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Electric Power Generation using Non-Conventional Energy Resources

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Abstract: As the world is stressed with the energy and fuel crises, compounded by pollution, any technology that brings out a solution to this problem is considered as a gift to man-kind. One of such new technologies is the development of a new engine called as "Compressed Air Engine or Pneumatic Motor". The primary objective of this paper is to present an idea about compressed air engine, to cope up the shortage of most commonly used fuels and go for compressed air as an alternate fuel; Compressed air engine can be one of the most promising electrical energy generating technology. Compressed Air Energy if combined with pneumatic motor connected to an alternator can be connected to the main grid or installed at isolated loads (remote areas for example) can be a viable alternative to others energy generating technologies. Indeed, because of the advantage of fast response, high economic performance and small environmental impacts, Compressed Air Energy has an extensive application prospect. In this paper, we present an idea about the use of this technology in both small and large scale for producing Eco-Friendly Electrical Energy. This review includes a Pneumatic Motor (Compressed air Engine), the alternators, storage of compressed gas, and smart switching of gas cylinders using microcontrollers.

Keywords: compressed air engine, alternate fuel, electrical energy generating technology, fast response, high economic performance, small environmental impacts.

I. INTRODUCTION

A compressed air piston Cylinder Engine is coupled with a generator (1-ph or 3-ph alternator), the piston cylinder engine is driven by the expansion of the compressed air entering the cylindrical chamber which moves the piston downwards for the intake stroke and then escapes out the other exit when the piston engine gives exhaust stroke, this movement has a rotational force which can be used to run an alternator producing (1-ph or 3-ph) power as required at certain rpm for maintaining std frequency.

The same shaft can even be coupled to aid the compressor store compressed air in the storage compartments provided.
This type of power generation will give no harmful pollutant to the atmosphere and would work without any power input.

The rotor containing (housing) the field winding will be given a dc input at start through a battery and later will be provided dc energy by the generated power itself using ac-dc converter.
The Pneumatic Motor at start will be run by a starter motor at first to provide it with an initial torque and then would later run with compressed air as fuel.

II. THE PNEUMATIC ENGINE

A **pneumatic motor** (**Air motor**) or **compressed air engine** is a classification of motor which does mechanical work by expanding compressed air. Pneumatic motors convert the compressed air energy to mechanical work through either linear or rotary motion. Linear motion can come from a piston actuator, and rotary motion is supplied by either a vane type air motor, piston air motor, air turbine or gear type motor.

A compressed air engine uses the expansion of compressed air to drive the pistons of an engine, turn the axle.

A highly efficient arrangement uses high, medium and low pressure pistons in series.

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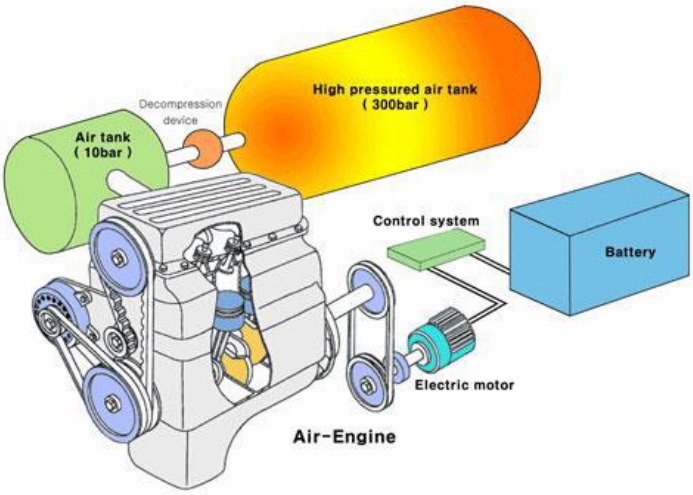

Figure1: The Pneumatic Engine (Courtesy: www.Google.co.in)

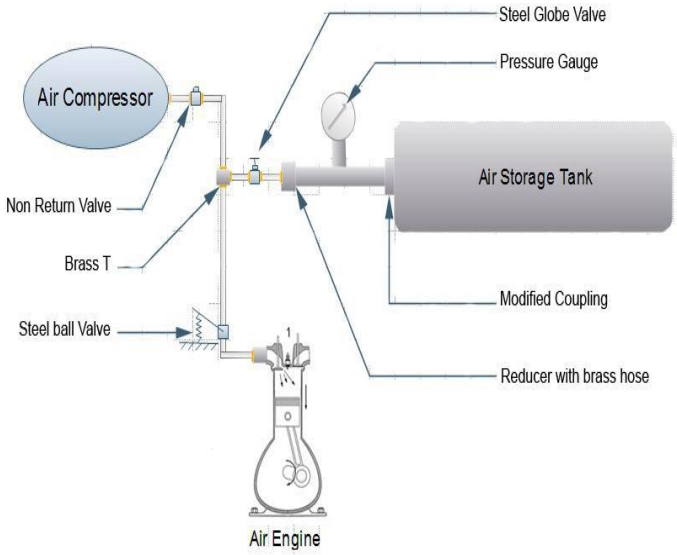

Figure2: Compressor coupled with gas cylinder to power the engine (Courtesy: www.Google.co.in)

