TITLE PAGE

INTEGRATION OF ATOMIZER INTO ECONOMIZER SYSTEM IN PETROL ENGINES

DEDICATION

This project is dedicated to Almighty God, also to my wife, my children and friends for their contributions towards the realization of this programme. Glory be to God for His inspirations to a successful end.

CERTIFICATION

This is to certify that the project of achieving fuel economy, that is, petrol in an automobile through the design of fuel atomizer device incorporated in fuel economizer system was carried out by Engr. King, Udofia Johnson under the supervision of Engr. (Dr.) Edelugo, S. O. and submitted to the Department of Mechanical Engineering, University of Nigeria, Nsukka.

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NOMENCLATURE

^{o}C	=	Degree centigrade
R, r	=	radii (m)
C	=	Carbon
O_2	=	Oxygen
HE	=	Heat Engine
SIE	=	Spark Ignition Engine
⬂	=	Isotropic index
ECE	=	External Combustion Engine
ICE	=	Internal Combustion Engine
P	=	Pressure (Pa)
CIE	=	Compression Ignition Engine
V	=	Volume (m^3)
HEC	=	Heat Engine Chart
T	=	Temperature (^{o}K)
ECM	=	Electronic Control Module
ECCS	=	Electronic Concentrated Engine Control System
SI	=	Spark Ignition
hp	=	horse power (w)
V_c	=	clearance volume (m^3)
V_s	=	swept volume (m^3)
V_v	=	compressor ratio
U	=	flow velocity ratio of air (Kg sec^{-1})
hs	=	stroke (m)
D	=	diameter (m)
Di	=	Internal Diameter (m)
Pi	=	Internal Pressure (Pa)
t	=	thickness (m)
p_o	=	Stagnation Pressure (Pa)
T_o	=	Stagnation temperature (^{o}K)
KSi	=	Kilo pound per square inch (MPa)
N	=	Newton
n	=	Polytrophic index
cm	=	centimeter
BMW	=	Bavarian Motor Works
CCC	=	Computer Command Control

ABSTRACT

The thesis is aimed at designing a fuel atomizer device to be incorporated in a fuel economizer system for use in petrol engines for more efficient fuel consumption. The principle adopted is based on the spraying paint machine. A compressor is used to compress air from the atmosphere and deliver it to the carburetor. The power required to operate the compressor is obtained by connecting the compressor pulley and the crankshaft pulley with a fan belt. A fuel atomizer device is used to ensure that correct orifice released air to the carburetor with the aid of control valve and air pressure gauge to ensure that correct air/fuel ratio is maintained. An air dryer is installed to absorb moisture from the air. An air cylinder is installed to store compressed air, while a high pressurized air incorporated inside the carburetor through a pipe and atomizer deviceôs orifice to atomize fuel into tiny possible particles to achieve a complete combustion and fuel economy. This was ascertained by testing vehicle with fuel economizer with measured quantity of fuel, noting the speedometer at the start of the vehicle for a certain distance and doing the same without a fuel economizer. The speedometer and time taken were recorded and graph of the result was shown in figure 4.20. The result showed that vehicle installed with fuel economizer device gives complete combustion than vehicle without it. It also reduces petrol waste, lessens pollution and installation is environmental friendly.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE RESEARCH

The fuel atomizer system in petrol engine is a designed mechanism for reducing the rate of fuel consumption and obtaining a complete combustion process in a petrol engine. Some companies introduce fuel injection system method of delivering fuel to internal combustion engine. Car designers such as BMW, Mercedes Benz and Volvo have incorporated different designs to improve fuel economy in cars.

Modern computerized fuel injection produced more power, lower exhaust emission, improved fuel economy than other carburetor systems. However, the following factors affect the process of carburetion:

(a) **Time:** The higher the engine speed, the lesser time is available for mixture formation.

(b) **Temperature:** A higher temperature of mixture improves vaporization of fuel and mixture quality and consequently, increases indicated efficiency of the engine.

(c) **Design:** The design of the carburetor with its elements, heating system for mixture, shape and cross-sectional area of intake pipe, and the shape of the combustion chamber have good effect on the uniform distribution of the mixture among the cylinders and in various operating conditions of the engine.

(d) **Quality of Fuel:** The greater the carbon contents in hydrocarbon the less volatile the fuel as stated in the table 1.1 below.

Table 1.1: The physical properties of the first twenty members of straight-carbon alkanes

Number of Carbon Atom(s)	Molecular Formula	States (at 25 °C)	Melting Point (°C)	Boiling Point (°C)	Density at 25 °C (g cm^{-3})
1	CH_4	Gas	-183	-161	0.424
2	C_2H_6	Gas	-172	-89	0.546
3	C_3H_8	Gas	-188	-42	0.501
4	C_4H_{10}	Gas	-135	0	0.579
5	C_5H_{12}	Liquid	-130	36	0.626
6	C_6H_{14}	Liquid	-95	69	0.657
7	C_7H_{16}	Liquid	-91	98	0.684
8	C_8H_{18}	Liquid	-57	126	0.703
9	C_9H_{20}	Liquid	-54	151	0.718
10	$C_{10}H_{22}$	Liquid	-30	174	0.730
11	$C_{11}H_{24}$	Liquid	-26	196	0.740
12	$C_{12}H_{26}$	Liquid	-10	216	0.749
13	$C_{13}H_{28}$	Liquid	-7	233	0.753
14	$C_{14}H_{30}$	Liquid	-3	260	0.761
15	$C_{15}H_{32}$	Liquid	10	271	0.769
16	$C_{16}H_{34}$	Liquid	18	287	0.773
17	$C_{17}H_{36}$	Liquid	22	302	0.777
18	$C_{18}H_{38}$	Solid	28	316	0.777
19	$C_{19}H_{40}$	Solid	32	330	0.786
20	$C_{20}H_{42}$	Solid	37	344	0.785

1.2 PURPOSE/OBJECTIVE OF THE RESEARCH

The main purpose of this fuel atomization mechanism is to achieve a complete combustion process in petrol engine 504 Peugeot Station Wagon to achieve a better power output at lowest possible fuel consumption through a tiny fuel atomization. The fuel will be sprayed in small particles which will help the fuel to be in vapour phase to increase complete combustion to achieve this, a higher power output at lowest possible fuel combustion.

1.3 COMBUSTION IN SPARK IGNITION ENGINE

Combustion is a relatively rapid chemical combination of hydrogen and carbon in the fuel with the oxygen in the air, resulting in liberation of energy in the form of heat, thus is exothermic reaction in that heat is given out.

$$C_7H_{16} + 11O_2 + 11N_2 \rightarrow 7CO_2 + 8H_2O + 11N_2$$

In spark ignition engine, a carburetor generally supplies a combustible mixture and the electric spark from a spark-plug initiates combustion.

The spark ignition system component sketch in shown in fig. 1.1 below

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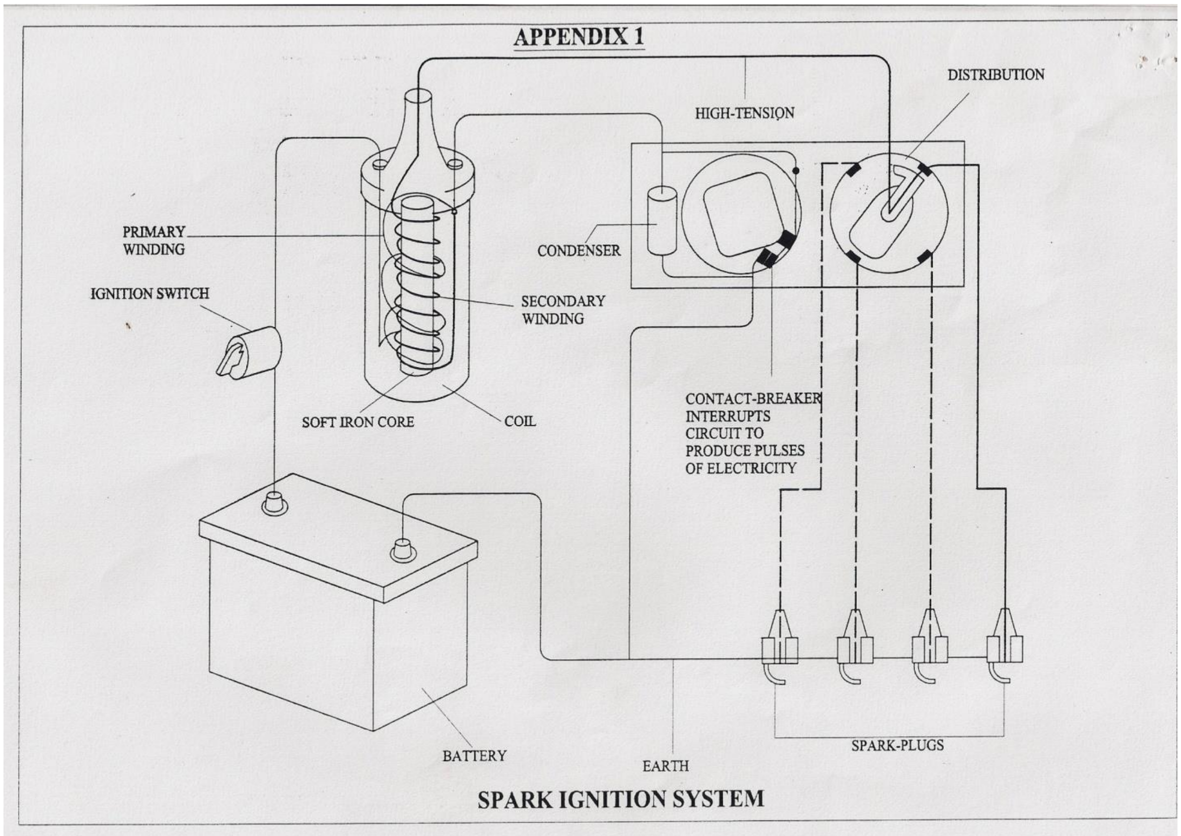


Fig: 1.1: Spark Ignition System

1.4 COMBUSTION PHENOMENON: NORMAL COMBUSTION

In a Spark Ignition (SI) Engine, a single intensely high temperature spark passes across the electrodes leaving behind a thin thread of flame.

From this thin thread, combustion spreads to envelope a mixture immediately surrounding it at a rate which depends primarily upon the temperature of the flame front itself and to a secondary degree upon both the temperature and the density of the surrounding envelope. In the actual engine cylinder, the mixture is hot at rest in highly turbulent condition. The following conditions are necessary for combustion to take place:

(i) A combustible mixture

(ii) Some means to initiate combustion

(iii) Stabilization and propagation of flame in the combustion chamber

In a fuel injection system, electronically controlled fuel injectors spray measured amount of fuel into each of the engine cylinders where the fuel is burned, powering the engine.

The spread of the flame throughout the combustion chamber is shown below.

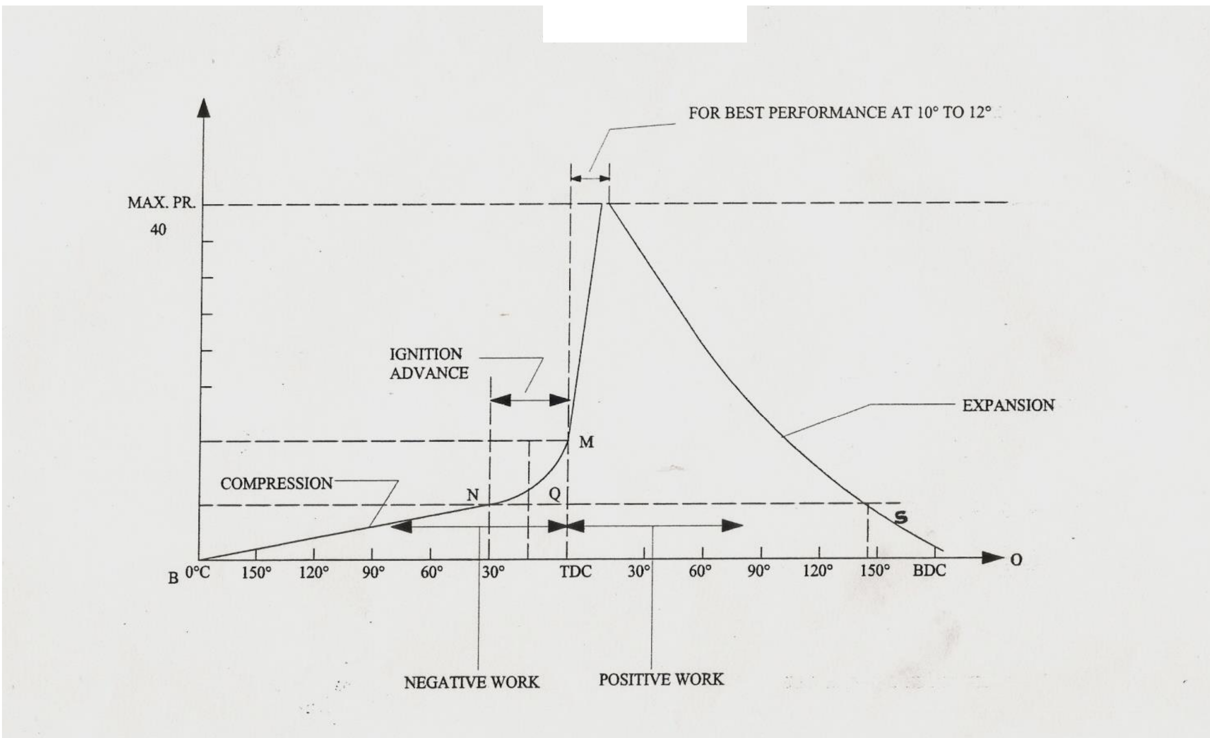


Fig. 1.2: Pressure-crank angle diagram of a petrol engine

LNQM assumes compression curve having no ignition

- First stage of combustion, the ignition lag, starts from this point and no pressure rise is noticeable.
- Q is the point where the pressure rise can be detected. From this point it deviates from the simple compression (motoring) curve.

- The time lag between first ignition of fuel and the commencement of the main phase of combustion is called the period of incubation or is also known as ignition lag. The time is normally about 0.0015 seconds. The maximum pressure is reached at about 12^o after dead centre point. Although the point of maximum pressure marks the completion of flame travel, it does not mean that at this point the whole of the heat of fuel has been liberated, for even after the passage of the flame, some further chemical adjustments due to reassociation etc, will continue to a greater or less degree throughout the expansion stroke. This is known as after burning (Rajput, 2007).

1.5 FACTORS AFFECTING NORMAL COMBUSTION IN S. I. ENGINE

Factors affecting normal combustion in S. I. Engine are:

(i) **Induction Pressure:** As the pressure falls, delay period increases; and the ignition must be earlier at low pressure a vacuum control may be incorporated.

(ii) **Ignition Timing:** If ignition is too earlier the peak pressure will occur too early and work transfer falls. If ignition is too late, the peak pressure will be too low and work transfer will fall. Combustion may not be completed by the time exhaust valve opens and the valve may burn.

(iii) **Mixture Strength:** Although the stoichiometric ratio should give the best result, the effect of disassociation is to make a slightly rich mixture necessary for maximum work transfer.

(iv) **Fuel Choice:** The induction period of the fuel will affect the delay period. The calorific value and the enthalpy of vaporization will affect the temperature achieved.

(v) **Combustion Chamber:** The combustion chamber should be designed to give a short flame path to avoid knock and it should promote optimum turbulence.

1.6 STATEMENT OF PROBLEM

The main problem of this work is to combat the issue of incomplete combustion which encourages unwanted waste of fuel and environmental pollution.

1.7 INCOMPLETE COMBUSTION

The incomplete fuel combustion occurs when the oxidizable fuel elements are not oxidized to the ultimate state. Here, there will be excessive waste of fuel (unburned fuel) and it encourages pollution.

1.8 DISADVANTAGES OF INCOMPLETE COMBUSTION

There are so many disadvantages that follow an incomplete combustion of fuel.

(i) **DETONATION:** is a very sudden rise of pressure accompanied by metallic-hammer sound. The result is tremendously rapid and local increase in pressure which sets up pressure waves that hit the cylinder walls with such violence that the walls emit a sound like a ñpingò. It is the ping that manifests detonation.

(ii) **SMOG**: This is a type of light fog which is unpleasant and a cause of irritation to the eyes and nasal passage. Although not affecting visibility greatly, it does affect vegetation and has caused serious economic loses in horticulture and agriculture.

1.9 PRODUCTS OF INCOMPLETE COMBUSTION OF FUEL

The products of incomplete combustion of fuel are: CO, CO_2, N_2, NO, NO_2, SO_2, HC and H_2O

1.10 LIMITATION

Ignition limit: It has been observed through experiments that ignition of charge is only possible within certain limits of fuel-air ratio.

Combustion Limit: It is important to note that excess air will be needed for complete combustion.

Ignition timing is important in combustion general limit.

General Limit: No liquid fuel can ignite without being vaporized. Therefore good quality of fuel is important for any combustion. Consequently, calorific value of fuel plays important role in limitation of combustion to avoid explosion

RESEARCH METHODOLOGY

This research will consider all the design principles which require the calculation of various parameters. Lastly, it deals with the testing of the fabrication mechanism to evaluate performance.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Before contemplating on the purchase of any vehicle certain factors are always taken into consideration. These include among others the cost of the vehicle itself, the cost of maintenance and above all, the cost of operation ï fuel, oil, etc. The last one is now receiving a lot of attention due to rising cost of fuel in the world market, a case study of fuel economizer in petrol engine. It is important issue commonly discussed by customers since the increase in the price of fuel is a set back to individual economy. The need to save cost, reduce atmospheric pollution, increase the efficiency of automobile engine and reduce fuel consumption had encouraged many companies and scientists to come out with the product that can fulfill these demands of fuel economy. Basically, there are three current ways of fuel economizer in vehicles. These include;

a) Compressing more air into combustion chamber.
b) Clamping a magnet at the fuel line before combustion chamber.
c) Use of revolutionary technology that allows engine to gain more power and torque; that is installing spark ignition product into the engine system.

I Spark™ Company of USA used revolutionary technology to obtain fuel economy by burning fuel completely and efficiently. It controls carbon monoxide emission in spark ignition engines using the electronic optimizer developed by the Fe⊂de⊂ration Internationale deôs Socie⊂te⊂s de Inge⊂nieurs des Techniques de lôAutomoblie (FISITA) (Schwaller, 1993).

The I Spark^{TM} revolutionary circuitry provides added storage, energy to optimize any inductive ignition coil and raises performance by up to 5%. It provides good starting, highly intensified powerful. Sparks that ignite every fuel/air mixture quicker and completely, thus increasing engine efficiency, horse power and torque and at the same time reducing fuel consumption and hazardous emission.

2.1.1 THE IGNITION SYSTEM SPARK REACTION

Most ignition systems comprise of an inductive coil and a point inductive or electronical trigger module. The coil is charged and triggered to induce a second set up higher voltage. When the ionization point is reached, the inducted electrical energy dumps the spark plug gap creating a spark. Provided the spark intensity is powerful enough, the fuel/air mixture in the combustion chamber will ignite.

The initial spark that starts the fuel ignition affects the rate of burning. The faster the process of burning the fuel the more powerful the engine becomes mathematically given as:

Power = Work / Time

P = W / T

A good analogy would be if to burn a tank full of petrol, over a period of 60 seconds, or below it up in a second. The total energy released remains the same but the latter will be much more powerful. Slow combustion rate in engine causes incomplete burning resulting in loss of power, excess carbon build up and also emission of toxic gases, clogging the electronic converter and causing the pollution in the environment.

I Spark^{TM} revolutionary circuitry optimizes the rise and saturation time of inductive ignition coil. ñIntelligent Sparkò allows engines to increase power without extensive mechanical modification. By using I Spark^{TM} there will be;

a) Increased Horse power and torque.

b) Better fuel mileage.

c) Easier engine starting.

d) Quicker acceleration.

e) Higher top speed.

f) Smoother running.

g) Less carbon build-up.

h) Less pollution.

2.1.2 VG FUEL SAVERS METHOD

The VG fuel savers are affixed to the vehicles using high quality double-sided adhesive tape or industrial silicone adhesive. They are precision designed vortex generators specifically tailored to the speeds of todayꞌs motor vehicles. These units produce strong vortices (small tornadoes) which cause the boundary layer of the airflow to stick to the back of the vehicle. This gets rid of the drag inducing eddysô of air and introducing smooth laminar airflow. The same applies to station wagon hatches 4ds and other vertical backed wheeled vehicles, although the airflow does not stick to the back of the vehicle, it only fills in the low pressure areas behind the vehicle reducing the drag. This reduction in the total drag of the vehicle shows its benefit by reducing fuel consumption due to the engine not having to work as hard for the same vehicle speed as the total vehicle load is less. This technology is extensively used by major aircraft manufacturers (Boeing, Airbus, Learjet) to improve the performance of their aircraft (www.fuelsaver.com).

This innovation uses aerospace technology to reduce fuel consumption of motor vehicles and is achieved by the use of specifically designed economizer. VG fuel savers had been developed for speed ranges of modern motor vehicles and they are constructed from folded aircraft aluminium alloy for maximum strength and durability with cost and manufacturing issues taken into consideration. They may be painted with good quality paints, this will not degrade performance of VG fuel savers. Drag reduction system improves fuel economy and fuel efficiency.

2.1.3 VORTEC CYCLONE

Gas Saving Calculator

The Vortec Cyclone gas savings calculator gives immediate mileage increase allowing the user to go further on a tank of gas and thus, saving a lot of money. This calculator is to figure out how much money will be saved when you increase mileage by three or even four Km per gallon or more. The average is shown in the Table below.

