HYDRAULIC VALVE LASH ADJUSTER

Fig 1

A Hydraulic Lash Adjuster (HLA) for an engine valve train comprises a hydraulic lash adjusting arrangement for automatically compensating for lash in an engine valve train; and is characterized by a lost motion arrangement for inhibiting motion induced in the valve train in response to a lift profile of a rotating cam from being transferred to an engine valve.
HYDRAULIC VALVE LASH ADJUSTER

Field of the Invention

The present invention relates to a hydraulic lash adjuster for use in an engine valve train assembly. In particular, the present invention relates to a hydraulic lash adjuster that provides a lost motion stroke variable valve actuation (VVA) capability.

Background of the Invention

A typical hydraulic lash adjuster (HLA) comprises a first oil chamber defined between an outer body and a plunger assembly slidably mounted within the outer body, and a spring biased to enlarge the first oil chamber by pushing the plunger assembly outwardly from the outer body to extend the HLA. Typically, the HLA has a second oil chamber, defined by the plunger assembly and which is in fluid communication with the engine's oil supply. The first oil chamber and the second oil chamber are separated by a one way valve and oil flows from the second chamber into the first chamber through the one way valve when the HLA extends (and hence the first chamber
enlarges) because the oil pressure in the second chamber becomes higher than that in the first chamber. Whereas oil can flow into the first pressure chamber via the one way valve, it can only escape the first pressure chamber very slowly, for example, via closely spaced leak down surfaces. Accordingly, a HLA can extend to accommodate any slack in a valve train assembly, such as between the cam and the roller but after it is extended, the incompressible oil in the first chamber provides sufficient rigid support for the HLA to open the valve when a rocker arm pivots (i.e. the incompressible oil prevents the plunger assembly being pushed back inwardly of the outer body so that the HLA acts as a solid body).

Compression engine brakes are typically used as auxiliary brakes, in addition to wheel brakes, on relatively large vehicles, for example trucks, powered by heavy or medium duty diesel engines. A compression engine braking system is arranged, when activated, to provide an additional opening of an engine cylinder's exhaust valve when the piston in that cylinder is close to the top-dead-center position of its compression stroke so that compressed air is released through the exhaust valve. This causes the engine to function as a power consuming air compressor which slows the vehicle.

In a typical valve train assembly used with a compression engine brake, the exhaust valve is actuated by a rocker arm to provide an additional
compression brake exhaust valve lift in addition to the main exhaust valve lift. The rocker arm rocks in response to a cam on a rotating cam shaft and acts on the exhaust valve, either directly, or indirectly (for example, by means of a valve bridge) to open it. Lost motion variable valve actuation systems may be used to inhibit the additional compression brake exhaust valve lift when the engine is in normal engine combustion mode.

A hydraulic lash adjuster may also be provided in the valve train assembly to remove any lash (i.e. gap) that develops between components in the valve train assembly.

US 7156062 describes a valve actuation system that comprises a lost motion system and a separate, distinct automatic lash adjuster. The system is complicated and has a large number of distinct components.

US 7484483 describes a variable valve actuation system that comprises a manual lash adjuster. Manual lash adjusters have the disadvantage of not providing automatic lash adjustment. Instead, a mechanic must adjust a manual lash adjuster during engine servicing.

Summary of the Invention
According to the invention, there is provided the Hydraulic lash adjuster of claim 1.

Incorporating a lost motion arrangement into a HLA provides a system that is simpler has fewer components than known systems in which HLAs and lost motion systems are separate and distinct. This simplifies manufacturing and reduces costs.

According to the invention, there is also provided the valve train of claim 12.