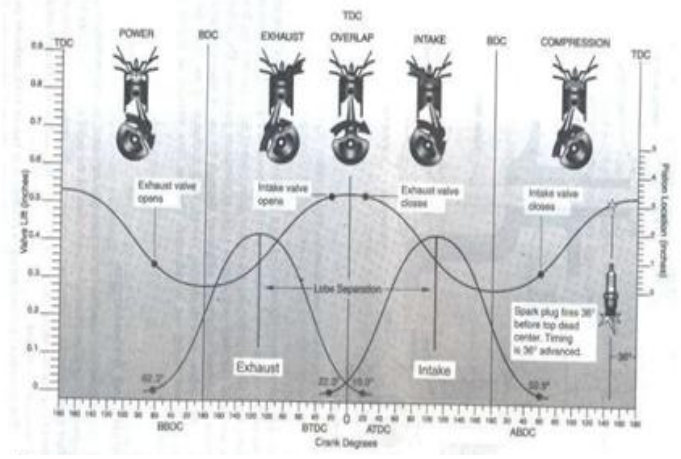

Figure3: Positions of the piston for different strokes of the engine (Courtesy: www.Google.co.in)

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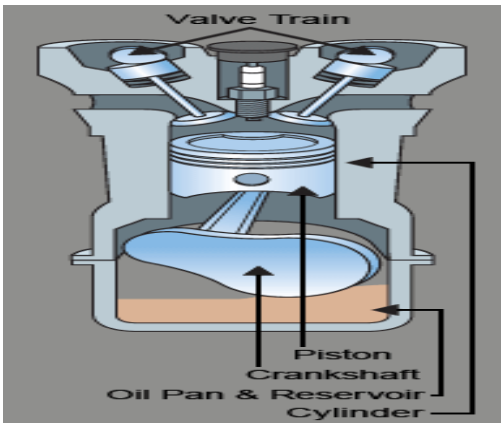

Figure4: The Basic Overview of Pneumatic Engine (Courtesy: www.Google.co.in)

III. STORAGE OF COMPRESSED AIR

Compressed air energy storage (CAES) is a way to store compressed air in air-tight chambers at safe conditions. At utility scale, energy generated during periods of low energy demand (off-peak) can be used to meet higher demand (peak load) periods. Small-scale systems have been in use from a long in such applications as propulsion of mine locomotives. For Large-scale applications heat energy associated with compressing air must be conserved; dissipating the heat will lowers the energy efficiency of the storage system.

The storage system of a **CAES (Compressed Air Energy Storage)** is one of the most interesting characteristics of this technology, and it is strictly related to its economic feasibility, energy density and flexibility. There are two categories of air storage vessels, based on the thermodynamic conditions of the storage, and on the technology chosen:

1. Constant Volume Storage
2. Constant Pressure Storage

Figure5: Carbon-fiber Gas Cylinder (Courtesy: www.Google.co.in)

Air vessel (Compressed Air Tank)

A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. The pressure differential is very high and can lead to fatal accidents if not taken care of with precaution.

In case of air engine the vessel can be made using carbon fiber. This has high tensile and compressive strength and is lighter in weight too. Carbon-fiber, (alternatively) graphite fiber, carbon graphite or CF, is a material consisting of fibers about 5–10 μm in diameter and composed mostly of carbon atoms. The carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber. The crystal alignment gives the fiber high strength-to-volume ratio. Several thousand carbon fibers are grouped together to form a tow, which may be used by itself or woven into a fabric.

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them the first option for constructing an Air Container. However, they are relatively expensive when compared to similar fibers, such as plastic fibers and glass fiber.

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IV. COMPRESSOR AND EXPANDERS

Compression can be done with electrically powered turbo-compressors and expansion with turbo 'expanders' or air engines driving electrical generators to produce electricity.

Figure6: Compressor coupled with gas cylinder (Courtesy: www.Google.co.in)

V. STARTER MOTOR

Initial torque is supplied from the DC exciter motor, and then the engine operation starts. This motor is supplied power from a small battery and its On/Off operation is controlled by the micro-chip on board.

