the PNP transistor, where the N and P stand for negative and positive, respectively. The only difference between the two is the arrangement of bias voltages.

To understand how a transistor works, you have to understand how semiconductors react to an electric potential. Some semiconductors will be N-type, or negative, which means that free electrons in the material drift from a negative electrode (of, say, a battery it's connected to) toward the positive. Other semiconductors will be P-type, in which case the electrons fill "holes" in the atomic electron shells, meaning that it behaves as if a positive particle is moving from the positive electrode to the negative electrode. The type is determined by the atomic structure of the specific semiconductor material.

Now we have to use transistor for switching .We have to use transistor which switches only when 24 V is applied. After so much research work we have decided

that we should use NPN transistor which is made up of Si and maximum temperature can be sustain of the order 170˚ C. As well as which is made up with maximum collector base voltage of 90 V and maximum emitter base voltage of 4 V.

Type	Material	Structure	Pc	Ucb	Ueb	Ic	Tj	Cc (pF)
2N3033	Si	NPN	0.3	160	4	0.2	175	6
2N3034	Si	NPN	0.3	120	4	0.2	175	6
2N3035	Si	NPN	0.3	90	4	0.2	175	6
2N6232-4	Si	NPN	15	140	6	10	200	6
2N6430	Si	NPN	0.5	200	5	0.5	175	4
2N6431	Si	NPN	0.5	300	6	0.5	175	4

Where,

Pc - Maximum collector power dissipation

Ucb - Maximum collector-base voltage

Ueb - Maximum collector-base voltage

Ic - Maximum collector current Tj - Maximum temperature

Cc - Collector capacitance

Thus we have used 3035 transistor which is cost effective and fulfill our requirements.

COMPARATOR

In electronics, a comparator is a device that compares two voltages or currents and outputs a digital signal indicating which is larger. It has two analog input terminals and one binary digital output. The output is ideally.

Here the comparator used is lm 528. It mainly consists of 8 terminals out of which 5 terminals are in use. The negative terminal is connected to the voltage divider and the positive terminal is connected to the sensor. The output is taken from the output

terminal to the transistor which acts as a switching device. The fourth terminal is grounded and the eighth terminal is given the 5v supply.

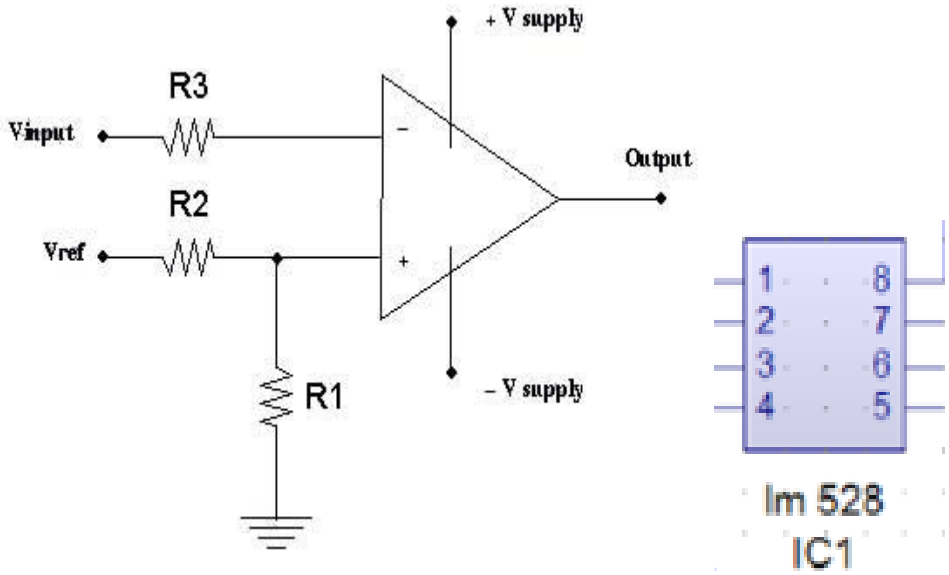
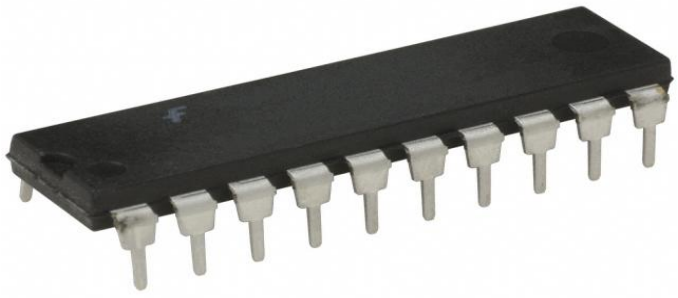


Fig 6.8

The 5 terminals used are the following

- Negative terminal(2)
- Positive terminal(3)
- Output terminal(1)
- Ground terminal(4)
- Supply terminal(8)



Now we have to use sensing circuit which senses power stroke. So we have used proximity sensor which consist of infrared emitter and sensor. This signal is fed to electric circuit which actuates transistor.

Now we have to use various resistors for electric circuit. We have used 100k resistor for step down the high voltage of 24v before voltage regulator. We have used various resistors 470 Ω, 10 k Ω, 1k Ω, 150 Ω which are necessary in the circuit.

The complete layout of electric circuit is shown below:

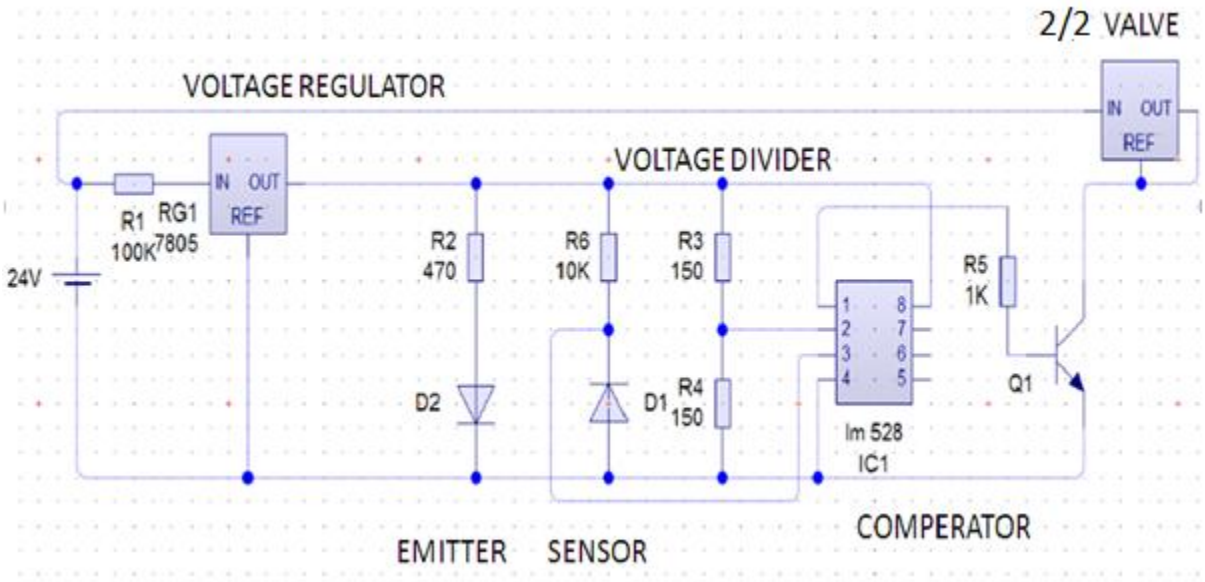


Fig.2.4 The Circuit

Working of circuit:

The Supply voltage as shown in figure is 24v DC. This high voltage is supplied to the voltage regulator. A 100k resistor is used before voltage regulator in order to reduce high current. Voltage regulator regulates voltage and step down it to 5v, since all the component in the circuit works only at 5v.This 5v is given to all circuit components. The emitter is provided with 470ohm resistor and collector is provided with 10k resistor which reduces the voltage. The transistor will work as a switch.