Brief Description of the Drawings

Figure 1 is a schematic side view of a valve train assembly;

Figure 2 is a schematic cross sectional side view of a HLA;

Figure 3a is a schematic cross sectional side view of a HLA with its components in a first configuration;

Figure 3b is a schematic cross sectional side view of the HLA of Figure 3a with its components in a first configuration;

Figure 4 is a schematic side view of a valve train assembly;

Figure 5 schematic side view of a valve train assembly;

Figure 5 is a perspective view of a clip component;
Figure 6a is a schematic cross sectional side view of a HLA;
Figure 6b is a schematic cross sectional side view of a HLA;
Figure 7 is a schematic side view of a valve train assembly; Figure 8 shows a component of an actuator;
Figure 8 shows a plot of valve lift against cam angle;
Figure 9b shows the actuator and the engine brake capsule in a second configuration;
Figures 9a, 9b and 9c each show schematic cross sectional side views of alternative HLAs.

Detailed Description of Illustrated Embodiments of the Invention

Figure 1 schematically illustrates a valve train assembly 1 comprising an exhaust rocker arm 3, mounted for pivotal movement about a rocker shaft 5. The exhaust rocker arm 3 comprises, at a first end 7, a rotatably mounted roller 9 for engaging an exhaust cam 11 which is mounted or formed on a rotatable cam shaft 13. The exhaust cam 11 comprises a base circle 11a, a main exhaust lift profile 11b and an additional exhaust lift profile 11c.

As shown in Figure 1, the exhaust rocker arm 3 comprises, at a second end 15, a cavity 17 in which is supported a Hydraulic Lash Adjuster (HLA)
19. The HLA 19 is for contacting an exhaust valve 20 of an engine cylinder 21.

Referring to Figure 2 the HLA 19 comprises a hollow outer body 21 supported within the cavity 17 by means of a first retaining clip 23. The hollow outer body 21 comprises a first closed end 25 which protrudes from the cavity 17 and defines a spigot 27 which is received in a socket 29 defined by an E-foot 31. The E-foot 31 comprises a flat base end 33 for contacting a stem 35 of the exhaust valve 20. The spigot 27 is retained within the socket 29 by means of a second retaining clip 37.

The HLA 19 comprises a first plunger 39 slidably mounted within the hollow outer body 21 and which extends above a second open end 26 of the hollow outer body 21. In this example, the first plunger 39 is a hollow two part component comprising a first hollow body 39a and a second hollow body 39b. The second body 39b rests co-axially within the first body 39a, for example, on a first annular lip 41 defined by the first hollow body 39a. A first biasing means 40, for example a compression spring, located at the first closed end 25 of the outer body 21 biases the first plunger 39 outwardly away from the outer body 21 such that a first open end 45 of the first plunger 39, defined by respective ends of the first 39a and second 39b hollow bodies, presses against an upper inner surface 47 of the cavity 17.
The HLA 19 further comprises a second plunger 49 slidably mounted within the first hollow body 39a of the first plunger 39. The second plunger 49 is coaxial with and opposes the second hollow body 39b. In the position shown in Figure 2, the second plunger 49 rests upon a second annular lip 50 defined by the first hollow body 39a. The second plunger 49 defines a first aperture 51 for connecting a first chamber 52, defined by the hollow outer body 21, the first hollow body 39a and the second plunger 49, and a second chamber 54 defined by the first hollow body 39a the second plunger 49 and the second hollow body 39b.

The second oil chamber 54 contains a second biasing means 53, for example a compression spring, which biases the second plunger 49 away from the second hollow body 39b.

The HLA 19 is further provided with a check ball valve 56 which comprises a ball 58 captured by a cage 60 supported in the first chamber 52 by the second plunger 49 and is biased by a third biasing means 62, for example a small compression spring, to a position closing the first aperture 51.

In use, if a lash (i.e. a gap) develops between any of the components in the valve train assembly 1, the first biasing means 40 can expand the overall effective length of the HLA 19 by pushing the first plunger 39 away from the
hollow outer body 21 so as to take up the slack in the valve train assembly 1. During the course of this motion, the ball valve 58 allows oil to flow from the second chamber 54 to the first chamber 52 through the first aperture 51 so that the first chamber 52 is maintained full of pressurised oil. The oil is prevented from flowing back from the first chamber 52 to the second chamber 54 by the ball valve 60. The HLA 19 therefore provides for automatic hydraulic lash adjustment.

