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Development and Fabrication of Airbrake System Using Engine Exhaust Gas

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Abstract: *The aim of this project is to develop an air brake system based on exhaust gas is called "Development and Fabrication of air brake system using engine exhaust gas". The main aim is to reduce the workloads of the engine drive to operate the air compressor, because here the compressor is not operated by the engine drive. Here we are placing a turbine in the path of exhaust from the engine. The turbine is connected to a dynamo by means of coupling, which is used to generate power. Depending upon the airflow the turbine will start rotating, and then the dynamo will also starts to rotate. A dynamo is a device which is used to convert the kinetic energy into electrical energy. The generated power can be stored in the battery and then this electric power has loaded to the DC compressor. The air compressor compresses the atmospheric air and it stored in the air tank and the air tank has pressure relief valve to control the pressure in the tank. The air tank supplies the compressed pneumatic power to the pneumatic actuator through solenoid valve to apply brake. The pneumatic actuator is a double acting cylinder which coverts pneumatic pressure into linear motion*

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I. Introduction

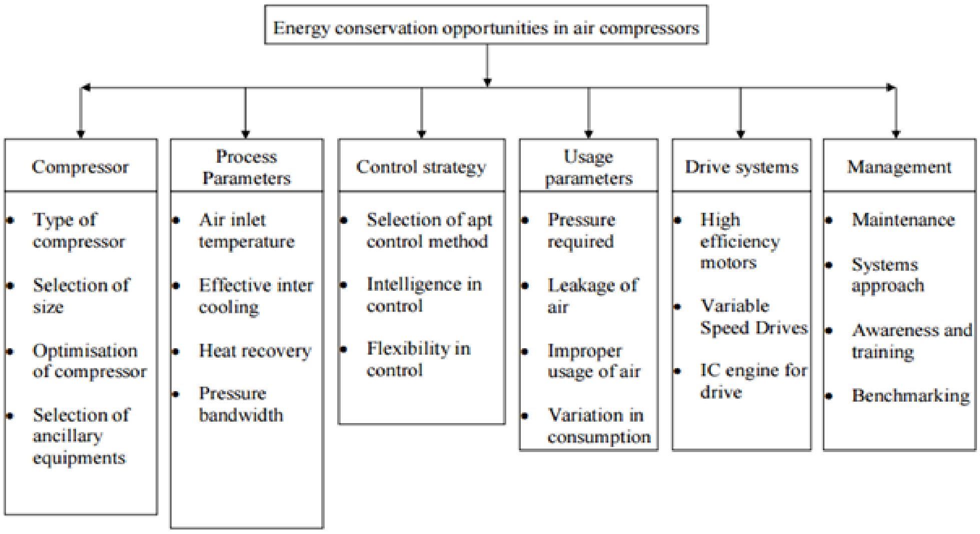
Braking System

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction. Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel. Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. When the brake pedal of a modern vehicle with hydraulic brakes is pushed against the master cylinder, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel down.

II. Literature Survey

The various research works attempted in the area of energy conservation and specifically in the area of air compressor and pneumatic systems have been referred and discussed here.

