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(54) **EGR valve for a turbocharged diesel engine**

(57) An EGR valve for a turbocharged diesel engine has valve having a valve closure member (12) movable relative to a mating surface (14) for regulating the flow of EGR gases and a first actuator (16) for enabling the position of the valve closure member (12) to be varied continuously. A second actuator (18) is provided to close the valve fully regardless of the position of the first actuator (16), so as to enable the EGR flow to be reduced more rapidly than can be achieved by said first actuator alone.

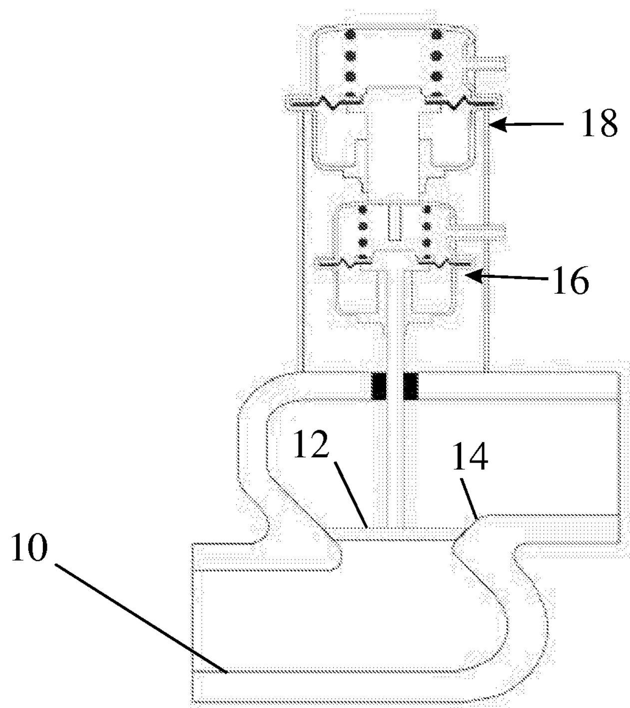

Fig. 1

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Description

[0001] The present invention relates to an exhaust gas re-circulation (EGR) valve for use in a turbocharged Diesel engine to improve the transient torque rise rate when operating with high levels of EGR.

[0002] It is known that modern light-duty diesel engines use high levels of exhaust gas re-circulation. A major consequence of this is that the mass flow rates through the compressor and turbine of the turbocharger are significantly reduced as compared with an engine operating without high levels of EGR. Conventionally, the amount of EGR is managed by controlling the orifice size of an EGR valve and the pressure differential across the EGR valve.

[0003] In current, state of the art, diesel engines variable geometry turbines "VGT" are used to manage the pressure differential across the EGR valve. Opening the VGT nozzles reduces boost, much as a waste-gate would, but it also reduces the exhaust back pressure on the engine. Conversely closing the turbine nozzles can be used to increase the pressure difference across the engine to increase EGR, a function that would previously have been carried out by an intake throttle.

[0004] Modern EGR valves are continuously variable and position controlled, rather than on/off valves, and as a consequence the EGR valve and the VGT interact to provide the required amount of EGR. Because of this, they need relatively sophisticated controllers and control strategies.

[0005] The relative priorities and speeds of response of the EGR valve and VGT nozzle controllers are a major constraint on calibration of light duty diesel engines as there is a trade-off between fuel economy and transient drivability through the interaction of the VGT and EGR valve orifice settings. Fuelling systems can respond on a stroke by stroke basis and will, within measurement system accuracy, follow a prescribed air-fuel ratio trajectory very closely. Therefore, limitations on transient operation are imposed by the air/EGR management.

[0006] When using AFR fuelling control, as is now common, transient torque rise is a function of how quickly the air flow can be increased. There is initially a problem of rapidly reducing the amount of EGR to increase air flow and then of achieving a target boost level, through management of the turbine and, if present, variable valve actuation (VVA), as quickly as possible to maximise volumetric efficiency throughout the transient.

[0007] The present invention seeks to provide an EGR valve that is capable of reducing the EGR flow as quickly as possible to enable the mass flow through the compressor and turbine to be increased.