The second hollow body 39b and the upper inner surface 47 of the rocker arm 3 define a third chamber 68 located above the second chamber 54. The second hollow body 39b defines a second aperture 64 that connects the third chamber 68 and the second chamber 54.

Oil is supplied to the third chamber 68 from the engine's oil supply (not shown) via an oil supply conduit 65 formed through the rocker shaft 5 and exhaust rocker arm 3 into the HLA 19. Oil is supplied from the third chamber 68 into the second chamber 54 when the relief valve 70 is open. In effect, the second chamber 54 and the third chamber 54 act as an oil reservoir for supplying the first chamber 52 when the HLA 19 extends and for replenishing oil that escapes from the first chamber 52 via leak down surfaces (illustrated by vertical dashed lines), for example, when the HLA is under load during a valve lift event.
In this example, the relief valve 70 is a poppet valve comprising an elongate stem 72 that extends along the longitudinal axis of the third chamber 68 and terminates at a first end in a valve head 74 that forms a seal with the second hollow member 39b when the relief valve 70 closes the second aperture 64. Many other types of valve may instead be used. A second end 78 of the stem 72 extends through an upper wall 80 of the HLA 19 where it is contactable by an actuator 82 which is operable to push the relief valve 70 from a first position in which the second aperture 64 is closed, to a second position in which the second aperture 64 is open. A fourth biasing means 84 is located in the third chamber 68 and is arranged to bias the relief valve 70 to the position in which the second aperture 64 is closed.

In this example, the actuator 82 comprises a lever 84 having a contact head 86. When the relief valve 70 is in the first position in which it closes the second aperture 72, the lever 84 is in a position in which the contact head 86 is above and not in contact with the second end 78 of the valve stem 72. The lever 84 is moveable from this position into contact with the second end 78 of the valve stem 72 so as to push the relief valve 70 against the bias of the fourth biasing means 84 to open the second aperture 64. The lever 84 may be moved for example by an electro-magnetic system 87 controlled by an engine control system. Other types of actuators may be used to actuate the relief valve 70, for example, hydraulic actuators.
The HLA 19 is configurable by means of the actuator 82 to be in either a 'combustion mode' in which the relief valve 70 is open, or a 'braking mode' in which the relief valve 70 is closed. The 'combustion mode' corresponds to normal engine operation in which the engine cylinders provide power strokes. In contrast, the 'braking mode' corresponds to engine operation mode in which combustion is inhibited and de-compression engine braking is implemented.

In the braking mode, pivoting of the exhaust rocker arm 3 in response to the additional exhaust lift cam profile 11c engaging the roller 11 causes an additional valve lift of the exhaust valve 20, once per engine cycle, to provide a de-compression engine brake event. In contrast, in the combustion mode, the pivoting of the exhaust rocker arm 3 in response to the additional exhaust lift cam profile 11c engaging the roller 11 is absorbed by a variable valve actuation 'lost motion stroke' of the HLA 19 and so the additional valve lift of the exhaust valve 20 is inhibited.

Referring now to Figures 1, 3a, 3b and 4, the combustion mode of operation will be explained. As illustrated in Figure 1, the cam shaft 13 is rotating clockwise in the sense of the page and the actuator 82 has configured the HLA 19 in combustion mode by pushing the relief valve 70 to open the second aperture 72. Figure 1 shows the valve train assembly 1 when the roller
9 is engaged with the base circle 11a of the cam 11 and the exhaust valve 21 is closed, momentarily before the roller 9 begins to engage with the additional exhaust lift profile 11c.

Figure 3a is an enlarged view of the HLA 19 as it is in Figure 1 and shows the second plunger 49 resting upon the annular lip 50 formed around the bottom of the first hollow body 39a and that there is a gap between the second plunger 49 and the second hollow body 39b.