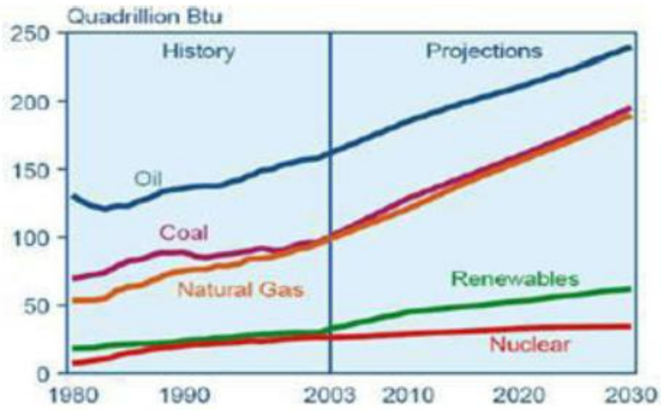


Block diagram showing energy conservation opportunities in air compressors

1. According to John (1995), the opportunities for cost savings in compressed air supply system includes but not limited to waste heat recovery, compressed air leakage reduction, use of outside air for compressor, compressor control, air pressure control, compressor selection and usage of IC engine for compressor driving.
2. The solution for compressed air leaks is to make leak finding and correcting as a part of the normal maintenance process and repeating leak survey at least once a year (John Holdsworth 1997). Over-pressurization can also result from short sighted selection of ancillary equipments. Bill Howe and Bill Scales (1998) report that the opportunities for improved compressed air efficiency where air is used internally, but uneconomically are less understood.
3. Cost effective efficiency opportunities in production and usage of compressed air are often ignored by the industries due to various reasons and selection of correct compressor control also plays a major role in the energy consumption by the air compressors (Robert 1999). Leaks, inappropriate usage of compressed air, poor selection of compressors and ancillary equipments, pressure problem and poor attempts to solve these problems are some other common causes of inefficiency in the compressor system

2.1 Literature Review

In recent years the scientific and public awareness on environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. Viewing from the socio-economic perspective, as the level of energy consumption is directly proportional to the economic development and total number of population in a country, the growing rate of population in the world today indicates that the energy demand is likely to increase. Substantial thermal energy is available from the exhaust gas in modern automotive engines. Two-thirds of the energy from combustion in a vehicle is lost as waste heat, of which 40% is in the form of hot exhaust gas. The latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE). These include thermoelectric generators (TEG), Organic Rankine cycle (ORC), six-stroke cycle IC engine and new developments on turbocharger technology. Being one of the promising new devices for an automotive waste heat recovery, thermoelectric generators (TEG) will become one of the most important and outstanding devices in the future. A thermoelectric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) due to a temperature gradient into electrical energy based on "Seebeck effect". The thermoelectric power cycle, charge carriers (electrons) serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine.



World Marketed Energy Use by Fuel Type 1980 – 2030

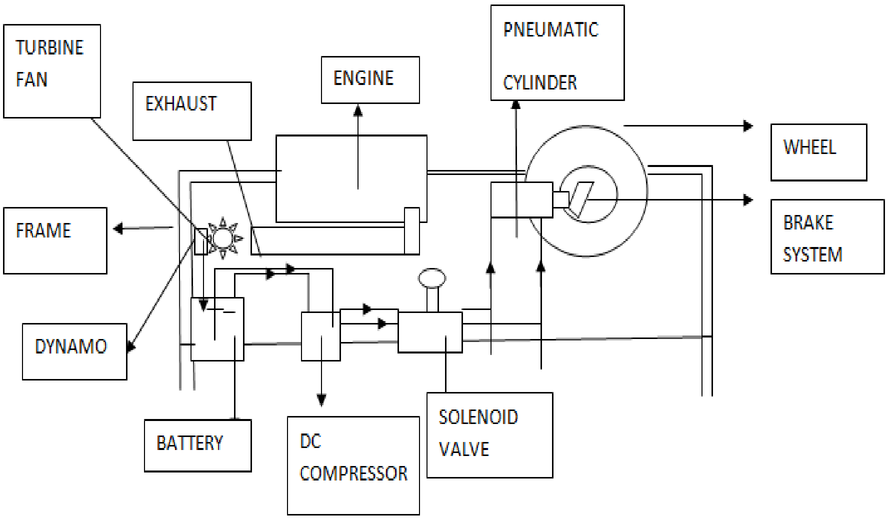
One potential solution is the usage of the exhaust waste heat of combustion engines. This is possible by the waste heat recovery using thermoelectric generator. A thermoelectric generator converts the temperature gradient into useful voltage that can used for providing power for auxiliary systems such as air conditioner and minor car electronics. Even it can reduce the size of the alternator that consumes shaft power. If approximately 6% of exhaust heat could be converted into electrical power, it will save approximately same quantity of driving energy. It will be possible to reduce fuel consumption around 10% hence AETEG systems can be profitable in the automobile industry.

