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Classification and Characteristics of Vehicle Retarder

Yunfei Liao

Department of Automation, Chongqing Industry Polytechnic College, Chongqing, China

Abstract

This essay briefly discusses the vehicle retarder, followed by the discussion of advantages and disadvantages of the engine retarder, hydraulic retarder, and eddy current retarder, which is based on engine braking theory. It expounds such aspects as mechanical structure, retardation principal, operation method, thermal performance, etc., and concludes the scope of application of different retarders, as well as their advantages and disadvantages.

Keywords

Vehicle retarder; Auxiliary brake; Mechanical structure; Thermal properties.

1. INTRODUCTION

As an important auxiliary braking device, vehicle retarder has been paid more and more attention in the field of safe driving in recent years [1]. There are mainly the following two braking conditions during the driving process of the vehicle, namely dynamic brake and steady brake [2, 3]. Among them, dynamic brake refers to the ability of the complete vehicle braking system to reduce the vehicle speed or its acceleration; steady brake is the ability of the complete vehicle braking system to eventually stop the vehicle. Grochowicz have pointed out in the service life analysis of brake pad that its wear degree under the dynamic braking condition is much higher than that under the steady braking condition [4]. This is because the continuous sliding and friction of the brake pad over a long period of time causes its temperature to rise greatly, and then causes problems such as cracking and thermal decay, resulting in irreversible damage to the brake lining of the service brake, and ultimately greatly reduces its braking capacity, creates a safety hazard and is even more detrimental to the transport of dangerous goods. At present, the service brake in the commercial vehicle braking system has been developed from drum brake to disc brake, and its braking performance has been obviously improved, but it is still not enough to meet the increasing demand of braking force when the vehicle is running [5]. In particular, there has been no safe and effective solution to the problem of continuous consumption of friction plate in the power brake process.

Today, more attention is paid to the running safety, and the whole vehicle factory considers the braking safety of the commercial vehicle more deeply than before; on one hand, the braking performance of the running brake is constantly improved, on the other hand, a variety of auxiliary braking devices are provided to reduce the service time and frequency of the service brake [6]. Except the relatively mature engine auxiliary braking device, the retarder auxiliary braking device also starts to be used in a large number of vehicles, further improving the performance of the vehicle auxiliary braking system, make it possible to use an auxiliary braking system to respond to the braking requirements under dynamic brake conditions. Under this working conditions, the service brake only acts as a secondary output source and does not require intervention at all. The introduction of the whole vehicle auxiliary braking system can greatly reduce the use time and frequency of the friction plate under the power braking condition, ensure the best braking efficiency when it takes effect, effectively extend the service

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life of the service braking, and a sufficient braking force is reserved for steady brake operation to ensure the safety running of the vehicle.

2. DEVELOPMENT OF ELECTROMAGNETIC EDDY CURRENT RETARDER

In 1855, Mr. Leon Foucault, a French physicist, discovered the eddy current phenomenon. In 1903, Mr. STECKEL, a French engineer, declared the world's first patent for an eddy current retarder [7]. Since the 1930s, some European manufacturers have paid more and more attentions to the necessity of using retarder for commercial vehicles in mountainous areas and accident-prone areas [8]. But until 1936, JOURDAIN MONNERET, a French company, produced the world's first eddy current retarder according to another patent of Raoul SARAZIN, who is a French engineer [9].

For commercial vehicles, with the increase of engine power, the decrease of engine speed, the acceleration of vehicle speed and the improvement of vehicle quality, the safety problem of vehicle running becomes very serious. The main braking mode of vehicle is still friction braking, although the improvement of friction performance of the brake shoe and the hub improves the shortening of the one-time braking distance, in the case of long-time or distance downhill and frequent braking, its braking durability is not significantly improved [10]. The adoption of many advanced electronic technologies such as anti-lock brake system (ABS), electronic brake system (EBS) and acceleration slip regulation (ASR) greatly improves the reliability of the friction brake system within the effective capability range thereof, but it contributes nothing to solving such problems as too high temperature of the brake and the brake wearing [11].

According to the different working principles of the retarder, the retarder can be divided into engine retarder, hydraulic retarder, electric turbine retarder, motor retarder, aerodynamic retarder, etc.

3. ENGINE RETARDER

3.1. Engine Exhaust Brake

The principle of engine exhaust braking is that an exhaust throttle valve is installed between the exhaust manifold and the muffler, and the engine is changed into an air compressor driven by the automobile during the exhaust stroke by the exhaust throttle valve. Due to the increased exhaust back pressure, the negative work done during the exhaust stroke can be increased. When the difference between the forces acting on both sides of the exhaust valve, under the exhaust back pressure and the cylinder pressure, exceeds the spring pressure of exhaust valve, the exhaust valve will float (open) without being controlled by the camshaft, the compressed air escapes from the intake valve during the valve overlap time, thereby reducing the work done by expansion during the intake stroke, the operating principle of which is shown in Figure 1[12].

