Design and Fabrication of Airbrake System using Engine Exhaust Gas

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Abstract: *The focus of this project is to review the latest development and technologies on waste heat recovery of exhaust gas from internal combustion engines. This is one of the efficient braking systems using the vehicle's exhaust gas. The exhaust gases are filtered and the pure form of gas is stored in an air tank which in turn can be used for actuating the pneumatic cylinder which results in applying the brakes. With the development of highways, logistics and the pace of life, weight and velocity of vehicles has become more and larger, which has reduced the safety of driving. The braking load of vehicles increases quickly so that the primary brake system is easily overloaded and can be damaged by overheating. The main advantage of this project is that separate air tank for the pneumatic brakes are not needed. The air exhausted from the engine is stored in a tank and later is used up for applying the brakes.*

1. Introduction

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. With the development of highways, logistics and the pace of life, weight and velocity of vehicles has become more and larger, which has reduced the safety of driving [1]. The braking load of vehicles increases quickly so that the primary brake system is easily overloaded and can be damaged by overheating. Vehicles operating in the hills, mountains will use the brakes frequently and leads to reduction in the average fuel economy and performance [3]. Petrol engine is chosen because it produces less impurity in exhaust than diesel engines. Hence an alternative braking system are necessary for the safety of the driver [2]. This project proposes a braking system which actually works on the engine exhaust gases. Braking system is necessary in an automobile for stopping the vehicle. Brakes are applied on the wheels to stop or to slow down the vehicle.

2. Components used

Battery, Pneumatic cylinder, Frame, Engine, Sprocket and chain drive, Solenoid valve, Push button, Wheel arrangement, Air tank.

2.1. Battery

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. We use lead acid battery for storing the electrical energy from the solar panel as shown in figure 1.

Figure 1- Battery

2.2. Pneumatic Cylinder

Mechanization is broadly defined as the replacement of manual effort by mechanical power. Pneumatics is an attractive medium for low cost mechanization particularly for sequential or repetitive operations. Many factories and plants already have a compressed air system, which is capable of providing both the power or energy requirements and the control system (although equally pneumatic control systems may be economic and can be advantageously applied to other forms of power). The main advantages of an all-pneumatic system are usually economy and simplicity, the latter reducing maintenance to a low level. It can also have outstanding advantages in terms of safety.

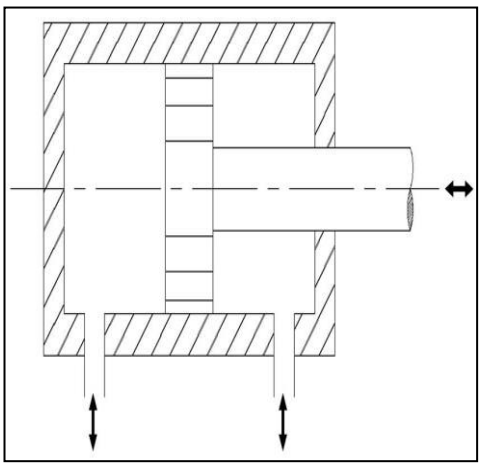

Figure-2 Double acting pneumatic cylinder

Figure 2 shows Double acting Pneumatic Cylinder. It means that the air pressure operates alternatively (forward and backward). The air from the compressor is passed through the regulator which controls the pressure to required amount by adjusting its knob. A pressure gauge is attached to the regulator for showing the line pressure. Then the compressed air is passed through the directional control valve for supplying the air alternatively to either sides of the cylinder. Two hoses take the output of the directional control valve and they are attached to two ends of the cylinder by means of connectors. One of the outputs from the directional control valve is taken to the flow control valve from taken to the cylinder. An air cylinder is an operative device in which the state input energy of compressed air i.e. pneumatic power is converted in to mechanical output power, by reducing the pressure of the air to that of the atmosphere. A double acting cylinder is employed in control systems with the full pneumatic cushioning and it is essential when the cylinder itself is required to retard heavy messes. This can only be done at the end positions of the piston stock. In all intermediate position a separate externally mounted cushioning derive most be provided with the damping feature. The normal escape of air is out off by a cushioning piston before the end of the stock is required. As a result the sit in the cushioning chamber is again compressed since it cannot escape but slowly according to the setting made on reverses. The air freely enters the cylinder and the piston stokes in the other direction at full force and velocity.