The number of vehicles (passenger and commercial vehicles) produced from 2005 to 2010 shows an overall increasing trend from year to year despite major global economic downturn in the 2008–2010 periods. Note that China's energy consumption in transportation sector is the lowest (13.5%) although the country produced the highest number of vehicles in 2009 to 2010 as compared to the other countries.

A number of irreversible processes in the engine limit its capability to achieve a highly balanced efficiency.The rapid expansion of gases inside the cylinder produces high temperature differences, turbulent fluid motions and large heat transfers from the fluid to the piston crown and cylinder walls. These rapid successions of events happening in the cylinder create expanding exhaust gases with pressures that exceed the atmospheric level, and they must be released while the gases are still expanding to prepare the cylinder for the following processes. By doing so, the heated gases produced from the combustion process can be easily channeled through the exhaust valve and manifold. The large amount of energy from the stream of exhausted gases could potentially be used for waste heat energy recovery to increase the work output of the engine. Consequently, higher efficiency, lower fuel consumption by improving fuel economy, producing fewer emissions from the exhaust, and reducing noise pollutions have been imposed as standards in some countries. Hatazawa et al., Stabler, Taylor, Yu and Chau and Yang stated that the waste heat produced from thermal combustion process generated by gasoline engine could get as high as 30–40% which is lost to the environment through an exhaust pipe.

In internal combustion engines a huge amount of energy is lost in the form of heat through the exhaust gas.Conklin and Szybist investigated that the percentage of fuel energy converted to useful work only 10.4% and also found the thermal energy lost through exhaust gas about 27.7%. The second law analysis of fuel has been shown that fuel energy is converted to the brake power about 9.7% and the exhaust about 8.4%. In another research the value of exhaust gases mentioned to be 18.6% of total combustion energy. It is also found that by installing heat exchanger to recover exhaust energy of the engine could be saved up to 34% of fuel saving.

III. Methodology



2-D VIEW OF AIR BRAKE SYSTEM USING EXHAUST GAS

The two stroke petrol engine is connected to the wheels in which exhaust gas braking is attached. Pressure tank is used to store the exhaust gas under required pressure. The braking speed is varied by adjusting the valve is called flow control valve.

Solenoid valve is used to operate the pneumatic cylinder which actuates the brake lever of the wheels. The flow chart of the experiment is given in the figure.4.

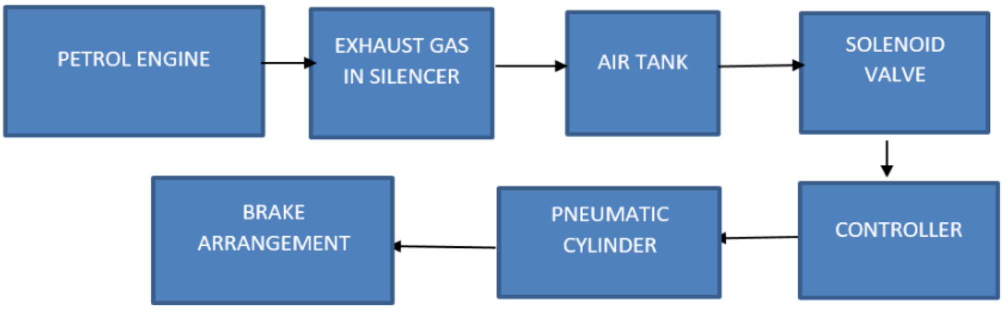
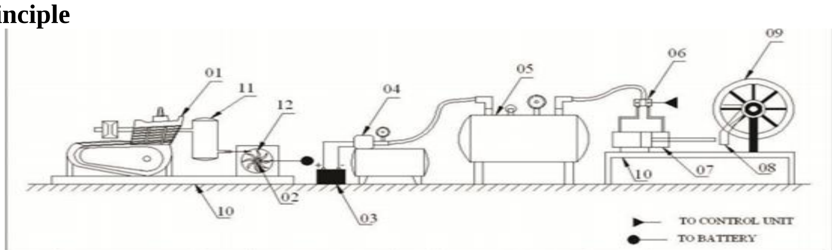


Fig.2.1. Working flow chart

During the operation of the engine, the exhaust gas is stored in the pressure tank. If the pressure of the tank exceeds certain limit then pressure relief valve will open. It is used to maintain the required pressure in the pressure tank. When the brake is applied, control circuit detects the signal and operates the solenoid valve. Exhaust gas stored in the pressure tank is used to actuate the pneumatic cylinder.

