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DESIGN OF REGENERATIVE PNEUMATIC BRAKES

Steven Rodrigues[1]

[1] *Mechanical Engineer, St. John College of Engineering and Management, Mumbai*
Author Correspondence: Email address: stevenrodrigues64@gmail.com

Abstract

Looking at current requirement of fuel for transportation it can be estimated that the world will soon face energy crises. The rate at which vehicles are consuming fuel indicates that the fuel reserves will be almost empty by the year 2050. The fuel consumed by the vehicles is not completely utilized. Lot of energy is dissipated in the environment in the form of heat. Technologies have been developed to avoided such losses and recover some part of the otherwise wasted energy. Regenerative braking system is one such technology used in automobiles to recover the energy that is wasted to slow down or stop the vehicle. The vehicles that are incorporated with regenerative brakes more often have an alternator to convert kinetic energy of the moving vehicle into electrical energy but there are other ways available to regenerate the energy. In this paper the regenerative braking system restores the kinetic energy of the vehicle into pressurized air.

Keywords*:* regenerative brakes, hybrid vehicle

1. Introduction

Regenerative braking is used in automobiles to recover some of the energy that is lost while the vehicle is slowing or stopping. The vehicle which uses this technology are hybrid vehicles that use both gas and some other energy, regenerated in the form of air pressure in this case, as sources of power. In vehicles with regular conventional brakes, friction is used to counteract the forward momentum of a moving vehicle. As the brake pads rub against the drum on wheels or a disc that is connected to the axles, heat energy is created. As much as 30 percent of the vehicle's generated power is wasted in dissipation of this heat in the air. Over time, this wasted heat energy reduces the vehicle's fuel efficiency. The energy that was lost by braking is replaced by the new energy generated by the engine. In this paper a combined system of piston and cylinder is used as a regenerative brakes to pressurize the air in this concept the energy that is recovered is stored in the form of air pressure in an air tank which can be later used to power the vehicle. Use of a pneumatic system for regenerative braking eliminates the requirement of an alternator, storage battery and series of large capacitors thereby reducing the overall weight of regenerative braking system. The advantage of this system over alternator is that every wheel can have its own individual regenerative brake that works more efficiently. Regenerative brake is always backed up by conventional friction brakes in case of any possible failure that may occur at higher speed. An electric regenerative braking system consists of an alternator and battery which are

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quiet large and can't be used in all the vehicles, whereas a pneumatic regenerative braking system can be easily used in a two wheeler as well as heavy vehicles

2.1 Principle concept

Whenever the driver is willing to stop or slow down the vehicle, it is ultimate requirement that the possessed kinetic energy of vehicle due to its motion is reduced. Application of regenerative brakes in a moving vehicle converts kinetic energy into pressure energy slowing the vehicle. This air pressure is used to reciprocate the piston in brake cylinder. Conventional braking dissipates almost 30% of energy generated by engine. Regenerative braking doesn't recover all the energy but a part of it. As we know a vehicle utilizes about 35% of the actual energy from the fuel burned by the engine. Adding regenerated power the total performance of the vehicle improves as 50% of the energy wasted in braking is restored.

2.2 Components

2.2.1 Piston

Piston is the most vital moving part of the brake. It reciprocates in the cylinder to either compress the air or run the vehicle similar to an internal combustion engine.

2.2.2 Cylinder

Cylinder makes the major part of the chamber where air is compressed and expanded whenever required. Its guides the to and fro motion of piston

2.2.3 Connecting rod

This rod connects the piston and brake shaft delivering motion from piston to the wheel via drive shaft and vice versa.

2.2.4 Shaft

The shaft is directly coupled to the main axle.

2.2.5 Non return valves

These valves timely open and close to let the pressurized air flow in only one predetermined direction. This direction is determined by the function that is braking or powering.

2.2.6 Tubes

Tubes carry the air from brake cylinder to air tank and vice versa.

2.2.7 Air tank

It stores the pressurized air and delivers when required.

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2.2.8 Intercooler

An intercooler increases the volumetric efficiency of allowing the tank to store more volume of air by reducing its temperature.

2.2.9 Pressure gauge

Pressure gauge is connected to the air tank to monitor the pressure in it

2.2.10 Relief valve

This valve opens when the pressure in tank exceeds safe and allowable pressure limit.

