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Transmission and Transaxle Torque Braking

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Abstract—*Through analyzing the operating principles of the hydraulic retarder of automatic transmission, it is indicated the necessity of hydraulic retarder in heavy vehicles. From testing the operating procedures and retarding ability of the hydraulic retarder, it is verified that the hydraulic retarder could extend the life of brake and enhance the driving safety.*

Keywords: *Hydraulic; Transmission, Torque Brake*

1. INTRODUCTION

The safety of automobiles is important all the time, especially nowadays when the road transportation flourishes. Due to the demand for the higher operating efficiency, it is inevitable of the increased load and speed. The braking capability of automobile brakes is limited of many factors, so the life of automobile brakes and the driving safety could be reduced during the conditions such as steep downhill braking and high speed braking etc. However, the hydraulic retarder can absorb up to 90% of braking energy and guarantee comparatively high-speed driving, so that automobile brake is auxiliary functioned to increase the operating efficiency, improve driving safety and reduce maintenance cost.

Purpose of the proposed project:

The current dual full s-cam air brake system has the disadvantages of braking at the condition of high payload, and continuous braking, which results in increased braking distance, shorter brake liner work duration.

2. OPERATING PRINCIPLES

Hydraulic retarder is composed of stator, rotor, enclosure and controlled valve (see Fig.1). Stator is connected and synchronously spinning with the output shaft of transmission through splines. Stator, rotor and enclosure have integral blades so that the rotor could spin in the stationary stator and enclosure. After the enclosure is filled with hydraulic oil, The oil starts to work and the compressed hydraulic oil blocks and reduces the speed of rotor, output shaft and automobile. The hydraulic oil of the retarder camber is firstly filled with an external oil tank. When the retarder is out of operation, the hydraulic oil is discharged into the oil tank from the retarder.

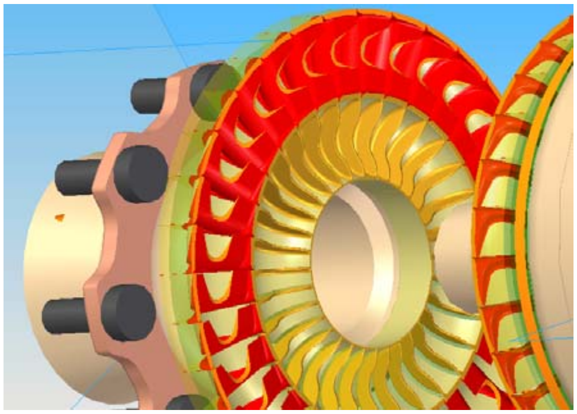
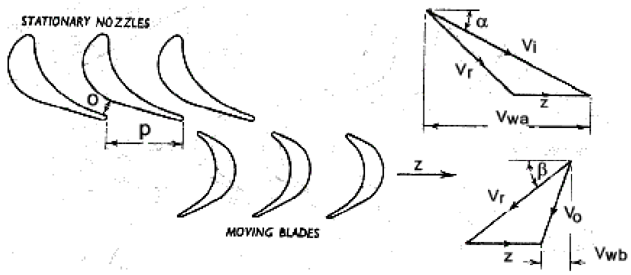


Fig. 1: The structure of Hydraulic retarder

Generally speaking, the retarder can be installed on the input shaft or the output shaft of the transmission. A mechanical model will be presented to analyze the advantages and disadvantages of these two kinds of installation. As depicted in Fig.2, if the transmission is simplified as a pair of gear,



the ratio of the input torque and the output torque of the transmission satisfied the following equation:

$M_o / M_i = i$

1) if the transmission stays in low gear ratio which is greater than 1, the postposition-type (i.e. installed on the output shaft) retarder requires more braking torque and increasing its size under the condition of the equal oil flow;
2) oppositely, if the transmission stays in high gear ratio, the postposition-type requires less braking torque and its size is decreased simultaneously.

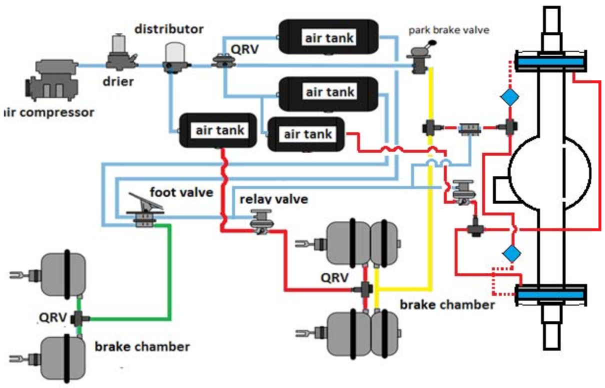
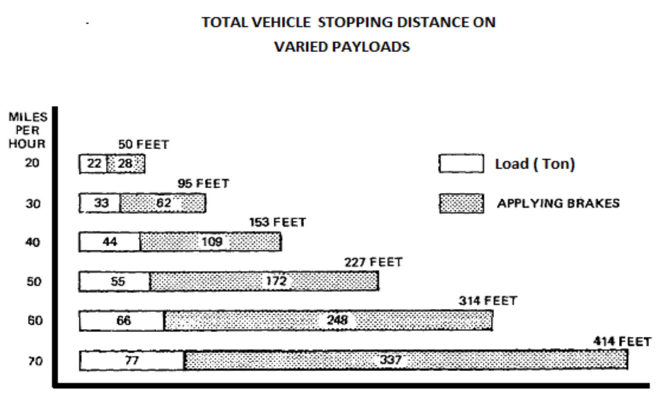