End of the actuator is connected to the brake lever. When pneumatic cylinder is actuated, brake lever is operated and applies the brake to the wheels. Brake pad is connected to the cam mechanism. Lever turns the cam, thus opening of brake show is obtained. Brake lever will come to the original position when it is not required. DCV is used to retract the pneumatic cylinder when not required.

3.1 Working Principle



S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME
01	ENGINE	04	12V COMPRESSOR	07	PNEUMATIC CYLINDER	10	BASE FRAME
02	DYNAMO	05	AIR TANK	08	BRAKING PLATE	11	SILENCER
03	BATTERY	06	SOLENOID VALVE	09	WHEEL	12	TURBINE

Diagram showing the methodology of the project

Air from exhaust gas is forced in to a turbine which acts as a dynamo, the turbine fan is made of light material which will rotate for even minimum force of air. The turbine thus produces millivolts of charge which is shown using a LED. A diode is connected to the circuit of the dynamo which is connected to a battery to have a one way flow of current. Thus charge stored in a battery is used to run a 12v dc compressor which actuates flow of air through solenoid valve. The solenoid valve acts as switch for braking mechanism. Hence braking facility is obtained by using pneumatic cylinder to a drum brake. Air brakes are very efficient as only solenoid valve has to be actuated for braking which requires only a small amount of force compared to any other braking systems.

3.2 Components and Functions

The generations of electricity using the flow or velocity of vehicle exhaust gas of the following components to full fill the requirements of complete operation of the machine.

1. Dynamo
2. Turbine
3. Battery
4. Engine

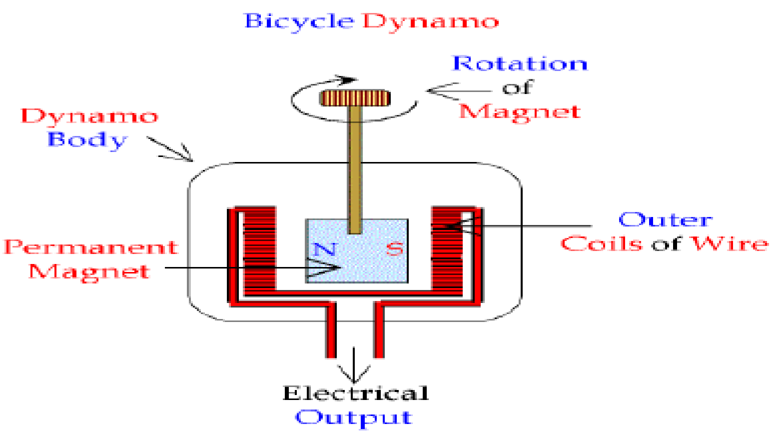
3.2.1 TURBINE

A steam turbine is a mechanical device that extracts thermal energy from pressurized steam, and converts itinto rotary motion. It has almost completely replaced the reciprocating piston steam engine primarily because of its greater thermal efficiency and higher power-to-weight ratio. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator. About 90% of all electricity generation in the United States is by use of steam turbines. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible process.