3.1 Layout of the system

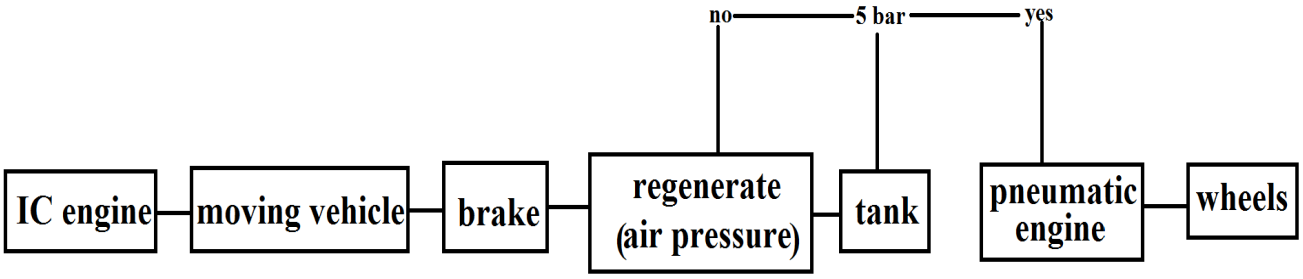

Fig. 1: Layout of pneumatic system

3.2 Design of system

Cylinder dimensions may vary according to the weight and average speed of the vehicle. For brake to be more effective the piston cylinder is double acting and applies brakes as much as twice the single acting. The valves are flexible non return type which can change the flow direction according to the requirement. The air tank is designed to withstand the pressure of about 5 MPa. Most of the IC engines have 3 to 5 MPa as mean effective pressure thus, 5 MPa is enough to stop a car or even run it at a descent speed.

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3.3 Assembly and implementation

The shaft is coupled to the main axle of the vehicle. The cylinder is connected to the chassis of the vehicle. As brake pedal is pressed the shaft gets engaged with the axle and pushes the piston via connecting rod. The piston moves to and fro which compresses the air and delivers to the air tank through the intercooler. When the air pressure is reached up to 5 MPa the vehicle can be switched from IC engine to Air brake piston cylinder system which can be used as an engine as well as a braking system just by adjustment in valve timing and nature. Complete assembly is shown below in

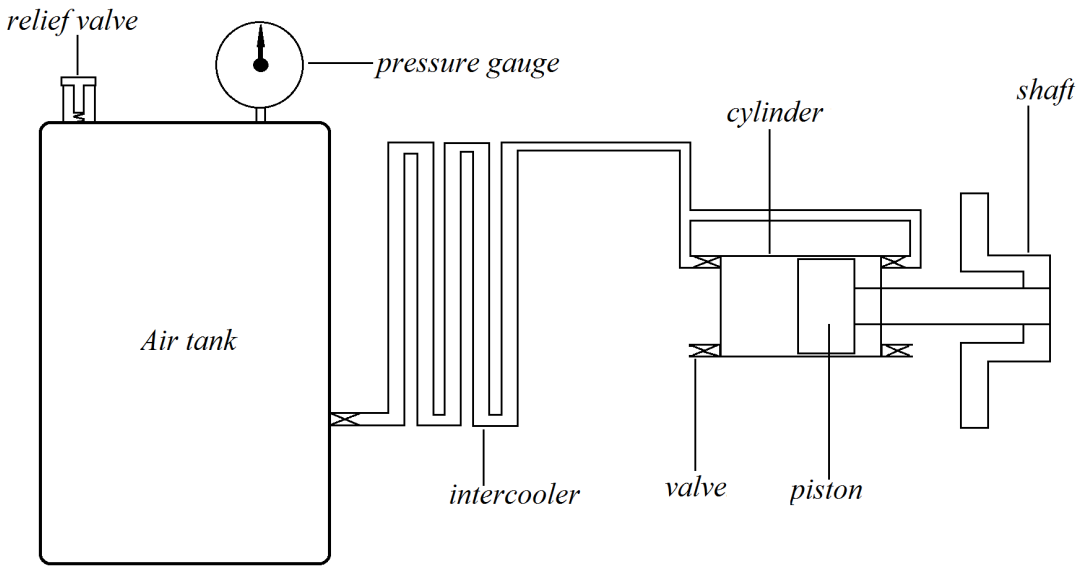

fig. 2 (assembly of system)

Fig.2: Assembly of regenerative braking system

3.4 Mechanism

A microcontroller is programmed in such a way that when the brakes are applied the brake shaft gets engaged with the axle which is normally disengaged with the help of a clutch. This clutch is controlled with solenoid switches. To switch from brake to air engine the valves Ade needed to be reversed using solenoid or servomotor.

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4.1 Merits

1. Light in weight as compared to battery and alternator system
2. System is inexpensive.
3. It is very compact as to electronic system
4. Can be installed in almost all the vehicles

4.2 Demerits

1. As air pressure is high, the system needs to regularly checked for any leakages
2. Regular lubrication is required
3. The regenerated power isn't usable at low air pressure.

5. Conclusion

The overall efficiency of the vehicle is increased. Pneumatic regenerative braking system is better than electric regenerative braking system in terms of compactness. This system can be installed in all the wheels of a vehicles giving better control to the driver. Pneumatic system is inexpensive and light weight as compared to a batter and alternator system and hence can be more widely and commonly used in almost any type of vehicles including bicycles. The recovered energy is clean and with no hazard or threat to the environment making the overall drive low polluting.

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