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

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

Decision Making for Piping System:

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

We have take decision to use **High Density Poly ethylene (HDPE) pipes** because of the following reasons.

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.

It has outstanding chemical and environmental stress crack resistance.

Corrosion is one of the most costly problems associated with metal piping systems. It occurs both inside and outside the pipe and affects hydraulic efficiency. Many cities treat their water to help slow rust and pitting that is inevitable with metal pipes. Others choose costly cathodic protection, plastic coating, or sieving to try and extend the service life of the pipe.

Unlike traditional metal infrastructure products, HDPE pipe does not rust, rot or corrode. It is resistant to biological growth. This means an extended service life and long term cost savings.

An independent study reports that municipalities in 43 states average a water loss of 16% due to leaking joints. Some report water losses as high as 50%.

In addition to its outstanding physical characteristics, HDPE is recognized for its minimal impact on the environment:

• It takes less energy to manufacture HDPE than non-plastic pipes.

• HDPE is lightweight and is often more cost effective to transport than metal pipes.

• The flexibility of HDPE, **combined with the use of heat fusion to join the pipe**, means fewer fittings are required.

• In trenchless installations, the physical characteristics of HDPE pipe enable you to use a smaller pipe, resulting in less ground disruption than when installing other fusible products.

• HDPE pipe joined with heat fusion provides leak free connections.

• HDPE does not emit potentially hazardous levels of toxins into the air during production, during fusion or into the ground or water during use.

• HDPE pipe can be recycled back into non-pressure piping applications.

1. Polyvinyl chloride (PVC) is a cheap and durable vinyl polymer used in construction projects while high density polyethylene (HDPE) is a polyethylene thermoplastic that is made from petroleum.

2. Polyvinyl chloride (PVC) is the third most widely used plastic while polyethylene of which HDPE is a type is the most widely used plastic.

3. PVC is amorphous while HDPE is semi-crystalline.

4. Both are strong and durable, but their strengths vary and they have different applications. PVC is heavier and stronger while HDPE is harder and more abrasion and heat resistant.

5. HDPE pipes are found to be **able to dampen and absorb shock waves** minimizing surges that can affect the system while PVC cannot.

6. HDPE is more suitable for lower pressure installations while PVC is more suitable for direct burial and trenchless installations.

So, from above advantages of poly urethane pipe we have taken decision to use this pipe. From our last semester work we had decided that pipe diameter we needed of the order of 12 mm and length should be around 1 m.

Frictional Losses in pipe:

Before taking final decision for selection of pipe size and appropriate material we have to consider one of the major loss occurred in each and every system and that is the friction loss.

Friction loss takes place as a gas, say air, flows through duct work. The difference in the character of the flow from the case of water in a pipe stems from the differing Reynolds number Re and the roughness of the duct.

The friction loss is customarily given as pressure loss for a given duct length, $\Delta p / L$, in units of (US) inches of water for 100 feet or (SI) kg / m^2 / s^2.

For specific choices of duct material, and assuming air at standard temperature and pressure (STP), standard charts can be used to calculate the expected friction loss. The chart exhibited in this section can be used to graphically determine the required diameter of duct to be installed in an application where the volume of flow is determined and where the goal is to keep the pressure loss per unit length of duct *S* below some target value in all portions of the system under study. First, select the desired pressure loss $\Delta p / L$, say 1 kg / m^2 / s^2 (0.12 in H_2O per 100 ft) on the vertical axis (ordinate). Next scan horizontally to the needed flow volume *Q*, say 1 m^3 / s (2000 cfm): the choice of duct with diameter *D* = 0.5 m (20 in.) will result in a pressure loss rate $\Delta p / L$ less than the target value. Note in passing that selecting a duct with diameter *D* = 0.6 m (24 in.) will result in a loss $\Delta p / L$ of 0.02 kg / m^2 / s^2 (0.02 in H_2O per 100 ft), illustrating the great gains in blower efficiency to be achieved by using modestly larger ducts.