Table 2.1: Average result in Km per gallon to save money

VEHICLES	BASE MPG	MPGW/VORTEC	% GAIN
06 Ford FI50	17.2 MPG	19.8 MPG	15 %
00 Ford Ranger	18.0 MPG	24.0 MPG	33 %
02 Mustang GT	19.5 MPG	24.2 MPG	24 %
00 Camry	25.2 MPG	26.7 MPG	6 %
04 Caravan	21.1 MPG	23.5 MPG	11 %

Source: (Vortec Cyclone, 2008)

Advantages of Vortec Cyclone Gas Calculator

i. It saves money.
ii. It saves fuel.
iii. It keeps planet clean.

iv. It reduces our oil consumption by 20 % in the coming decade.

2.1.4 TONY'S GUIDE TO FUEL SAVING GADGETS

Devices to improve fuel atomization (petrol/gasoline only) include Ecotek, TORNADO fuel saver, Spiralmax, Vaporate with Acetone as an additive. Petrol naturally exists at room temperature as a liquid, surprisingly the liquid form does not in fact burn in an engine. The fuel must first be vaporized before it can be burnt. Liquid petrol burns very slowly, while rapid combustion is required in an engine. It is therefore very important to introduce the fuel to the intake manifold as a fine ñmistò which can rapidly vaporize large drops of fuel to collect on cylinder walls in the head gasket crevice etc, and do not take part in the combustion process. This fuel is then released in the exhaust stroke as unburnt hydrocarbon, and represents both toxic emissions and worse fuel consumption. The above explanation is what the maker of these devices claim and it is quite correct. What they did not say is that modern fuel injection systems already delivered this extremely fine fuel mist. Thanks to year of intensive development. The average drop size from a topical modern injector is around 0.1 mm, almost invisibly small, and so the vaporization is very good any way. A device to increase atomization might provide real benefit on an old carburetor fuelled vehicle but not anything with fuel injection. One technology that undoubtedly does improve atomization is the air-assist injector. This is a normal fuel injector surrounded by a shroud connected to atmospheric air. Air is sucked through fine slots in the shroud and blasts directly into the fuel spray. This device is state of the art in fuel atomization. The air enters the injector at several hundred meters per second and hits the fuel spray at the best possible place, right as it emerges from the injector. The result is much smaller fuel drops which can give significantly reduced hydrocarbon emissions under cold running conditions. As a result, they are already fitted to many cars.

2.1.5 KENTUBE FUEL ECONOMIZER

Kentube fuel economizer is designed by Fintube Technologies Inc, a subsidiary of United States steel. This Kentube fuel economizer is designed to heat deaerated, chemically treated boiler feed water with fuel gases. This product is not protected to withstand extended out-of-door storage. The unit should be protected from the rain. Although rust is not harmful to the operation of the unit it could cause damage to control valves installed down stream of the fuel economizer. This unit has not been freeze protected unless, as stated on the shipping tag.

2.1.6 MAGNETIC FUEL SAVER

This is developed from magnetic Technology magnet in South Africa. The liquid fuel used for an internal combustion engine is composed of a set of molecules where each molecule includes a number of atoms, which are composed of nuclei with electrons orbiting around the nuclei. The molecules have magnetic moment in themselves and the rotating electrons cause magnetic phenomena. Thus positive (+) and negative (-) electric charges exist in the fuelôs molecules. For this reason the fuel particles of the negative and positive electric charges are not split into more minute particles. Accordingly, the fuels are not actively interlocked with oxygen during combustion, thereby causing incomplete combustion. To improve above the fuel have required to be decomposed and ionized. The ionization of the fuel particles is accomplished by the supply of magnetic force from a magnet. Applying a magnetic field to ionizing fuel to be fed to combustion devices, can ensure more complete combustion, obtaining a maximization of the fuel economy and reducing polluting emissions.

The fuel is subjected to the lines of forces from permanent magnet mounted on fuel inlet lines, increasing the internal energy to obtain easier combustion. The molecules fly apart easier, join with oxygen easily and ignite faster. Ionization implies that the fuel acquires a charge and molecules of like charge repel each other. This makes fuel dispersal more efficient.

Benefit of these devices is that magnetically charged fuel and air molecules with opposite polarities dissolve build-ups in carburetor jets and combustion chambers helping to clean up the engine and maintain the clean condition (http://usuaris.tinet.cat/sje/mag).

2.1.7 FUEL ECONOMIZER CAR ENGINE FUEL SAVER

According to Haibo (2005) of Ningbo Centre Magnetic and Electronic Company Limited, China, since carbon and oxygen have opposite magnetic polarities then by using the super fuel saver both carbon and oxygen are easily fused together producing a better and efficient combustion of fuel and air thus, the engine **works more efficiently generating greater power, and, reducing the consumption of fuel with more efficient combustion.**

2.1.8 ZYDEX INDUSTRIES INDIA COMBUSTION ATOMIZER

According to above company, new generation fuel efficiency enhancer ZYCRYL-15 (patented) improves fuel efficiency.

2.2 INNOVATION IN ATOMIZATION

A team of business engineers compared the inherent differences between fuel firing and studied the typical application for fuel burner. From the analyses the team made a break through in atomization technology that controls emission, reduces steam consumption and dramatically improves residual fuel combustion (Chung, 2002).

2.2.1 NEW FUEL GUN DEVELOPMENT

Considering the array of liquid fuel properties and application, the team of research development and commercialization engineers embarked on a program to determine the optimal way to burn fuel. The engineers used a series of spray test to analyze droplet size measurements in a pilot-scale spray research laboratory. The engineers conducted full scale combustion tests in the companyøs combustion research facility to determine flame length and quality. **According to John Zink Company Tulsa, Oklahoma, USA, the performance of new fuel gun to date has been excellent. Field reports suggest that the new fuel gun provides significant performance improvement and dramatically lower emission**.

2.2.2 PRESSURE-SWIRL ATOMIZERS (MEMS JET FUEL ATOMIZER)

According to TDA Research Inc., operational requirements documents expressed a need for high speed and long-range stand off missiles against mobile targets. Further, the ability to penetrate deeply burned and hardened targets is also needed. Of the air breathing propulsion cycles that could enable this missile, the Pulse Detonation Engine (PDE) is most efficient and has great potential for improved range and thrust. Most research has been performed with low energy-density gaseous fuel, so demonstrating rapid deflagration-to-detonation. Using storage liquid hydrocarbon fuel is essential to successful development and widespread application of the engine. Unfortunately, liquid fuel requires atomization which introduces the challenge of detonating a liquid droplet spray. Recent research shows that droplet sauter-mean diameter (SMD or d_{32}) as small as 3 mm may be required to achieve detonation under cold-start conditions (Brophy, *et al*. 2000).

2.3 BENEFIT

The MEMS liquid fuel atomizer project founded by Dr. Chris Brophy (Navel Postgraduate School, Monetary (A)) provides technical oversight. Atomizer development will enable efficient liquid fueled PDE for high speed missiles. In another development Pratt and Whitney Seattle Aerosciences Centre and General Electric have been developing PDEs for high-speed missiles, manned/unmanned aircraft and access to space application. All need liquid fuel atomizers and would immediately transition TDAôS MEMS atomizer into their technology program.

2.3.1 BASELINE TECHNOLOGY

Current atomization techniques include the orifice (simple, dual, swirl, pulse-width modulated, etc) poppet-type, air atomizing, ultrasonic, electrostatic and inkjet atomization technologies. Of these the orifice type injectors are the most widely used but their minimum droplet SMD is limited to about 20 mm for an orifice diameter of less than 250 mm with a feed pressure of 100 psi.

2.3.2 IMPORTANT FACTS OF ATOMIZATION

Atomization is usually accomplished by spreading the fuel into a thin sheet to induce instability, thus promoting its disintegration into ligaments which collapse into droplets due to surface tension action. The discharging of the fuel through orifices with specially shaped passages leads the fuel to become a thin sheet from which ligaments and ultimately droplets are formed and these resulting droplets will be distributed through combustion zone in a controlled pattern and direction.

The liquid fuel injection process plays an important role in many aspects of combustion processes performance. To obtain the surface to mass high ratios in the liquid phase which lead to the desired very high evaporation rates, the liquid fuel must be fully atomized before being injected into the combustion zone.

2.3.3 STUDY ON ATOMIZATION AND FUEL DROP SIZE

Diverse techniques have been developed for spray investigations, especially high speed cinematography and microphotography. Recently, the progresses obtained in the application of laser techniques to simultaneous measurements of droplet size and velocity have opened new perspectives for in situ investigations of liquid fuel jets (Quoc, et al., 1994). The above study was based on a laser measuring system and also on the Phase Droplet Anemometry method, PDA applied to examine the dynamic behaviour of the fuel jet. The experimental set up to examine different aspects of fuel spray such as nature of atomization process, the influence of injection conditions (advance of injection and injected fuel quantity) and the spatial and time resolved evolution of droplet diameter in the combustion chamber. The recent progress made in the field of fuel injection has improved engine performance as well as reducing exhaust gas emission.

2.4 HEAT ENGINE

Any type of engine which derives heat energy from the combustion of fuel and converts the energy into mechanical works is termed a Heat Engine.

Heat engines may be classified into two main classes as follows:

(a) **External Combustion Engines** in which combustion of fuel takes place outside the cylinder, for example, steam engine.

(b) **Internal Combustion Engines** in which combustion of the fuel with oxygen of the air occurs within **the** cylinder of the engine, for example, Petrol Engine. It is important to note that those using lighter liquid fuel are known as **Spark Ignition Engine** while those using heavier liquid fuel are called **Compression Ignition Engine**.

The detailed classification of Heat Engines is shown in Figure 2.1 below.

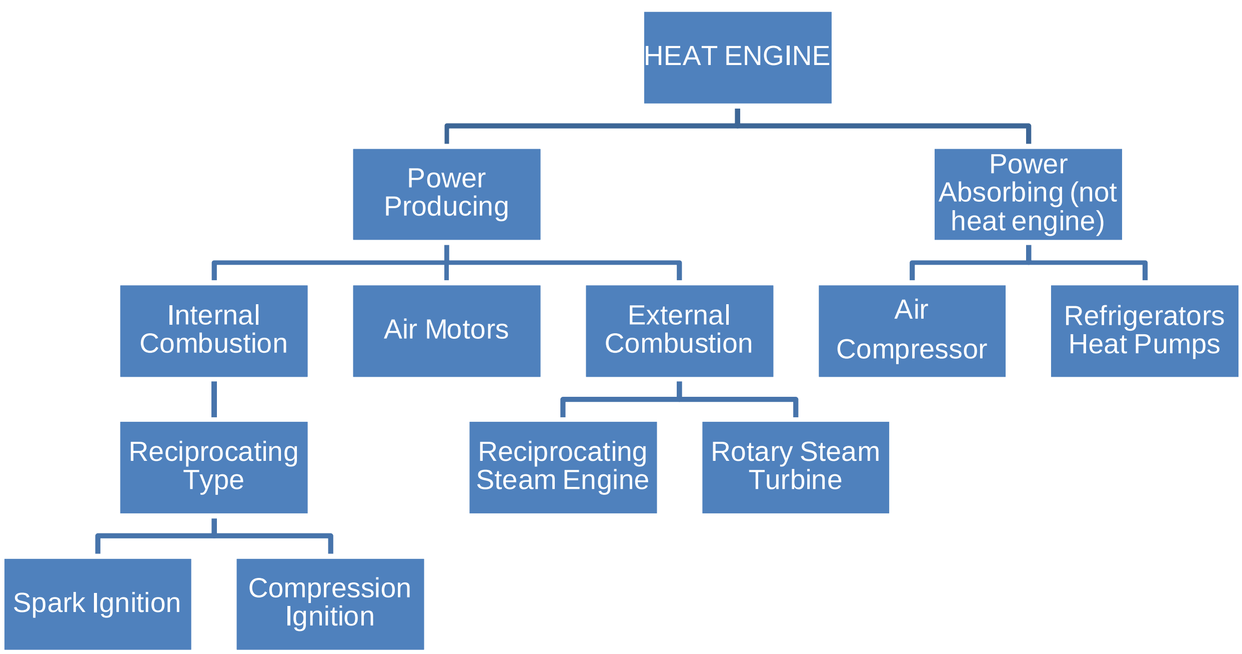


Fig. 2.1: Classification of heat engines

2.5 DEFINITION OF CARBURETOR

A Carburetor is a device which atomizes the fuel and mixes it with air. It is the most important part of the induction system.

The function of the carburetor is to measure out the correct proportion of liquid fuel and air for the particular engine condition. The liquid fuel must be atomized at the carburetor (i.e. broken up to a fine spray to assist mixture in the cylinders to produce homogenous mixture). The metering process is carried out at the carburetor but the actual mixture ratio, its condition and distribution between cylinders depend also on the design of the complete induction system and temperature therein.

2.5.1 BASIC FORMS OF CARBURETOR

Carburetor may be of the following three basic forms:

(i) **Up-draught:** This type of carburetor in which the fuel-air mixture has to be drawn up from below into the intake pipes and cylinders, is no longer used on motor vehicles as the mixture has a strong tendency to separate.

(ii) **Down-draught carburetor:** The down-draught carburetor is used in the majority of cases since the fuel-air mixture is encouraged to flow into the cylinder by the force of gravity as by the usual suction effect.

(iii) **Horizontal Carburetor*:*** This type of carburetor is usually found in motor-cycle engines.

Basic forms of carburetors are shown in the figure below.

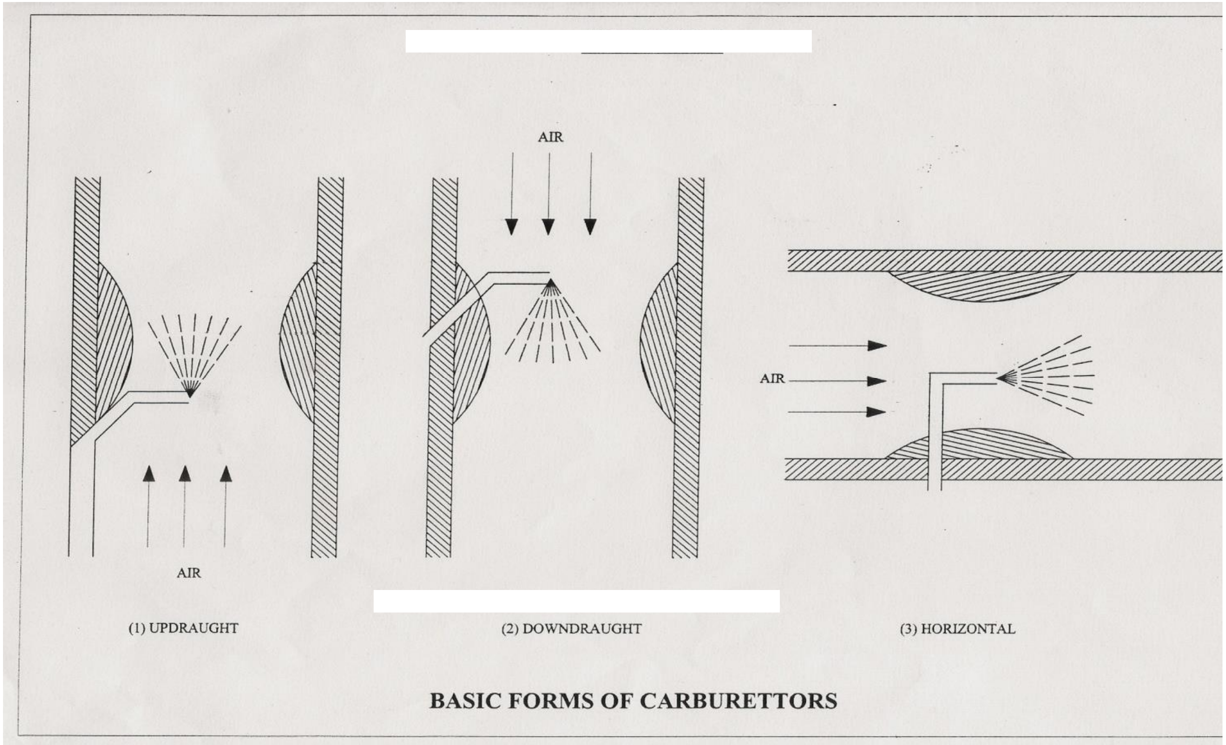


Fig. 2.2: Basic forms of carburetors

CARBURETOR FAULTS AND POSSIBLE CAUSES AND REMEDIES

Table 2.2: Carburetor faults and remedies

Trouble-shooting of Carburetor in a tubular form is given below.

S/NO	TROUBLE	CAUSES	REMEDY
1	Flooding of carburetor	(i) Excessive pressure of fuel by fuel pump (ii) Float level set high (iii) Punctured float ball (iv) Restricted movement of float ball level. (v) Worn out or broken gasket of float ball (vi) Loose, worn out or pitted seat of needle valve (vii) Dirty valve seat (viii) Loose main jet	(i) Give thicker packing between fuel pump body and block. (ii) Adjust float ball level correctly. (iii) Replace it with a new float ball. (iv) See that the ball is moving freely on pin. (v) Replace the gasket. (vi) Replace needle valve (vii) Clean it and lap with valve. (viii) Check up and tighten

			the main jet.
2	Low speed or idle speed Circuit sending lean fuel	(i) Blocked metering hole (ii) Blocked economizer hole (iii) Blocked idle jet (iv) Blocked idle passage in carburetor (v) Torn out gasket of carburetor foundation (vi) Any connection of intake manifold leaking (vii) Wiper connecting tube leaking	(i) Clean the passage. (ii) Clean economizer hole. (iii) Clean idle jet. (iv) Clean idle passage. (v) Replace the gasket. (vi) Change the gasket. (vii) Change the tube or plug the hole.
3	Rich mixture on idle or slow speed	(i) Use of bigger size of jet for slow running (ii) Slow speed jet hole has become bigger (iii) Restricted passage of bypass or air bleed (iv) Damaged idle port (v) Worn out thread of idle screw (vi) Wrong fitting of throttle valve	(i) Use correct size of jet (ii) Replace the jet (iii) Clean the carburetor (iv) Get it repaired. (v) Replace the screw and in case of body threads, get it repaired. (vi) Set it correctly.

2.6 ATOMIZATION MECHANISM

This is a process whereby liquid is being atomized or pulverized into its smallest possible particles (gaseous form) for the purpose of economizing the waste of the liquid itself. A simple atomizer can only achieve coarse atomization of a liquid. The air flow through the intake pipe creates a partial vacuum. This draws the liquid up to the supply pipe. At the upper end, it is carried by the airflow and atomized into coarse droplet.

In automobiles, fuel has to be atomized to give a large surface area to volume ratio for effective complete combustion purposes.

2.6.1 TYPES OF FUEL ATOMIZATION

Generally there are two main types of fuel atomization. They are

(a) Jet of fuel is made to impinge on a jet of air stream and the mixing process breaks up the fuel into fine particles. Here the fuel is said to be low pressure.

(b) High atomization: In this case, the fuel is compressed to a high pressure of about 6.9 to 21 bar and allowed to pass through a nozzle and this breaks up the fuel particle into a fine mist. Fuel atomization can be obtained by causing fuel to atomize by adding pressurized air to blow it and create the surface area of fuel. The heat needed for gasification of the atomized fuel, the heat of vaporization is obtained from intake air and the engine.

Fuel not atomized and Fuel Atomized is shown in the figure below.

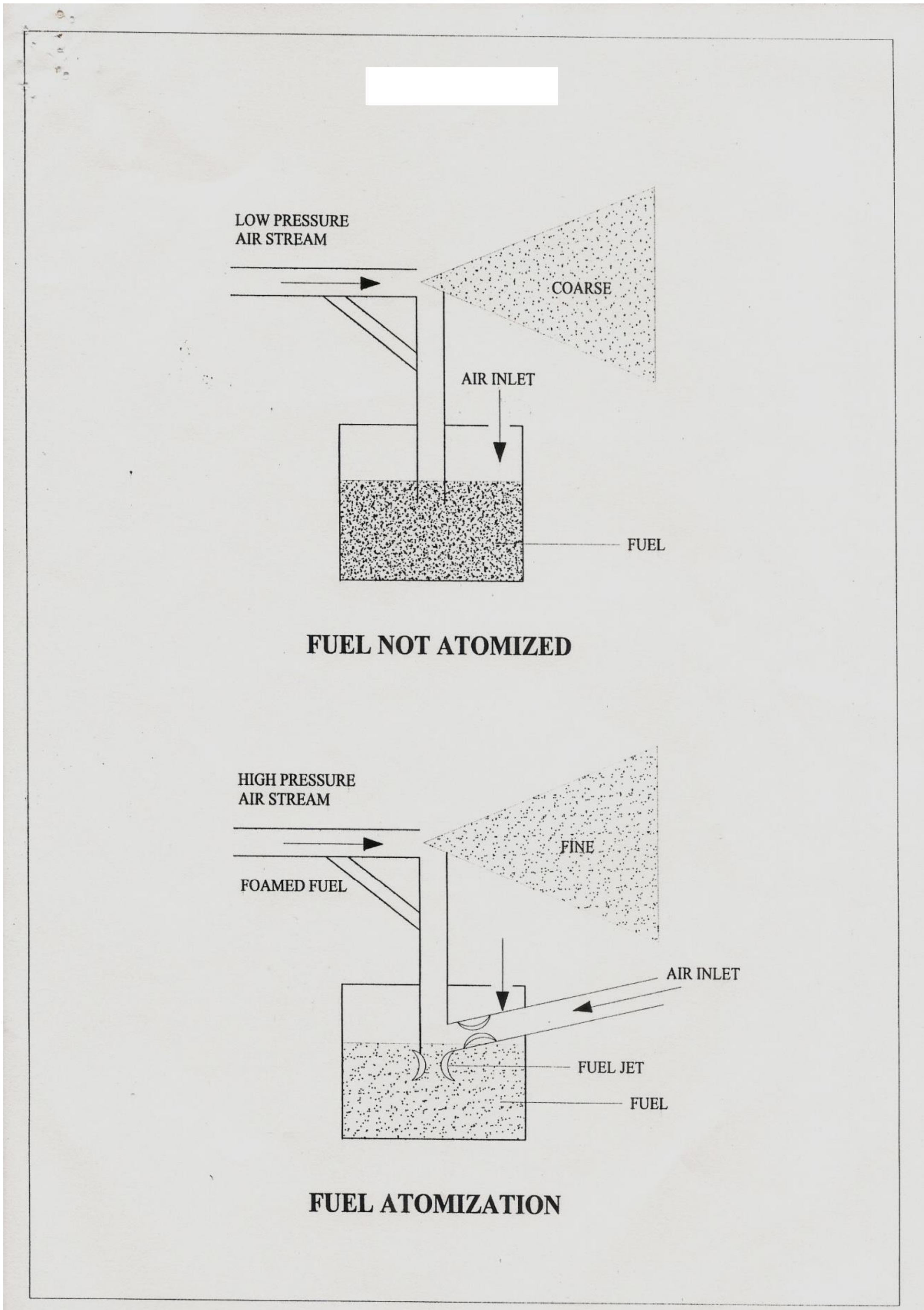


Fig. 2.3: Fuel not atomized and fuel atomized

2.7 MANUAL SPRAYING DEVICE

This is a mechanism adopted by spray-painters in painting car bodies. The old system of painting practice by the painters was the use of hand brush. Later it was discovered that the use of hand brush consumes paint more than required. It was due to this discovery that led to the manufacturing of spraying machine. Since the spraying came into practice it was discovered that can use a small quantity of paint to spray a whole car. This system is very easy and faster.