3.2.2 Dynamo

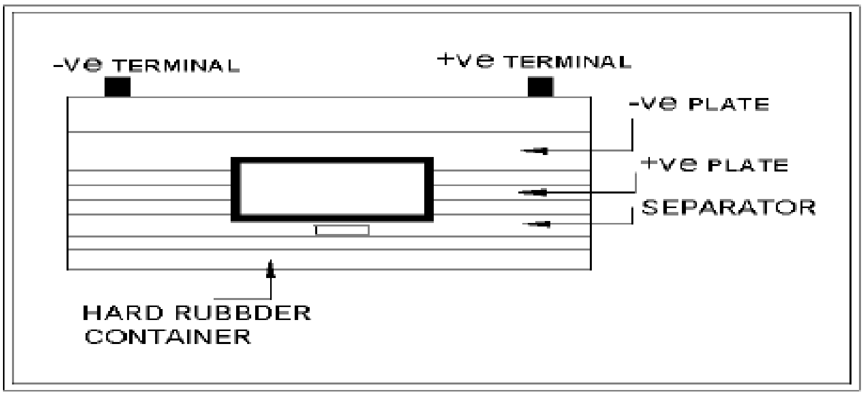
Dynamo is an electrical generator. This dynamo produces direct current with the use of a commutator. Dynamo was the first generator capable of generating power in the industries. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. On small machines the constant magnetic field may be provided by one or more permanent magnets, larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

The commutator was needed to produce direct current. When a loop of wire rotates in a magnetic field, the potential induced in it reverses with each half turn, generating an alternating current. However, in the early days of electric experimentation, alternating current generally had no known use. The few uses for electricity, such as electroplating, used direct current provided by messy liquid batteries. Dynamos were invented as a replacement for batteries. The commutator is a set of contacts mounted on the machine's shaft, which reverses the connection of the windings to the external circuit when the potential reverses, so instead of alternating current, a pulsing direct current is produced.



3.2.3 Battery

In our project we are using secondary type battery. It is rechargeable type. A battery is one or more electro chemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy.



3.2.4 Engine

An engine or motor is a machine designed to convert energy into useful mechanical motion. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which then creates motion. The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines.

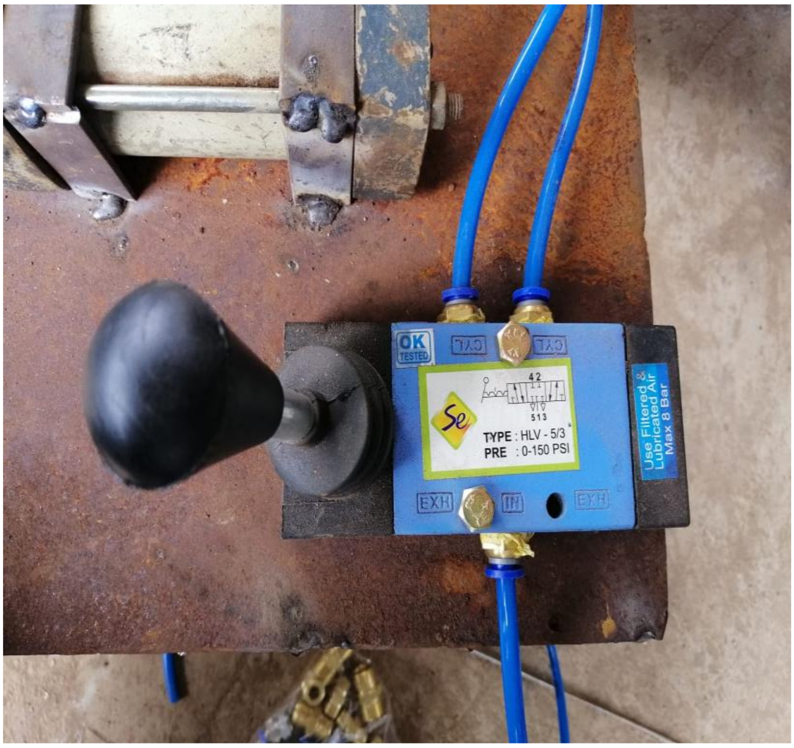
IV. Fabrication

Turbine Coupled With Dynamo

Air Tank

Pneumatic Cylinder

Air Compressor



Solenoid Valve

Final Model

V. Future Scope

As we could not afford the engine of heavy vehicle we have used a two wheeler engine. By implementing this project on heavy vehicles which have powerful engines we will be able to produce more power from the engine exhaust gases. Low cost dynamo, battery and the turbine had to be purchased due to the low budget. By using high voltage battery, high voltage producing dynamo and by using proper turbine we can considerably increase the power production required for the air braking system.

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