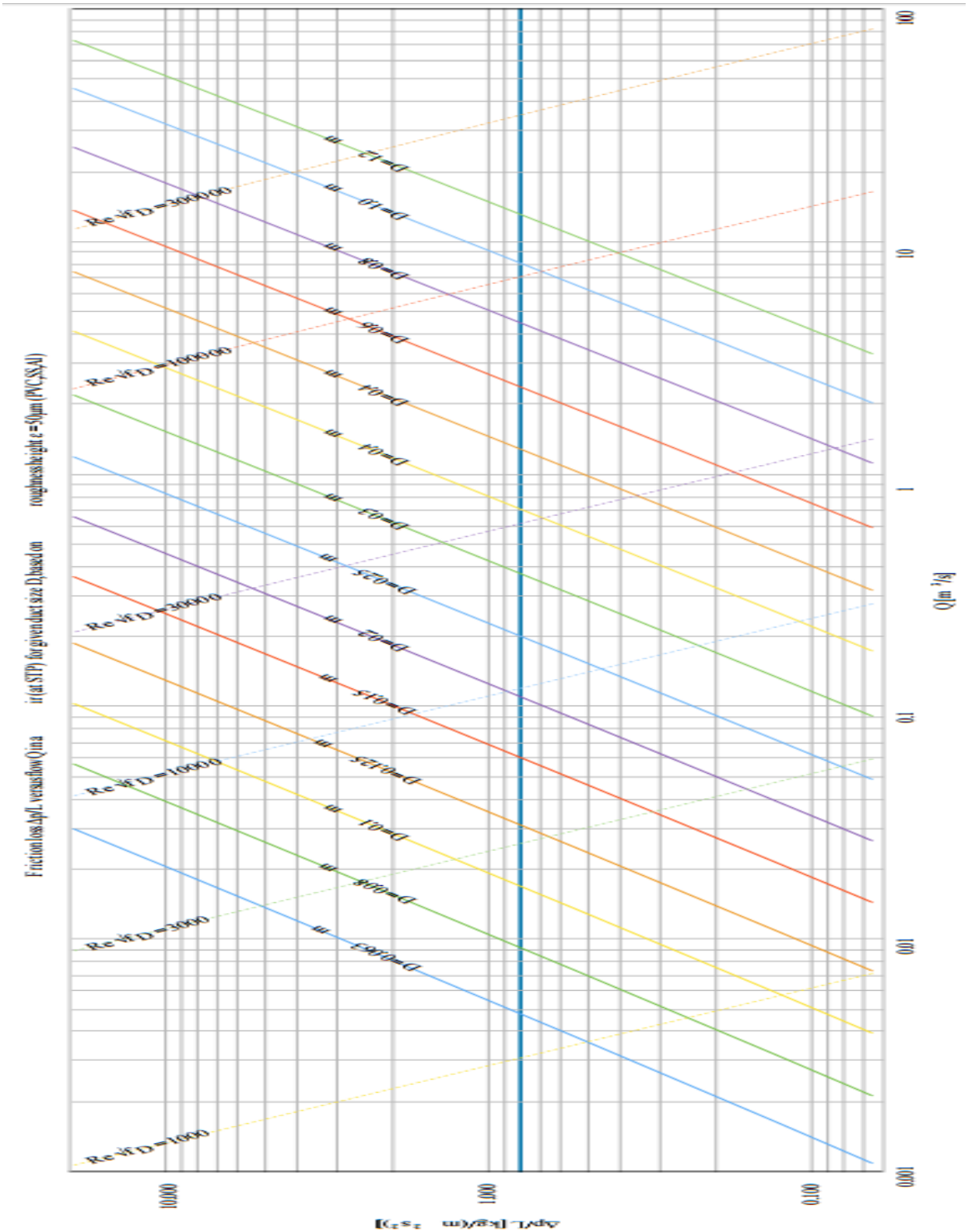


Fig.2.5 Frictional Losses in pipe

From above graph, we can conclude that as inner diameter of duct increases friction loss decreases respectively. As well as higher is the flow rate, higher will be the friction loss. **But in our case inner diameter of duct is fixed. So, in our case lesser flow rate will be desired for lesser friction losses. And as flow rate of air decreases, our engine can't start due to higher inertia.** Hence it is very much critical task to adjust flow rate from the pipe.

So, from above theory we have concluded that for starting of engine we should provide higher flow rate. And after overcoming inertia of the moving and reciprocating parts of the engine we should decrease the flow rate of compressed air.

Decision making of Valve timing disc:

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 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 allows 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 past 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 continue.

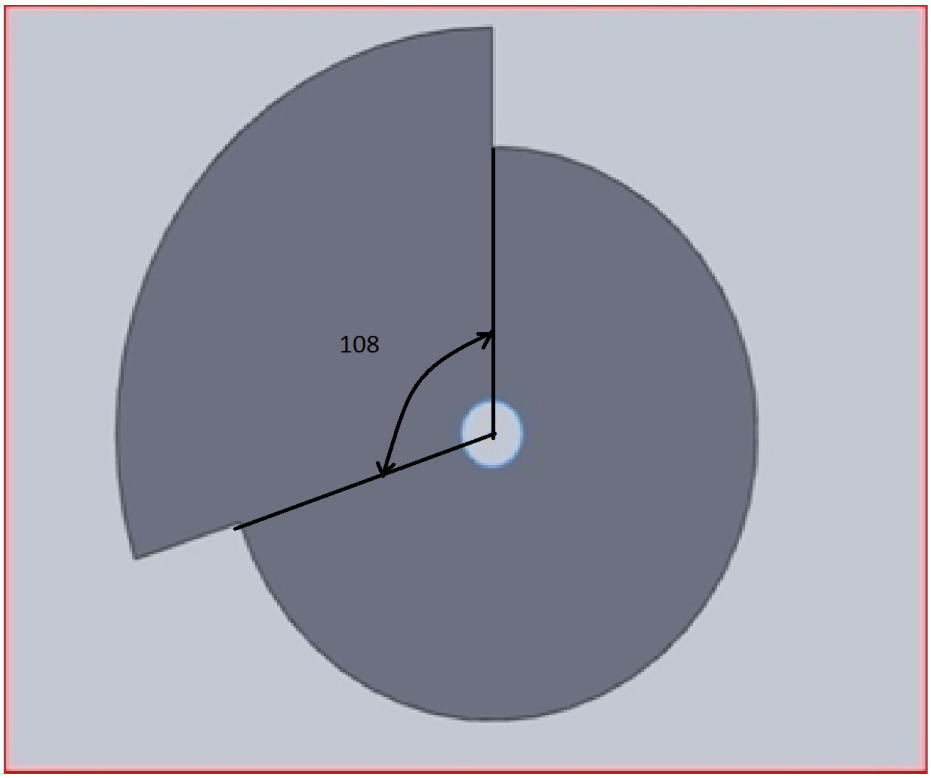


Fig.2.6 Valve timing disc

Decision Making for Compressor:

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 effect 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 main applications:

We have to supply a high-pressure clean air to fill gas cylinder. 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

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 lubed and oil less. The oil less 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.

Type of Compressor	Capacity (m^3 /h)		Pressure (bar)	
	From	To	From	To
Roots blower compressor single stage	100	30000	0.1	1
Reciprocating-Single / Two stage	**100**	**12000**	**0.8**	**12**
Reciprocating -Multi stage	100	12000	12	700
Screw – Single stage	100	2400	0.8	13
Screw – Two stage	100	200	0.8	24
Centrifugal	600	300000	0.1	450

But in our case, use of specific kind of air compressor is restricted due to cost of project will increase at so high level. Because of that reason we are going to use compressor of our college.

It is multi stage compressor so we can get maximum pressure up to 8 bars. So it is suitable for our task.

But for application level we suggest one more device named air amplifier. With the help of that device pressure of air can be increased up to 16-20 bars. So it will very use full to bring up upper limit of maximum speed of the engine.

CHAPTER 3
PROCUREMENT OF COMPONENTS

Now after finishing all decision making work, we are going to put our small foot in the process of manufacturing. Before starting manufacturing, we have to procure required components for manufacturing. That takes around period of one month. As we have to find right supplier as well as the components in the right cost.

In manufacturing work, now we have to use our already bought two strokes I.C. Engine for modification and for making Pneumatic Engine. So as per our decision making work, we have bought 2/2 Solenoid control valve. For that, two members of our group started searching for the right supplier. After two days of searching on internet as well as on nearby shops at last we got one supplier from Karnataka named integrated services on internet. We mailed for our requirement to that supplier. After 2-3 days that company replied us and tell us about its' another branch which is situated at Vadodara. After that almost after one and a half week of to and fro procedure we got suitable 2/2 solenoid control valve. Its' specification is mentioned in decision making phase,

During these two weeks our other two team members were searching for some circuit components in cities like Ahmedabad, Vadodara and Jamnagar. At last at the end of two week they found most of the major circuit components like comparator, transistor, voltage divider, etc.

So, at the end of two week we all four member were ready with major components other than piping system, valve timing disc and infrared sensor. For deciding valve timing disc shape we have to conduct some experiments with our engine. So after completion of two days experiments we decided critical shape of valve timing disc.

Now for selecting piping system we have to take permission from our college to use compressor of the college. After getting permission from respective professor we

were able to decide components of piping system like connector, reducer, pipe diameter and length, etc. So after deciding those all critical parameters at the end of another one and a half week, we were ready with whole piping system.

