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(54) **Particulate filter regeneration**

(57) A power system comprises an air breathing, fuel consuming internal combustion engine (12) having a plurality of cylinders (16) and producing a rotary output and products of combustion; an intake manifold (18) receiving combustion air from a common inlet and distributing such

air to the cylinders (16) of the engine (12); a fuel system (58) for delivering fuel at controlled rates to at least a group of cylinders less than the total of the cylinders (16); a particulate filter (36) receiving products of combustion from the engine (12), the particulate filter (36) requiring periodic regeneration.

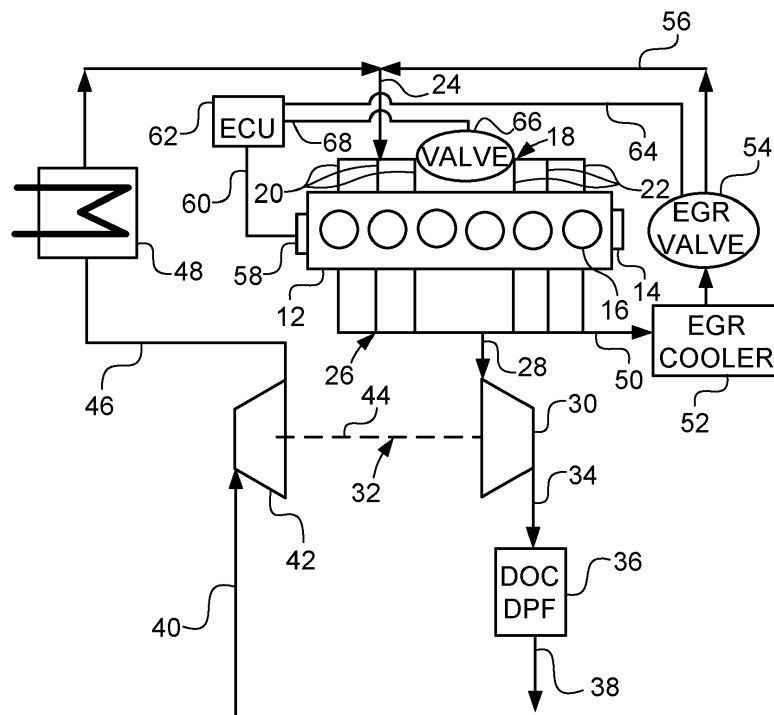


FIG. 1

Description

[0001] This invention relates to internal combustion engines, and, more particularly, to systems for facilitating the regeneration of particulate filters used with such internal combustion engines.

[0002] For a number of years, the evermore stringent US Environmental Protection Agency (EPA) limitations on products of combustion from internal combustion engines have given rise to the need for particulate filters filtering particles from an internal combustion engine's exhaust system. Although diesel power systems have employed particulate filters, known as diesel particulate filters (DPF) for a number of years, direct fuel injection for other types of internal combustion engines have also indicated the need for a particulate filter. Such particulate filters have filtration media for collecting particles on the filter media to prevent the particles from being discharged to the atmosphere. As with any filter, there is a finite capacity to the particles trapped by the filter and there exists a need for regeneration of the filter or burning off the particles.

[0003] Generally, such regeneration requires an elevated temperature in the exhaust, either by the addition of hydrocarbon fuels or by other forms of temperature increase. Regardless of the specific mechanism to regenerate the filter, there have been a number of systems proposed for increasing the load on engines and, therefore, increasing the exhaust temperature upstream of the particulate filter. Such systems may involve manipulation of exhaust gasses by increased restriction or manipulation of flow through complex variable intake valve systems or variable turbine geometry systems. While these provide the increase in exhaust temperatures necessary, they do so at an increased cost and complexity in the engine system.

[0004] What is needed, therefore, in the art is a simplified system for increasing exhaust gas temperatures for regeneration purposes.

[0005] It is therefore the object of the present invention to comply with one or all of these needs.

[0006] This object is met according to the invention by the teaching of claim 1, while features developing the solution in an advantageous manner are set forth in the further claims.

[0007] The present invention includes, in one form, a power system with an air breathing, fuel consuming internal combustion engine having a plurality of cylinders and producing a rotary output and products of combustion. An intake manifold receives combustion air from a common inlet and it distributes the air to the cylinders for combustion. A fuel system delivers fuel at controlled rates to at least a group of cylinders less than the total number of cylinders for such engine. A particulate filter receives products of combustion from the engine with the particulate filter requiring periodic regeneration. A valve is positioned in the intake manifold to at least restrict combustion air flow to the group of cylinders, the fuel system at

least reducing fuel flow substantially simultaneously with the reduction of airflow to the group of cylinders.