Fig. 2: The simplified model of the torque brake circuit

The hydraulic retarder follows the Principle of Energy Conversion. Like other braking styles, it converts the kinematic energy into the heat energy which is dissipated to the atmosphere. The dissipated energy W during the constant speed steep driving is obtained as

$$W = mgH$$

Where, m represents automobile mass, kg; g represents gravity, m/s2; H represents the height of slope, m.



When the brake or the retarder works independently, kinematic energy is converted to heat energy and dissipated to guarantee the braking or retarding capability. With the improvement of the dissipating capability of the engine coolant system, the retarding capability is accordingly improved. Since the hydraulic retarder and the engine works in different phases, the thermal load of the engine is not increased during normal conditions. Therefore, automobiles can be stopped or parked during the long-time steep downhill. The retarding capability of the retarder depends on the controlled valve in the body of the retarder and the external control system. The retarding capability of the retarder can be configured as high, medium and low types.

Element	Inlet angle Deg	Exit angle Deg	Number of blades
Turbine	33°	-66.75°	32
Stator	33°	65.65°	32

When opening of the foot valve the air flows through the bypass line and actuates the stator chamber, the oil flows through stator and the friction is developed between the rotor and stator and the braking torque is created. Moreover, the operating level can be regulated based on actual needs.

The operating process of the retarder is presented as follows:

The foot valve which actuates pneumatic main line which pushes the piston chamber of the stator blades to overcome the spring force. This action will bring about two procedures: firstly, the channel connecting the main oil pressure to the retarder is opened to fill oil into the retarder, while its pressure depends on the duty ratio and spring stiffness; secondly, opening another channel for bringing the main oil pressure into the controllable flow valve and push it to move left. Automobiles' air pressure is allowed to act on the piston of the power accumulator, and pushes the piston to move right to fill the accumulated oil into the retarder chamber. Since these two simultaneously functioning pressures, the internal retarder is continually filled with oil which generating the resistant force to block the rotational moment of the rotor for reducing vehicle speed. During the process, the route of the retarder oil is shown as follows: through the retarder and controllable flow valve one by one, then get into the coolant system, and finally return to the retarder chamber after cooled. During the working phase of the retarder, the oil which is flowed out of the torque converter flows into the lubrication circuit. Through analyzing, the process depends on the following parameters:

1) The position of the retarder handle;
2) The speed of the transmission output shaft.

When the speed limited in the standard range, the retarding capability reaches its maximum. When the speed exceeds the standard range, foot valve will adjust the oil pressure. When the speed of the drive shaft is lower than 165-450rpm, the retarder will stop working; 3)the transmission temperature of the internal retarder; 4) the current transmission gear.

As shown in the oil pressure of the hydraulic increases along with the increase of the duty ratio of the driving valve, while its retarding capability, i.e. the torque of the output shaft is also increased. It can be seen that the retarding capability of the hydraulic retarder depends on the oil pressure and the speed of the output shaft. That's to say, the retarding capability of the retarder can be adjusted in term of the actual driving conditions.