Figure-3- Pneumatic Cylinder

2.3. Frame

This is made of mild steel material. The whole parts are mounted on this frame structure with the suitable arrangement. Boring of bearing sizes and open bores done in one setting so as to align the bearings properly while assembling. Provisions are made to cover the bearings with grease.

2.4. Engine

An engine or motor is a machine designed to convert one form of energy into mechanical energy. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which then creates a force. Electric motors convert electrical energy into mechanical motion, pneumatic motors use compressed air and others—such as clockwork motors in wind-up toys—use elastic energy. In biological systems, molecular motors, like myosins in muscles, use chemical energy to create forces and eventually motion [4]. A four-stroke cycle engine is an internal combustion engine that utilizes four distinct piston strokes (intake, compression, power, and exhaust) to complete one operating cycle. The piston make two complete passes in the cylinder to complete one operating cycle. An operating cycle requires two revolutions (720°) of the crankshaft. The four-stroke cycle engine is the most common type of small engine.

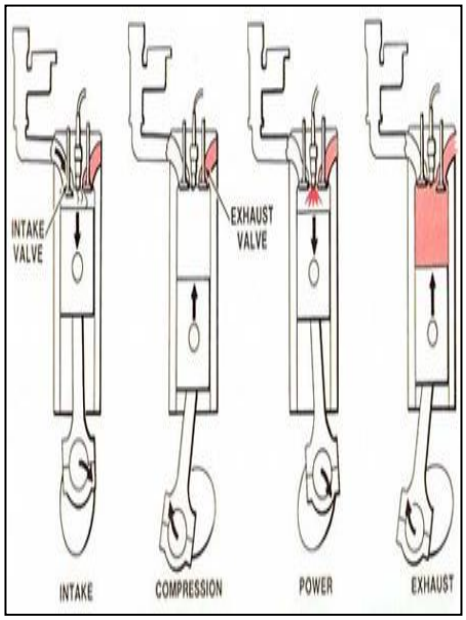

Figure-4- Engine

Figure 4 Shows the four strokes of Engine which are intake, compression, power and exhaust.

2.4.1 Intake Stroke

The intake event is when the air-fuel mixture is introduced to fill the combustion chamber. The intake event occurs when the piston moves from TDC to BDC and the intake valve is open. The movement of the piston toward BDC creates a low pressure in the cylinder. Ambient atmospheric pressure forces the air-fuel mixture through the open intake valve into the cylinder to fill the low pressure area created by the piston movement. The cylinder continues to fill slightly past BDC as the air-fuel mixture continues to flow by its own

inertia while the piston begins to change direction. The intake valve remains open a few degrees of crankshaft rotation after BDC. Depending on engine design, the intake valve then closes and the air-fuel mixture is sealed inside the cylinder.

2.4.2 Compression Stroke

The compression stroke is when the trapped air-fuel mixture is compressed inside the cylinder. The combustion chamber is sealed to form the charge [7]. The charge is the volume of compressed air-fuel mixture trapped inside the combustion chamber ready for ignition. Compressing the air-fuel mixture allows more energy to be released when the charge is ignited. Intake and exhaust valves must be closed to ensure that the cylinder is sealed to provide compression. *Compression* is the process of reducing or squeezing a charge from a large volume to a smaller volume in the combustion chamber. The flywheel helps to maintain the momentum necessary to compress the charge.

2.4.3 Power Stroke

The power stroke is an engine operation Stroke in which hot expanding gases forces the piston head away from the cylinder head. Piston force and subsequent motion are transferred through the connecting rod to apply torque to the crankshaft. The torque applied initiates crankshaft rotation. The amount of torque produced is determined by the pressure on the piston, the size of the piston, and the throw of the engine. During the power Stroke, both valves are closed.

2.4.4 Exhaust Stroke

The exhaust stroke occurs when spent gases are expelled from the combustion chamber and released to the atmosphere. The exhaust stroke is the final stroke and occurs when the exhaust valve is open and the intake valve is closed. Piston movement evacuates exhaust gases to the atmosphere.

