

Hydraulic Lash Adjuster Compatible Engine Brake

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ABSTRACT

Current heavy duty diesel valvetrains are not able to utilize hydraulic lash adjusters (HLA) in conjunction with an engine brake. During a braking event the engine brake introduces substantial lash into the vehicle valvetrain. The HLA reacts by pumping out to take up the lash encountered during braking, thereby preventing the valves from properly seating at the end of the cycle. Jacobs Vehicle Systems has developed a new mechanism to allow the inclusion of an engine brake into a valvetrain equipped with hydraulic lash adjusters. The fulcrum system maintains a load on the hydraulic lash adjuster during engine brake operation preventing the HLA from extending. HLA are appealing to engine manufacturers because they allow for simpler manufacturing, less maintenance, reduced NVH and valve motion enhancements. This paper describes the design, simulation and testing of the lashless valvetrain with engine brake including the next steps in the development of the valvetrain.

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INTRODUCTION

Compression-release engine braking or "Jake Braking" is used to slow heavy machines, such as, heavy duty trucks and construction/agricultural equipment [1]. In many markets around the world the engine brake has become standard equipment due to its ability to provide fade free stopping ability while reducing the wear on wheel brakes. The compression release engine brake works in concert with the engine's positive power valvetrain to effectively convert a diesel engine from a power producing machine into a power consuming air compressor through selective control of various engine valves. As heavy duty diesel engines advance, manufacturers have begun experimenting with hydraulic lash adjusters (HLA) in their valvetrains. The benefits of HLAs include

- Simplified engine assembly by removing lash setting stations on the assembly line
- Reduced service downtime and cost by eliminating the need for periodic valve adjustment.
- Reduced noise vibration and harshness experienced by the driver.
- More precise control of valve motion over the entire engine life and temperature, resulting in consistent fuel consumption and engine emissions.

As valve timing becomes increasingly important to meet increasing demands for noise emissions, economy, performance, and ease of maintenance, HD diesel engine OEMs are carefully considering equipping their engine with hydraulic lash adjusters.

COMPRESSION RELEASE ENGINE BRAKE

Compression release engine brake or JakeBrake® is a device commonly found in vehicles operating over 30 tons. Engine brakes provide supplemental braking force on heavy vehicles reducing the thermal loading on the vehicle's service brakes. Typical diesel compression release engine brakes operate by actuating one or more exhaust valves near piston top dead center (TDC) on the compression stroke [1]. As the piston approaches TDC of the compression stroke, the exhaust valve is opened, exhausting the high pressure air in the combustion chamber (Figure: 1). The sudden release of compressed gasses into the exhaust manifold prevents the energy stored in the compressed gasses from returning to the piston on the subsequent expansion stroke. This net loss of energy is called 'engine retarding' and provides the deceleration of the vehicle. The compression release engine brake will considerably slow the vehicle and minimize the chances of service brake overheating. In an effort to obtain improved engine braking performance, the exhaust valve may also be opened during the intake stroke in order to recirculate exhaust gases back into the cylinder. This is commonly referred to as a brake gas recirculation event, or BGR event [4].

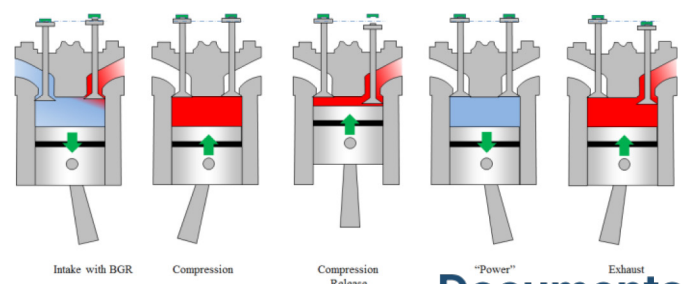


Figure 1. Typical engine cycle during compression release braking

HYDRAULIC LASH ADJUSTER

Automatic lash adjusting devices and hydraulic lash adjusters (HLA) in particular have been widely adopted in passenger vehicle engines for several decades. HLAs compensate for engine variations such as thermal growth, manufacturing differences, and wear, ensuring the engine valve timing remains optimal under all operating conditions.

When the engine valve is seated the hydraulic lash adjuster plunger is free to expand and fill with hydraulic fluid, thereby taking up any lash present between the camshaft and the valve tip (Figure: 2). When external force is applied to the lash adjuster, the internal fluid supply is checked and the resulting fluid pressure within the HLA prevents the plunger from collapsing, thereby transmitting the camshaft motion into valve lift. HLAs offer heavy duty diesel equipment manufacturers a way of improving NVH characteristics of their trucks and engines, while achieving more consistent control of valve motion throughout the life of the engine. In addition to consistent valve motions and improved NVH characteristics, HLAs also reduce the total cost over ownership by eliminating the need for periodic lash setting maintenance throughout the life of the engine. Reduced maintenance is particularly appealing for vehicle owners whose engine overhauls are difficult to service due to tightly packaged engine compartments.

