



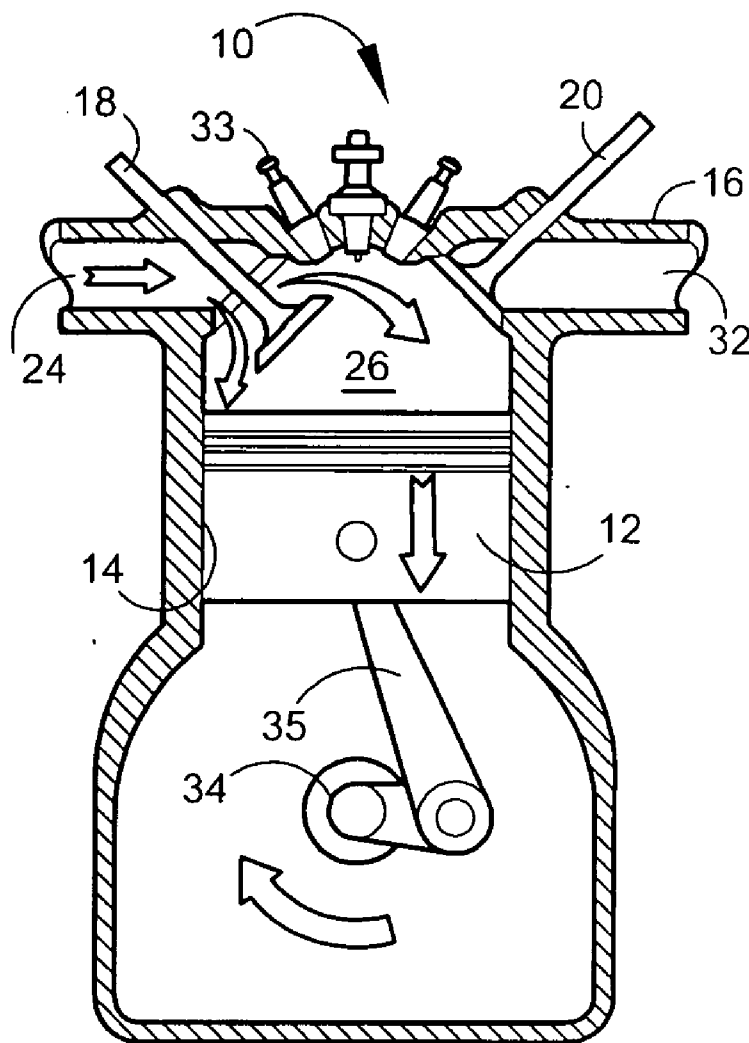
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(19) **United States**(12) **Patent Application Publication**
Crower(10) **Pub. No.: US 2007/0022977 A1**(43) **Pub. Date: Feb. 1, 2007**(54) **METHOD AND APPARATUS FOR
OPERATING AN INTERNAL COMBUSTION
ENGINE****Publication Classification**(51) **Int. Cl.**
F01B 29/04 (2007.01)(52) **U.S. Cl.** **123/25 C**(76) **Inventor: H. Bruce Crower, Jamul, CA (US)**

Correspondence Address:

DONN K. HARMS
PATENT & TRADEMARK LAW CENTER
SUITE 100
12702 VIA CORTINA
DEL MAR, CA 92014 (US)(57) **ABSTRACT**

An internal combustion engine and method of operation employing timed injection of water into the combustion chamber for one or a combination of recapturing waste heat, cooling the engine, and lowering Nox emissions of the engine. The water injection subsequent to the power stroke of the engine employs residual heat and heat conducted from surfaces of the combustion chamber, to form steam to drive a second power stroke. The water injection can also be employed to pre-cool the combustion chamber to avoid formation of Nox gases during fuel combustion and by recapturing residual and conductive heat from the combustion chamber the engine is cooled thereby minimizing or eliminating exterior cooling system requirements.