As the piston reaches BDC during the power stroke combustion is complete and the cylinder is filled with exhaust gases [7]. The exhaust valve opens, and inertia of the flywheel and other moving parts push the piston back to TDC, forcing the exhaust gases out through the open exhaust valve. At the end of the exhaust stroke, the piston is at TDC and one operating cycle has been completed.

2.5. SPROCKET AND CHAIN DRIVE

The chain sprocket is coupled with another generator shaft. The chain converts rotational power to pulling power, or pulling power to rotational power, by engaging with the sprocket. The sprocket looks like a gear but differs in three important ways: Sprockets have many engaging teeth; gears usually have only one or two, The teeth of a gear touch and slip against each other; there is basically no slippage in a sprocket, The shape of the teeth is different in gears and sprockets as shown in figure 5

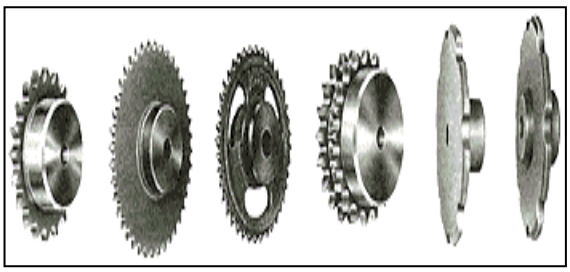

Figure-5-Sprocket

2.6. SOLENOID VALVE

A solenoid valve is used to actuate the pneumatic cylinder at required time interval. Solenoid valve is operated by means of electrical signal. The directional valve is one of the important parts of a pneumatic system. Commonly known as DCV, this valve is used to control the direction of air flow in the pneumatic system [1]. The directional valve does this by changing the position of its internal movable parts. This valve was selected for speedy operation and to reduce the manual effort and also for the modification of the machine into automatic machine by means of using a solenoid valve. A solenoid is an electrical device that converts electrical energy into straight line motion and force. These are also used to operate a mechanical operation which in turn operates the valve mechanism. Solenoids may be push type or pull type. The push type solenoid is one in which the plunger is pushed when the solenoid is energized electrically. The pull type solenoid is one in which the plunger is pulled when the solenoid is energized. The name of the parts of the solenoid should be learned so that they can be recognized when called upon to make repairs, to do service work or to install them.

Figure-6-Solenoid Valve

The solenoid valve has 5 openings. This ensure easy exhausting of 5/2 valve. The spool of the 5/2 valve slide inside the main bore according to spool position; the ports get connected and disconnected.

Figure 7 shows 5/2 Solenoid Valve.

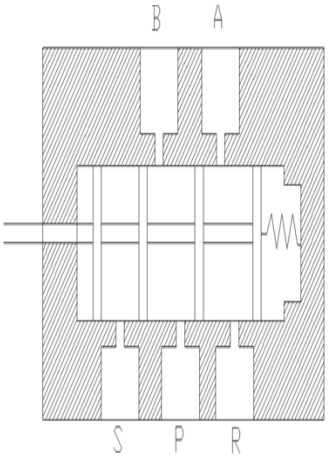

Figure-7- 5/2 Solenoid Valve

Position-1

When the spool is actuated towards outer direction port 'P' gets connected to 'B' and 'S' remains closed while 'A' gets connected to 'R'.

Position-2

When the spool is pushed in the inner direction port 'P' and 'A' gets connected to each other and 'B' to 'S' while port 'R' remains closed.

2.7. PUSH BUTTON

A push-button or simply button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. Buttons are most often biased switches, though even many un-biased buttons (due to their physical nature) require a spring to return to their un-pushed state. Different people use different terms for the "pushing" of the button, such as press, depress, mash, hit, and punch. The "push-button" has been utilized in calculators, push-button telephones, kitchen appliances, and various other mechanical and electronic devices, home and commercial. In industrial and commercial applications, push buttons can be connected together by a mechanical linkage so that the act of pushing one button causes the other button to be released. In this way, a stop button can "force" a start button to be released. This method of linkage is used in simple manual operations in which the machine or process have no electrical circuits for control. Pushbuttons are often color-coded to associate them with their function so that the operator will not push the wrong button in error. Commonly used colors are red for stopping the machine or process and green for starting the machine or process.