Now we have to procure infrared sensor from the market. First of all we tried to find out circuit diagram and according to that we had purchased circuit components from the market. But in that circuit diagram we could not find two major components such as IC and Infrared pair. So we searched for readymade infrared sensor. And after searching for that in the market we got it from one supplier.

Now as per our decision making at the end of one month we all were ready with all components of the system. And now we could proceed with manufacturing work.

CHAPTER 4
MANUFACTURING OF THE PNEUMATIC ENGINE

Every one believes that if procurement of components is done than it is very easy to manufacture any system. But believe us according to our experience it was not so easy.

Fig.4.1 Engine

According to our plan first of all we have to mount timing disc on the crank shaft of the engine. But as shown in picture above on such a small shaft how can we able to mount timing disc?

So now for mounting timing disc we have to elongate the length of the crank shaft. For that we have open up the whole engine and try to find out some way. As our engine was too old we found so much difficulty in getting the tools for opening the

engine parts. After so many brainstorming activities we were able to get one smart idea for elongate the nut and bolt of the flywheel. So as shown in picture below we have make one long bolt and nut from one shaft.

Fig.4.2 Engine with disc

After this for starting our engine we have to apply kick. But though engine was too old its kick became very hard. Now for that we have to again open up the engine. And as said earlier it was very difficult because of unavailability of tools. We tried to find out reason for locking of the kick but unable to resolve the problem.

So in place of kick we have to put some extra arrangement for starting. Again after a lot of brainstorming were able to get one new idea like arrangement of pulley from one mechanic at Gujarat garage. So we are very much thankful to him. That arrangement is shown in picture below.

The idea was fantastic but difficult to apply. For applying that it took almost one week. As the bolt as well as nut was manufactured by us. So it was very difficult to get pulley with exact dimension. After tremendous searching work in the market as well as in the garages, at the end we were able to find out one pulley with nearby dimension. So after making turning and pressing operations we were able to fix the

pulley on the crank shaft. Now for starting we have to apply torque by pulley and thread just like chakda rickshaw.

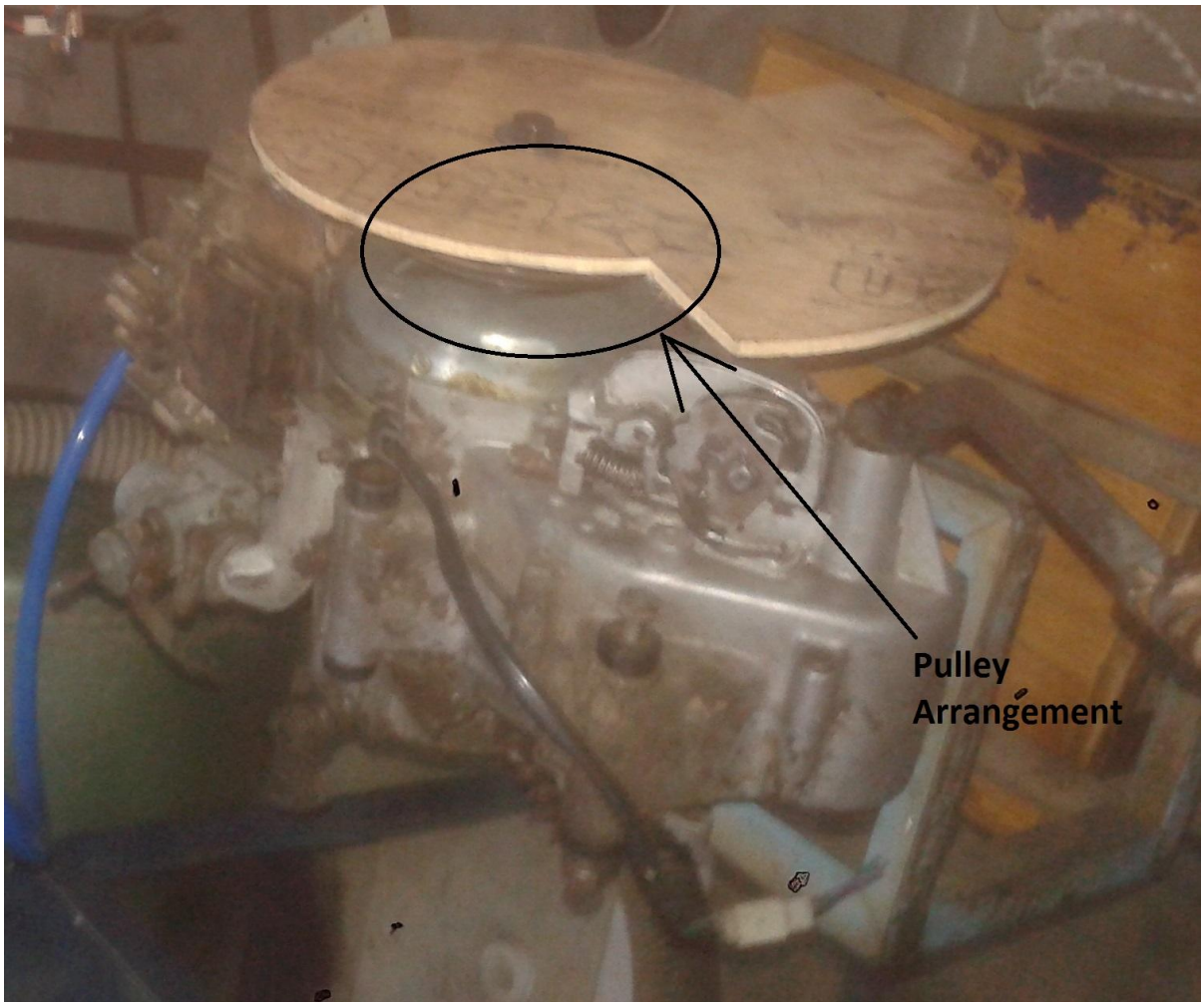


Fig.4.3 Pulley attachment

With these many field works now we could say that our manufacturing work had been done. Though actual conditions can be find out after testing procedures. So now we have to go for testing procedures.

CHAPTER 5
TESTING OF THE PNEUMATIC ENGINE

PURPOSE OF TESTING

Load testing is the process of loading the engine for the purpose of calculating the maximum torque and brake power by a load testing apparatus.