The detail of Manual Spraying Device is shown in the figure below.

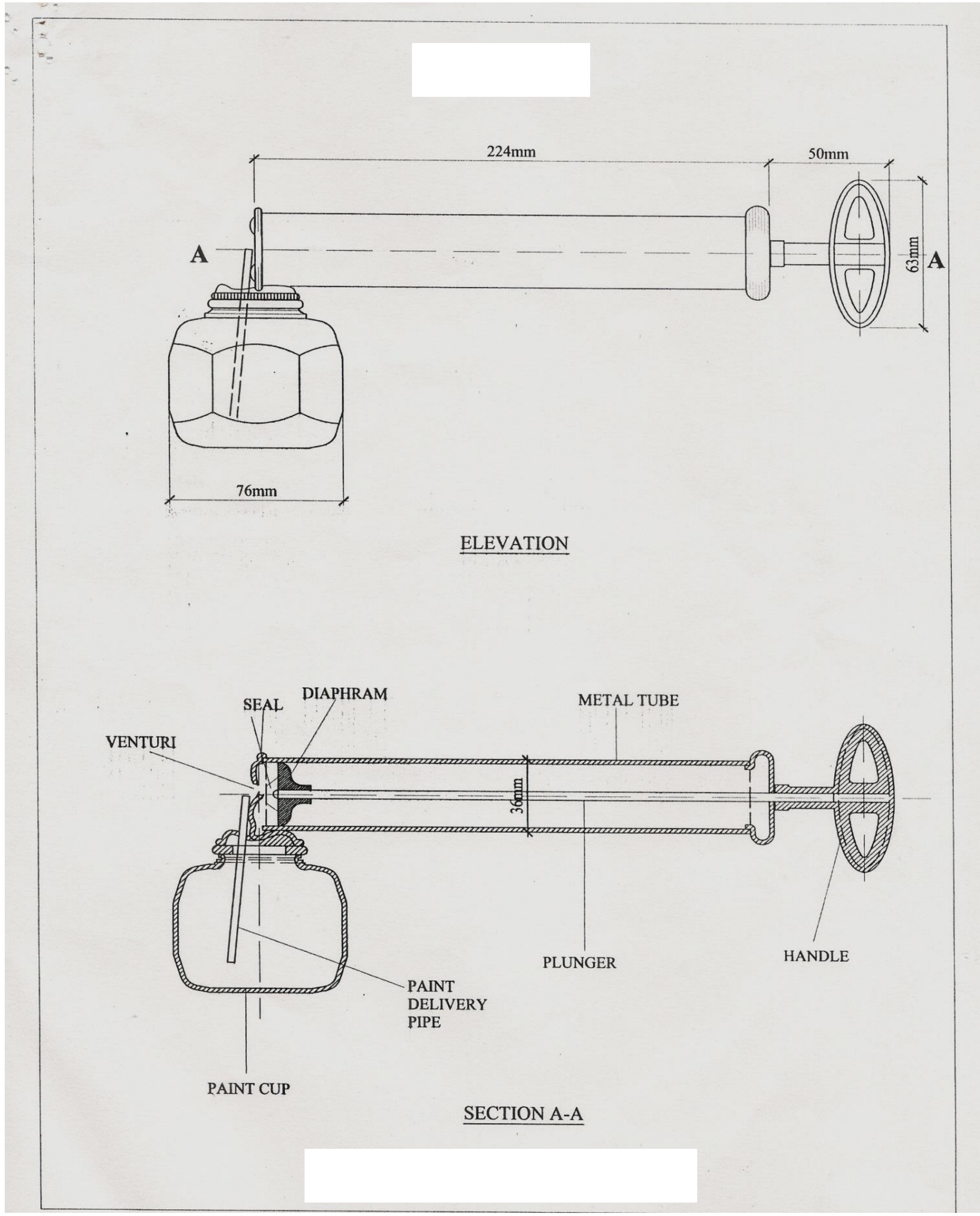


Fig. 2.4: Manual spraying device (Elevation and cross section)

2.7.1 MODE OF OPERATION OF SPRAYING MACHINE

This entails some components like electric motor or low horse power engine, fan belt, reciprocating compressor, storage tank, hose and the spraying nozzle. The compressor is mounted on the flat surface provided on the tank in connection to the electric motor or an engine through a fan belt. A hose is now attached to the outline of the compressor, to the spraying nozzle, when the compressor is powered; it now supplies compressed air to the storage tank which goes to the spraying nozzle. The atomization now comes in when the liquid content (paint) is introduced in the cup of the spraying nozzle (which controls the valve in the spraying nozzle) that is compressed and a finer atomizer is produced. It is this principle that we adopted in this work.

The detail of Spraying Machine is as shown below.

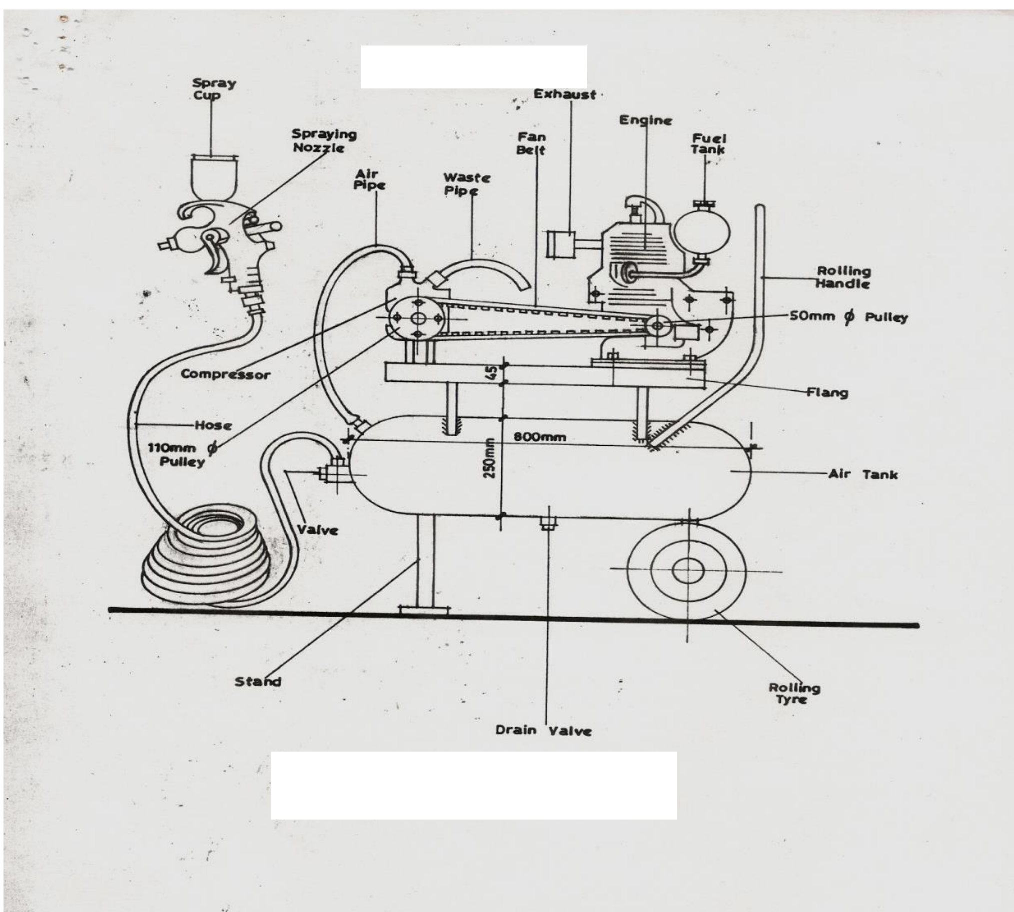


Fig. 2.5: Manual spraying machine

2.8 SUPER FUEL SAVER MECHANISM

This process uses magnet such as **magnetic fuel economize**r (Super Fuel Saver).

The detail of super fuel saver mechanism is seen in the figure below.

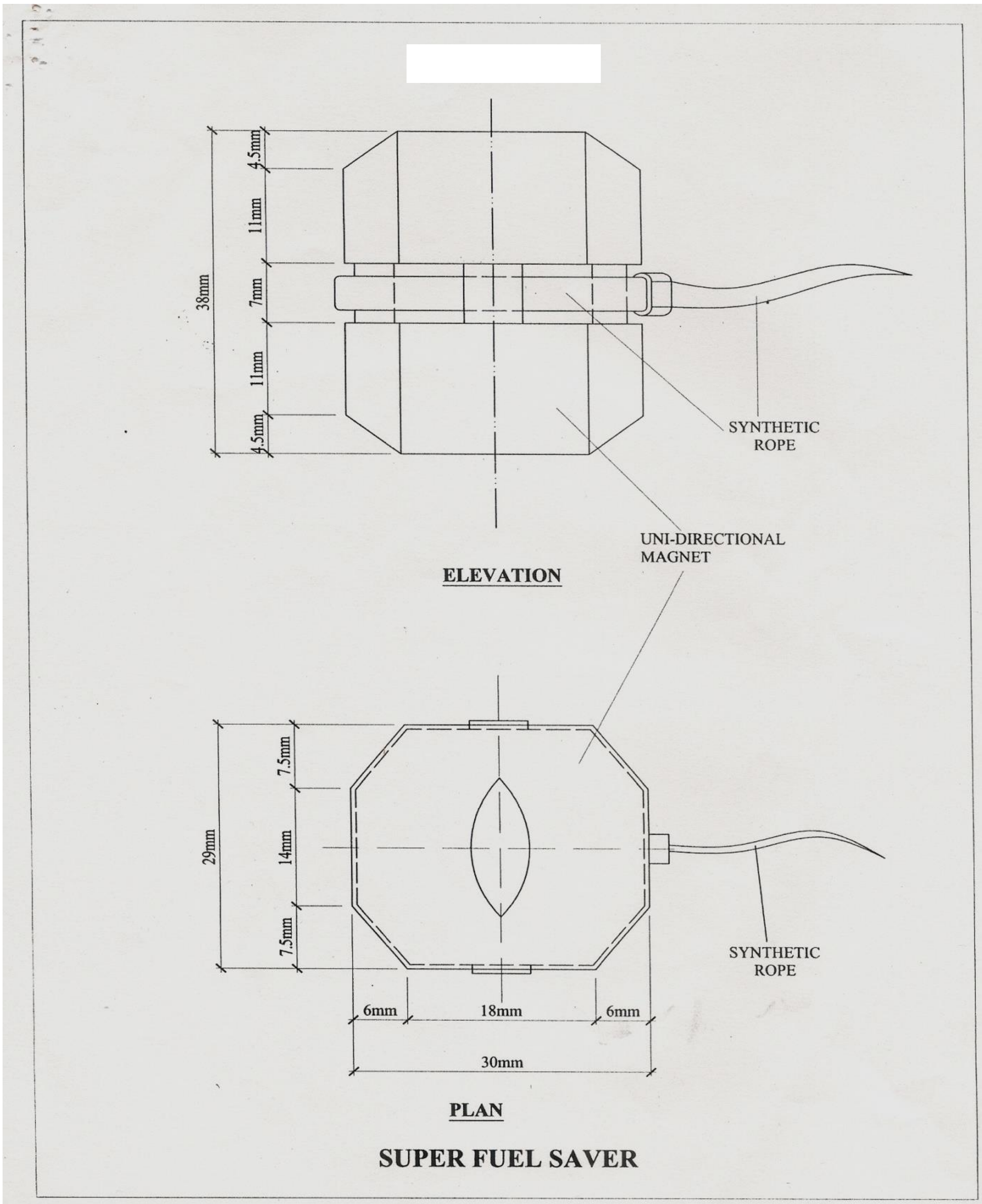


Fig. 2.6: Diagram of super fuel saver (Elevation and plan)

2.8.1 PRINCIPLE OF FUEL SAVING

When fuel is flowing to the fuel saver, it magnetizes fuel molecule and directs the molecule temporarily into cathode. Fuel burning will be more efficient in engine while reducing carbon.

The unit can improve fuel mileage by an average of 10% to 20% (Vortec, 2008). The unit gives high test performance and leaves no carbon monoxide.

2.8.2 OPERATION OF SUPER FUEL SAVER MECHANISM

Fuels are mainly made up of hydrocarbons. With the use of the Super Fuel Saver, fuel savers change their magnetism orientation as they cross a magnetic field in the opposite direction of the external magnetic field. At the same time, hydrocarbon molecules change their configuration which reduces the intermolecular attraction forces.

The fuel savers finely divide and distribute the particles evenly thus making combustion more efficient. The fact that carbon and oxygen have opposite magnetic polarity by using the super fuel saver both carbon and oxygen are easily fused together producing a better and efficient combustion.

2.9 MECHANICAL ECONOMIZER WITH SENSORS

Important components are:

(i) Two number Sensors Mechanism

(ii) Two number Venuses Mechanism

That is one for inlet cam shaft, one for exhaust cam shaft.

The detail of Mechanical Economizer with Sensors is shown below.

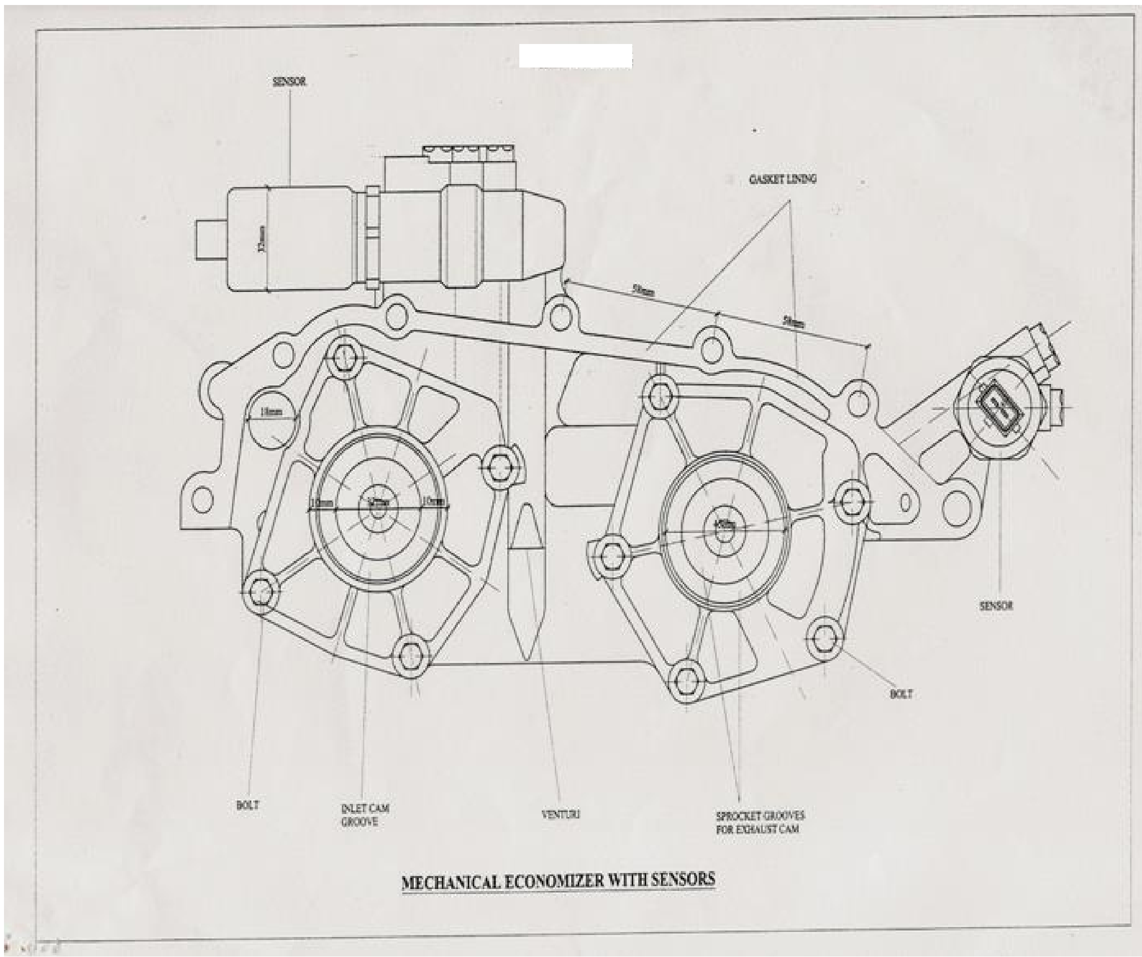


Fig. 2.7: Mechanical economizer with sensors for BMW (cross section)

2.9.1 FUNCTION OF SENSORS

The two sensors send signals to the control unit for power spark and mixture of fuel. The two venous mechanisms are for opening channel for oil flow through control unit when oil flows in, there will be advancement of shaft to increase the engine torque. Note: At high torque there will be a low speed, this economized fuel consumption.

It is important to note that the right side view sketch of Fuel Economizer Mechanism Using

Pressurized Air Pipe with pedal connection is shown in fig. 2.8 while the one without pedal sketch is shown in fig. 2.9.