[0008] According to an embodiment a power system, may comprise an air breathing, fuel consuming internal combustion engine having a plurality of cylinders and producing a rotary output and products of combustion; an intake manifold receiving combustion air from a common inlet and distributing such air to the cylinders of the engine; a fuel system for delivering fuel at controlled rates to at least a group of cylinders less than the total of the cylinders; a particulate filter receiving products of combustion from the engine, the particulate filter requiring periodic regeneration; and a valve positioned in the intake manifold to at least restrict combustion air flow to the group of cylinders, the fuel system at least reducing fuel flow substantially simultaneously to the group of cylinders, thereby increasing the load on the engine and the temperature in the exhaust gas flow for regeneration of the particulate filter.

[0009] The valve may totally restrict flow to the group of cylinders.

[0010] The valve may be a butterfly valve.

[0011] The valve may be a guillotine valve, having a plate displaceable to vary and restrict the flow to the group of cylinders.

[0012] The power system may further comprise an electronic control unit (ECU) connected to control and actuate the valve and the fuel flow.

[0013] The group of cylinders may constitute half of the total number of cylinders of the multi-cylinder engine.

[0014] The internal combustion engine may be a compression ignition diesel engine and wherein the filter is a diesel particulate filter.

[0015] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 shows a schematic drawing of a power system embodying the present invention;

Fig. 2 shows the power system of Fig. 1 with a first kind of valve, and

Fig. 3 shows the power system of Fig. 1 with a second kind of valve.

[0016] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate one embodiment of the invention and such exemplification is not to be construed as limiting the scope of the invention in any manner.

[0017] Referring now to the drawings, and more particularly to Fig. 1, there is shown a power system with a multi-cylinder internal combustion engine 12 having a

plurality of cylinders 16 in which pistons (not shown) reciprocate to produce a rotary power output via a crank shaft 14. The engine 12 receives air for combustion from an intake manifold 18 comprising inlets 20 for a first group of cylinders and inlets 22 for a second group of cylinders. As illustrated, the engine 12 has six cylinders and the group of cylinders fed by intake runners 20 and 22 is equal. However, it should be apparent to those skilled in the art that the number of cylinders within each group may be varied.

[0018] The cylinders of engine 12 receive fuel, as will be described later, and produce combustion, which is delivered past exhaust valves (not shown) and exhaust manifold 26 and from there to the inlet 28 of the turbine 30 for a turbocharger 32. The exhaust gasses thus passing from turbine 30 pass through turbine outlet 34 to an exhaust aftertreatment device 36, which may be an oxidation catalyst or particulate filter or a combination of both and, from there, through an exhaust line 38 to the ambient. The exhaust aftertreatment device 36 does collect particles harmful to the environment and must be periodically regenerated or cleaned of the particles.

[0019] The air for combustion enters the power system via intake line 40 through appropriate filtration devices and is delivered to the intake of compressor 42 connected to and driven by the turbine 30 by shaft 44. Pressurized air from compressor 42 extends via line 46 to the inlet of an after cooler or intercooler 48 for reducing the temperature of the pressurized gas and, thus, the density of air and oxygen consumed by engine 12. The after cooler or intercooler may be any one of a variety of coolers including air-to-air coolers relying on ambient air for cooling or an air-to-liquid cooler relying on engine coolant for particular applications. The air thus cooled enters intake line 24 leading to intake manifold 18.

[0020] The power system of Fig. 1 includes exhaust gas recirculation or EGR and this is accomplished by a line 50 tapping into exhaust manifold 26 or some portion of the exhaust flow path and extending through a cooler 52, which may be employed to decrease the temperature of exhaust gasses thus passed to the intake manifold and increasing efficiency of the engine 12. Whether the exhaust gas is cooled or not, it is passed through an EGR valve 54, which controls flow through a line 56 connected to inlet line leading to intake manifold 18.

[0021] Engine 12 has a fuel system indicated schematically by reference character 58, which receives control inputs from engine parameter sensors and a primary input via line 60 or a plurality of lines from an electronic control unit 62 or ECU. The ECU 62 preferably provides control of EGR valve through line 64 to control flow of exhaust gasses from the products of combustion of engine 12 to the intake manifold 18.

[0022] In accordance with the invention, a valve 66 is provided within intake manifold 18 and is controlled by ECU 62 via line 68. Valve 66 is established in flow relation between the intake runners 20 and 22 within intake manifold 18 to selectively at least restrict and also to block

intake air flow to cylinders 16 fed by runners 22. Substantially simultaneously with the blockage or restriction of flow to the cylinder group fed by runners 22, the fuel flow to that group of cylinders by fuel system 58 is reduced or terminated. This, in effect, eliminates the group of cylinders fed by runners 22 to take away their power generating capacity and increase the load on the remaining cylinders both from overall engine parasitic loads and from the additional parasitic loads produced by the inactive group of cylinders.

