SYSTEM AND METHOD FOR ENGINE LUBRICATION

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ABSTRACT

The invention resides in an internal combustion engine (20) comprising an air intake system (24) operatively connected to a cylinder (21), a gaseous phase fuel delivery system (25) operatively connected to the cylinder (21), and a liquid phase lubricant injection system (10) operatively connected to the cylinder (21). An atomised portion of liquid phase lubricant is injected into a mixture of gaseous phase fuel and air by the liquid phase lubricant injection system (10) to lubricate components of the cylinder (21) prior to burning the mixture in the cylinder (21).
SYSTEM AND METHOD FOR ENGINE LUBRICATION

FIELD OF THE INVENTION

[0001] The present invention relates to lubrication of internal combustion engines. In particular, although not exclusively, the invention relates to a system and method for lubricating engine cylinder walls using lubricant injectors.

BACKGROUND TO THE INVENTION

[0002] Flammable gas is considered a waste bi-product of many industrial processes. For example, coal mine gas (commonly known as firedamp) consists primarily of highly flammable methane that is produced during the geochemical process of carbonizing organic material into coal. Coal mine gas has produced many lethal explosions in coal mines. Therefore, coal mines today are generally elaborately and carefully ventilated to ensure that explosive concentrations of coal mine gas are removed. However, rather than simply venting coal mine gas directly to the atmosphere as pollution, coal mine gas is sometimes captured and used as a fuel to run engines that can perform useful work at a mine site. For example, large, stationary engines fuelled by coal mine gas can be coupled to electric generators. Resulting electricity then can be used at a mine site or fed back into a public power grid.

[0003] Other industrial processes also generate flammable waste gases that can be used to power generator engines. For example, landfill gas and biogas consist primarily of mixtures of methane, carbon dioxide and nitrogen and are commonly produced in landfills and other organic waste sites as organic substances decompose. To prevent hazardous and other unwanted conditions such as foul odours, landfill gas and biogas can be extracted from a waste site using perforated cylinders that are piped through waste material. The extracted gas then can be used as a fuel.

[0004] The waste gas engines used to run generators at industrial sites are generally massive and powerful engines such as turbocharged and intercooled 12- to 20-cylinder V-engines. Such engines typically run continuously at a constant speed to produce a steady output of thousands of horsepower. The engines are thus complex and expensive but must be highly reliable to ensure low operating costs and profitable investment returns.

[0005] Unfortunately, many waste gases such as methane are relatively "dry" fuels that can result in significant wear and deterioration of engine parts. In a typical liquid fuelled gasoline or diesel engine, the fuel itself can effectively lubricate exposed engine components such as valve stems and piston cylinder walls. However, in waste gas fuelled engines, the waste gases generally do not provide significant lubrication to prevent wear on the engine components such as valve stems and piston cylinder walls. Methane-powered engines also suffer from an abrasive crystalline build-up on the valve stems and piston cylinder walls due to a chemical product in the gas which is unable to be pre-filtered. Without some form of additional lubrication or wear protection, these engines can be subject to high maintenance costs and premature failure.

[0006] Proposed solutions to the need for additional lubrication in waste gas engines resulting from "dry" fuel have included adding lubricants to waste gas in a waste gas fuel tank, and using low-friction coatings on susceptible engine components. However, many of these solutions are impractically expensive and still do not provide for the engine reliability required to make the use of waste gas engines economical and profitable.

[0007] There is therefore a need to overcome or alleviate the above discussed problems associated with fuel-induced high wear and the resulting low service life of waste gas engines.

OBJECTS OF THE INVENTION

[0008] An object of the present invention is to overcome or alleviate one or more limitations of the prior art and/or provide a consumer with a useful commercial choice by providing a system and method for engine lubrication of "dry" fuel engines.

SUMMARY OF THE INVENTION

[0009] In one form, although it need not be the only, or indeed the broadest form, the invention resides in an internal combustion engine comprising:

[0010] an air intake system operatively connected to a cylinder;

[0011] a gaseous phase fuel delivery system operatively connected to the cylinder; and

[0012] a liquid phase lubricant injection system operatively connected to the cylinder;

[0013] wherein during use an atomised portion of liquid phase lubricant is injected into a mixture of gaseous phase fuel and air by the liquid phase lubricant injection system to lubricate components of the cylinder prior to burning the mixture of gaseous phase fuel and air in the cylinder.

[0014] Preferably, the liquid phase lubricant system comprises one or more lubricant injectors located in an intake manifold of the engine.

[0015] More preferably, each lubricant injector is positioned adjacent an intake valve of a cylinder.

[0016] Alternatively, the liquid phase lubricant system comprises one or more lubricant injectors located in a cylinder head of the engine.