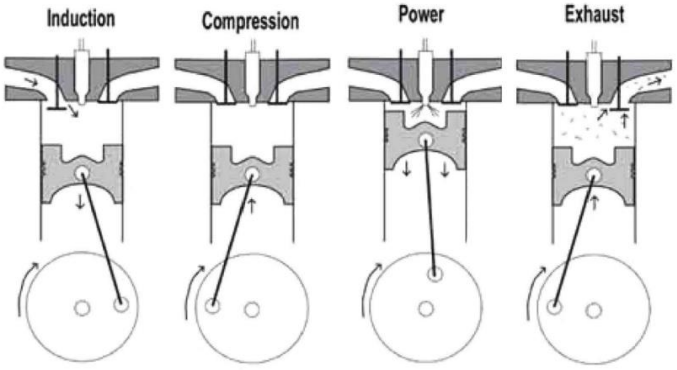

Figure 1. Principle of engine exhaust braking

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Exhaust throttle valve is mostly butterfly valve, and it adopts to such working modes as mechanical control, pneumatic control, and electronically controlled pneumatic control. The most common working mode is electromagnetic pneumatic control. Shut off the fuel supply to the engine when closing the valve. In order to minimize wear of the wheel brake, exhaust brake actuation has a tendency to interact with the brake pedal and the accelerator pedal. When the brake pedal is depressed or the accelerator pedal is released, the exhaust brake is automatically activated.

The effectiveness of exhaust braking is proportional to the braking pressure generated by the engine (depending on the exhaust manifold pressure before the exhaust valve is opened, the degree of valve overlap, and the amount of exhaust system leakage, etc.), the displacement, and the rotational speed. Generally, the power of exhaust brake is about 70% ~ 100% of the rated power of the engine, which is 50% ~ 100% higher than that of pure engine braking, which is roughly equivalent to the effect of lowering a gear (transmission) in the later case. The vehicle deceleration is about 0.3 ~ 0.7m / (lower limit for high gear and upper limit for low gear). The exhaust brake can not only guarantee the running safety, but also increase the average speed, reduce the wear of wheel brakes and tires, and help maintain the normal operating temperature of the engine and improve the service life of the engine.

3.2. Compression Braking of the Engine

The engine compression braking is an air compressor, also referred to as Jacobs engine braking, which causes the diesel engine to absorb power in the compression stroke, and the operation principle thereof is shown in Figure 2[13].

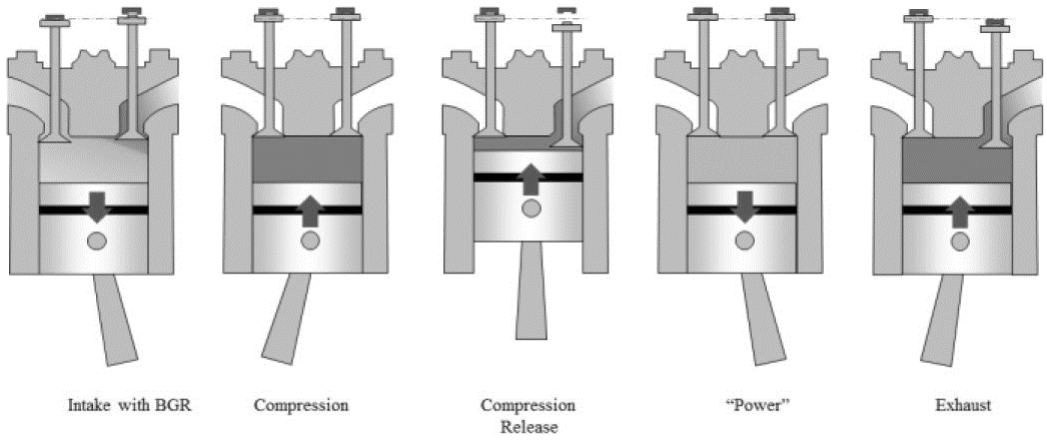

Figure 2. Typical engine cycle during compression release braking

When the compression stroke of the diesel engine is near the top dead center, the control device opens the exhaust valve so that the compressed air is discharged through the exhaust manifold, and the compressed energy is no longer returned to the engine. When braking is required, turn on the solenoid valve, and the oil pump will suck the oil from the oil pan into the control valve, and enter the slave piston and the driving piston through the oil passage, so that the piston will descend and push against the fuel injector pushrod. When the third cam controlling the fuel injection on the camshaft forces the piston up through the pushrod, the check valve closes and the pressure in the oil passage rises, pushing the piston down to open the exhaust valve.