[0023] The valve 66 may take several forms, some of which are illustrated in Figs. 2 and 3. Fig. 2 shows the valve 66 in the form of a butterfly valve 70 mounted on a central pivoting shaft 72 and pivotable via connection 68 to ECU 62 within a semi-hemispheric chamber 74 to either present substantially no restriction to flow in a horizontal position, as viewed in Fig. 2, or substantially blocking flow in a position that is vertical, as viewed in Fig. 2 and illustrated in dashed lines. Butterfly valves have progressed so that, with improved sealing edges, a substantial reduction of flow may be accomplished to eliminate flow to the group of cylinders fed by runners 22 and thus increase the load on the engine 12.

[0024] Fig. 3 shows another form of a valve 66, in this case, a guillotine valve in the form of a plate 80 that slides in the inner surfaces 82 of housing 84 extending from intake manifold 18. The plate 80 is mounted on and guided by a shaft 86 that is connectable via connection 68 so as to displace plate 80 from a position in which there is substantially no restriction to flow through intake manifold and another position illustrated in dashed lines in which plate 80 seats in recess 88 to substantially block flow through intake manifold 18. Although not shown, the connections 68 for both the valve 70 and 80 typically include an actuator (not shown) controllable by ECU 62.

[0025] Using both forms of valves, and others as apparent to those skilled in the art, the flow to the second set of cylinders fed by runners 22 is varied to the point where combustion air flow may be substantially blocked along with a substantially simultaneous termination of fuel flow to the cylinders 16. This effectively imposes an increased load on the engine, especially during part throttle conditions in which there is insufficient natural load on the engine 12 to raise exhaust temperatures to the point of facilitating regeneration of particulate filter 36. In addition, the valves provide a simplified way of increasing exhaust temperatures during light load conditions by partially blocking flow, thus improving operation of various exhaust aftertreatment devices.

[0026] While this invention has been described with respect to at least one embodiment, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the

limits of the appended claims.

Claims

1. A power system comprising:
 - an air breathing, fuel consuming internal combustion engine (12) having a plurality of cylinders (16) and producing a rotary output and products of combustion; 10
 - an intake manifold (18) receiving combustion air from a common inlet and distributing such air to the cylinders (16) of the engine (12);
 - a fuel system (58) for delivering fuel at controlled rates to at least a group of cylinders less than the total of the cylinders (16); 15
 - a particulate filter (36) receiving products of combustion from the engine (12), the particulate filter (36) requiring periodic regeneration; **characterized by** 20
 - a valve (66) positioned in the intake manifold (18) to at least restrict combustion air flow to the group of cylinders, the fuel system (58) at least reducing fuel flow substantially simultaneously to the group of cylinders, thereby increasing the load on the engine (16) and the temperature in the exhaust gas flow for regeneration of the particulate filter (36). 25
2. The power system according to claim 1, **characterized in that** the valve (66) totally restricts flow to the group of cylinders. 30
3. The power system according to claim 1 or 2, **characterized in that** the valve (66) is a butterfly valve. 35
4. The power system according to claim 1 or 2, **characterized in that** the valve (66) is a guillotine valve, having a plate (80) displaceable to vary and restrict the flow to the group of cylinders. 40
5. The power system according to one of the previous claims, further comprising an electronic control unit (62) connected to control and actuate the valve (66) and the fuel flow. 45
6. The power system according to one of the previous claims, **characterized in that** the internal combustion engine (12) is a compression ignition diesel engine and wherein the filter (36) is a diesel particulate filter. 50