(21) **Appl. No.: 11/494,090**(22) **Filed: Jul. 26, 2006****Related U.S. Application Data**(60) **Provisional application No. 60/703,394, filed on Jul. 27, 2005.**

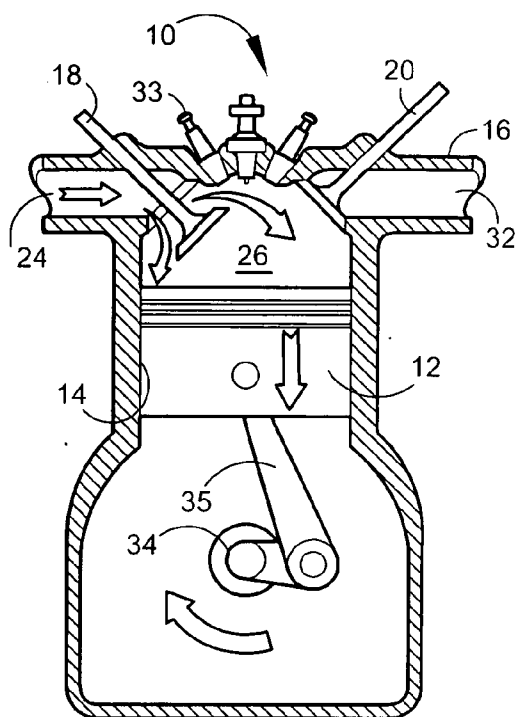