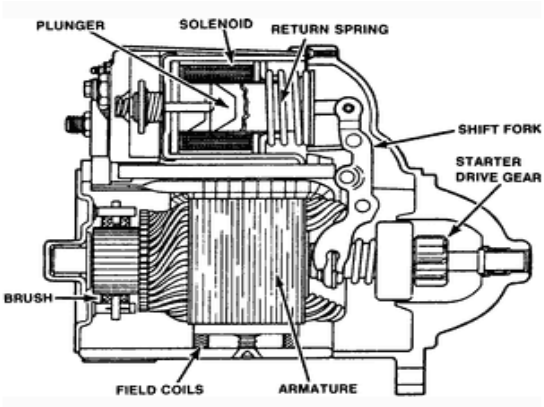

Figure7.a: Starter-motor coupled to a reciprocating engine (Courtesy: www.Google.co.in)

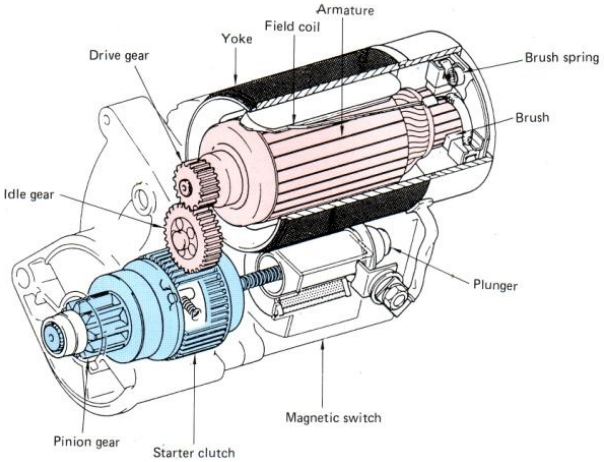

Figure7.b: Starter-motor coupled to a reciprocating engine (Courtesy: www.Google.co.in)

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VI. ALTERNATORS

An **alternator** is an electrical machine that converts mechanical energy to electrical energy in the form of **alternating current**. For maintaining low cost and simplicity of design, most alternators use a **rotating magnetic-field** with **stationary armature**.

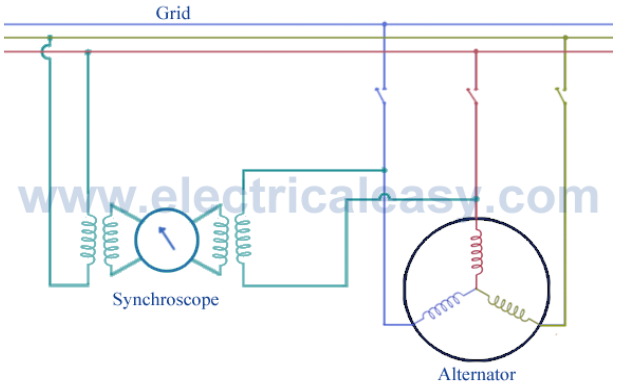

Figure8: Alternator (Courtesy: www.Google.co.in)

VII. PRINCIPLE OF OPERATION

A conductor moving against a magnetic field develops an **electromotive force (EMF)** in it according to Faraday's Law of Electromagnetic Induction. This **EMF** reverses its polarity when it moves under magnetic poles of opposite polarity. Generally, a rotating magnet, called the rotor, within a stationary set of conductors wound in coils on an iron core, called the stator. As the mechanical input causes the rotor to turn, the field cuts across the conductor which generates an **induced EMF (electromotive force)** in the stator coils.

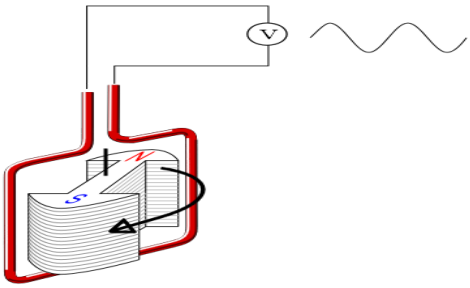

Figure9: Faradays Law of Electromagnetic Induction (Courtesy: www.Google.co.in)

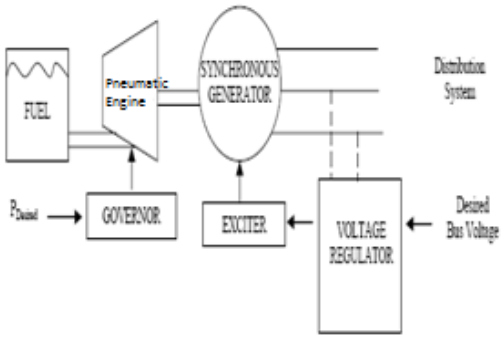

Figure10: Basic overview of power generation for distribution to houses (load) (Courtesy: www.Google.co.in)

An automatic voltage control device controls the field current to keep output voltage at a constant value. If the output voltage from the stationary armature coils drops due to an increase in demand, more current is fed into the rotating field coils through a **voltage regulator**. This increases the magnetic-field around the field coils which induces a higher value voltage in the armature coils. Thus, the output voltage is brought back up to its original value.