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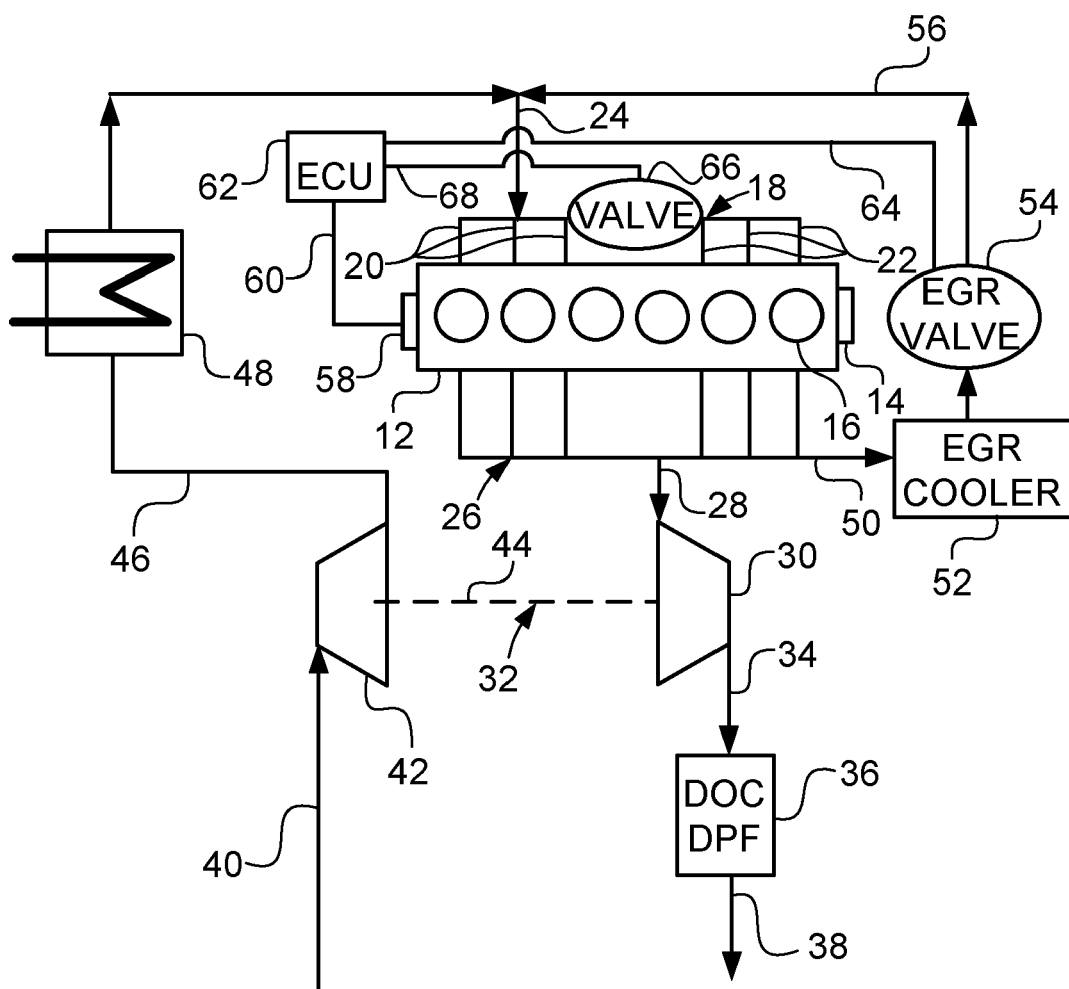


FIG. 1

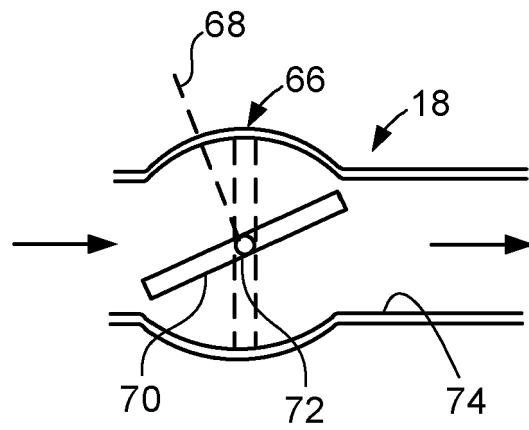


FIG. 2

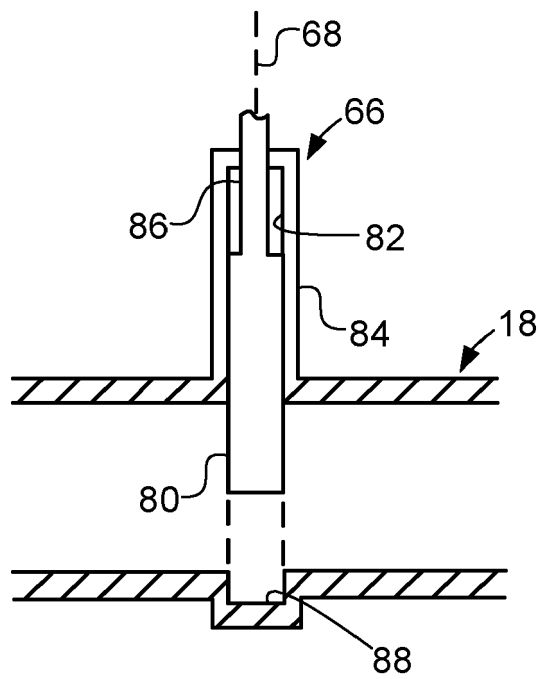


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 11 18 1608

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Y	* column 3, line 25 - line 33; claim 1; figure 1 *	2-4	
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	* page 4, line 5 - line 15; claim 10 *		
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 November 2011	Examiner Zebst, Marc
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 18 1608

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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