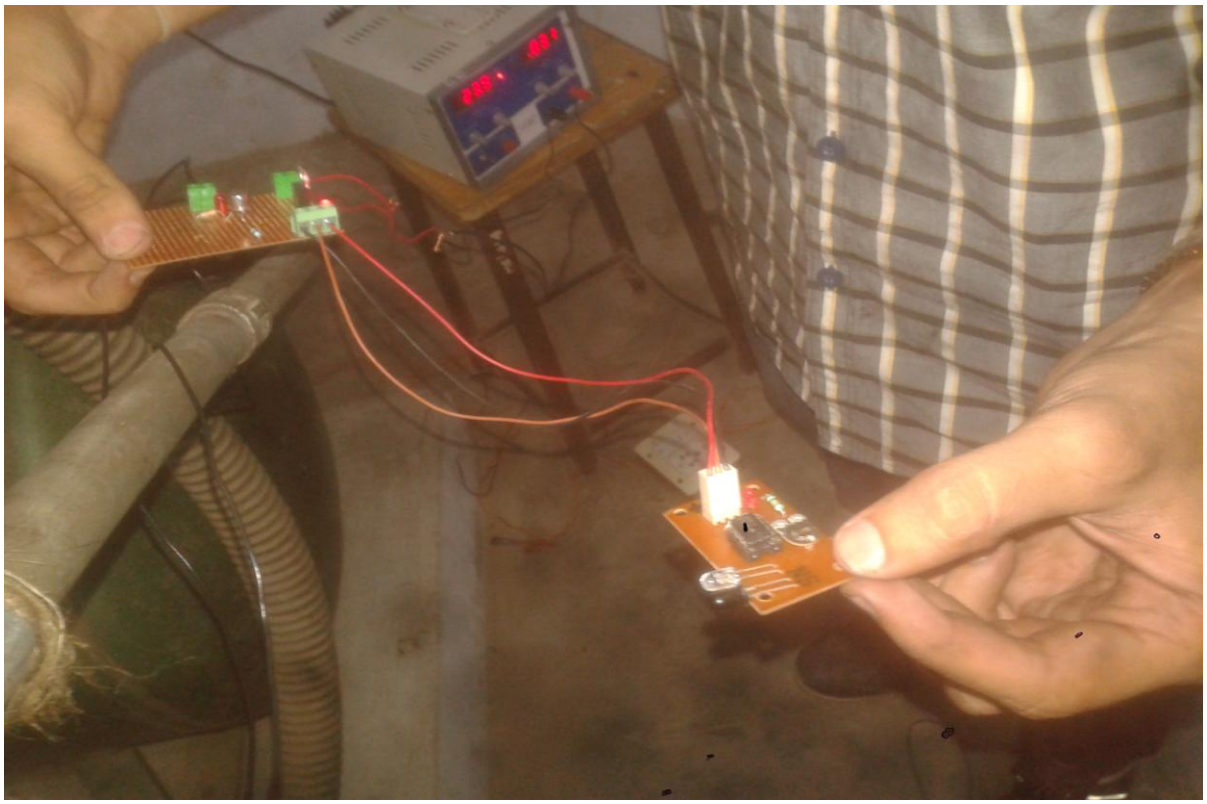
TESTING PROCEDURE

1. Made sure that all the connections were made correctly.
2. Made sure that the valve of compression tank is in closed position.
3. Then the tank is filled up to the required pressure by running the compressor.
4. The electrical circuit is turned on by closing the connection.
5. Made sure that the engine is in no load condition.
6. Then the valve of the compressor tank is opened gradually to the maximum.
7. For the engine to start running it is cranked with the help of the kicker.
8. When the engine starts running and gained speed; no load readings of pressure in BAR as indicated by the pressure gauge on the engine and the speed of the brake drum in RPM as indicated by the tachometer is taken down.
9. This process is repeated for different values of pressure ranging between 5bar and 9bar and the corresponding readings of speed of rotation are noted.
10. The readings thus obtained are tabulated in the tabular column.

TESTING SET UP

Following are some photo graphs of setups of the testing procedures carried out by us.


24V DC



Testing Result:

1) Pressure is continuously decreasing

Pressure (kg f/cm^2)	Rotation of crank(RPM)		
	Percentage of flow rate		
	100%	75%	50%
8	1200	1130	1000
7	1080	1000	900
6	900	850	740
5.5	830	650	580
5	650	600	565
4.5	580	550	480