Figure-8- Push button

2.8. WHEEL ARRANGEMENT

The simple wheel arrangement is fixed to the frame stand. Near the wheels, the hydraulic jack is fixed. This wheel arrangement setup is for showing the successful working of our project. But the real implementation can be done in the automobile and the lifting can be applied to all the four wheels independently. Figure 9 shows wheels.

Figure-9- Wheels

2.9. Air Tank

The air tank is the tank used to store the high pressure air. Whenever the brake pedal is pressed, the high pressure air stored in air tank passes through the pneumatic cylinder, which results in the application of brake [6]. A properly sized air storage tank reduces frequent cycling and venting. Figure 10 shows air tank.

Figure-10-Air Tank

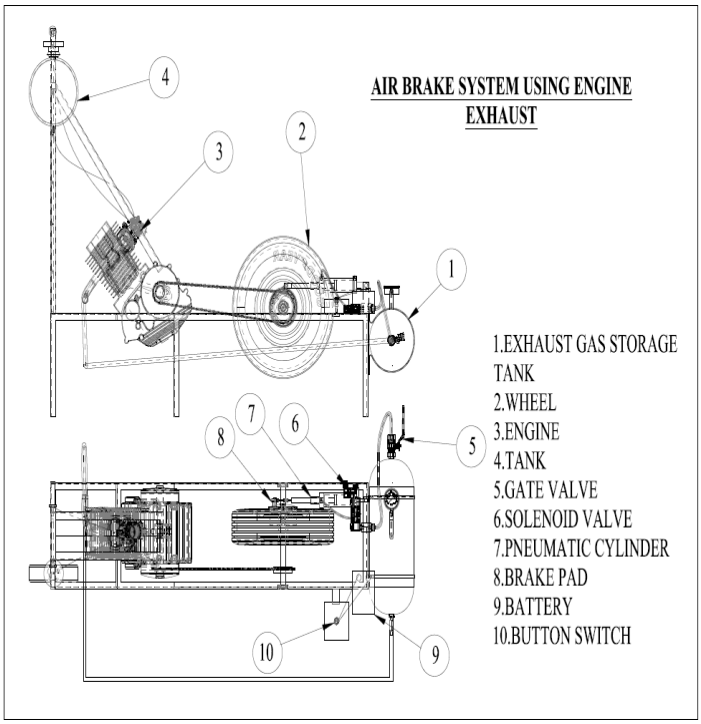

Figure- 10- 2D Drawing

3. Working Principle

The experimental setup of our project consists of an engine setup with a wheel arrangement. The engine and the wheel are connected with the sprocket and the chain drive. The wheel arrangement is provided for showing effectively the working of the braking system. An air tank is mounted on the frame in which the exhaust gas from the engine is stored [9]. 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 [5]. 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 [4]. The air from the air tank passes to the solenoid valve from which it reaches the pneumatic cylinder which in turn is connected with the brakes by using the cable arrangement. While the vehicle is running, the exhaust gases are stored in an air tank instead of letting it out [3]. Then the air from the air tank passes to the solenoid valve. While applying the brakes, the solenoid valve is opened and the air is allowed to pass to the pneumatic cylinder [5]. The air entering the pneumatic cylinder pushes the piston of the cylinder forward thereby applying the brakes. Brake lever will come to the original position when it is not required. DCV is used to retract the pneumatic cylinder when not required [1]. 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.

4. Applications

This pneumatic brake is mainly used in large vehicles such as trucks, buses, trailers and semi trailers.

5. CONCLUSION

The project **"DESIGN AND FABRICATION OF AIR BRAKE SYSTEM USING ENGINE EXHAUST GAS"** is successfully done. A lot of practical knowledge is gained while doing this project work. The work is completed with the limited time successfully. This project work has provided us an excellent opportunity and experience, to use our limited knowledge. It is understood that **"AIR BRAKE SYSTEM USING ENGINE EXHAUST GAS"** helps to achieve more efficient method of braking system using the exhaust gas of the engine with the minimal initial cost. By using more techniques, they can be modified and developed according to the applications.

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