The effectiveness of engine compression braking is related to engine displacement and intake air volume. Normally, the braking power of the non-supercharged diesel engine is 75% of the rated power, while the supercharged diesel engine can be increased to 90%. It is not only

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suitable for automobiles used in mountainous or hilly areas, but also for urban passenger cars used in plain areas from the viewpoint of increasing the service life of friction plates.

4. HYDRAULIC RETARDER

By employing the hydraulic devices, the running speed of the vehicle could be reduced by the hydraulic retarder; generally, it's composed of the retarder body, control device, electronic control unit, etc.; in the retarder body, a rotor and a stator together consist a work chamber. When the hydraulic retarder is running, the electronic control system shall control the proportional valve to apply air pressure to the working fluid, thus the working fluid flows into the working chamber, the structure of which is shown in Figure 3[14]. The working principle of the hydraulic retarder is shown in [15].

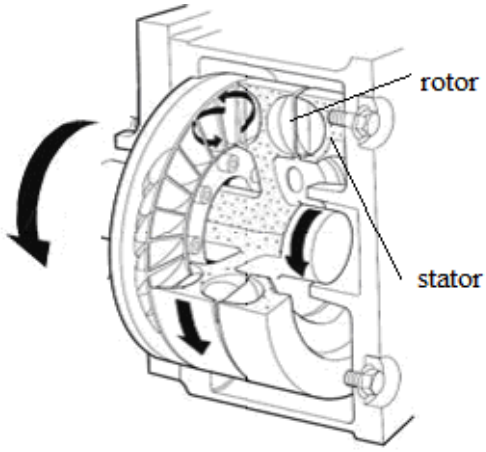

Figure 3. Prototype of hydraulic retarder

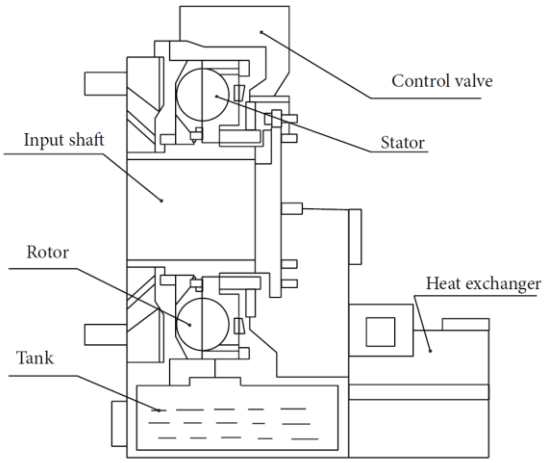

Figure 4. Schematic diagram of hydraulic retarder structure

The stator is integrated with the retarder housing, connected with the rear end of the transmission or the frame, the rotor is connected with the transmission shaft through the hollow shaft, and the blades are cast on the rotor and stator. When the hydraulic retarder is working, a certain pressure is applied to the sump by operation of the control valve to fill the working chamber between the rotor and the stator. When the rotor rotates, a torque is applied to the stator by the working fluid, and the counter torque of the stator becomes the braking torque of the rotor, the value of which depends on the amount of fluid in the working chamber and the pressure (depending on the gear of braking strength set by the control valve) and the rotational speed of the rotor. The kinetic energy of the automobile is consumed by the friction of the working fluid and the impact on the stator, which shall be converted into thermal energy, so that the temperature of the working fluid is increased. The operation is also introduced into the heat exchange circulating flow, transferring heat to the cooling water, which is then dissipated through the engine cooling system. For the automobile using hydraulic transmission, the oil pool, oil pump, heat exchanger (which needs to be enlarged in size) and the working fluid using hydraulic transmission can be omitted, so the hydraulic retarder is mostly used in the hydraulic transmission automobile.

Advantages of the hydraulic retarder: its retardance efficiency is higher than the engine retarder and can run downhill at a relatively high speed; small size and light-weight, can be integrated with the transmission; no wearing during operation; the heat generated by the working fluid can be easily sent out and removed, and the normal operating temperature of the engine can be maintained on a long downhill slope; at low speed, the braking torque tends to zero, and the wheel will not slip when braking on the sliding path. Disadvantage of the hydraulic

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retarder: the engagement and disengagement lag time is long, there is power loss when not working, and the structure is complicated when used for mechanical transmission vehicles, especially for trailers.