[0017] The lubricant injector preferably injects the liquid phase lubricant immediately prior to or during an intake stroke of the engine.

[0018] The gaseous phase fuel is preferably coal bed methane (CBM), coal mine methane (CMM), abandoned mine methane (AMM), landfill gas, biogas, liquid petroleum gas (LPG) or natural gas.

[0019] The liquid phase lubricant preferably comprises a mineral or synthetic oil.

[0020] In another form, the invention provides a method for lubricating a dry fuel internal combustion engine, the method comprising the following steps:

[0021] injecting an atomised portion of liquid phase lubricant into a mixture of gaseous phase fuel and air contained in an intake manifold of the engine;

[0022] drawing the mixture of gaseous phase fuel and air into a cylinder of the engine; and

[0023] allowing the atomised liquid phase lubricant to lubricate components of the cylinder prior to burning the mixture of gaseous phase fuel and air in the cylinder.

[0024] The method for lubricating a dry fuel internal combustion engine, wherein the step of injecting an atomised portion of liquid phase lubricant into a mixture of gaseous
phase fuel and air preferably occurs immediately prior to or during an intake stroke of the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] To assist in understanding the invention and to enable a person skilled in the art to put the invention into practical effect, preferred embodiments of the invention are described below by way of example only with reference to the accompanying drawings, in which:

[0026] FIG. 1 is a plan view of a liquid phase lubricant system according to one embodiment of the invention showing how lubricant is delivered to an engine;

[0027] FIG. 2 is a plan view of the liquid phase lubricant system of FIG. 1 showing how the delivery of lubricant is controlled;

[0028] FIG. 3 is a sectional view of the liquid phase lubricant system of FIG. 1 showing an injector mounting on a wall of an intake manifold; and

[0029] FIG. 4 is a flow diagram of the method of delivering the lubricant to the engine.

DETAILED DESCRIPTION OF THE INVENTION

[0030] FIGS. 1 and 2 show a liquid phase lubricant system 10 retrofitted to an existing stationary 20-cylinder diesel V-engine 20 that has been converted to using methane gas.

[0031] The engine 20 includes two rows of cylinders 21. Each cylinder 21 is operatively connected to an intake manifold 22. An air intake system 23 and a gaseous phase fuel delivery system 24 is operatively connected to each cylinder 21 via the intake manifold 22, as known in the prior art.

[0032] The liquid phase lubricant system 10 includes a lubricant delivery system 30 and a lubricant control system 40. Although the invention is explained with reference to stationary engines, the inventor envisages that the invention is also applicable in other environments such as vehicle engines running on similar ‘dry’ fuels.

[0033] FIG. 1 shows the lubricant delivery system 30 which delivers a 10-weight mineral oil to each cylinder 21 of the engine 20. However, it is to be appreciated that other forms of lubricant may be used, such as a lightweight synthetic oil. Embodiments of the lubricant may also include additives such as a combustion enhancer to improve fuel efficiency and reduce exhaust emissions of the engine 20. The lubricant delivery system 30 includes a series of injectors 31, a high pressure pump 32, a reservoir 33, a pressure regulator 34, and a supply rail 35. Only one side of the engine 20 is shown fluidly connected to the lubricant delivery system 30 for clarity.

[0034] Each injector 31 is mounted through an intake manifold 22 of the engine 20 such that a nozzle of the injector 31 points towards a respective intake valve of each cylinder 21, as will be discussed in detail later. Alternately, each injector 31 may be mounted through a cylinder head 23 of the engine 20 such that the nozzle of the injector is located inside each cylinder 21. An inlet of each injector 31 is fluidly connected to the supply rail 35 that runs along the intake manifold 22 adjacent each row of cylinders 21.

[0035] The high pressure pump 32 supplies lubricant from the reservoir 33 to the supply rail 35 under pressure. An inlet of the high pressure pump 32 is fluidly connected to the reservoir 33 while an outlet of the high pressure pump 32 is fluidly connected to an inlet of the supply rail 35. However, it is to be appreciated that the outlet of the high pressure pump 32 may also be connected to an inlet of another supply rail to lubricate the other row of cylinders 21.

[0036] The reservoir 33 is used to store a constant supply of lubricant to the high pressure pump 32. The reservoir 33 includes a swirl pot 36 having two inlets and two outlets, a low pressure pump 37, and a supply tank 38. An inlet of the swirl pot 36 is fluidly connected to the supply tank 38 via the low pressure pump 37. The other inlet of the swirl pot 36 is fluidly connected to an outlet of the pressure regulator 34. An outlet of the swirl pot 36 is fluidly connected to the supply rail 35 via the inlet of the high pressure pump 32. The other outlet of the swirl pot 36 is fluidly connected to the supply tank 38. Alternatively, it is to be appreciated that the reservoir 33 may only comprise the supply tank 38.