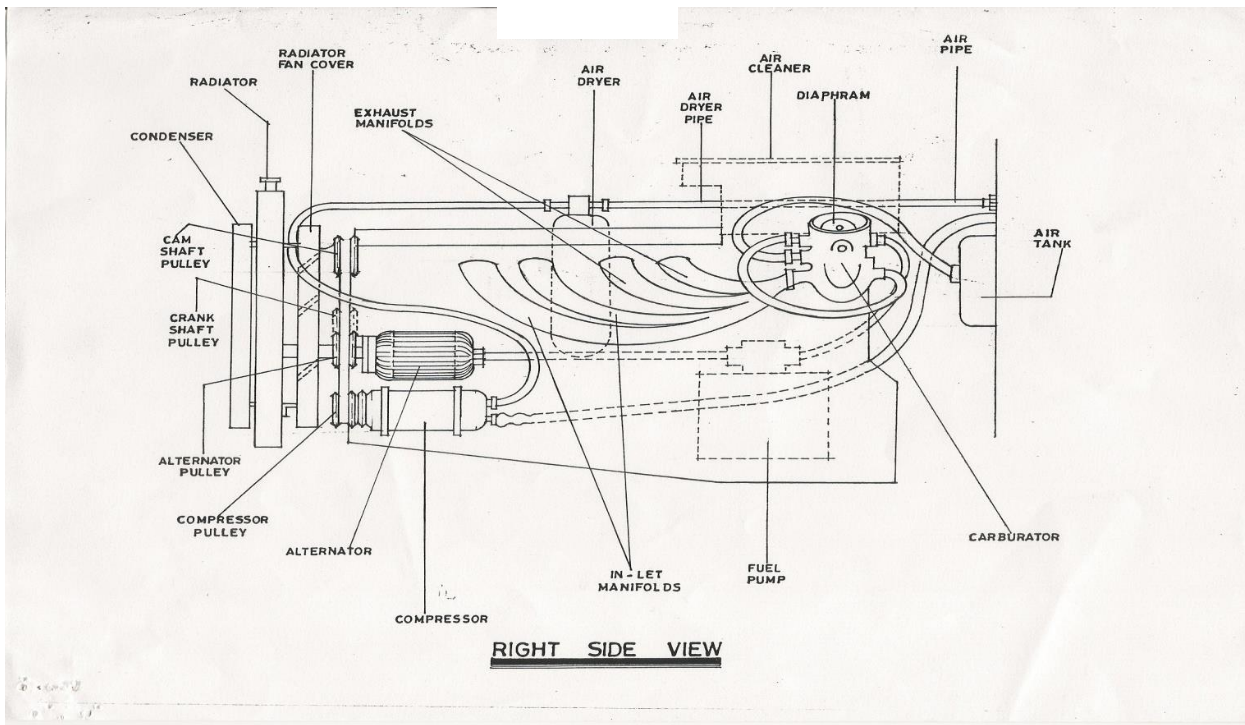


Fig. 2.8: Fuel Economizer Mechanism Using Pressurized Air Pipe without pedal

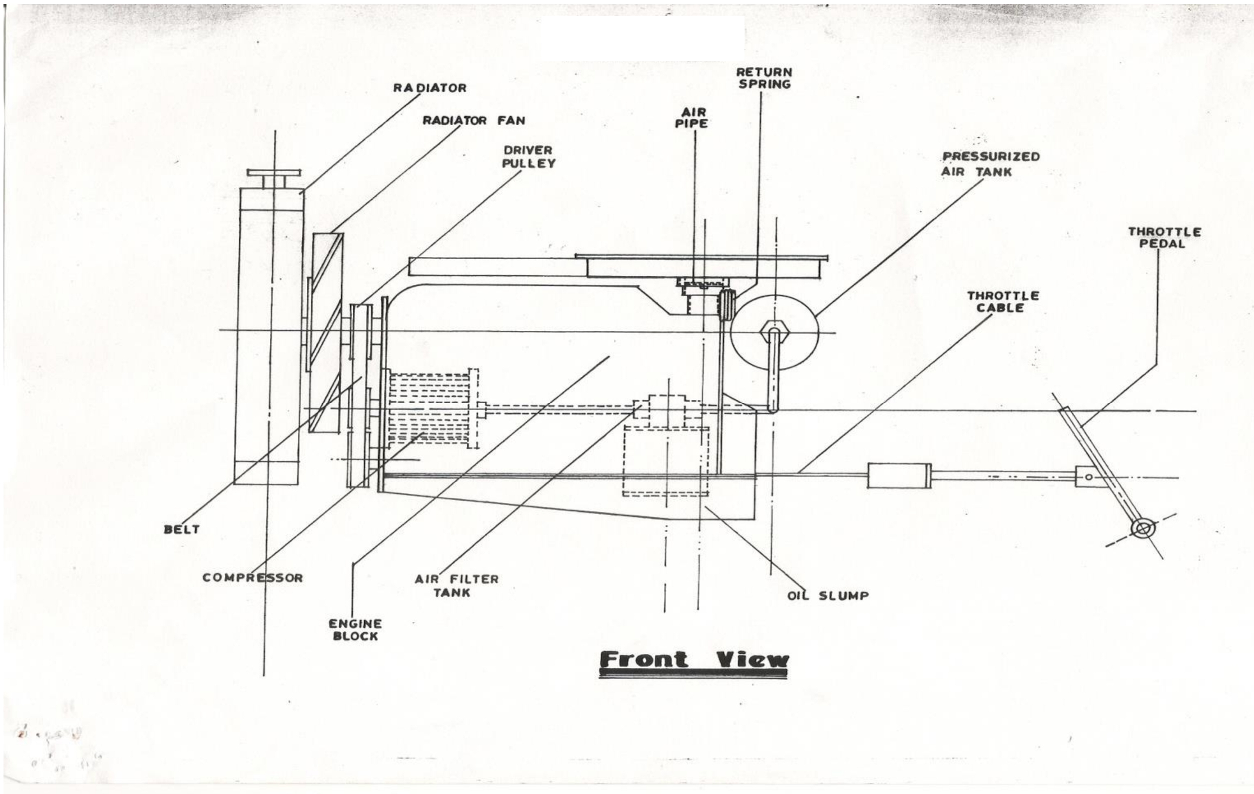


Fig. 2.9: Fuel Economizer Mechanism Using Pressurized Air Pipe with pedal

The fuel economizer mechanism with air compressor of the following components: air dryer, compressor, air tank, alternator, air cleaner, air pipe and carburetor.

2.10 FUEL INJECTION SYSTEM

Fuel Injection System is a method of delivering fuel to an internal combustion engine. In a fuel injection system, electronically controlled fuel injectors spray measured amounts of fuel into each of the engineȏs cylinders where the fuel is burned, powering the engine. Modern computer operated fuel injection produces more power, lowest exhaust emissions, improved fuel economy and smoother operation than a carburetor system. Fuel injection began replacing the carburetor during the 1980s.

2.10.1 FUEL INJECTOR

A typical injector has a nozzle, a needle valve that blocks the opening in the nozzle by protruding from it, and a compression spring. A pump controlled by the ECM shoots fuel into the injector with enough pressure to compress the spring. This pressure lifts the needle valve, which opens the nozzle. In another type of injector, the nozzleǿs opening is blocked by a small upward pin and let fuel spray past the ball into the combustion chamber. Another signal from the ECM pushes the plunger, which pushes the ball into the place and stops the flow of fuel. An ECM opens the injector nozzle, holds it open, and closes it after a precise interval, more than 1000 times per minute at highway speeds (Schwaller, 1993).

Fuel Injection System is shown in fig. 2.10 below.

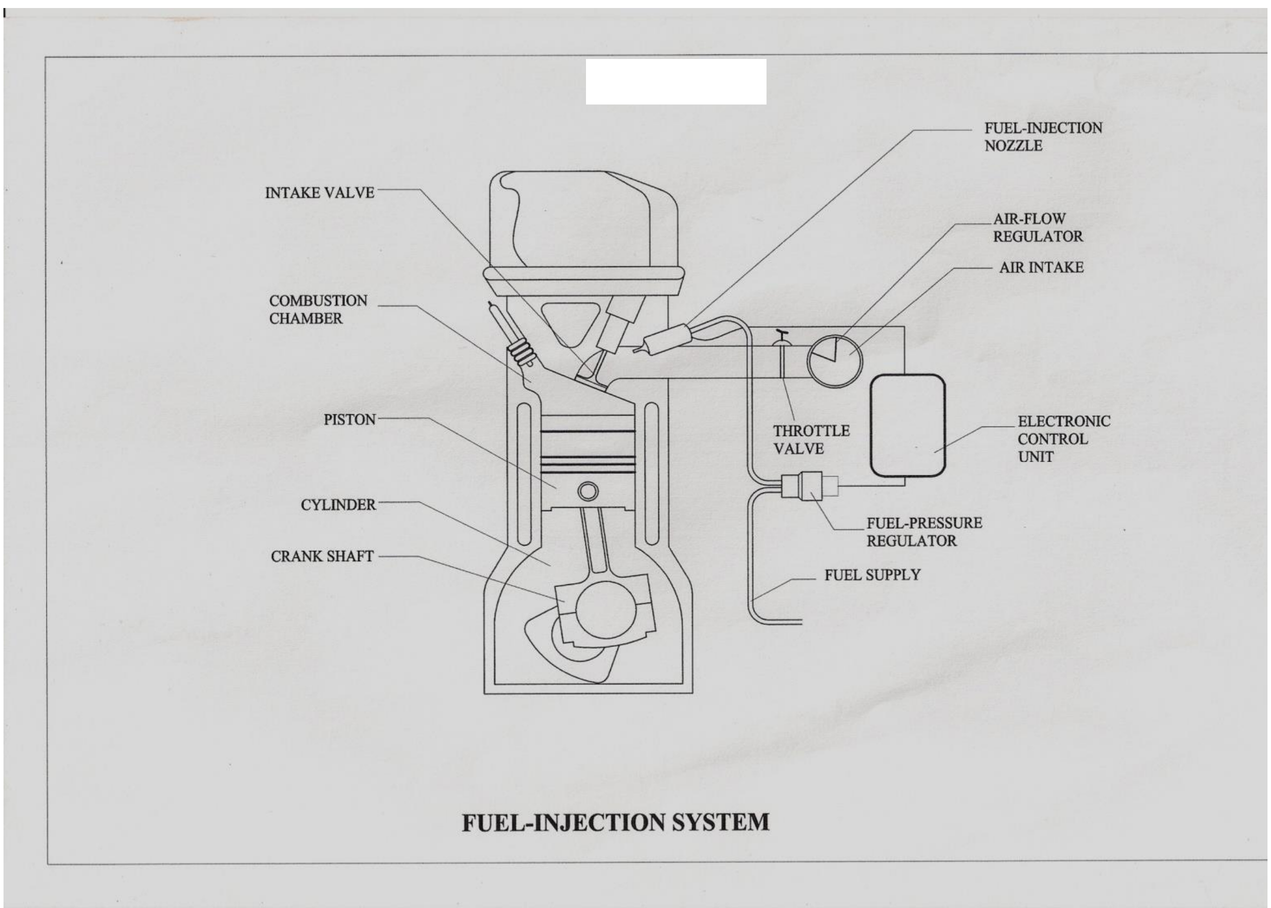


Fig. 2.10: Fuel Injection System

A case study of fuel injection (throttle body injection (TBI)) sprays a fuel mist through one or more injectors located near the start of the intake manifold, which carries air to the individual cylinders. The injectors in a TBI system are located in the intake manifold close to where a carburetor was typically housed. The pistons in the cylinders create a partial vacuum that pulls fuel and air through the manifold into the combustion chambers. Port-type fuel injector systems, sometimes called multi-port systems, have injectors that spray fuel directly into each cylinderôs intake-port ï an opening through the engine into the combustion chamber.

Note: A part-type injector is better able to deliver equal amounts of fuel to each cylinder. Moving the injectors to the ports also permits alterations to the intake manifold that improve engulf performance (Microsoft®Encarta®, 2008).

2.11 SUMMARY OF THE LITERATURE REVIEW

Compressing more air into combustion chamber by fuel economizer device is the best method with the following reasons:

a) The air used is free of charge.
b) Compressor single stage used will obtain power from vehicle through installation of fan belt of the vehicle crankshaft pulley with that of compressor pulley to drive compressor for operation which is convenient in combined cheapness during production.

CHAPTER THREE

MATERIAL SELECTION AND ATOMIZATION PROCEDURES

3.1 MATERIAL SELECTION

In every engineering design, material selection is a very vital aspect of the design which generates some factors like tool life, durability, portability and so many other factors too numerous to mention.

3.2 COMPRESSOR

Compressor is used to compress air or gases and discharging at a required pressure, based on the type of horse power (hp) and the speed in revolution per minute (rpm) with free cost of air. Based on this fact, a reciprocating type of compressor of single stage and single acting (i.e. one cylinder), will be selected.

3.3 AIR CYLINDER

Here, some factors were considered before choosing the material of which the cylinder is being produced. After assessing other material properties, both in size and weight, mild steel material will be selected based on the fact that it has high resistance to stress (stress concentration factor) and high yield strength. The work of the air cylinder is to store the compressed air from the compressor.

3.4 AIR DRYER AND PRESSURE RELEASE VALVE

Air dryer will be used to absorb moisture containing in the air. In engineering, safety is our main goal, based on this, a pressure release valve is introduced in the air cylinder to regulate the amount of pressure in the air cylinder in accordance to cylinderøs capacity to avoid tank explosion.

3.5 AIR THROTTLE VALVE

This was introduced to regulate air flow from the tank to the carburetor as it is powered by accelerator pedal through a cable which has common connector with the throttle cable of the carburetor.

3.6 HIGH PRESSURE PIPES

This is made of steel or rubber pipe. It transfers the high pressure air through the throttle valve to the carburetor. It is connected with the main jet in the carburetor in right angle to locate the molecules of fuel into tiny particles. All these and more were initially selected during material selection.

3.7 DESIGN OF FUEL ECONOMIZER DEVICE (METAL CUP)

Design Approach

The most important aspect is to reduce sectional area of the air flow to increase the velocity of air flow. Therefore, this device incorporated in carburetor will take active part of that aspect.

Geometrical Aspect

The diameter of the carburetor air flow must be considered where economizer device will be fixed. The difference between the carburetor air flow and the diameter of the economizer device will be a little clearance as to be fixed with the carburetor air diameter. Therefore, the diameter was specified in accordance with its tolerance. The shape of the device is a cylindrical cup. An alloy steel material was used. A special orifice with specific diameter was inserted and access for pipe was provided. The two screws to hold it firm were also provided. The detailed drawings are shown in figs. 3.1 and 3.2 below.

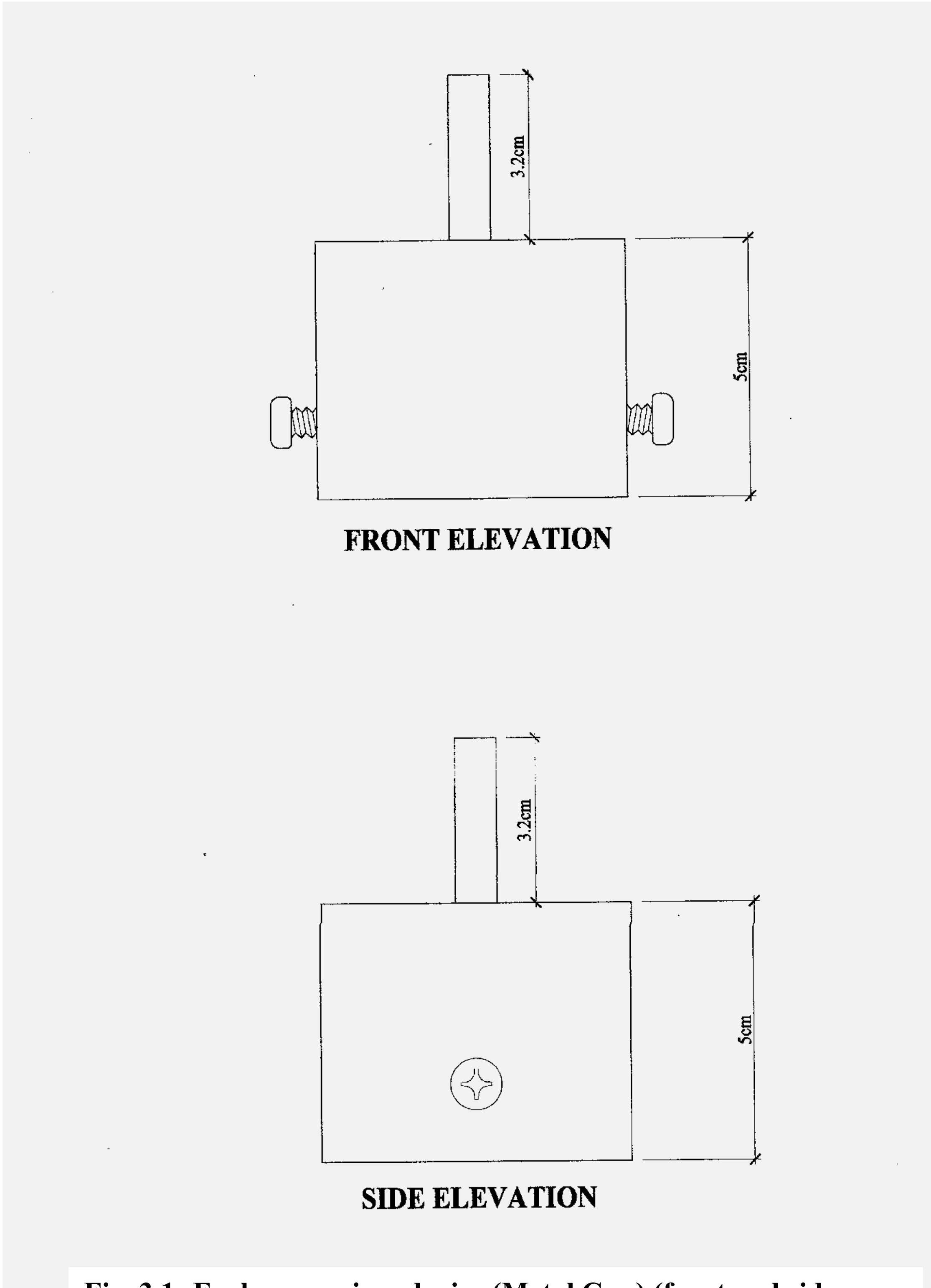


Fig. 3.1: Fuel economizer device (Metal Cup) (front and side elevations)

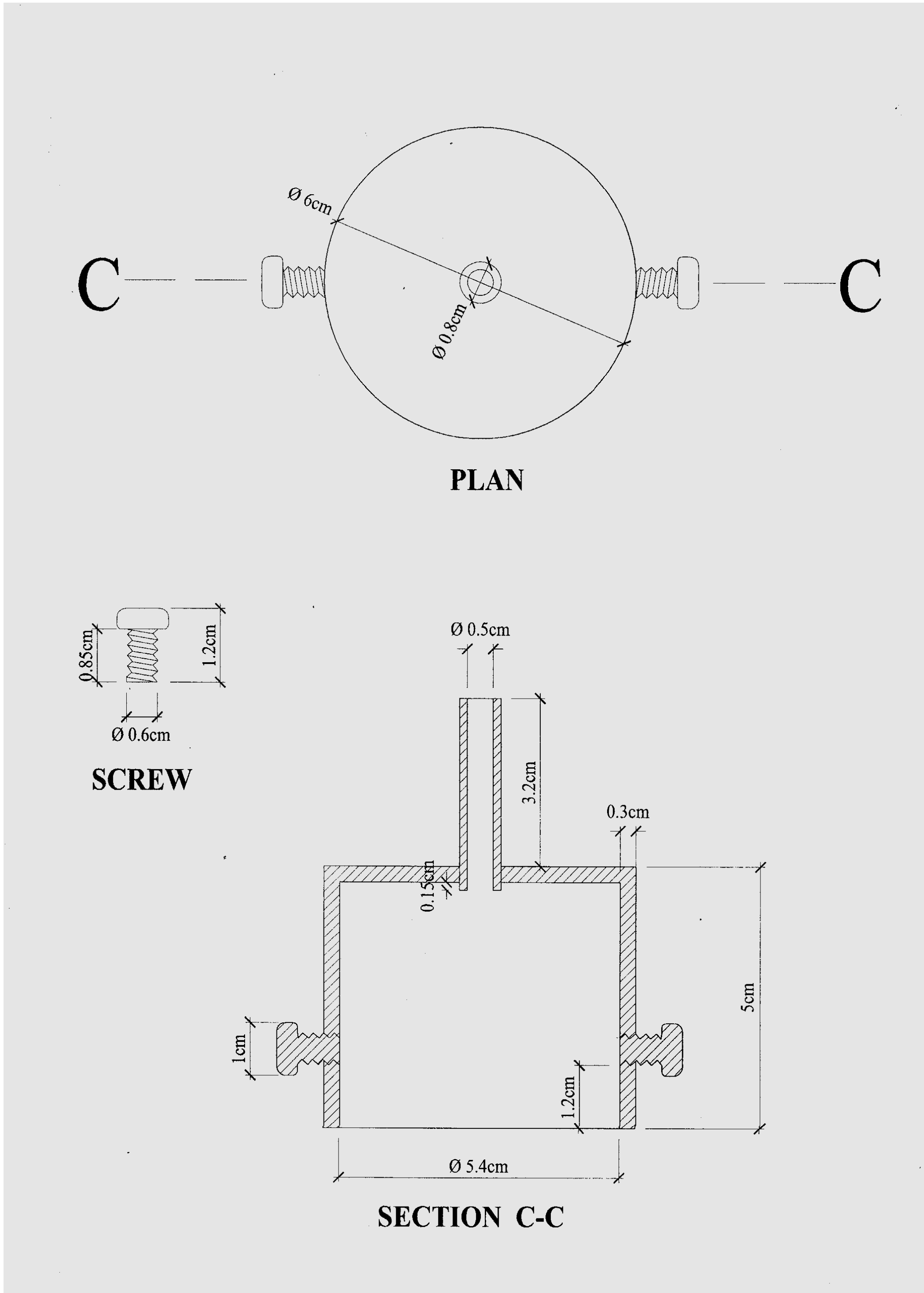


Fig. 3.2: Fuel economizer device (Metal cup) (plan and cross section)

3.8 ATOMIZATION PROCESS

Atomization of fuel creates enormous surface area per unit weight of the fuel which helps the heterogeneous combustion of the liquid fuel. Detailed explanation of fuel atomization in the 504 Peugeot Station Wagon is as follows: it first of all starts from rotary movement of the crankshaft pulley of the engine which is connected to the compressor pulley with a fan belt. Therefore, the power is from the ignition engine. The compressor absorbs air from the atmosphere; the air is compressed by the piston during the return stroke. The compressed air is passed through a pipe to the storage cylinder, where the compressed air is connected through pipe to an air dryer to absorb the moisture also passed through air pressure gauge. The control valve for regulating pressure and ensure correct air/fuel ratio is maintained. While a high pressurized air connected through a pipe to the atomizer device incorporated inside the carburetor, to atomize fuel into tiny possible particles to achieve complete combustion and fuel economy. Detailed diagram is shown in fig. 3.3 below.