5. EDDY CURRENT RETARDER

An eddy current retarder is a device for obtaining a retardation by using an eddy current generated by a rotating metal disk under the action of a magnetic field, as shown in Figure 5[16] and Figure 6[17].

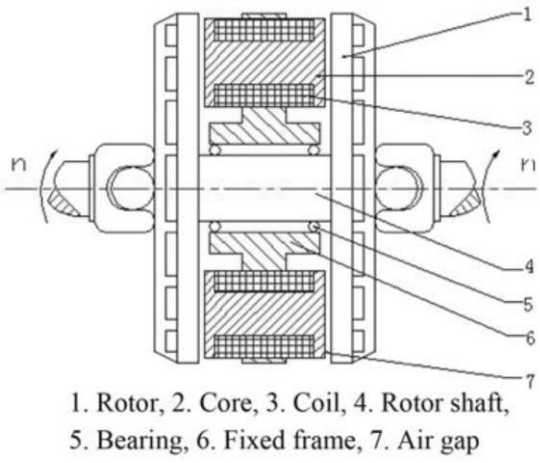

Figure 5. Structure of eddy current retarder

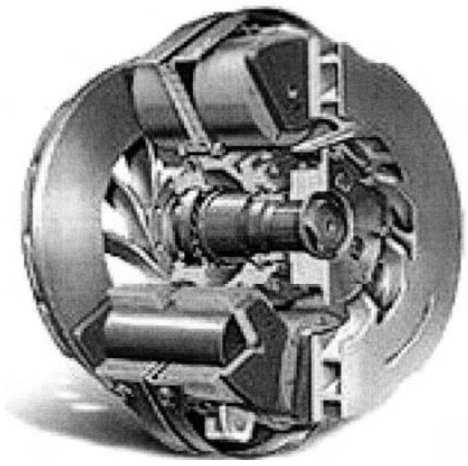

Figure 6. Prototype of eddy current retarder

The front and rear rotors of the eddy current retarder are connected to the input flange of the main reducer through a transition plate, the stator housing is fixed to the main reducer housing through a bracket, and the stator is equipped with an excitation coil. During operation, a magnetic field is generated by passing an electric current through an automobile battery, and an eddy current is induced in that rotor, and the eddy current magnetic field generates a braking torque to the rotor, and the value is related to the magnitude of an excitation current (controlled by a selector) and the rotor speed. The cooling duct is cast in the rotor interlayer, so that the heat generated by the eddy current is dissipated through the forced convection flow.

Eddy current retarder is a new type of non-contact speed reducer, which has high braking efficiency, in addition to stable vehicle speed, it can reduce the temperature of wheel brake, improve the service life of friction plate, and improve the safety and smoothness of automobile. The disadvantage is the large size, heavy body, power consumption and the surrounding environment temperature impact, currently, it's only suitable for large commercial vehicles. In comparison with the conventional brake, the braking performance of the automobile is greatly improved.

6. CONCLUSION

For common automobile retarder, there are such three types as the engine retarder, hydraulic type and eddy current type, which respectively has its own advantages and disadvantages.

As the structure of engine exhaust braking is simple, the quality is small, the price is low, the use is convenient, so it has been widely used in the medium and heavy diesel vehicle, and has the tendency to expand to the light diesel vehicle. For gasoline vehicle, because the engine compression ratio is small, the braking efficiency is poor, the structure is complex, the valve is easy to jam and so on, the application is not much.

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Advantages of the hydraulic retarder: its retardance efficiency is higher than the engine retarder and can run downhill at a relatively high speed; small size and light-weight, can be integrated with the transmission; no wearing during operation; the heat generated by the working fluid can be easily sent out and removed, and the normal operating temperature of the engine can be maintained on a long downhill slope; at low speed, the braking torque tends to zero, and the wheel will not slip when braking on the sliding path. Disadvantage of the hydraulic retarder: the engagement and disengagement lag time is long, there is power loss when not working, and the structure is complicated when used for mechanical transmission vehicles, especially for trailers.

The eddy current retarder is driven directly by current without intermediate link, and its control response time is very short, only tens of milliseconds, which is much faster than the response time of hydraulic brake system. There is no contact between the stator and rotor, and there is no wearing, so the failure rate is very low and the maintenance is simple; when any trouble occurs to the eddy current retarder, the retarder can be turned off, and the vehicle can still continue to operate without affecting its normal use. The main disadvantages of eddy current retarder are its large size, heavy body, power consumption and greatly affected by the environmental temperature. At present, it is only suitable for large commercial vehicles.

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