[0037] The pressure regulator 34 is used to regulate lubricant pressure within the supply rail 35. The pressure regulator 34 is fluidly connected to the outlet of the supply rail 35. A pressure gauge 39 is included with the pressure regulator 34 to monitor the pressure of lubricant within the supply rail 35.

[0038] FIG. 2 shows the lubricant control system 40 which controls the delivery of lubricant to each cylinder 21. The lubricant control system 40 includes a lubricant control unit (LCU) 41, a crank pickup 42, and two cam pickups 43.

[0039] The LCU 41 monitors the engine’s operating parameters via each of the crank and cam pickups 42, 43 to control the delivery of lubricant to each cylinder 21. However, it is to be appreciated that the LCU 41 may be incorporated into an Engine Control Unit (ECU) of the engine 20 and use a number of other sensors to monitor the engine’s operating parameters such as air flow, fuel mixture, engine temperature, exhaust composition, etc. The LCU 41 is electrically connected to the crank pickup 42, the cam pickup 43, and each injector 31.

[0040] The crank and cam pickups 42, 43 measure the speed of rotation and/or relative position of each respective crank and cam shaft. Each of the crank and cam pickups 42, 43 comprise a hall effect sensor 44 fixedly positioned adjacent a sensor wheel 45 that is mounted on a respective crank and cam pulley 46, 47. The sensor wheel 45 has a number of magnets 48 equally spaced around its periphery such that when the sensor wheel 45 rotates due to rotation of the crank and/or cam shafts, the voltage of each pickup 42, 43 peaks as each magnet 48 approaches the hall effect sensor 44. Alternatively, the sensor wheel 45 may comprise a series of magnetised pointed teeth disposed around its periphery, such that the point of each tooth is detected as it approaches the hall effect sensor 44. It is also to be appreciated that optoelectronic or other forms of pickup devices can be used to measure the speed of rotation and/or relative position of the crank and cam shafts.

[0041] FIG. 3 shows an injector mounting 50 on a wall of an intake manifold 22 allowing the system to be installed in an existing engine that is operatively connected to an air intake system 24 and a gaseous phase fuel delivery system 25.

[0042] The injector mounting 50 may be installed on site to reduce the downtime that the engine is offline and minimise disruption. The injector mounting 50 includes a threaded boss 51 having an end 52 cut at an angle of 45°. However, it is to be appreciated that the end 52 of the threaded boss 51 may be cut at other angles to accommodate each particular injector 31 on the intake manifold 22. The end 52 of the threaded boss 51 is welded to the wall of the intake manifold 22 such that a nozzle 53 of the injector (not shown) will point in the general direction of an intake valve 54 in a cylinder 21. A hole 55 is drilled through the wall of the intake manifold 22 inside the threaded
boss 51. The intake manifold 22 may be removed from the engine either before or after drilling and cleaned after drilling to prevent any metal filings from the hole 55 being blown into the cylinder 21.

[0043] FIG. 4 shows a flow diagram of a method 60 of delivering the lubricant to the engine.

[0044] The method 60 commences at step 61 by injecting an atomised portion of liquid phase lubricant into a mixture of gaseous phase fuel and air contained in an intake manifold of the engine. Step 61 preferably occurs immediately prior to or during an intake stroke of the engine.

[0045] Step 62 involves drawing the mixture of gaseous phase fuel and air from the intake manifold into a cylinder of the engine.

[0046] Finally, step 63 involves allowing the atomised liquid phase lubricant to lubricate components of the cylinder prior to burning the mixture of gaseous phase fuel and air in the cylinder.

[0047] In operation, the low pressure pump 37 supplies lubricant from the supply tank 38 to the swirl pot 36. The swirl pot 36 remains fully primed with lubricant to provide the high pressure pump 32 with a constant source of lubricant to prevent cavitation within the supply rail 35 that can result in pressure fluctuations in one or more of the injectors 31. The oil pressure regulator 34 allows the pressure of the lubricant within the supply rail 35 to be controlled and provides a return path for lubricant to return to the swirl pot 36. The cam pickup 43 measures the position of the cam shaft allowing the LCU 41 to determine the timing when each injector 31 should be sequentially fired to deliver the lubricant immediately prior to or during an intake stroke of its respective cylinder 21. The crank pickup 42 measures the speed of rotation of the crankshaft allowing the LCU 41 to determine the duration that each injector 31 should be fired to deliver an amount of lubricant that is required by each cylinder 21 under the engine's current operating parameters. However, it is to be appreciated that other sensors may be used to calculate the appropriate amount of lubricant to be injected at each cylinder 21. Furthermore, the LCU 41 may be connected to the high pressure pump 32 and/or the pressure regulator 34 to monitor and control the pressure of lubricant in the supply rail 35 allowing the portion of lubricant delivered by each injector 31 to be further controlled. The firing of each injector 31 opens a solenoid valve in the injector 31 to allow lubricant to pass through the nozzle 53 and into a mixture of gaseous phase fuel and air contained in the intake manifold 22. As the mixture is drawn into the cylinder 21, the atomised lubricant is allowed to coat the stem of the intake valve and cylinder walls.