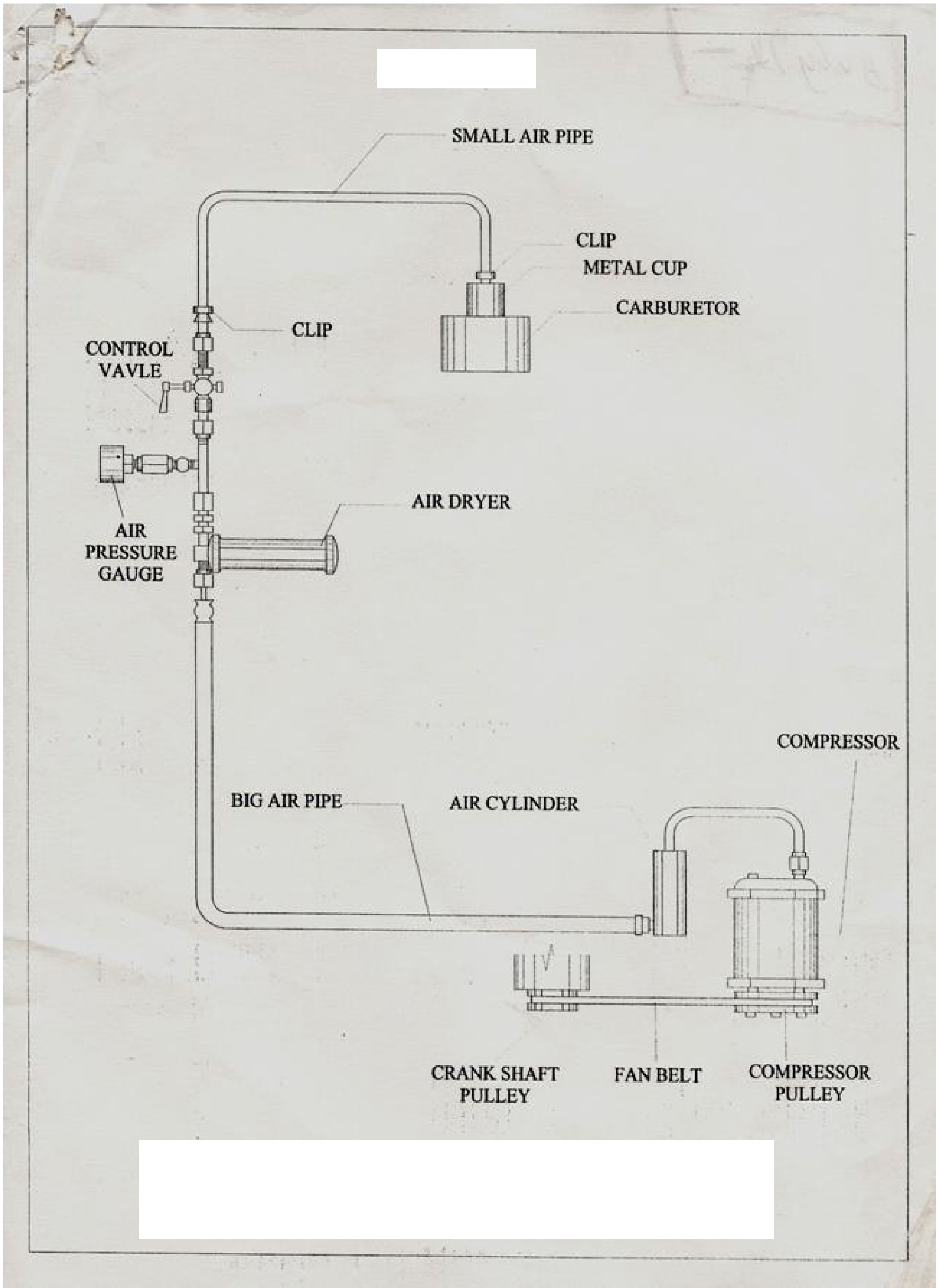


Fig. 3.3: Fuel Economizer Mechanism with Compressor

3.9 RECIPROCATING AIR COMPRESSOR OPERATION

Atmospheric air is drawn into a cylinder during suction stroke of the piston of compressor and is compressed by piston of compressor during return stroke. The piston is driven by power from an external source which is the ignition engine from crankshaft, as shown in fig. 3.4 below:

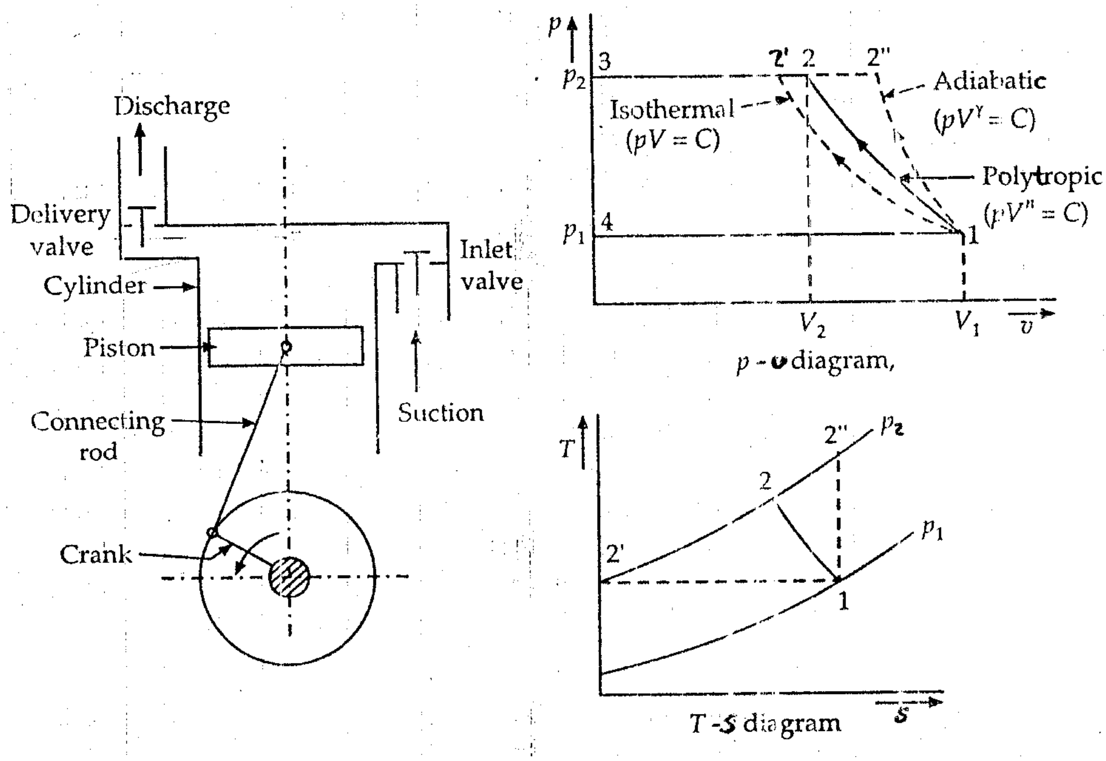


Fig. 3.4: Reciprocating Air Compressor

The working of single reciprocating compressor can be studied with the help of figure 3.4.

Process 1- 2: Air is compressed according to law $pV^n = C$, a polytropic process, from pressure p_1 to pressure p_2. Volume decreases from V_1 to V_2 and temperature increases from T_1 to T_2.

Process 2- 3: Compressed air at p_2, V_2 and T_2 is delivered from the compressor at constant pressure.

Process 4- 1: Atmospheric air at p_1, T_1 and V_1 is sucked into the compressor. The work required for compressing the air is given by the area of p ï v diagram 1- 2- 3- 4- 1. The p ï v diagram shows that the cylinder of the compressor has no clearance volume.

CHAPTER FOUR

DESIGN CALCULATIONS

4.1 FUEL ECONOMIZER DESIGN CALCULATION

Diameter = 8cm; Radius = 4cm

Area = πr^2

$= 3.142 \times (4)^2$

$= 50.27cm^2$

Volume of fuel economizer device = Area x height

Area $= 50.27cm^2$; height = 5cm

$= 50.27 \times 5$

$= 251.36cm^3$

Outlet for pipe

Diameter = 0.5cm; Radius = 0.25cm

Area = πr^2

$= 3.142 \times (0.25)^2$

$= 0.196cm^2$

Volume of outlet for pipe = Area x height

Area $= 0.196cm^2$; height = 3.2cm

$= 0.196 \times 3.2$

$= 0.6272cm^3$

Special orifice

Diameter = 0.15cm; Radius = 0.075cm

Area = πr^2

$= 3.142 \times (0.075)^2$

$= 0.0177cm^2$

4.2 COMPRESSOR ANALYSIS

The type of compressor that was used in this work is the reciprocating compressor.

Power input = 1hp = 0.746Kw

Bore D = 60mm = 0.06m

Stroke hs = 60mm = 0.06m

V_c = clearance volume

V_s = swept volume

V_v = compressor ratio = 6

H = total height

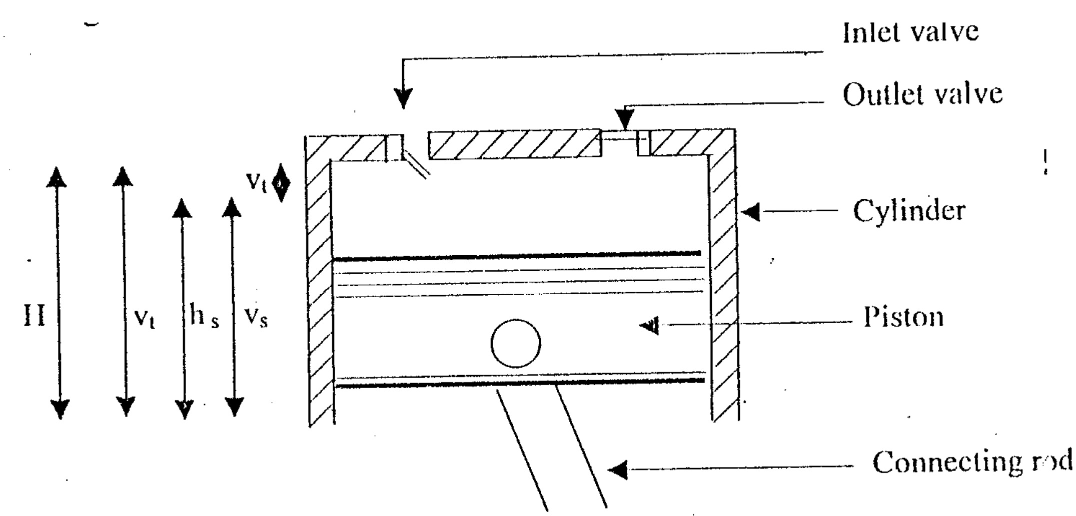


Fig. 4.1: Operation of Compressor

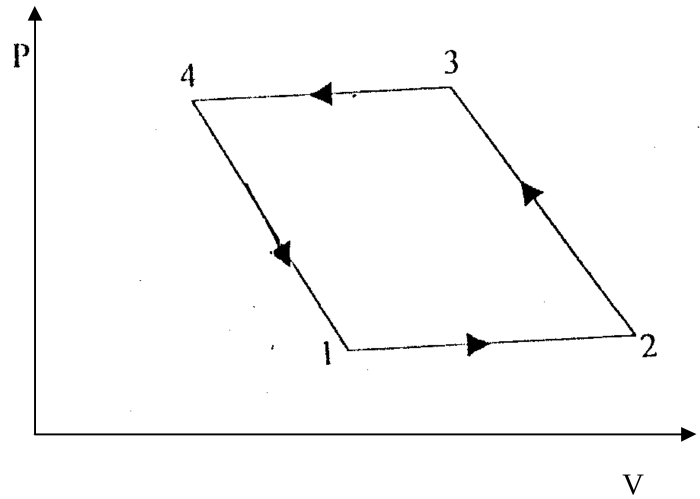


Fig. 4.2: Cross-section of the Compressor

The fig. 4 (b) shows the cross-section of the compressor. It is a square compressor, that is, the bore diameter D, and the volume V, is given by.

$$V_T = \frac{\pi D^2 H}{4}$$

$$H = \frac{4V_T}{\pi D^2}$$

$$H - h_s = h_c$$

$$r_c = \frac{V_T}{V_C}$$

$$V_s = V_T - V_C$$

$$r_v = 1 + \frac{I}{C}$$

The swept volume where Vs is given by

$$\mathrm{V_s} = \frac{\pi D^2 h_s}{4}$$

From the compressor data,

V = bore radius = 30mm = 0.03

H_s = stroke length = 60mm = 0.060

$r_v = 6$

Hence Vs = $\frac{\pi 60^2 \text{ x } 60}{4}$

$\frac{\pi 6^2 \text{ x } 6}{4} = 169.66cc$

r_v compressor ratio = 6

$r_v = V_T/V_C = V_1/V_2$

but $V_T = V_1 = V_S + V_C$

$r_v = V_S + V_C/V_C$ - - - - (1)

and $V_C = CV_S$

$r_v = V_S + CV_S/CV_S$

$r_v = 1 + C/C$

$r_v = 1 + 1/C$

r_v = Compression ratio which is the ratio of the total volume of the clearance volume.

Now from equation (1)

$r_v = V_C/V_S + V_C$

$r_vV_C - V_C = V_S$

$V_C(r_v - 1) = V_S$

$V_C = V_S/r_v - 1$

$V_C = 169.6/r_v$ ï 1 = 170/6 ï 1 = 34

Hence $V_T = V_1 = V_S + V_C$

= 170 + 34

V_1 = 204cc

V_C = 34cc

4.2.1 Thermodynamic Analysis of The Compressor

Recall fig 4 (b), p. 42 above (p-v diagram) for reciprocating compressor, the figure shows the ideal p-v diagram for the compressor. The processes are as follows.

1-2; A mass of fluid (air) Δme, is sucked into the cylinder without change in state. Δme mixes with the mass Δma in the clearance space which has, the same state as Δmc

2-3; The mass (Δma + Δmc) is compressed from 2 to 3 3-4; the mass Δma is delivered from the cylinder to the reservoir without change of state.

4-1; The mass Δmc is expanded from 4 to the original state 1.

The actual process is due to the inertia effect of the opening of valves. But for the purpose of this work, analysis shall consider the ideal p-v diagram, the compression and expansion processes are polytrophic, i.e. PV^n = constant. The work done per machine cycle is given by

$$§dw = \int_1^2 pdv + \int_2^3 pdv + \int_3^4 pdv + \int_4^1 pdv = § \text{ pdv}$$

This is equal to the area enclosed by the curve in the PV plane.

$$§dw = P_1 (V_2 - V_1) + \frac{P_3V_3 - P_2V_2}{1-n} \; P_2 (V_2 = V_S) + \frac{P_1V_1 - P_4V_4}{1-n}$$

Since $P_1 = P_2$, $P_3 = P_4$, the equation becomes

$$§dw = n/(n-1) [P_1 (V_2 - V_1) + P_3 (V_4 - V_3)] \quad - \quad - \quad - \quad - \quad - (2)$$

N.B: $V_1 = \Delta mcV_1$ where ï V_1 = specific volume

$V_2 = (\Delta mc + \Delta ma) V_S$; $V_4 = \Delta mcV_3$

Substituting in equation (2) above

$$§dw = \Delta ma (n/(1-n)) (P_1V_1 \text{ ï } P_3V_3) \quad - - \quad - \quad - \quad - \quad - (3)$$

The rate of work is given by equation (3) multiplied by number of cycles per unit time N, where NΔma is mass flow rate = Ma.

Hence equation (3) becomes

$W = Ma\ (n/(n-1))\ (P_1V_1$ ï $P_3V_3)$ - - - - - - (4)

$W = Ma\ P_1V_1\ (n/(n-1))\ [P_3V_3/P_1V_1 - 1]$

But $V_{3/}V_1 = (P_1/P_1)^{1/n}$ - - - - - - - - (5)

$W = Ma\ P_1V_1\ (n/(n-1))\ [\ (P_3/P_1)^{n-1/n} - 1]$ - - - - - (6)

From (5) above $P_1 = (V_3/V_1) \text{ x } P_3$ - - - - - - (7)

$V_3 = V_C = 34cc = 0.034m^3$

$V_1 = 204cc = 0.204m^3$

$P_1 = 101325N/m^3$ [Ambient (atmospheric) pressure]

n = 1.4 Polytropic index for ideal gas

ma = mass of air in Kg/s

$= V_1 \text{ x} P_a$

$P_a = 1.136\ Kg/m^3$

Mc = 0.204 x 1.136 = 0.0232 Kg/s

From (7),

$P_1 = (V_S/V_1)^n \text{ x } P_3$

$P_3 = P_1/(V_3/V_1)^n$

$P_3 = 101325/(0.034/0.204)^n\ N/m^3$

From (6)

$$W = 0.232 \text{ x } 101325 \text{ x } 0.204 \text{ x } 3.4 \text{ x } \left(\frac{101325}{\frac{0.167^{1.4}}{101325}} \right)^{0.29} - 1$$

$W = 0.232 \text{ x } 101325 \text{ x } 0.204 \text{ x } 3.4\ (0.167^{1.4})^{0.29} - 1$

$W = (16304.7 \text{ x } (0.167^{1.4})^{0.29} - 1$

Force inside the cylinder due to the air pressure is given by

$$F = P \text{ x } a = \frac{P_3 \pi D^2}{4} \quad - \quad - \quad - \quad - \quad - \quad - \quad - \qquad (8)$$

Where $P = P_3$

a_c = cross sectional area of the cylinder bore

$P_3 = 101325/0.167^{1.4} N/m^2$

$$a_c = \frac{\pi 0.06^2}{4}$$

$= 3.14 \text{ x } 0.06^2/4$

$a_c = 0.0028m^2$

$F = 101325/0.167^{1.4} \text{ x } 0.003 \text{ N}$

$= 303.975/0.167^{1.4} \text{ N}$

Velocity of flow of air into the reservoir tank via pipe is given by

Fu = W

$$U = W/F \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \qquad (9)$$

$$U = \left(\frac{16704.7(0.167^{1.4})^{0.29} - 1}{\frac{303.975}{0.167^{1.4}}} \right) \quad \text{m/s}$$

Volume flow rate through the pipe is given by Q = apU

Where Q = volume flow rate

ap = cross sectional area of pipe

U = flow velocity of air

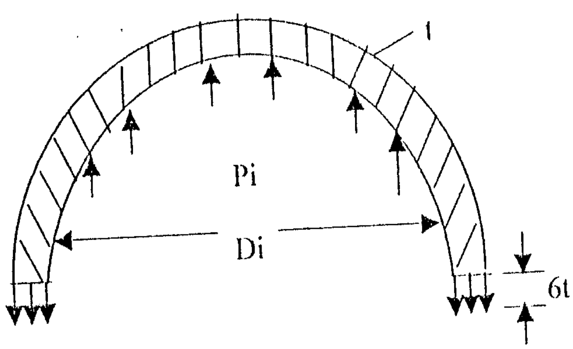
$ap = \pi D^2 p/U$; Dp = 6.25mm = 0.006m

$ap = 3.14 \text{ x } 0.002^2/4 = 2.826 \text{ x } 10^{-05}m$

4.2.2 Design of An Air Cylinder

Assumptions in designing a thin wall pressure vessels.

- No circumferential or longitudinal point in the cylinder
- Neglect the effect of the welded joints
- The ratio of its linear diameter to the wall thickness is more than 15.
- There are two principal stresses (longitudinal stress σL and circumferential stress σt)



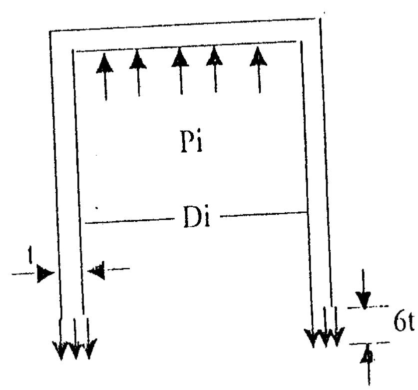


Fig 4.3: Circumferential open end cylinders **Fig 4.4: Longitudinal open end cylinders**

Bases on the equilibrium of forces acting on the half portion of cylinder of unit length we have

$DiPi = 2\sigma t$ - - - - (11)

Where $\sigma t = PiDi/2t$ - - - (12)

Di = Internal diameter of the cylinder

Pi = Internal pressure

t = Cylinder wall thickness

Considering the forces of equilibrium in the longitudinal direction. Fig 4.3 b, we see that

$Pi\ (\pi Di^2/4) = \sigma t\ (\pi Dit)$ - - (13)

$\sigma L = PiDi/4t$ - - - (14)

Now from equation (12) & (14), it can be observed that the circumferential stress σt is twice the longitudinal stress (σt).

$T = PiDi/2\sigma t$

having σt as the permissible tensile stress for closed cylindrical material. It is now assured in this analysis that there are no circumferential or longitudinal joint in the cylinder. For this project, steel was used (Syt = 230 N/mm^2) for better folding and durability.