As the roller 9 starts to engage the leading rising slope of the additional exhaust lift profile 11c, the exhaust rocker arm 3 starts to pivot clockwise in the sense of the page. As the exhaust rocker arm 3 pivots, the upper inner surface 66 of the exhaust rocker arm 3 pushes the first plunger 39 inwardly of the hollow outer body 21 in the direction of the bottom of the first chamber 52.

As the relief valve 70 is open, the movement of the first plunger 39 is able to displace oil in the first chamber 52 and the resultant pressure difference between the first chamber 52 and the second oil chamber 54 causes the second plunger 49 to move upwards towards the second hollow body 39b.

When the first plunger 39 and the second plunger 49 are moving in this way, the outer body 21 remains substantially stationary and no force sufficient to open the exhaust valve 20 is transmitted to it, despite the clockwise pivoting
of the exhaust rocker arm 3. This could continue until the second plunger 49 hits the second hollow body 39b, at which point, the HLA 19 would begin to act as a solid body that would transmit an opening force to the exhaust valve 21, but in this example, even at the point at which the roller 9 engages the peak of exhaust lift profile 11c, as shown in Figure 4, the second plunger 49 remains marginally out of contact with the second hollow body 39b, as shown in Figure 3B, and so the exhaust valve 20 remains closed. In effect, the movement of the second plunger 49 provides for a so-called 'lost motion stroke', in which the exhaust rocker arm 3 performs a pivoting stroke but the exhaust valve 20 remains closed.

When the roller 9 engages the rising slope of the main exhaust lift profile 11b (not shown in the Figures), the exhaust rocker arm 3 pivots clockwise to a greater extent than when the roller 9 engages the rising slope of the additional exhaust lift profile 11c. This motion is sufficient for the second plunger 49 to hit the second hollow body 39b which acts as a stopper, at which point, the HLA 19 acts as a solid body due to the incompressible oil in the first chamber 52 and transmits an opening force to the exhaust valve 20 for the exhaust valve to open for the exhaust stroke of the engine cycle.

The maximum valve lift of the exhaust valve 20 occurs when the roller 9 engages the peak of the main exhaust lift profile 11b. As the roller 9 passes
out of engagement with the peak of the main exhaust lift profile 1ib, the
exhaust rocker arm 3 starts to pivot anti-clockwise in the sense of the page and
the exhaust valve 21 begins to close under the action of a valve return spring
(not shown). When the roller 9 again becomes engaged with the base circle
11a the exhaust valve 21 is closed. Furthermore, the first plunger 39 returns
under the bias of the first biasing means 40 from its position shown in Figure
3b to its position shown in Figure 3a and, the second plunger 49 returns under
the bias of the second biasing means 53 from its position shown in Figure 3b
to its position shown in Figure 3a.

Referring to Figures 5, 6a, 6b and 7, the de-compression braking mode
of operation will be explained. In this mode, the actuator 82 remains out of
contact with the relief valve 70, which under the bias of the fourth biasing
means 84 keeps the second aperture 72 closed. Figure 5 shows the valve train
assembly 1 when the roller 9 is engaged with the base circle 11a of the cam 11
and the exhaust valve 20 is closed, momentarily before the roller 9 commences
to engage with the additional exhaust lift profile 11c.