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VIII. CLASSIFICATION

Alternators may be classified by the following:
1. Method of excitation,
2. Number of phases,
3. The type of rotation.

1. Method of excitation
There are two main ways to produce the magnetic field used in the alternators:
- by using permanent magnets which create their own persistent magnetic field, and
- by using field coils i.e. electromagnet.

2. Number of phases
Another way to classify alternators is by the number of phases of their output voltage.
- The output can be single phase,
- Or polyphase. (Three-phase alternators are the most common, but polyphase alternators can be two phase, six phase, or more.)

3. Type of Rotation
The revolving part of alternators can be
- Armature Winding
- Field Winding

IX. SPECIFIC APPLICATIONS

Electric generators
Most power generation stations use synchronous machines as their generators. Connection of these generators to the utility grid requires synchronization conditions to be met.
Automotive alternators
Alternators are used in modern automobile to charge the battery and to power the electrical system when its engine is running.

X. PISTON CYLINDER DRIVING AN ALTERNATOR

As the given Figure 10 shows, Pneumatic engines can be used in small scale to generate electrical energy for use of either powering domestic loads or electric automobiles using gear system assembly between the shaft and alternator to generate more electric energy by consuming minimum amount of the stored compressed air.

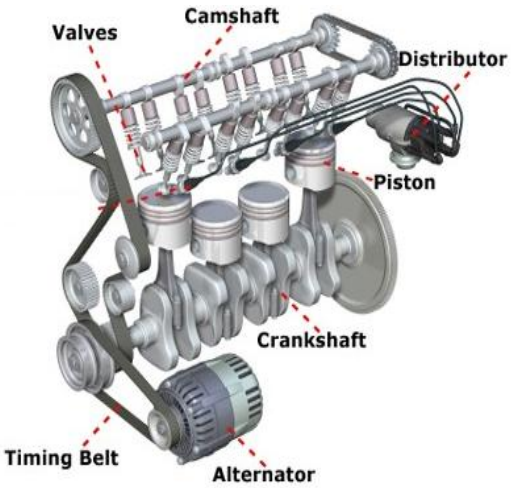

Figure11: Compressor coupled with gas cylinder (Courtesy: www.Google.co.in)

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XI. MICROCONTROLLER BASED GAS COMPARTMENT SWITCHING AND RUNNING OF STARTER MOTOR

Since the invention of computers, the automation technology has become possible. All machines in Industries today are automated for easier and faster production/manufacturing of goods for the market, not only it has helped in automation but also developing smart equipments to aid humans in their work using a microprocessor or micro controller.
Here we use a microcontroller embedded with a program to control the inlet switch between the gas storage compartments and maintain the gas pressure using inputs from various sensors, making uninterrupted supply of compressed gas to the Pneumatic motor and run the starter motor to provide initial torque to the pneumatic engine.

XII. ADVANTAGES AND DISADVANTAGES

Following are some advantages and disadvantages given for use of this technology:

a. Advantages

- The temperature of the engine while working will be slightly less than the ambient temperature so there isn't any need for cooling systems and spark plugs or complex fuel injection systems.
- Smooth working of the engine due to very less wear and tear of the components, resulting in lower maintenance cost.
- There is no possibility of knocking.
- No use of expensive fossil fuels as the free air is compressed and taken to use. For this reason people can easily shift to the new technology.
- Compressors use electricity for generating compressed air which is relatively much cheaper and widespread
- Cheaper in cost and maintenance and it doesn't cause any kind of harm to the environment.

Thus it can be a futuristic alternate mode for power generation and transport technology.

b. Disadvantages

There is no technology that doesn't come with any disadvantage. Hence, the major disadvantages that one can face with such technologies are:

- When air expands in the engine it cools dramatically and must be heated to ambient temperature.
- This also leads to the necessity of completely dehydrating the compressed air pressure using a heat exchanger.
- Refueling the compressed air container using a home or low-end conventional air compressor may take a long time, though specialized equipment at service stations may fill the tanks in only few minutes.

XIII. CONCLUSION AND RECOMMENDATION

As we see the world with the energy and fuel crises, compounded by pollution, this technology can help reduce the power generation crisis. This technology can be the alternate fuel option for the future, Compressed air engine is going to be one of the most promising mature electrical energy generating technology. Compressed Air Energy in combination with renewable energy generators connected to the main grid or installed at isolated loads (remote areas for example) are a viable alternative to others energy generating technologies. Indeed, because of the advantage of fast response, high economic performance and small environmental impacts, Compressed Air Energy has an extensive application prospect. This technology is going to be one of major fuel sources in both small and large scale for producing Eco-Friendly Electrical Energy in near future.

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