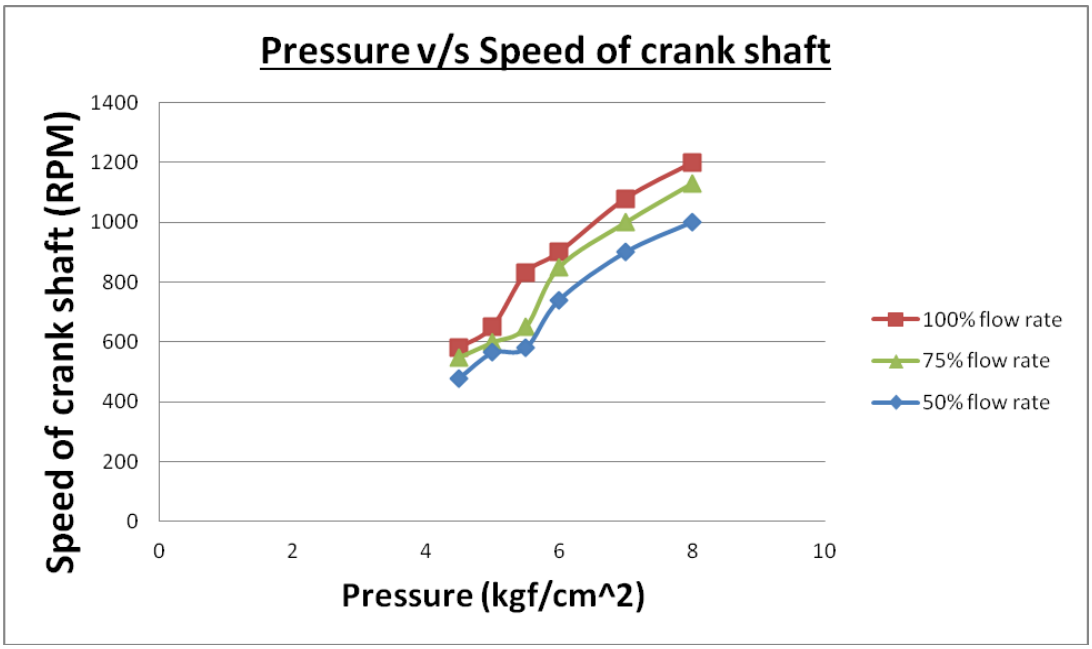


Fig.5.1 Pressure v/s Speed Graph

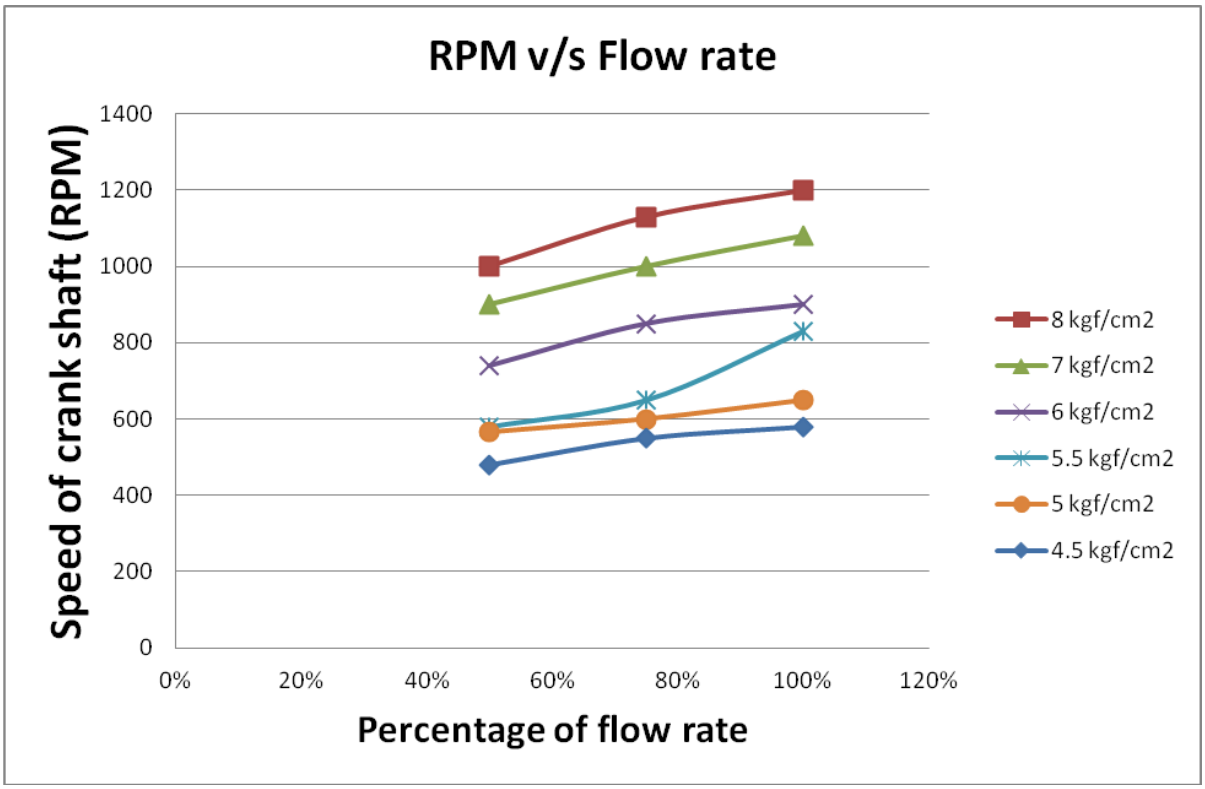


Fig.5.2 Speed of crank shaft v/s Flow rate

Calculations:

Pressure ratio = 8

No. of Revolution for reaching up to 8 bar pressure = 94

Energy meter reading = 200 Rev/ kwh

Cost of electricity per unit = 8 Rs.

Cost of charging air tank up to 8 bar = 94*8 / 200

= 3.76 Rs.

2) Pressure is constant

Engine run at constant pressure for time**, t= 2 minute** at particular pressure

Pressure (kgf/cm^2)	Rotation of energy meter	Speed of crank shaft (RPM)		
		Percentage of flow rate		
		100%	75%	50%
9	20	1050	980	840
8.5	20	1100	1000	850
8	19	1210	1125	980
7	20	1110	1000	910
6	19	900	860	730
5	20	640	580	550