[0008] According to the present invention, there is provided an EGR valve for a turbocharged diesel engine, the valve having a valve closure member movable relative to a mating surface for regulating the flow of EGR gases and a first actuator for enabling the position of the valve closure member to be varied continuously, characterised in that a second actuator is provided to close the valve fully regardless of the position of the first actuator, so as to enable the EGR flow to be reduced more rapidly than can be achieved by said first actuator alone.

[0009] It is an important feature of the invention that the same valve is used to achieve the continuous EGR flow regulation function and the rapid shut-off function. This enables rapid shut-off to be achieved by merely replacing the EGR valve, without having to redesign the intake system to accommodate a separate valve.

[0010] In one embodiment of the invention, the closure member is axially displaceable by both the first and the second actuator and the second actuator is operative to apply to the valve closure member a force significantly greater than the force applied by the first actuator.

[0011] In an alternative embodiment of the invention, the valve closure member is formed by a hollow body that is rotatable by the first actuator and has a flow regulating aperture in its wall and the second actuator acts on a plug for obstructing the flow regulating aperture of the valve closure member.

[0012] The invention will now be described further, by way of example, with reference to the accompanying drawings, in which :

Figure 1 is a schematic sectional view of a first embodiment of the present invention, and
Figure 2 is also a similar view to Figure 1 showing a second embodiment of the invention.

[0013] In Figure 1, there is shown an EGR duct 10 which is connected at one end to the intake system of an engine and at its other end to the engine exhaust system. The flow of EGR gases along the duct 10 is controlled by an EGR valve which comprises a closure member 12 moved by means of a first vacuum operated actuator 16 towards and away from a mating surface 14, having the form of a valve seat defined within the EGR duct 10.

[0014] The actuator 16 is generally conventional and need not therefore be described in detail. The illustrated actuator 16 comprises a diaphragm biased by a spring in a direction to close the EGR valve. By applying a vacuum to the working chamber above the diaphragm, the closure member 12 is raised off its seat 14 to open the EGR valve. The valve opening defined between the closure member 12 and the seat 14 is continuously variable by appropriately modulating the applied vacuum. It should be appreciated in this context that the actuator 16 need not necessarily be vacuum operated and that it could instead be powered electrically or by means of compressed gas.

[0015] The actuator 16 is not in itself capable of closing the EGR valve rapidly and for this purpose the embodiment shown in Figure 1 is provided with a second actuator 18. The actuator 18 has a larger diaphragm and a stronger spring than the first actuator 16. The spring is normally held compressed by a vacuum so that the actuator 18 is normally ineffective. When the EGR flow is to be cut off rapidly, the working chamber of the actuator 18 is connected to atmosphere whereupon the strong spring within the actuator 18 extends its output rod and moves the whole of the first actuator 16 in a direction to close the EGR valve. Because of the strength of the spring in the second actuator the EGR valve will be closed quickly regardless of the position of the diaphragm of the actuator 16. As with the actuator 16, the actuator 18 may alternatively be powered electrically or by means of compressed gas.

[0016] In the embodiment of Figure 2, the EGR valve is a rotary valve having a closure member 12' mounted in an EGR duct 10' and rotated by a rotary actuator 16'. The closure member 12', which is also shown separately in perspective in the drawing, is a hollow body having a flow regulating aperture in its wall, which is covered to a greater or lesser extent as the closure member 12' is rotated to regulate the flow of EGR gases along the duct 10'. To shut the EGR flow off rapidly, a linear actuator 26 acts on a plug 24 which is movable into the hollow closure member 12' of the rotary valve to cover the flow regulating aperture completely regardless of the angular position of the closure member 12'.

[0017] The position of the closure members 12 and 12' in the previously described embodiments is determined by the level of vacuum applied to their actuators and this is typically set by a vacuum modulator having a slow response time. However, the opening of the EGR valve need only occur at its normal rate as determined by the speed at which the actuator 16 or 16' can move the closure member 12 or 12' of the EGR valve. The desired rapid shut-off of the valve is achieved in each case by the use of the second actuator 18 or 26.

Claims

1. An EGR valve for a turbocharged diesel engine, the valve having a valve closure member (12,12') movable relative to a mating surface (14) for regulating the flow of EGR gases and a first actuator (16,16') for enabling the position of the valve closure member (12,12') to be varied continuously, **characterised in that** a second actuator (18,26) is provided to close the valve fully regardless of the position of the first actuator (16,16'), so as to enable the EGR flow to be reduced more rapidly than can be achieved by said first actuator alone.