$Pi = 12bar = 12N/mm^2$

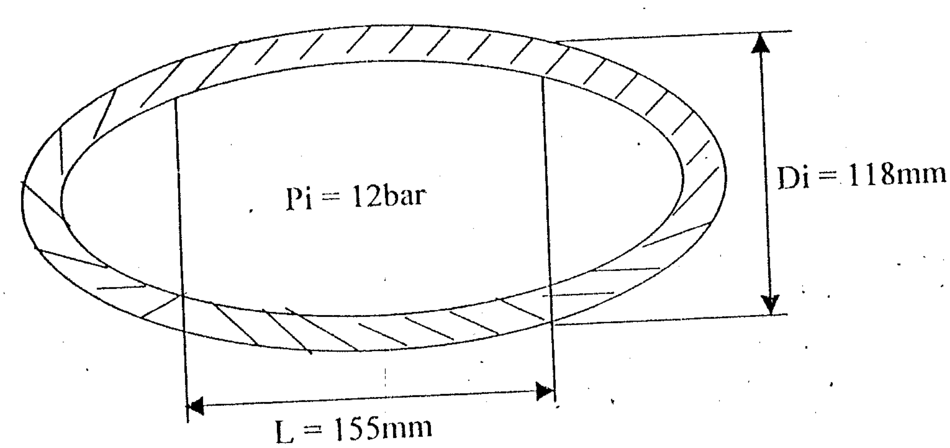


Fig 4.5: Fig 4.3: Circumferential closed end cylinders

The volume of the shell is given by $\pi/6\ Di^3$

$Di = (6v/\pi)^{1/3}$

Having assured a factor of safety n = 4

6t = Syt/2.5 = 230/4 = 57.5 N/mm^2

Thickness of ice wall t = PiDi/46t

But Pi = 1.2 N/mm^2 Di 118mm

t = 12 x 118/4 x 57.5 = 6.15mm = 6mm

4.2.3 Calculation for the Air Speed Entering the Carburetor

Assumptions

- Flow of an ideal gas
- Compressible field flow
- Steady flow
- One dimensional flow
- Fractional flow in a constant channel
- Using the computation of the Fanno line

DIAGRAM OF MODELING AND EQUATION OF FLOW OF AIR TO THE CARBURETOR

The modeling of the flow of the air from the air tank to the modeling carburetor can be stated as follows:

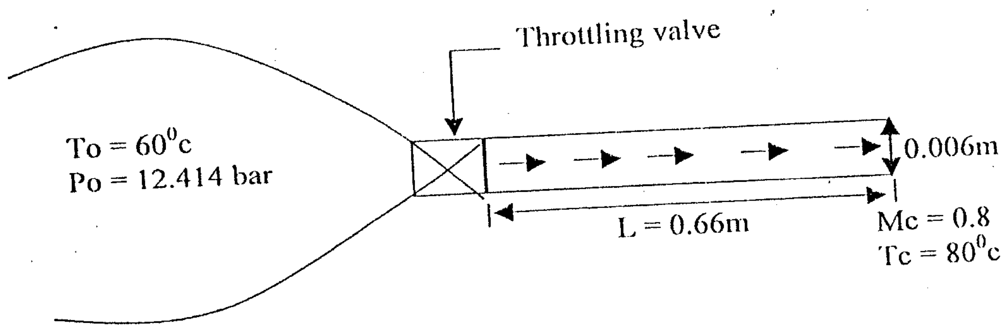


Fig 4.6: Air flow model air tank to carburetor

To = stagnation temperature = temp of air in the tank

Po = stagnation pressure = pressure of air in the tank

d = 6mm = 0.006m = diameter of pipe entering the carburetor

L = 66mm = 0.66m = length of pipe entering the carburetor

For the flow in a constant area duct with friction

T		T +dt
P		P + dp
E		E + de
V		V + dv

Engine temperature = outlet air temperature = 80^{o}C

Isotropic index γ = 1.4

Me = exit mach number of 0.8

Gas constant of air = 287kj/kg1k

Using the table for the Fanno line flow function

JI max/D

Speed of sound, C = γRT

T = 80 + 237 = 353^{o}K

C = 1.4 x 287 x 353 = 376.6m/s

But m = V/C = 0.8, V = 0.8 + 376.6 = 301.28m/s

This implies that the speed of air entering the compressor is = 301.28m/s

CLASSIFICATION OF COMPRESSORS

Air and gas compressors are mainly classified as reciprocating compressors and rotary compressors. The main classification of compressor along with their performance characteristics is given in the table 4.1 below.

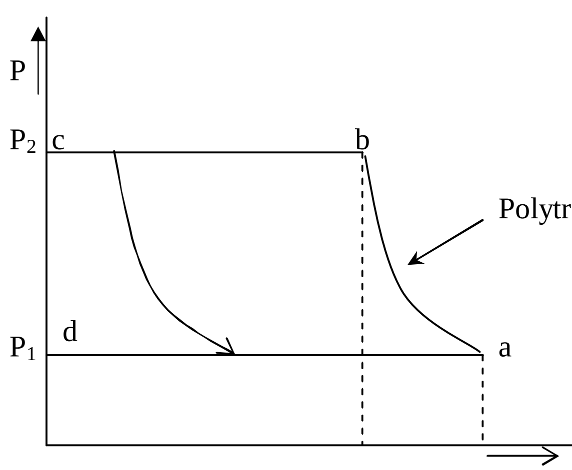
Table 4.1: Classification of Compressors

S/N	Type	Function	Free Air Delivery	Compression Ratio (r)	Speed (n) rpm
1.	Reciprocating	a. Vacuum pump b. Compressor	0 ï 100	1 -50	60 ï 1500
2.	Rotary	a. Vacuum pump b. Blower c. Compressor	0 ï 100 0 ï 500 0 ï 500	1 ï 50 1.1 ï 3 3 ï 12	250 ï 6000 300 ï 1500 300 - 1500
3.	Centrifugal	a. Fan b. Blower c. Compressor	0 ï 6000 0 ï 5000 100 ï 4000	1 ï 1.15 1.1 ï 4 3 ï 20	300 ï 3000 300 ï 3000 1500 ï 45000
4.	Axial	a. Fan b. Compressor	50 ï 10,000 100 ï 15,000	1 ï 1.04 2 ï 20	750 ï 10,000 500 ï 20,000

Source: Singal, 2004

4.3 Work Required in Single Stage Compressor

The initial condition of air P_1 (bar) V_1 (m^3) and is compressed to final stage of delivery pressure P_2 (bar) and volume V_2 (m^3).



V_2 V_1

f g h

Fig. 4.7: Single Stage Compressor

WORK REQUIRED PER CYCLE

W = Area abcd

= Area cbgf + Area gbah ï Area adfh

$$= P_2V_2 + \frac{P_2V_2 - P_1V_1}{n-1} - P_1V_2$$

$$= \frac{P_2V_2(n-1) - P_1V_1(n-1) + P_2V_2 - P_1V_1}{n-1}$$

$$= \frac{nP_2V_2 - P_2V_2 - nP_1V_1 + P_1V_1 + P_2V_2 - P_1V_1}{n-1}$$

CONTINUATION OF WORK REQUIRED IN SINGLE STAGE COMPRESSORS

$$W = \frac{n1}{n-1}\left(P_2V_2 + P_1V_1\right)$$

$$W = P_1V_1\left(\frac{n1}{n-1}\right)\left(\frac{P_2V_2}{P_1V_1} - 1\right)$$

For polytrophic compression

$$P_1V_1{}^n = P_2V_2{}^n$$

$$\frac{V_2}{V_1} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}$$

$$W = P_1V_1\left(\frac{n1}{n-1}\right)\left[\frac{P_2}{P_1}.\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

$$W = P_1V_1\left(\frac{n1}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$W = \frac{n1}{n-1}MRT,\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \therefore P_1V_1 = MRT,$$

The discharge temperature of air

$$\mathrm{T}_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

4.4 ANALYTICAL USE OF FUEL ATOMIZER COMPONENTS

Table 4.2: Analytical Use of Fuel Atomizer Component

S/N	Type of automobile	Type of fly wheel	Fuel used	Type of engine	Type of compressor
1	Peugeot 504 Station Wagon	Light weight fly wheel	Petrol	Spark ignition engine	Reciprocating compressor single stage

4.5 COMPARISON OF VEHICLE WITH FUEL ECONOMIZER MECHANISM AND THE ONE WITHOUT IT

Table 4.3: Comparison of Vehicle with and without Fuel Economizer Device

S/N	Vehicle with fuel economizer device	Vehicle without fuel economizer device
1	Fuel used is economically preserved	There is no fuel economy
2	Combustion is complete	Combustion is incomplete
3	Exhaust gas has no unburnt gas hence less air pollution	Exhaust gas has unburnt gas hence more air pollution

4.6 COST ANALYSIS

There is need to analyze the cost of producing the basic atomization process in 504 Peugeot Station Wagon automobile engine.

It is important to note engineering is all about safety and economy. Therefore, the objective of an engineer during the production process is to give consideration to cost production and good quality product by selecting good material.

4.6.1 COST ESTIMATES

The cost estimate can relatively be obtained in many ways, so that two or more designs can be roughly compared. A certain amount of judgment may be required in some instance: Take a case in point; the relative value of two automobiles can be compared by the dollar cost per pound weight. Another way to compare the cost of one design with another is simply to count the number of parts; the design having the smaller number of parts may have less or higher cost depending on the material used. Many other cost estimates can be depending upon the application, such as area, volume horse power, torque, speed and various performance ratios.

Cost can be regarded as the estimated price to be adopted for a production. For explicit components, cost is considered on its engineering viewpoint instead of its economic viewpoint and it would be explained under the subheadings; direct cost, indirect cost and actual cost.

4.7 BILL OF MATERIALS (DIRECT COST INCURRED)

Table 4.4: Bill of Materials (direct cost incurred)

The table below gives the breakdown of the cost of materials of this project.

S/N	ITEMS	QUANTITY	COST RATE (₦)	TOTAL COST (₦)
1.	Compressor	1	12,000	12,000:=
2.	Dryer	1	5,000	5,000:=
3.	Pressure Pipes	3	200	6,000:=
4.	Controlled Valve	1	4,000	4,000:=
5.	Air Pressure Gauge	1	8,000	8,000:=
6.	Ball joint Nuts	7	500	3,500:=
7.	Ordinal nuts	4	200	800:=
8.	Bolts	4	200	800:=
9.	Carburettor	1	15,000	15,000:=
10.	Fan Belt	1	500	500:=

11.	Special Nipple	1	3,000	3,000:=

Subtotal =

₦58,600

INDIRECT COST INCURRED

Table 4.5: Bill of Materials (Indirect cost incurred)

S/N	Item	Quantity	Rentage Period/Day	Unit Cost	Total Cost (₦)
1.	Transport				50,000
2.	Hotel bill				100,000
3.	Phone calls Pipes				5,000
4.	Internet information and printing				30,000
5.	Vehicle bought for testing and for experiment Peugeot pick-up	1			150,000
6.	Petrol for testing	50 liters			4,000
7.	Construction of atomizer device				50,000
8.	Textbooks				25,000

Subtotal =

₦414,000

LABOUR COST (INDIRECT COST)

Table 4.6: Labour Cost (Indirect cost)

S/N	Job description	No of hours	Cost/hour	No of person needed	Total Cost (₦)
1.	Construction of atomizer device	2	1000	2 Technicians	(2 x 1,000)2 = 4,000
2.	Construction of atomizer device	2	3000	1 Engineer	(2 x 3,000)1 = 6,000
3.	Consultancy	2	5000	1 Senior Registered Engineer	(2 x 5,000)1 = 10,000
4.	Design fee 10%	-	-	-	2,000

5.	Incidental Cost	-	-	-	10,000

Subtotal =

₦32,000

Total Cost of Production = Direct Cost + Indirect Cost + Labour Cost

= ₦58,600 + ₦414,000 + ₦32,000

= ₦504,600

Note that labour cost is also indirect cost

∴ Indirect Cost + Labour Cost = Indirect Cost

4.9 DETAILED PARAMETERS CALCULATED ARE SHOWN IN THE DETAILED DRAWINGS ATTACHED BELOW

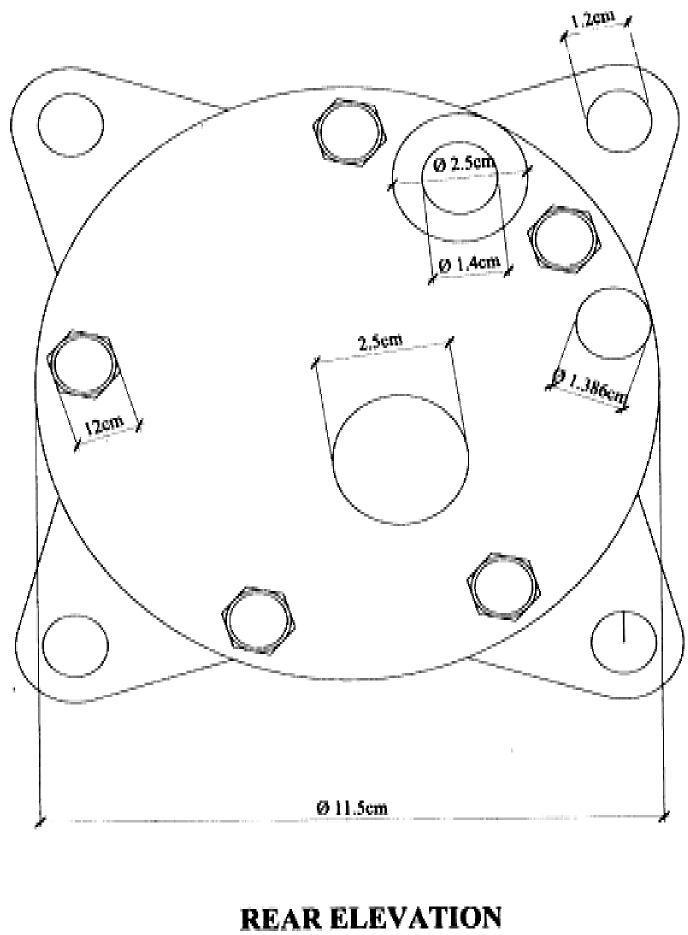


Fig. 4.8: Diagram of a compressor (rear elevation)

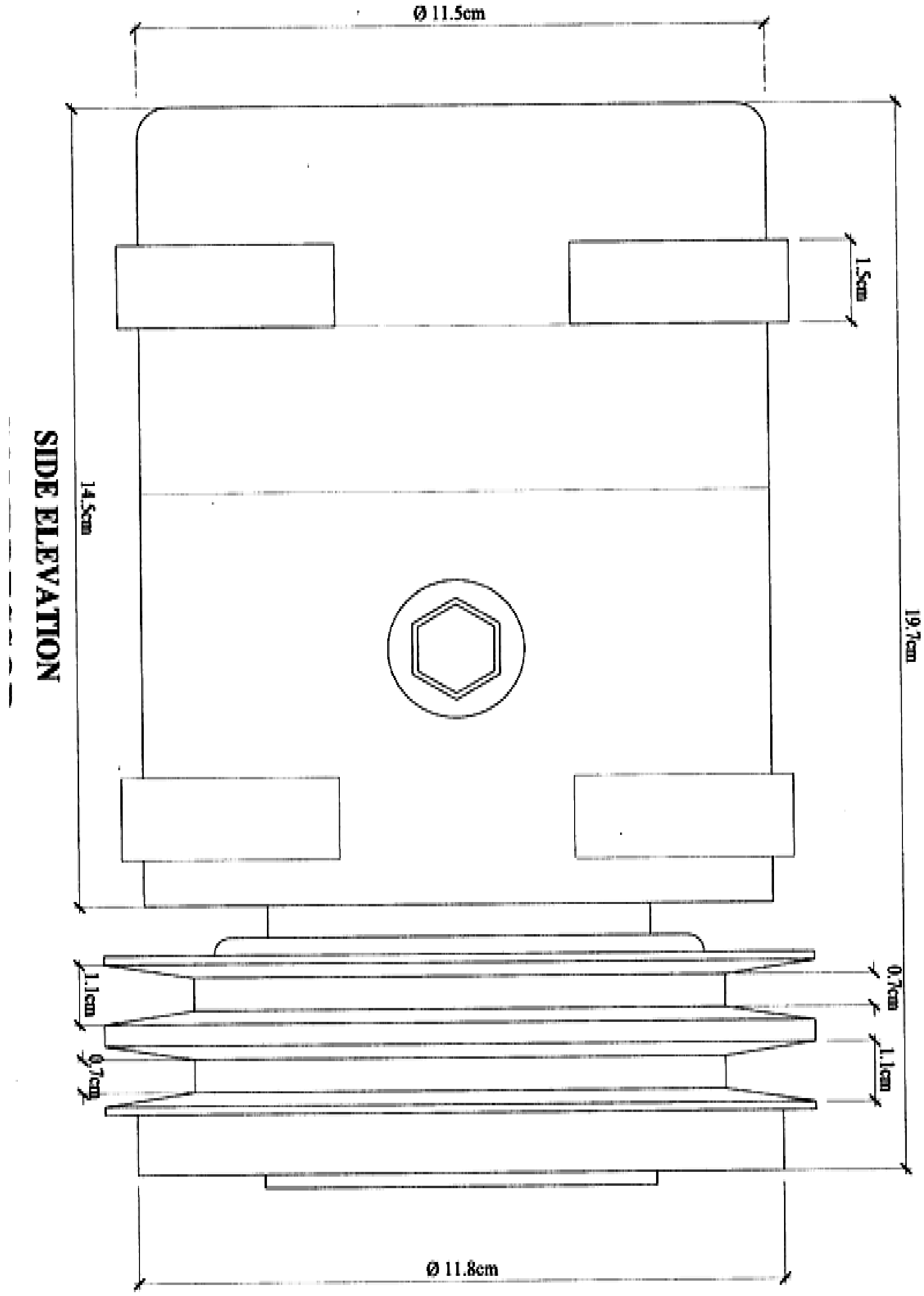


Fig. 4.9: Diagram of a Compressor (side elevation)

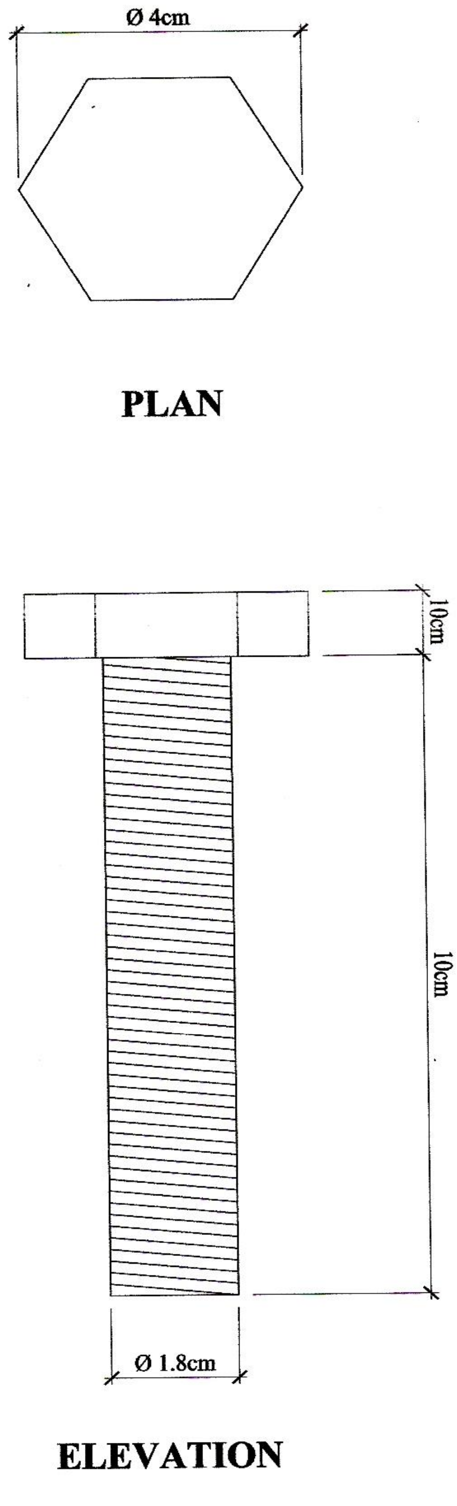
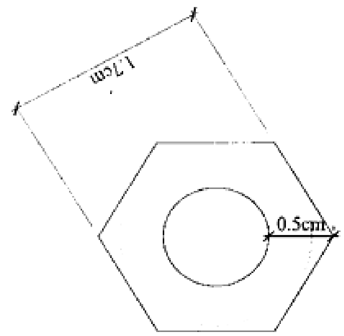
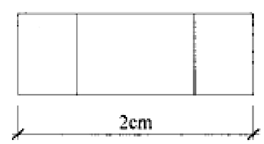


Fig. 4.10: Compressor Bolt (plan and elevation)



PLAN



ELEVATION

Fig. 4.11: Compressor Nut (plan and elevation)

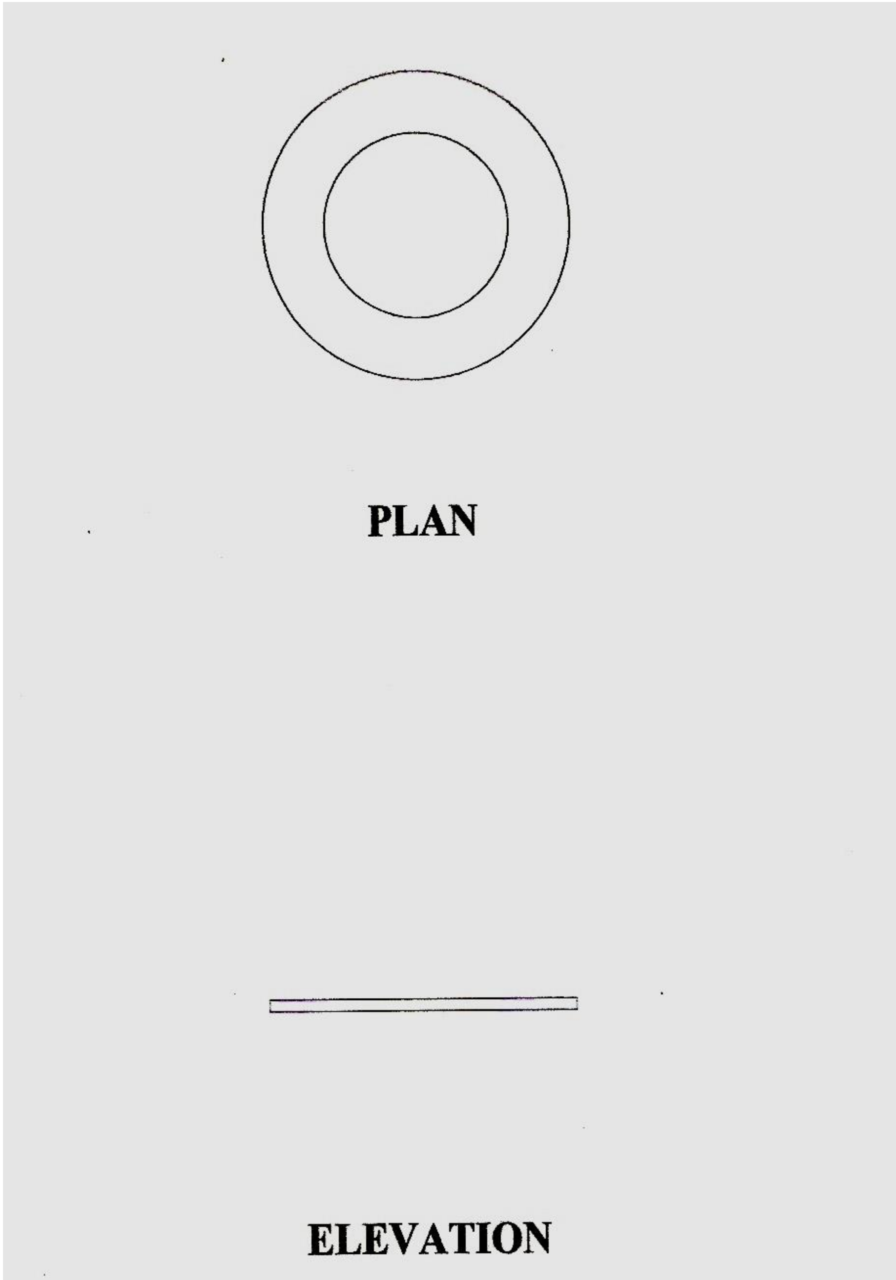


Fig. 4.12: Sketch of Compressor Washer (plan and elevation)