Figure 6a is an enlarged view of the HLA 19 as it is in Figure 5 and
shows that the second plunger 49 rests upon the annular lip 50 formed around
the bottom of the first hollow body 39a.
As the roller 9 starts to engage the leading rising slope of the additional exhaust lift profile 11c, the exhaust rocker arm 3 starts to pivot clockwise in the sense of the page. In this mode of operation, because the relief valve 70 is closed, as the exhaust rocker arm 3 pivots, the oil pressure exerted by the oil in the second chamber 54 on the second plunger 49 and oil pressure exerted by the oil in the first chamber 52 on the second plunger 49 remain balanced so that the first plunger 39 cannot move inwardly of the hollow outer body 21 and the second plunger 49 cannot move upwards towards the second hollow body 39b. Instead, the HLA 19 acts immediately as a solid body, due to the incompressibility of the oil in the first oil chamber 52, and pushes down on the valve stem to open the exhaust valve 20. The timing of the opening of the exhaust valve 20 is such that it opens by the end of the compression stroke of the engine cylinder so that compressed air is charged from the cylinder to provide de-compression engine braking. The maximum valve lift X (e.g. 1.9mm) of this additional valve event occurs when the roller 9 engages the peak of the additional exhaust lift profile 11c, see Figure 7. Figure 6b is an enlarged view of the HLA 19 as it is in Figure 7 and line have been drawn across Figures 6a and 6b to illustrate the valve lift X.

When the roller 9 engages the rising slope of the main exhaust lift profile 11b, the exhaust rocker arm 3 pivots clockwise to a greater extent than when the roller 9 engages the rising slope of the additional exhaust lift profile
lie, and the HLA 19 acts on the exhaust valve 20 to fully open it for the exhaust stroke of the engine cycle. The maximum valve lift of the exhaust valve 21 occurs when the roller 9 engages the peak of the main exhaust lift profile 1lb. As in combustion mode, as the roller 9 passes out of engagement with the peak of the main exhaust lift profile 1lb the exhaust valve 21 begins to close under the action of a valve return spring (not shown) and is fully closed when the roller 9 returns into engagement with the base circle 11a.

Figure 8 shows a plot of valve lift against cam rotation angle. The curve 101 is for the exhaust valve 20 and the curve 102 is for a corresponding intake valve (not shown in the Figures) for the engine cylinder, which is acted on by an intake rocker arm (also not shown in the Figures) in response to an intake cam (also not shown in the Figures). The lost motion stroke absorbed by the HLA 19 in the combustion mode is illustrated by the double headed arrow 100. In the combustion mode, the exhaust valve 20 remains shut during the 'lost motion stroke' and the exhaust valve opens at the point marked 'EVO' and closes at the point marked 'EVC'. In the brake mode, the exhaust valve 21 begins opening at the point ExBr VO for the additional valve event by the end of the cylinder's compression stroke, to enable compressed air to be discharged from the cylinder. It closes at the point ExBbVc after the main exhaust lift. It will be appreciated that the exact movement of the valve during
the additional valve lift will be dictated by the shape of the additional cam lift profile 11c.

Figures 9a to 9c illustrate alternative HLAs 19 that may be used in embodiments of the invention. In these Figures, like reference numerals refer to like features previously described.

In each of Figures 9a to 9c the first hollow plunger 39' is a single piece component rather than a two piece component as described above. The plunger 39' has an annular region 200 that defines the second aperture 64 and provides a contact surface for stopping the second plunger 49.

In Figure 9b, the relief valve 70' is a two piece component comprising a first part 70a' which extends from the HLA 19 and which is contactable by the actuator 82 (not shown in Figure 9b), and a second part 70b' which is acted upon by the first part 70a' to open the second aperture 62.

In Figure 9c, the relief valve 70" comprises a valve needle 70a" which extends from the HLA 19 and which is movable by the actuator 82 (not shown in Figure 9c), to act upon a check ball valve 201 to open the second aperture 62. The check ball valve 201 has a similar function and components to the check ball valve 60 that closes the first aperture 51.
The above embodiments are to be understood as an illustrative example of the invention only. Further embodiments of the invention are envisaged. For example, although in the above described embodiment the HLA is supported in a rocker arm, this need not be the case, and the HLA may be supported in a different location or in a different component in a valve train. Although in the above embodiment the HLA acts directly on an engine valve this need not be the case. Although in the above embodiment the HLA acts on a single valve it may act on multiple valves, for example, by acting on a valve bridge or other such component that carries multiple valves. Although in the above described embodiment the HLA is used in conjunction with an engine de-compression braking operation, uses in conjunction with other operations, for example, Exhaust Gas Recirculation are envisaged. Although in the above described embodiment the lost motion arrangement of the HLA is used to entirely inhibit the additional exhaust valve lift when in combustion mode (i.e. the additional lift does not occur at all), it may be used to partially inhibit valve events (e.g. a valve does lift but not to the extent that it otherwise would have done). Further equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.
CLAIMS