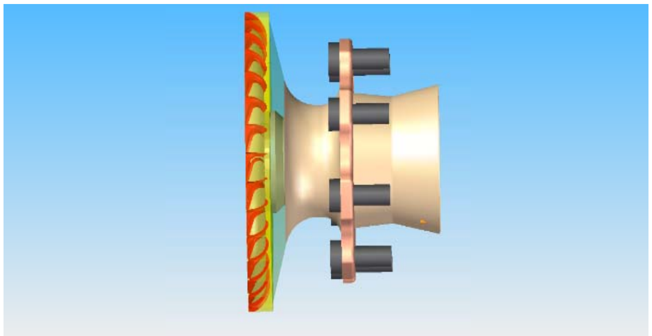


Fig. Shows the rotor hub blades setup

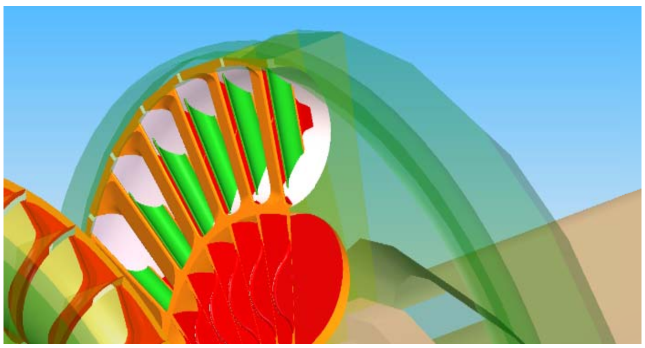
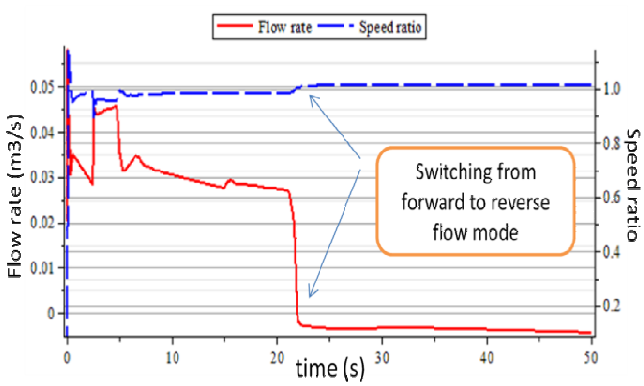
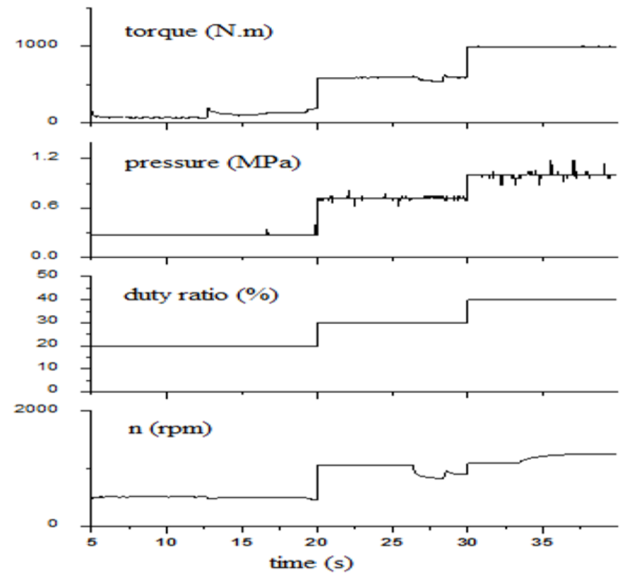


Fig. Shows The stator blades



Graph shows braking capability

The simulation results during the engine braking are compared with the case when the driver disconnects the engine from the transmission during the vehicle deceleration (e.g. neutral gear). The engine rotational speed, sharply drops when the engine shaft is disconnected from the rest of the powertrain. During engine braking, the transmission shaft rotates the engine shaft, and the engine rotational speed is not decreasing as quickly as the situation without engine braking. shows how the engine braking phenomenon can slow down the vehicle during deceleration. This happens because part of the vehicle kinetic energy is used to rotate the powertrain inertias, e.g. engine inertia, during the torque converter reverse flow operation.



When the retarder handle locates in different positions, the retarding capability can provide different resistant torques shown in Fig.5 and Fig.6. It can be seen that the retarder reaches the peak capability within 3s. When the speed of the output shaft is 1000rpm, the retarding capability reaches the peak which is 3000Nm, and then it gradually reduces according to the increase of vehicle speed.

That's to say, the retarder can provides good retarding effect during low speeds of the engine.

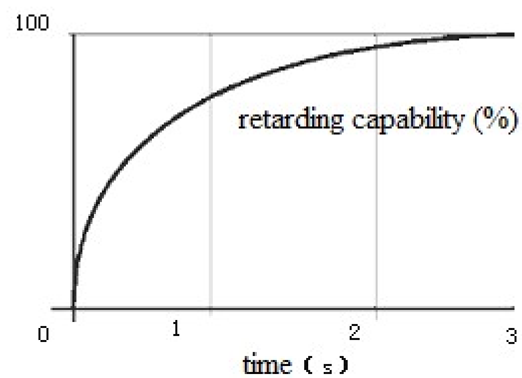


Fig. 6: The retarding capability of the hydraulic retarder changes over time.

3. CONCLUSION

Through the theoretical analysis and experimental research, it can be seen that the hydraulic retarder can auxiliary extend the life of the automobile brake and driving safety. Therefore, it is increasingly applied on the vehicles such as heavy vehicles and large agricultural vehicles due to several advantages of the hydraulic retarder.

Scope of The Proposed Project

The transport corporations (passenger, goods) intercity vehicles which have the major disadvantage of brake liner wear(every 42days) and braking failure at the peak load, over heated condition braking due to brake liner inefficient performance. The transport corporations where expecting the automotive industry for the braking system to have robust performance.

The automotive industries where developed the full dual airline s-cam brake system where it also faces the brake liner over heat, ineffective brake at high payload. Hence the proposed project which may satisfy the transport vehicle users and the industry, for the better braking performance.

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