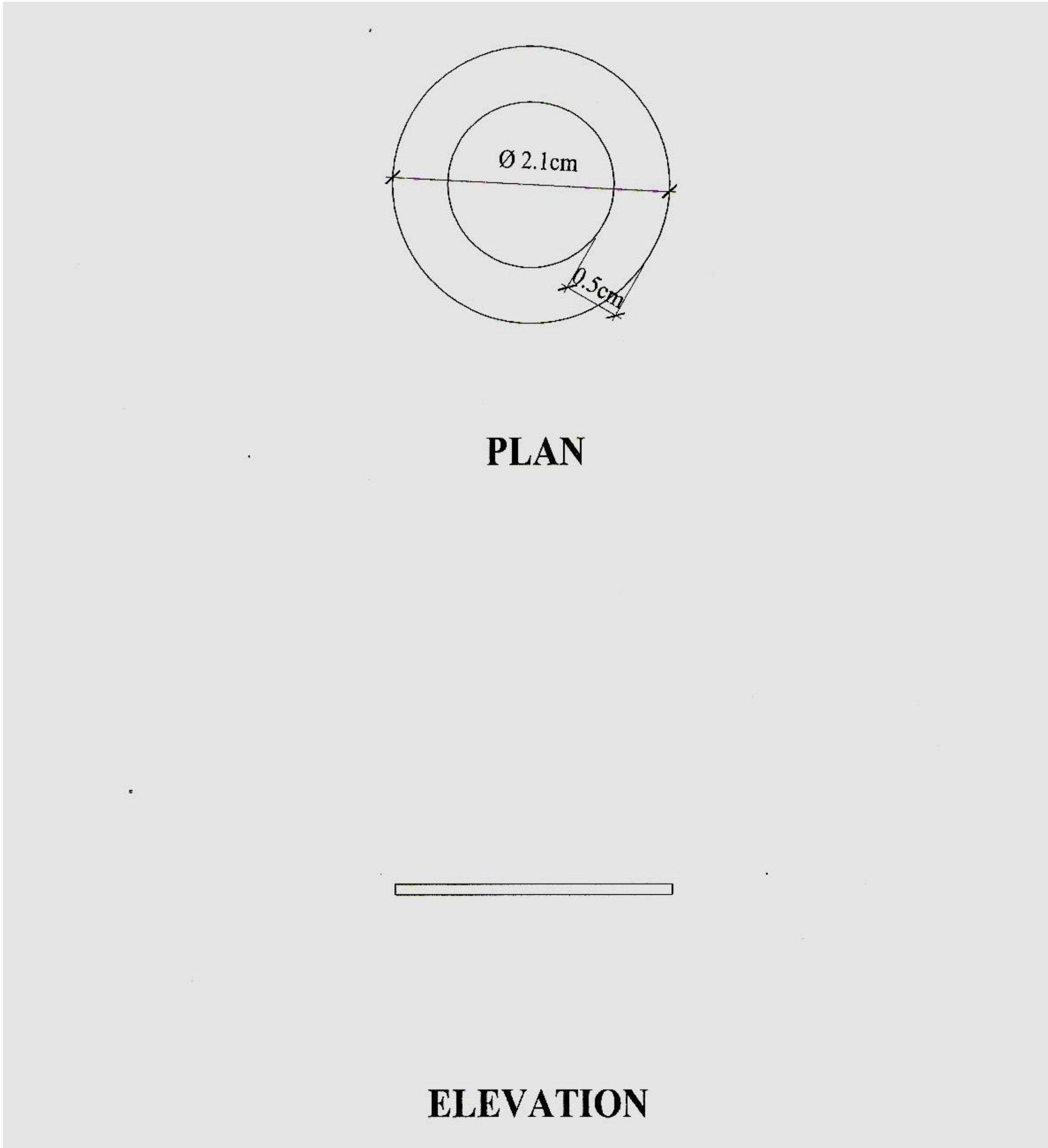


Fig. 4.13: Diagram of compressor washer (plan and elevation)

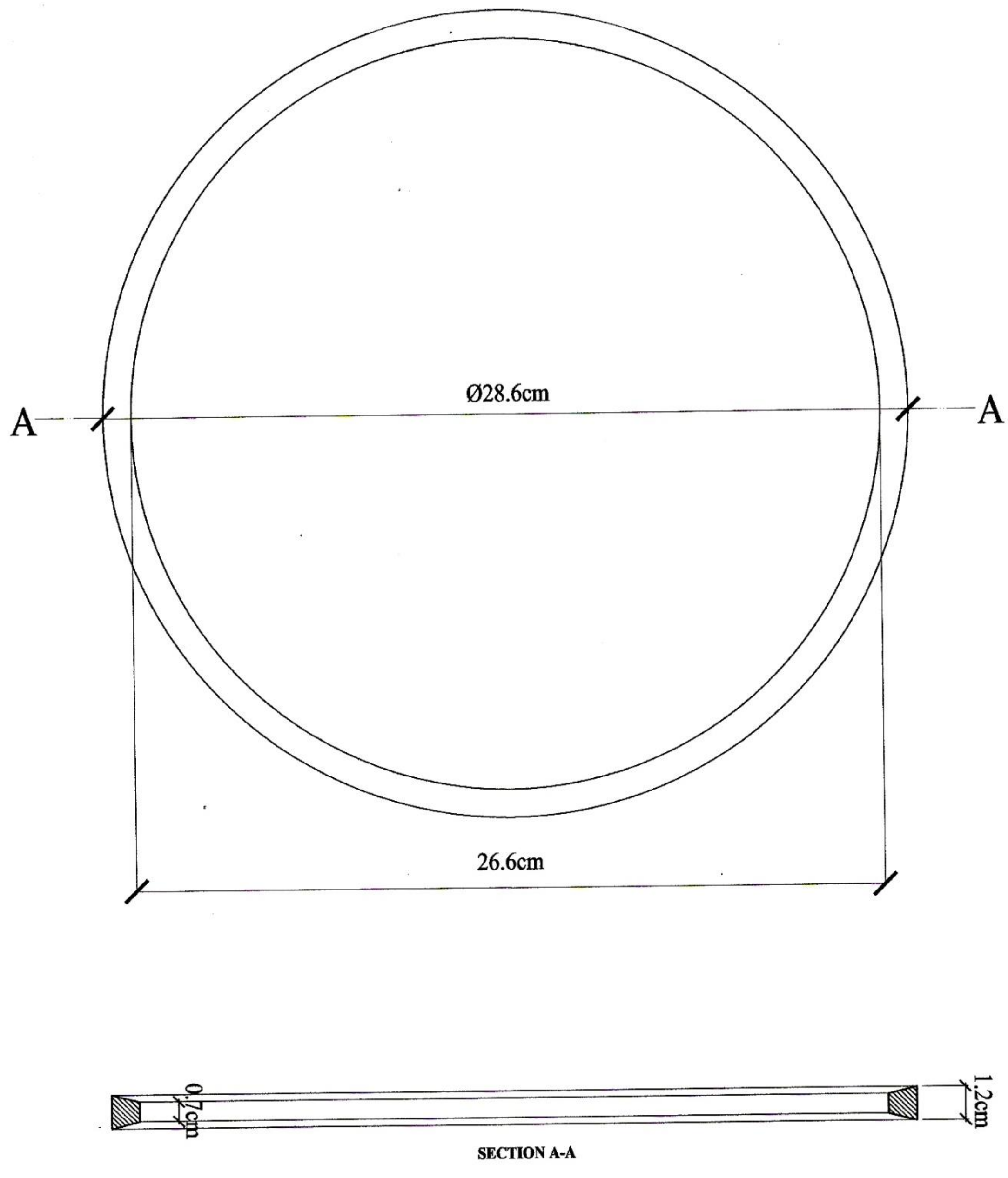


Fig. 4.14: Diagram of fan belt

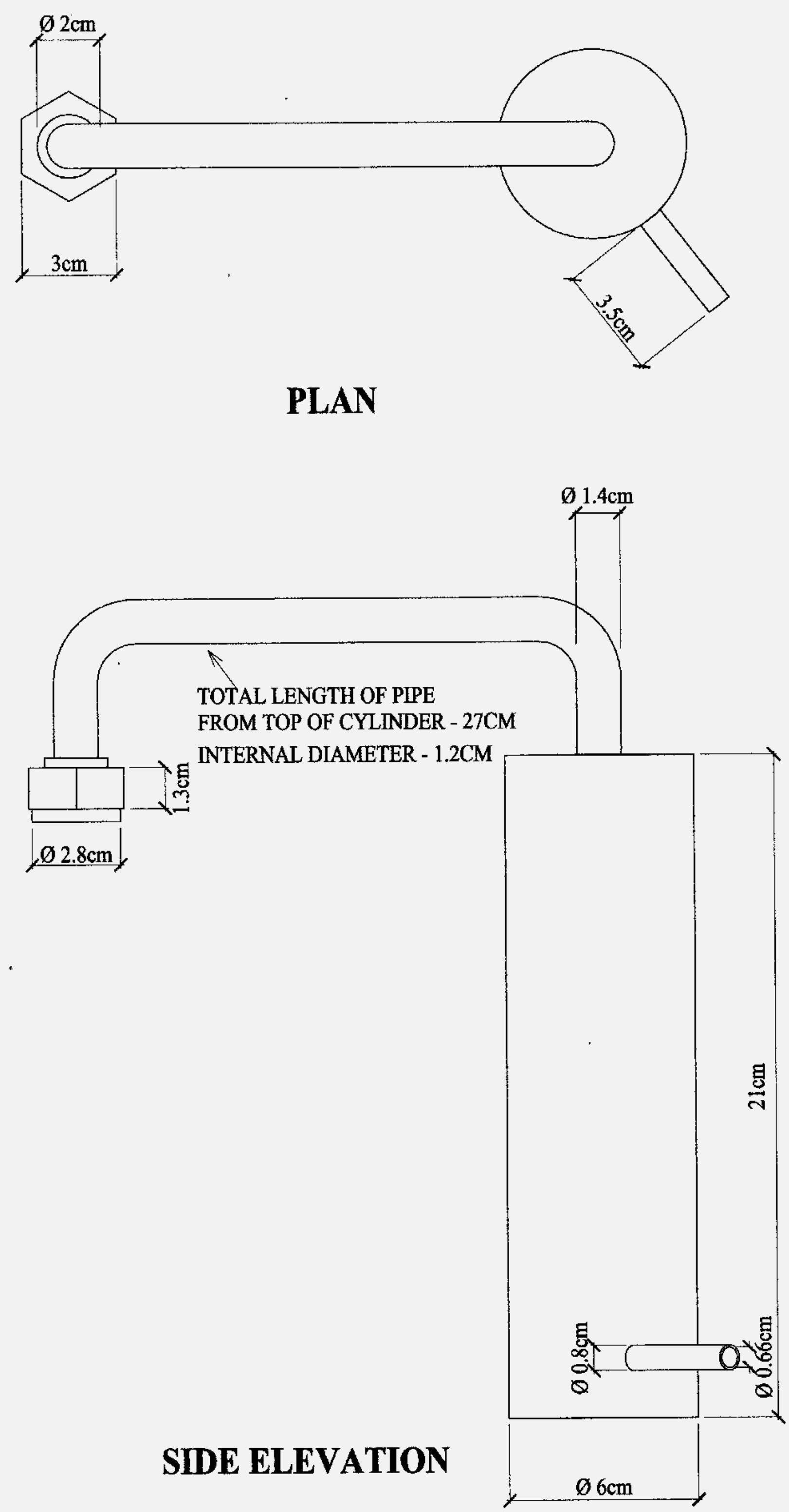


Fig. 4.15: Diagram of air cylinder (plan and side elevation)

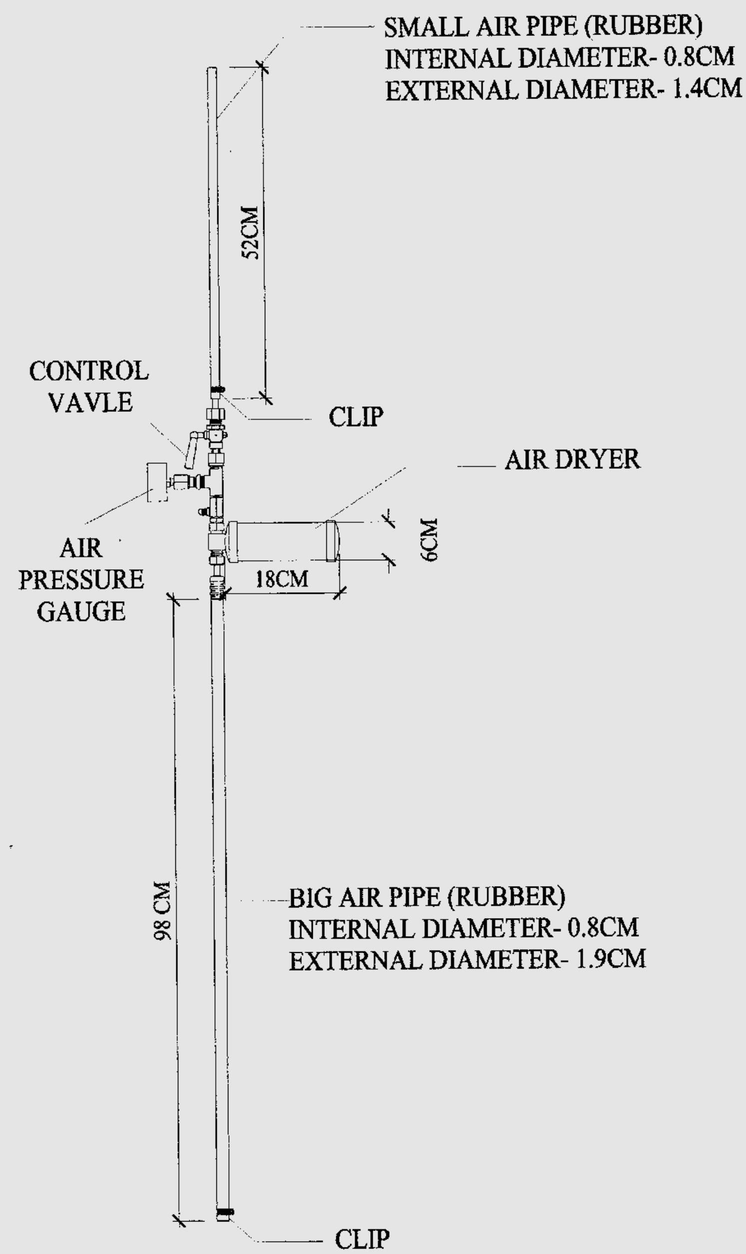


Fig. 4.16: Fuel economizer mechanism

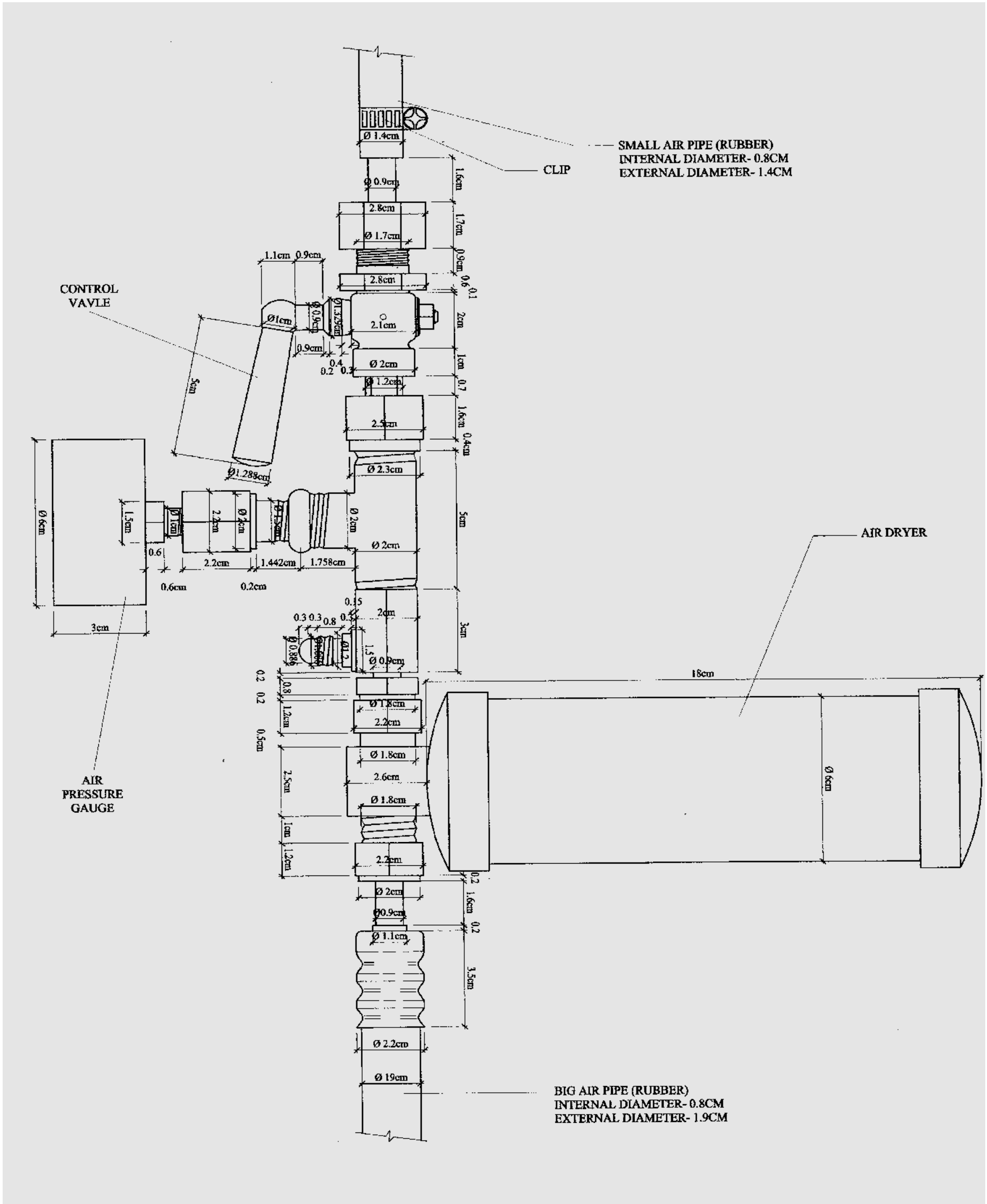


Fig. 4.17: Fuel economizer mechanism with air dryer and valve control

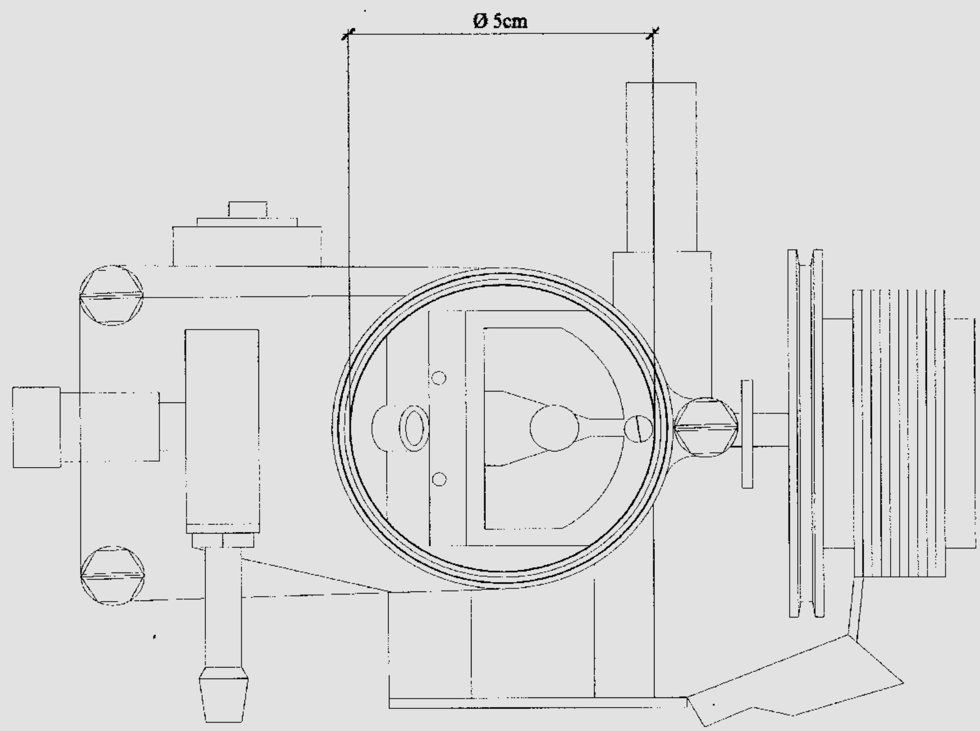


Fig. 4.18: Diagram of a compressor (plan)