1. A Hydraulic Lash Adjuster (HLA) for an engine valve train, the HLA comprising:
   a hydraulic lash adjusting arrangement for automatically compensating for lash in an engine valve train; and characterized by:
   a lost motion arrangement for inhibiting motion induced in the valve train in response to a lift profile of a rotating cam from being transferred to an engine valve.

2. A HLA according to claim 1 wherein the HLA is configurable in a first operational mode and a second operational mode, in the first operational mode the lost motion arrangement is enabled and in the second operational mode the lost motion arrangement is disabled.

3. A HLA (19) according to claim 1 or claim 2, the HLA (19) comprising:
   a first body (21);
   a second body (39) disposed for sliding reciprocal movement within the fist body (21);
   wherein the HLA (19) defines a first chamber (52) for containing hydraulic fluid and a second chamber (54) for containing hydraulic fluid;
a first valve (56) between the first chamber (52) and the second chamber (54);

a third body (49) disposed for sliding reciprocal movement within the second body (39); and wherein,

the lost motion arrangement comprises the second body (39) and the third body (49), wherein in use, motion induced in the valve train in response to the lift profile of a rotating cam is inhibited from being transferred to an engine valve by relative movement of the second body (39) with respect to the first body (21) displacing hydraulic fluid in the first chamber which causes a pressure difference between the first chamber (52) and the second chamber (54) which causes movement of the third body (49).

4. A HLA (19) according to claim 3 further comprising:

a stop member (39b) for stopping further movement of third body (49) when the third body (39) moves into contact with it, whereby the HLA then acts as a solid body.

5. A HLA (19) according to claim 3 or 4 further comprising:

a relief valve (70) for opening an aperture (64) into the second chamber (54), wherein, in use, when the relief valve (70) is open, the lost motion arrangement is enabled, and when the relief valve (70) is closed hydraulic fluid in the first chamber (52) and the second chamber (54) causes
the HLA to act as a solid body, whereby the lost motion arrangement is
disabled.

6. A HLA (19) according to claim 5, wherein, the HLA (19) defines a
third chamber (68) for containing hydraulic fluid and wherein the aperture (64)
fluidly connects the second chamber (54) and the third chamber (68) when the
relief valve is open.

7. A HLA (19) further comprising and actuator (82) for actuating the
relief valve (70).

8. A HLA (19) according to any of claims 3 to 7, wherein the first valve
(56) is supported by the third body (49) and is carried by the third body (49)
when the third body (49) moves.

9. A HLA (19) according to any of claims 3 to 8 further comprising a first
biasing means (40) for biasing the second body (39) away from the first body
(21).

10. A HLA (19) according to claim 4, the HLA (19) further comprising a
second biasing means (53) for biasing the third body (49) away from the stop
member (39b).
11. A HLA (19) according to claim 4 wherein, the stop member (39a) is integral with or a component of the second body (39).

12. A valve train for an engine comprising the HLA of any of claims 1 to 11.

13. A valve train according to claim 12 wherein the lost motion arrangement is useable to inhibit an additional valve lift of an engine valve.

14. A valve train according to claim 13 wherein the engine valve is an exhaust valve.

15. A valve train according to claim 14, wherein the additional valve lift is a de-compression engine brake valve event which the lost motion arrangement inhibits when in an engine combustion mode.
Fig. 2
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

FOIL

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
  
  "A" document defining the general state of the art which is not considered to be of particular relevance
  
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Name and mailing address of the ISA:

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Authorized officer: Kl ingen, Thi erry
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