2. An EGR valve as claimed in claim 1, wherein the closure member (12) is axially displaceable by both the first (16) and the second (18) actuator and wherein the second actuator (18) is operative to apply to the valve closure member (12) a force significantly greater than the force applied by the first actuator.

3. An EGR valve as claimed in claim 1, wherein the valve closure member is formed by a hollow body (12') that is rotatable by the first actuator (16') and has a flow regulating aperture in its wall and wherein the second actuator (26) acts on a plug (24) for obstructing the flow regulating aperture of the valve closure member (12').

4. An EGR valve as claimed in any preceding claim, wherein at least one of the first and second actuators (16, 16', 18, 26) is powered by vacuum or compressed air.

5. An EGR valve as claimed in any preceding claim, wherein at least one of the first and second actuators (16, 16', 18, 26) is electrically powered.

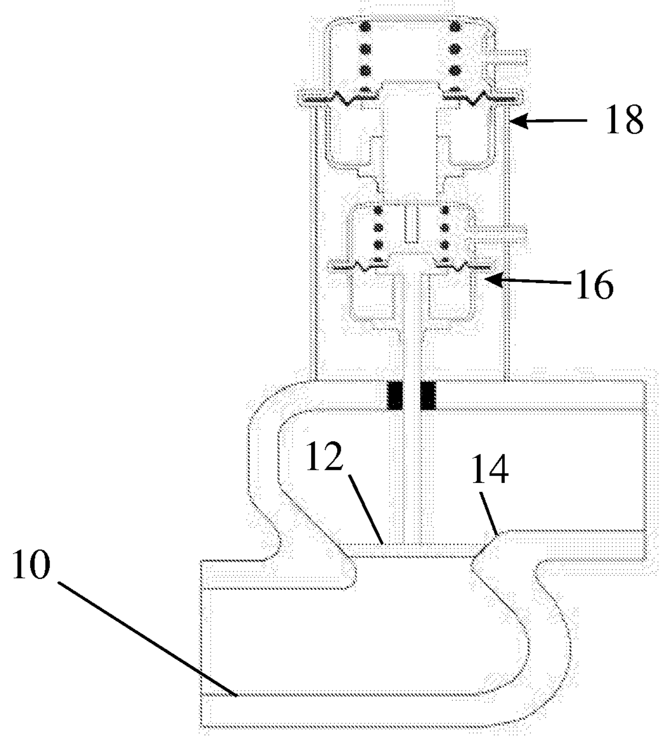

Fig. 1

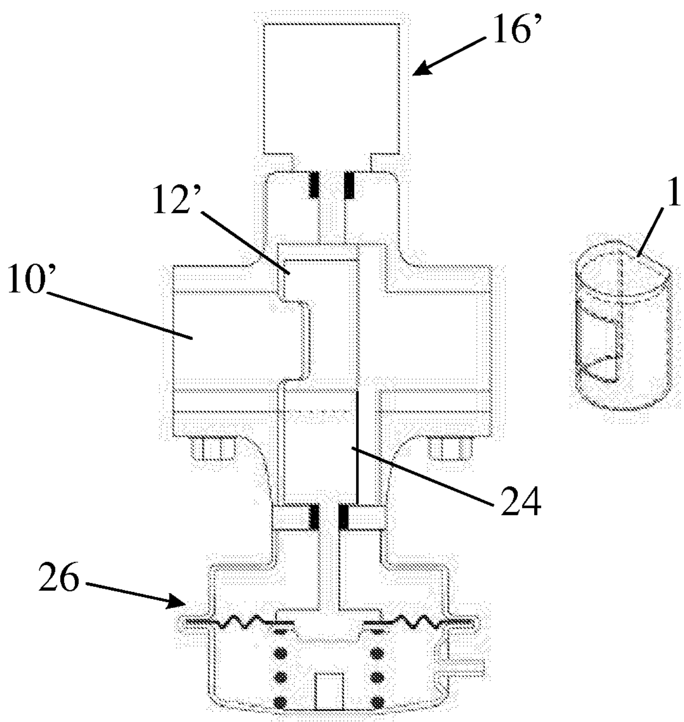

Fig. 2