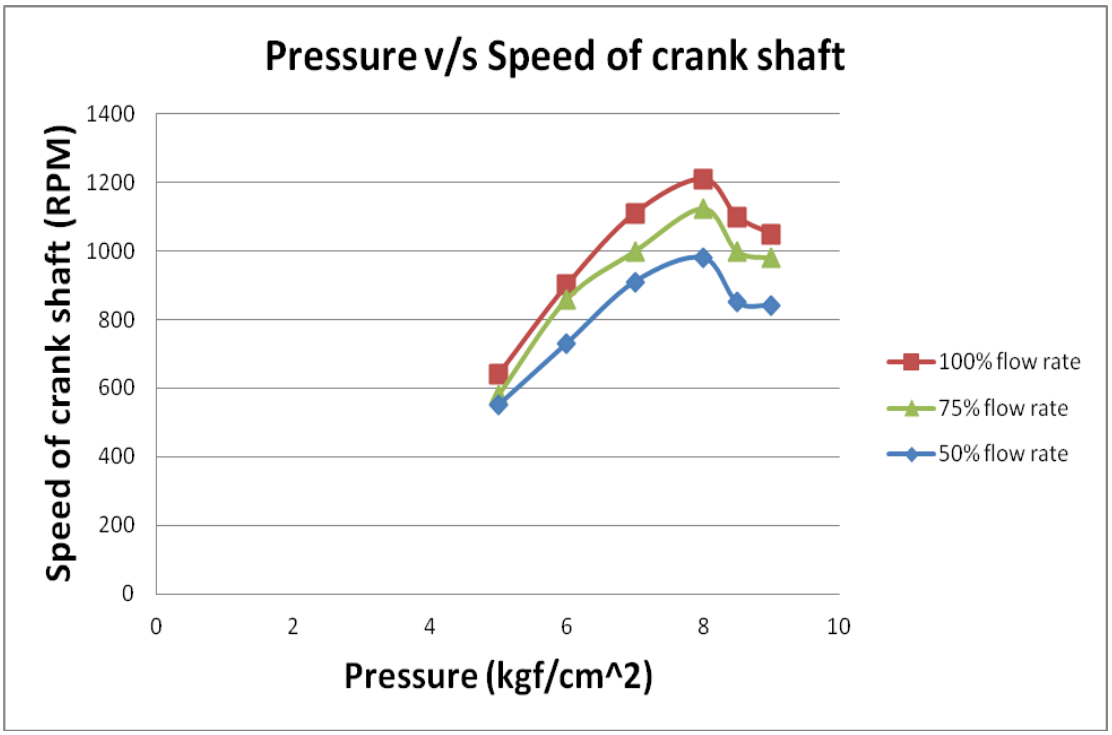


Fig.5.3 Pressure v/s Speed at constant pressure

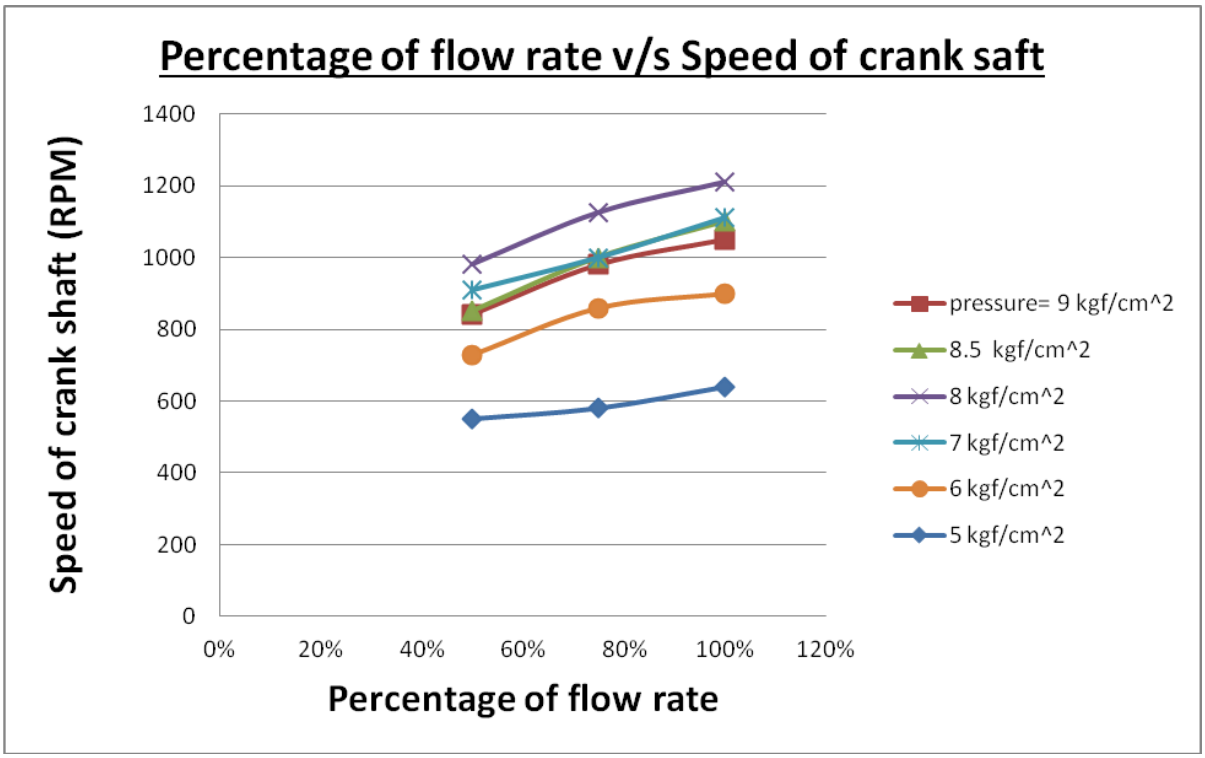


Fig.5.4 Percentage of flow rate v/s speed of crank shaft

Calculations:

Rotation of Energy meter = 20 Rev in 2 minutes

Cost of Electricity = 20*8 / 200

= 80 paise

CHAPTER 6
COST ANALYSIS

Sr. No.	Components	Cost (Rs/-)
1	2 stroke engine	1500
2	Engine modification	520
3	Circuit	215
4	Solenoid control Valve	2500
5	Piping System	315
6	Valve Timing Disc	60
7	Power Supply	1255
8	Air Compressor 50L Tank	15000
	Total Cost	**21365**

CHAPTER 7
ADVANTAGES OF THE PNEUMATIC ENGINE

- Less costly and more effective
- The air engine is an **emission-free** piston engine that uses compressed air as a source of energy.
- **Simple in construction**. The engine can be massively reduced in size
- **Easy to maintain and repair**.
- **No fire hazard** problem due to over loading. Air, on its own, is non-flammable.
- **Low manufacture and maintenance costs**
- Comparatively the **operation cost is less.**
- **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
- Compressed-air tanks can be disposed of or **recycled with less pollution** than batteries.
- Compressed-air engines are **unconstrained by the degradation problems** associated with current battery systems.
- 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.
- **Lighter vehicles** cause less damage to roads
- 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
- **Quick response is achieved**.

CHAPTER 8
NEW CONCEPTS

- Starting of this engine can be made easier and quicker by adopting servo mechanism.

  This servo mechanism will be attached with infrared sensor. So with the help of servo mechanism we can start and stop the engine only with the help of one switch only, which can on and off by operator.

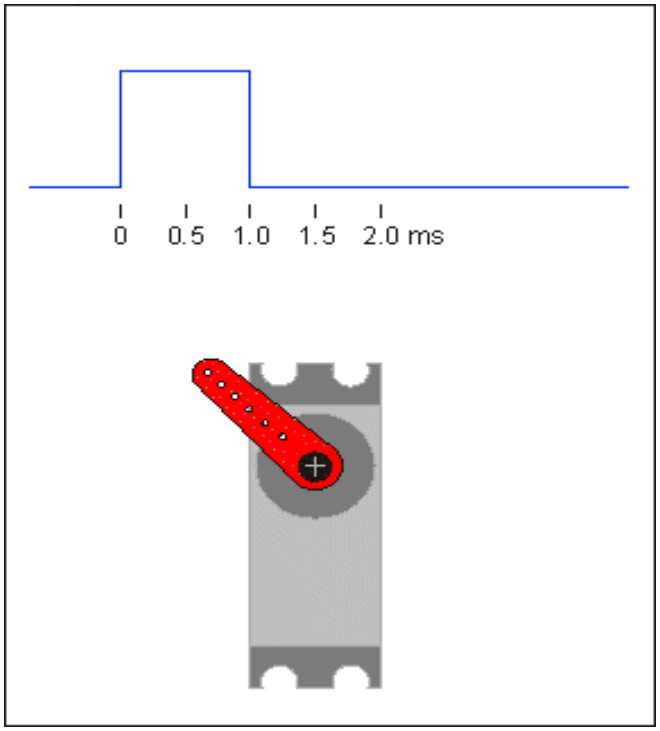


Fig.8.1 Servo motor

- In our engine at the exhaust side compressed air get expand in the engine. This will cause its temperature down. And it is up to that extent such that it will cause cooling effect similar to fan air in our car.

  So we can use that air for producing some amount of **cooling effect** in our automobile.

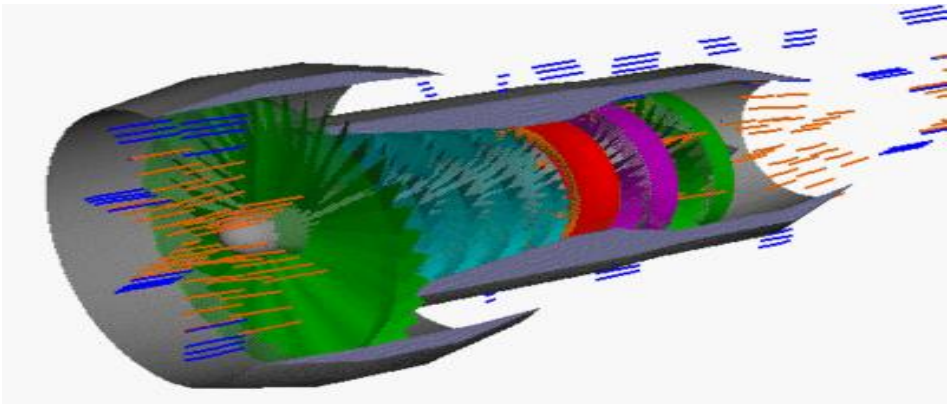


Fig.8.2 Turbo Fan

- We all know that air can be treated as a ideal gas.

According to Ideal Gas Law, p V = nRT

So we can say that for constant value of V **pressure is proportional to temperature**. Hence by using heating coil in the compressed air system we can increase pressure as well as entropy of the compressed air. So we can **re-energized the compressed air** using this concept.

Here volumetric efficiency decreases but for low flow rate requirement application we can use this concept.

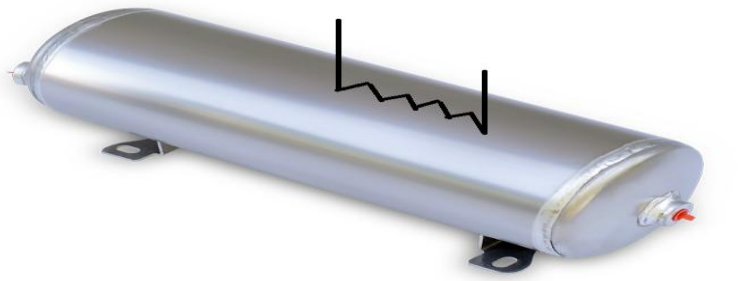


Fig.8.3 Air tank

CHAPTER 9
APPLICATIONS OF THE PNEUMATIC ENGINE

9.1. 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.