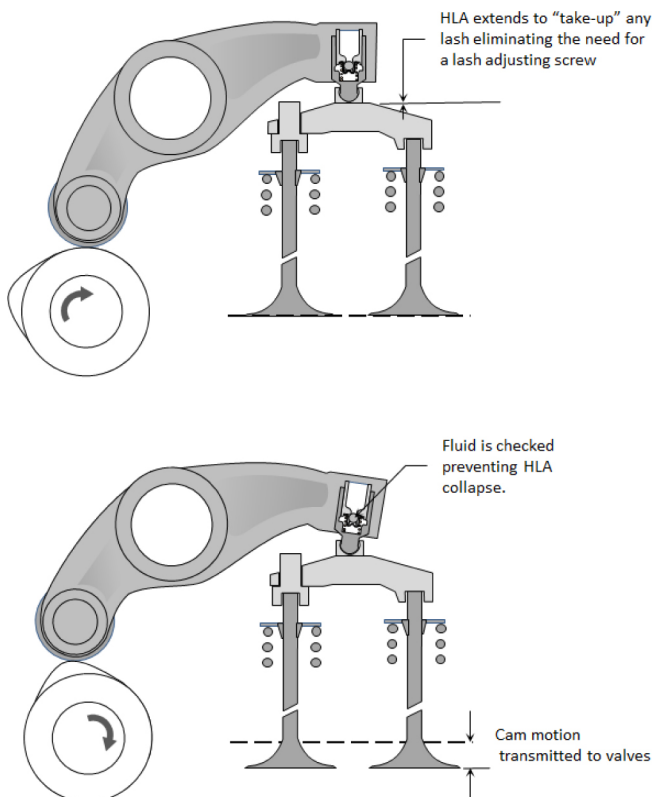


Figure 2. Typical HLA operation during non-braking events

HLA AND ENGINE BRAKE COMPATIBILITY

Although there are many benefits to using HLAs in HD diesel engine overhauls, there is also an inherent compatibility issue when used with conventional engine brakes. HLAs cannot discriminate between lash (due to wear or thermal growth) and brake valve motion. Brake

valve motion is not typically transmitted through the HLA, in many cases there is a dedicated actuator for braking loads. It would be undesirable to transmit the high loads associated with opening an exhaust valve against the high pressure of a compression release event through the HLA.

During positive power operation in a lashless engine, cam motion is directed to the valves through a hydraulic lash adjuster. The lash adjuster is designed to expand and take up any space between the valve tip and camshaft lobe, or retract absorbing any thermal growth in the system, ensuring a complete transmittal of cam motion to the valve tip while returning the valve to their seats upon completion of the motion (Figure: 2). During a compression release braking event, control of one or more exhaust valves is periodically handed off to the brake actuator (brake slave piston, or dedicated rocker brake). During this exchange, the exhaust valve motion is temporarily overridden by the brake cam lobe, leaving the HLA temporarily unloaded during braking events (Figure: 3a). Once unloaded the HLA extends to take up the lash induced by bridge tilt. The overextension of the HLA prevents the valves from seating upon completion of the brake event (Figure: 3b). This unwanted extension of the HLA risks valve damage due to heat and valve to piston contact, and poor engine performance.

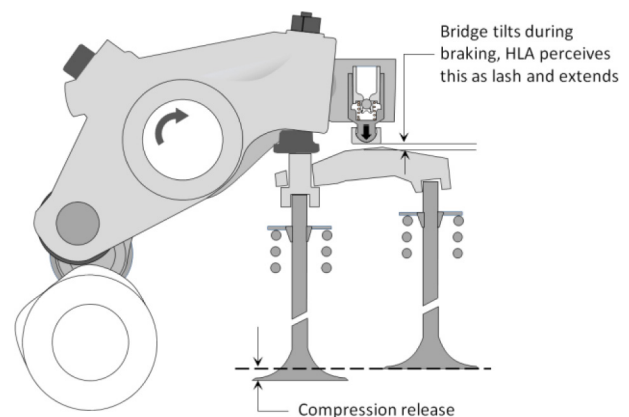


Figure 3a. HLA temporarily unloaded during a braking event and extends to close gap.

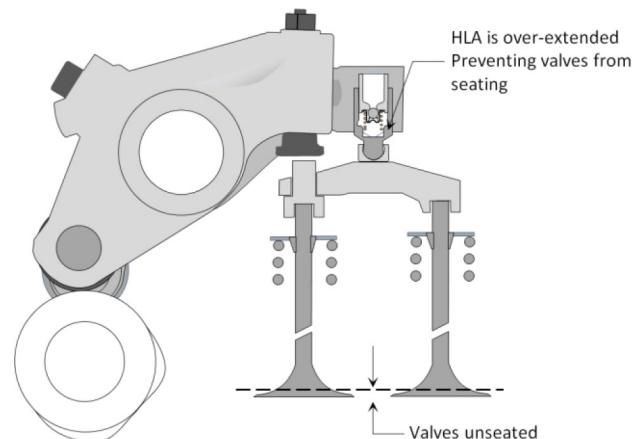


Figure 3b. Over-extended HLA prevents valves from seating