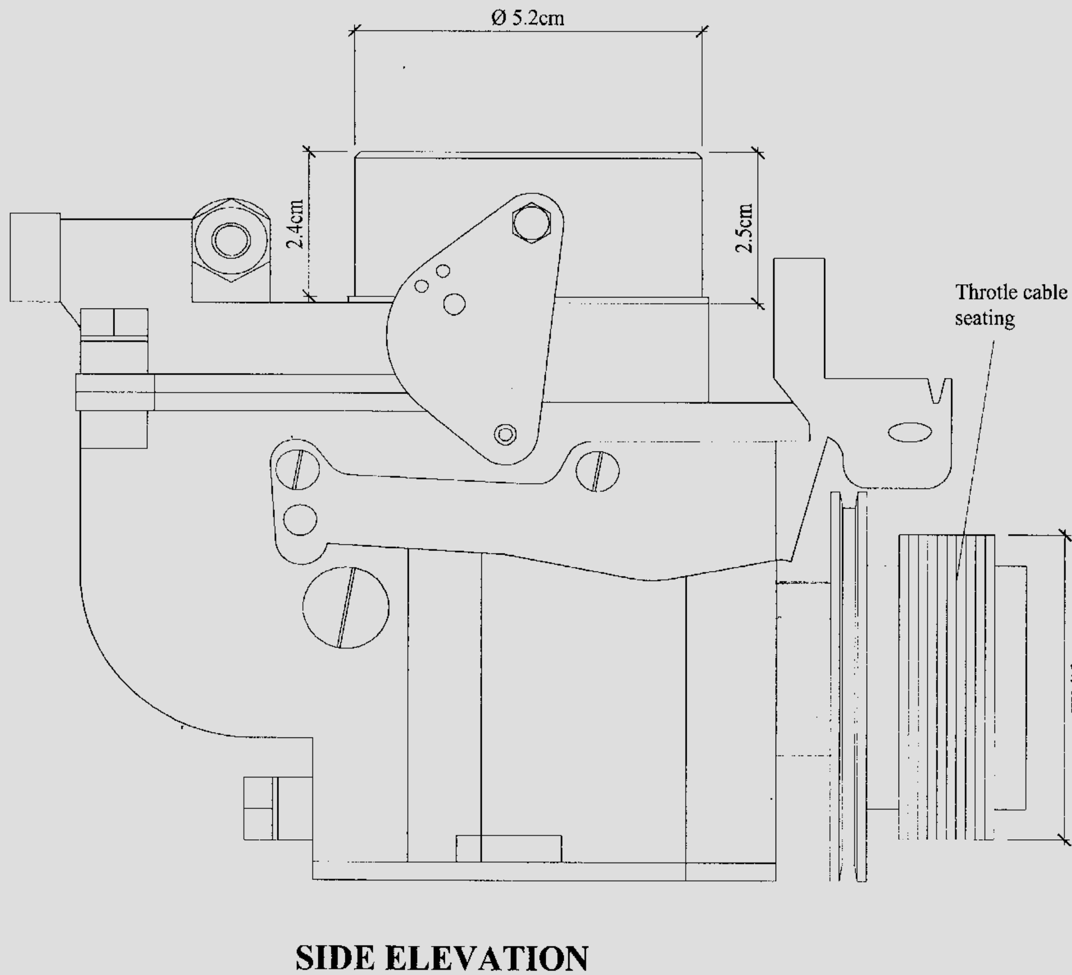


Fig. 4.19: Diagram of a compressor (side elevation)

Geometry of Fuel Economizer Device

The geometry of a fuel economizer device may be as simple as a circular cup of solid material connected with orifice of different sizes of pipes in which pressurized air passed through to atomize the fuel.

Engineering Design

Design is defined as ñdeliberate, purposeful planning.ò Engineering design is the creation of plan for machine, structures, systems or processes to perform the desired functions it requires need which in general terms defines problem and specification for major components.

The Principle of Design

The principle of design is illustrated below. Here, it required to draw an arc of a given radius r at a centre at O to have two radii small r and R. Where radius (r) of circular shape of carburetor which maintain circular plate of carburetor while radius R will be for circular shape of economizer device. Tolerance will be given to allow a circular shape of economizer device to be fixed inside it.

Therefore, using

R = radius of economizer circular device

r = radius of carburetor circular shape maintaining circular plate

A = area of the sectional tube

This can be used to get the diameter for the cross sectional area of a thin tube.

Approximately, according to fundamentals of mechanical design specification (Budinski, 1999)

$A = \pi dt$

where,

d = diameter of the tube

t = thickness of the tube (cross sectional area gives 2t for two sides)

$\pi = {}^{22}/_{7}$ or 3.142

Using a lower limit of 20 kilopound per square inch (ksi) for the yield stress of the steel, ½ inch for thickness of the tube and design load 80 lb, we get the estimated diameter, $d = {}^{80}/_{20}\ (2) = 8$. (8 cm was selected).

Calculation for Economizer

A = 3.142 x 8.0cm x (0.30 + 0.30) cm

= 15.08cm^2

Calculation for Carburetor

A = 3.142 x 5.0cm x (0.15 + 0.15) cm

= 4.71cm^2

Combustion Process for Spark Ignition Engines

Air-fuel mixture flows

↓

Into cylinder during induction process

↓

Mixes with the hot clearances gases and contact
hot combustion chamber

↓

Cylinder and piston with resulting heat transfer to the charge

↓

The compression process also increases the temperatures of the mixture so that unvaporized portion of the fuel entering the cylinder is vaporized usually before the beginning of the combustion.

↓

The charge is ignited by means of an electric spark and combustion begins at this point and spread in all directions from spark plug gap until stopped by coming in contact with chamber walls.

↓

The flame is propagated through the combustion chamber by the normal reaction rate and by the expansion of the burned fraction of the charge.

↓

Combustion begins before the piston is at the top dead centre and ends with the piston moving away from top dead centre.

↓

Thus work is done on both the burned and unburned fraction during the first part of combustion process and by both fraction during the caller part of the process.

↓

The burned fraction of the charges loses heat to the wall from the time it is burned till exhausted. The expansion of the burned fraction compresses the unburned fraction and raises its temperature. Therefore, it is also losing heat to the wall but usually at a negligible rate.

Reasons for Designing Fuel Economizer Device

Advantages

- Better fuel mileage (save money).
- To break up fuel mechanically into small particles by a process called atomization. This breaks up the fuel by subjecting it to a turbulent air flow through small holes. This action not only aids the production of a fast-burning mixture but also helps to mix the air and fuel equally that is it aims to produce a homogenous mixture.
- Easy installation.
- Environmental friendly.
- Ensure complete combustion.
- Smoother running of petrol engine.
- Less carbon build-up.
- Less pollution.
- Minimize fuel wastages and hazardous emission by simply burning fuel efficiently.

Experimental Test

Testing and comparison

The vehicle without fuel economizer mechanism was driven for a certain distance and the quantity of fuel noted as measuring parameter. Also the speedometer of the vehicle was noted for the speed at different times. The quantity of fuel used was noted by measuring the graduated fuel can. The same quantity of fuel used and at the same distance covered was recorded for comparison.

Evaluation Performance

Observation

The vehicle installed with fuel economizer mechanism drove for a longer distance than similar car which is not installed with fuel economizer mechanism.

Result

Vehicle installed with fuel economizer mechanism economizes the fuel because of complete combustion due to atomization of fuel. Fifty percent of fuel was preserved.

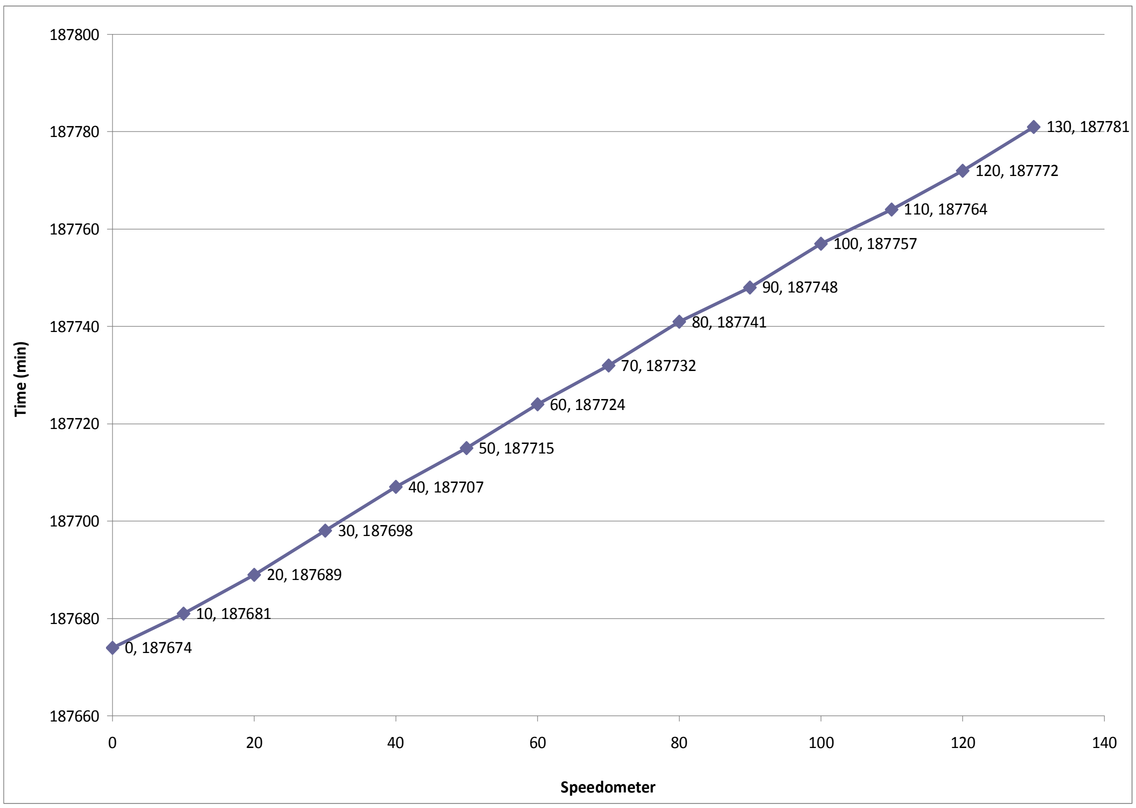
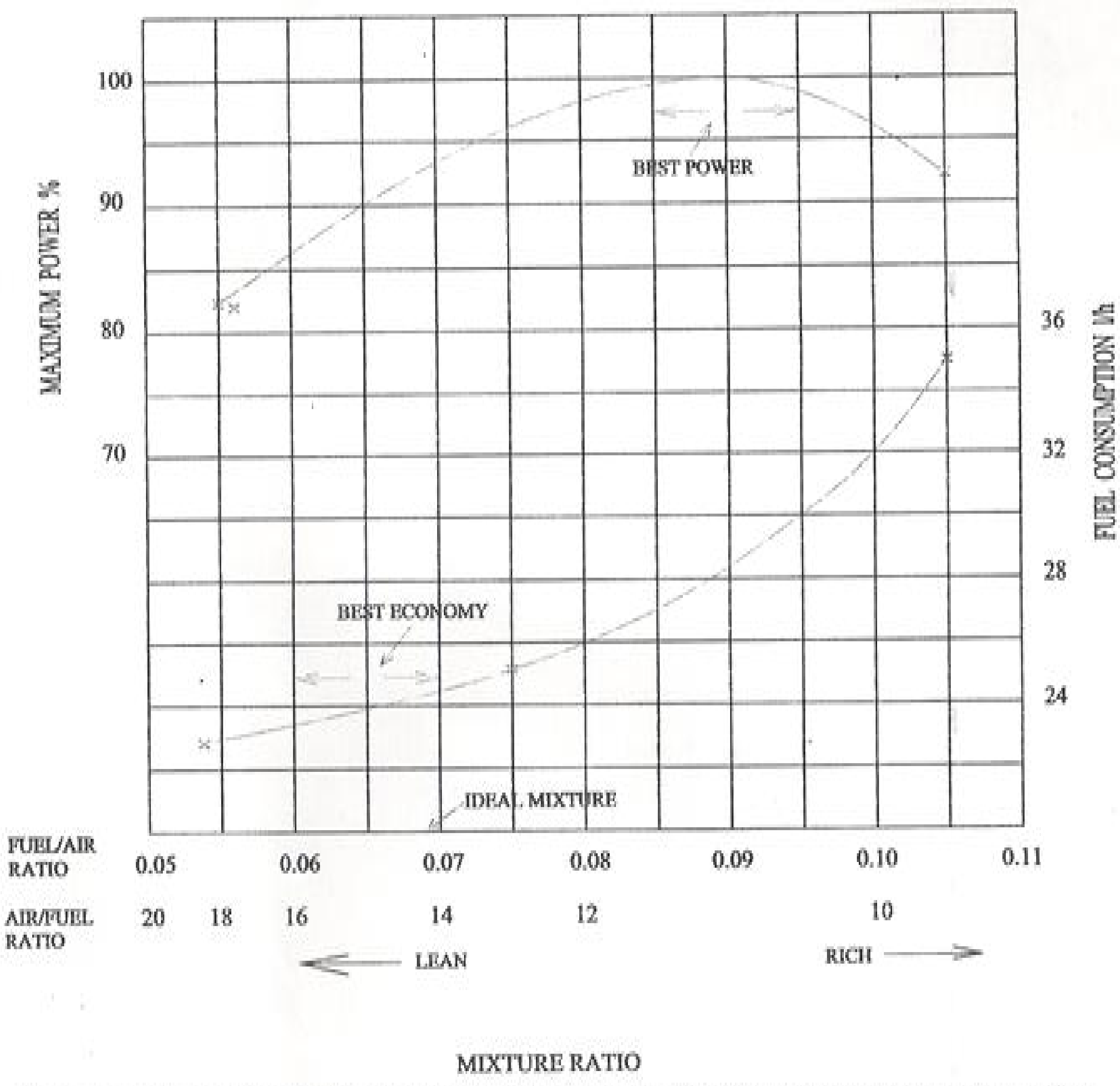


Fig. 4.20: Graph of Time versus Speedometer reading

The best fuel economy was obtained with a 15:1 to 16:1 ratio while maximum power output is achieved with 12.5 to 13.5. A rich mixture in the order of 11:1 I required for idle, heavy load, and high-speed conditions. a lean mixture is required for normal cruising and light load conditions.

In figure 4.21 the characteristic curves showing the effect of mixture ratio on efficiency and consumption is represented.

EFFECT OF AIR-FUEL RATIO ON EFFICIENCY AND FUEL CONSUMPTION



The approximate proportion of air to petrol (by weight) suitable for different operating conditions are stated below:

Starting: 9:1	Acceleration 12:1
Idling: 12:1	Economy 16:1
	Full Power 12:1

Fig. 4.21: Effect of air-fuel ratio on efficiency and fuel consumption

Thus, required air-fuel ratio is gotten from those resulting in maximum economy to maximum power. The carburetor must be able to vary the air-fuel ratio quickly to provide the best possible mixture for the engineæs requirements at a given moment. The best air-fuel ratio for one engine may not be the best ratio for another, even when the two engines are of the same size and design.

To accurately determine the best mixture, special construction of carburetor was designed as shown in figure 4.22 below.

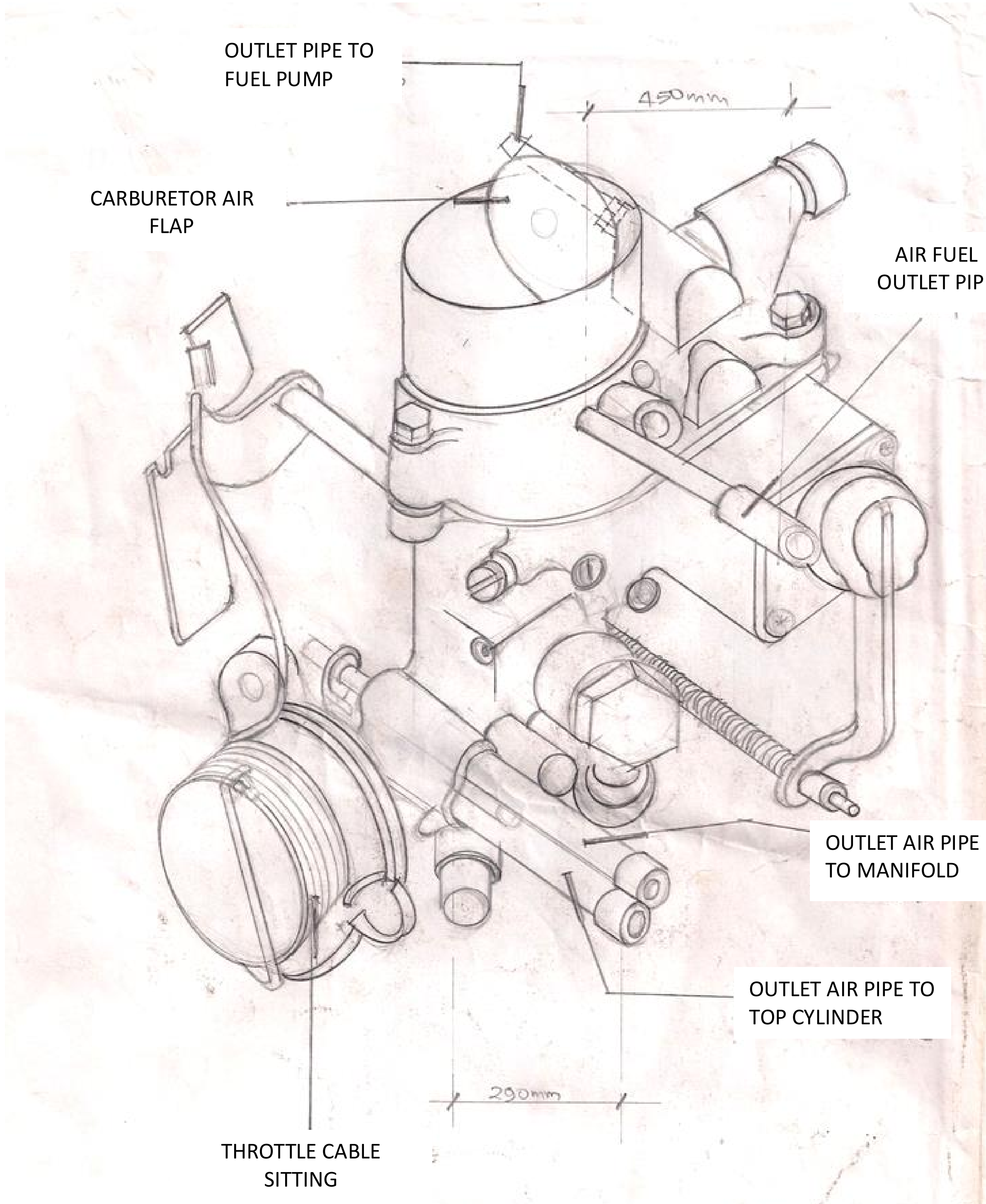


Fig. 4.22: Carburetor with special construction

Summary

Designing and constructing of a fuel economizer mechanism for use in petrol engine requires spray paint machine principle to be adopted. The more the fuel is atomized the more complete combustion is derived. In the case of the pressurized air, the velocity is greatest where the cross sectional area is least. Consequently, if the cross-sectional area is large, an incomplete combustion will occur.

The good result of this operation to the driver is that it saves fuel and money, provides more power and the vehicle burns fuel efficiently.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Vehicle installed with fuel economizer mechanism will economize fuel better than vehicle without it. The more the fuel is atomized, the more complete combustion is derived. In the case of introducing the pressurized air in the system, it is the best method of atomization. It is therefore very important to introduce the fuel to the intake manifold as a fine ñmistò which can rapidly vaporize noting that fuel must first be vaporized before it can be burnt in petrol engine. It is an innovative technology that optimizes fuel consumption besides been **smoother running**, **environmental friendly** due to complete combustion and also has **easier engine starting**.

5.2 RECOMMENDATIONS

The author is of the view that further research be embarked upon, since no machine can achieve one hundred percentage efficiency, hence, suggestion for the incorporation of the following:

(i) Electronic compressor should be incorporated in the system to improve the efficiency.

(ii) Computer should be used for operation of the fuel pump controlled by control unit. This particular manufacturer calls the computer control unit an E.C.C.S (Electronic Concentrated Control System) several signals are fed into the computer with different sensors with sensitive response.

(iii) More research should be made on a better material for atomizer device component.

(iv) Since atomization of fuel is the only way to achieve complete combustion which helps to reduce air pollution, Federal Government should be informed to assist universities financially to carry out more research on this project.

Preproduction: Certain factors must be taken into consideration.

i. Availability of selected materials
ii. Durability and safety of the atomizer components
iii. Economy of production and accessibility to machineries
iv. The engineer during production should consider that safety factor should be put in place to avoid explosion of air cylinder.

Post Production Process: cooling by quenching should be avoided and adopt cooling by atmosphere in other to allow easy machinebility of any component. The air cylinder surface must be improved to prevent crack and leakage.

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