Fig 9.1 belt conveyor

9.2. JOB CLAMPING

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

9.3. FLUID PUMPS

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

Fig. 9.2 Fluid pump

9.4. AUTOMOBILES

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

Fig. 9.3 air car

9.5. Power Generator:

It can store energy as compressed air in one cylinder and it can be used as a generator in absence of electricity.

- It can also used as a mobile power producing device in small villages where electricity is not available.

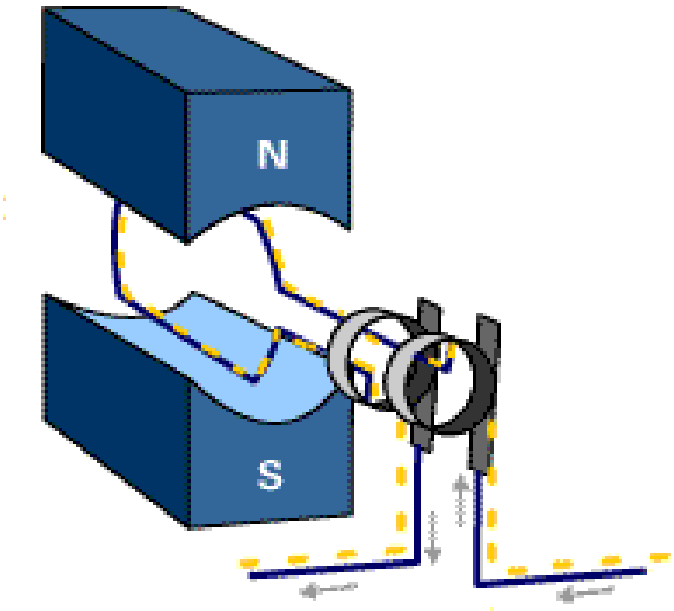


Fig.9.4 Generator

CHAPTER 10
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 as well as electronic circuit. The main thing we have learned during this project is gaining experience in actual field.

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.

CHAPTER 11
FUTURE SCOPE

- It is not going to finish only at this stage. A lot of testing as well as new materials will be required to find out to improve this system.
- 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.
- So, it is just starting with one small application of a lot of scientists' research work on compressed air technology and some known technology.

CHAPTER 12
PPMS ACTIVITIES

1. **Plagiarism Report**

Plagiarism Checker X Originality Report

Similarity Found: 24%

Date: Monday, April 18, 2016
Statistics: 2142 words Plagiarized / 6307 Total words
Remarks: Medium Plagiarism Detected - Your Document needs Selective Improvement.

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2) Business Model Canvas (BMC)

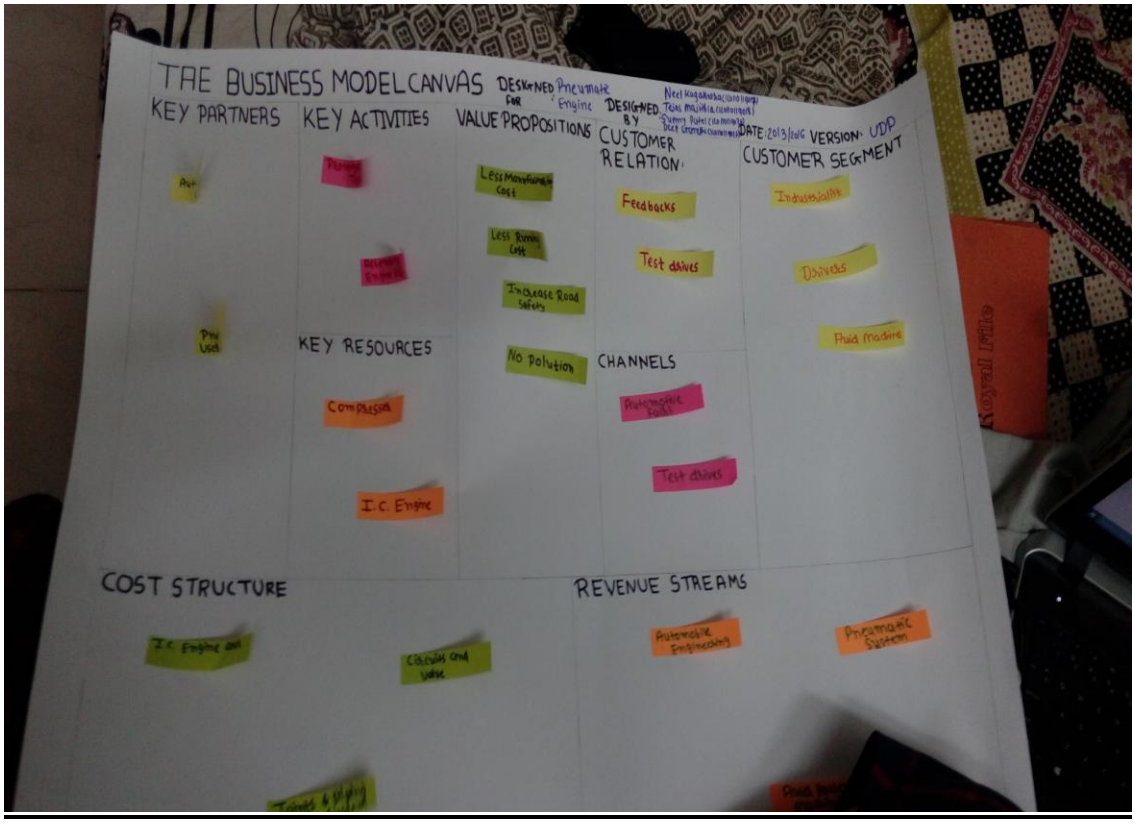

Fig.12.1 Business Model Canvas

❖ Business Model Summary

- The main purpose of this project is to find out alternative of conventional fuel for automotive vehicles and to reduce the pollution. Here, this is possible with the help of compressed air technology. This design is free from road accidents and running cost is very low.
- The 'Customer Segments' will include the target customers who will be using the proposed product viz. Industrialist, Drivers, Fluid Machines. The 'Customer Relationships' shows the quality of relation we will build. It includes Feedbacks, Test-drives, get the idea to change in design if any. The 'Key Partners' for product who will be helpful in project are Automotive Industries and Pneumatic System used Industries.
- The 'Value Propositions' will show a specific feature about the product which will prove to be a significant point for the users. It contains Less Manufacturing cost and less running cost as well, Increase road safety, very less pollution. The 'Key Activities' will show the methods of promotion as well as Improvements. Prototype testing, assembly of Engine and Components. The 'Key Resources' in achieving these would compressor, I.C. Engine.
- The 'Channels' for making & Promotion will be the key point of success of any product when introduced newly to the market. Automotive Fairs and Test-drives would help our product to make it popular. The 'Cost Structure' would include all the costs involved in its production like I.C. Engine Cost, Joints & Piping System, Circuits and valves. The 'Revenue Streams' will have Automobile Engineering, Fluid power, Pneumatic system based area.

CHAPTER 13
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