[0048] The liquid phase lubricant system dramatically improves the life of 'dry' fuel engines by providing lubrication to the components of the cylinder. The liquid phase lubricant system may also be retrofitted to existing stationary plant engines that have been converted to using 'dry' fuel and the cost of upgrading the engine is relatively cheap without causing major disruption. The invention allows the amount of lubricant delivered to each cylinder to be measured to comply with engine emission standards. For example, a test conducted on a 16-valve 4320 cu. in V-engine running at 1800 rpm found that only 0.2 L to 0.7 L per hour of lubricant is required to keep the cylinders fully lubricated. Furthermore, atomising lubricant in a localised area of the intake manifold adjacent each intake valve before drawing it into each cylinder is more effective than simply adding lubricant to a gas prior to piping it to the engine. When a lubricant is added to the gas, the majority of lubricant may not remain in suspension long enough to reach the cylinders where it is needed. Accordingly, adding the lubricant at a site immediately adjacent where it is needed ensures a majority of lubricant stay in suspension long enough to coat the components of the cylinder. Finally, it is hoped that reduced engine maintenance costs will encourage the use of land fill gas, biogas, methane, natural gas, and other gas products as a viable alternative to using petroleum, coal or nuclear power as a fuel source for the generation of electricity.

[0049] Words such as "comprises" or "includes" are not used to define an exclusive set of elements or method steps. Rather, such words merely define a minimum set of elements or method steps included in a particular embodiment of the present invention.

[0050] The above description of various embodiments of the present invention is provided for purposes of description to one of ordinary skill in the related art. It is not intended to be exhaustive or to limit the invention to a single disclosed embodiment. As mentioned above, numerous alternatives and variations to the present invention will be apparent to those skilled in the art of the above teaching. Accordingly, while some alternative embodiments have been discussed specifically, other embodiments will be apparent or relatively easily developed by those of ordinary skill in the art. Accordingly, this patent specification is intended to embrace all alternatives, modifications and variations of the present invention that have been discussed herein, and other embodiments that fall within the spirit and scope of the above described invention.

1. An internal combustion engine, comprising: an air intake system operatively connected to a cylinder; a gaseous phase fuel delivery system operatively connected to the cylinder; and a liquid phase lubricant injection system operatively connected to the cylinder; wherein during use an atomised portion of liquid phase lubricant is injected into a mixture of gaseous phase fuel and air by the liquid phase lubricant injection system to lubricate components of the cylinder prior to burning the mixture in the cylinder.

2. The internal combustion engine according to claim 1, wherein the liquid phase lubricant system comprises one or more lubricant injectors located in an intake manifold of the engine.

3. The internal combustion engine according to claim 2, wherein the lubricant injector is positioned adjacent an intake valve of the cylinder.

4. The internal combustion engine according to claim 1, wherein the liquid phase lubricant system comprises one or more lubricant injectors located in a cylinder head of the engine.

5. The internal combustion engine according to claim 1, wherein the lubricant injector injects the liquid phase lubricant immediately prior to or during an intake stroke of the engine.

6. The internal combustion engine according to claim 1, wherein the gaseous phase fuel is coal bed methane (CBM), coal mine methane (CMM), abandoned mine methane (AMM), land fill gas, biogas, liquid petroleum gas (LPG), or natural gas.

7. The internal combustion engine according to claim 1, wherein the liquid phase lubricant is a mineral or synthetic oil.
8. A method for lubricating a dry fuel internal combustion engine, the method including the steps of:

i) injecting an atomised portion of liquid phase lubricant into a mixture of gaseous phase fuel and air contained in an intake manifold of the engine;

ii) drawing the mixture into a cylinder of the engine; and

iii) allowing the atomised liquid phase lubricant contained in the mixture to lubricate components of the cylinder prior to burning the mixture in the cylinder.

9. The method of claim 8, wherein step i) occurs immediately prior to or during an intake stroke of the engine.

10. The method of claim 8, wherein the gaseous phase fuel is coal bed methane (CBM), coal mine methane (CMM), abandoned mine methane (AMM), landfill gas, biogas, liquid petroleum gas (LPG), or natural gas.

11. The method of claim 8, wherein the liquid phase lubricant is a mineral or synthetic oil.

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