FIG. 1

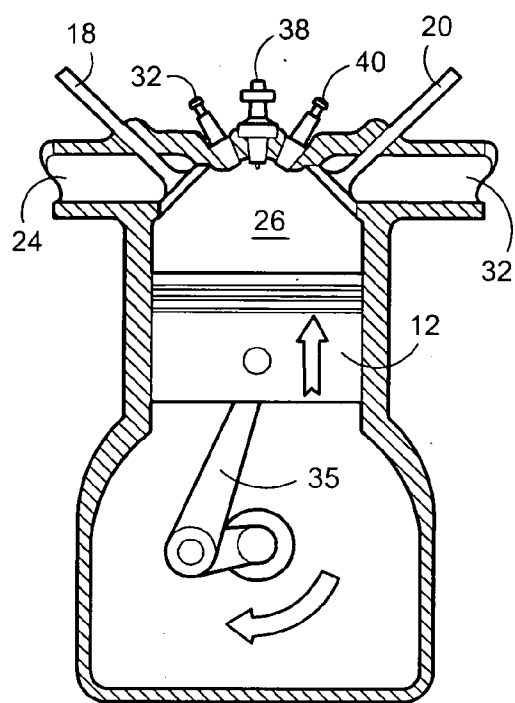


FIG. 2

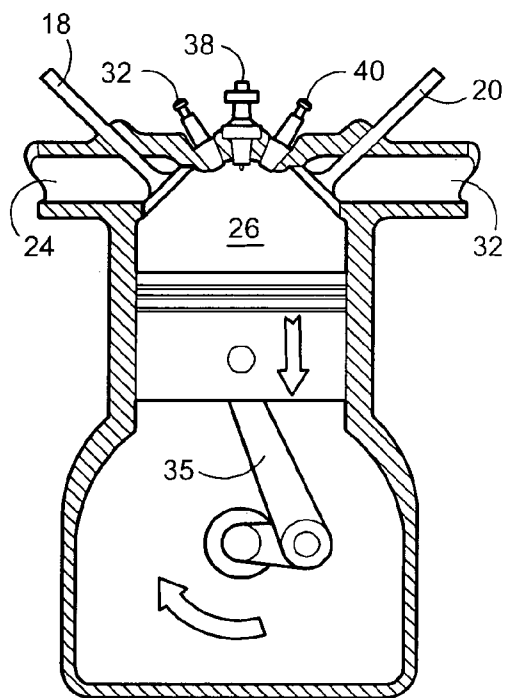


FIG. 3

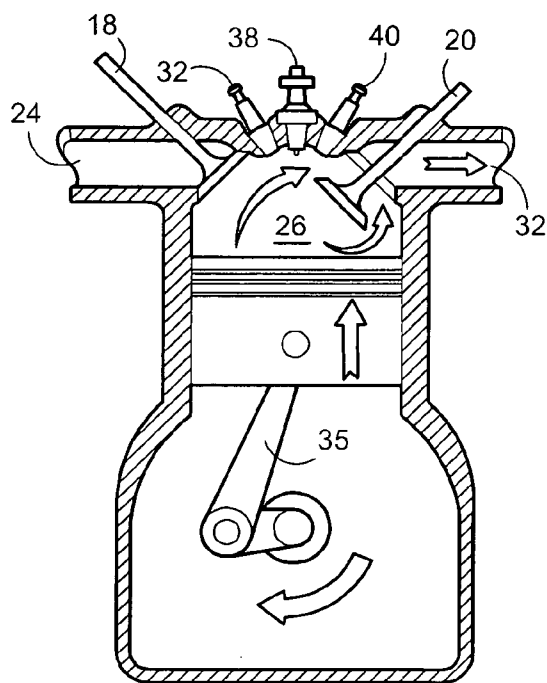


FIG. 4

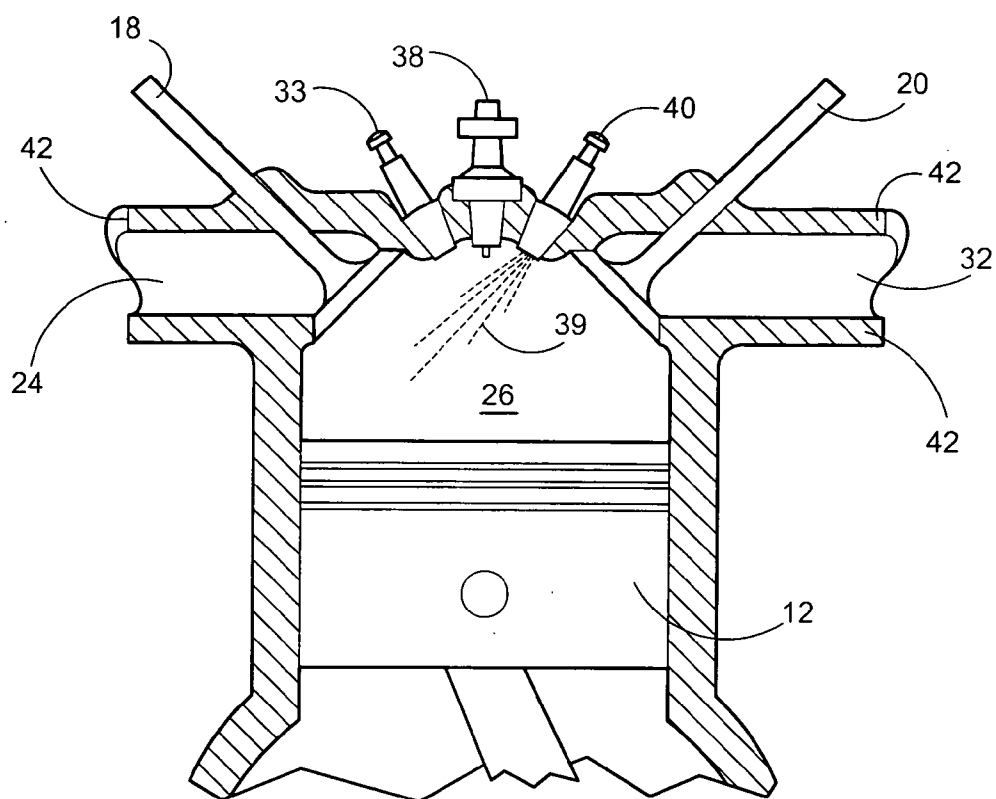


FIG. 5

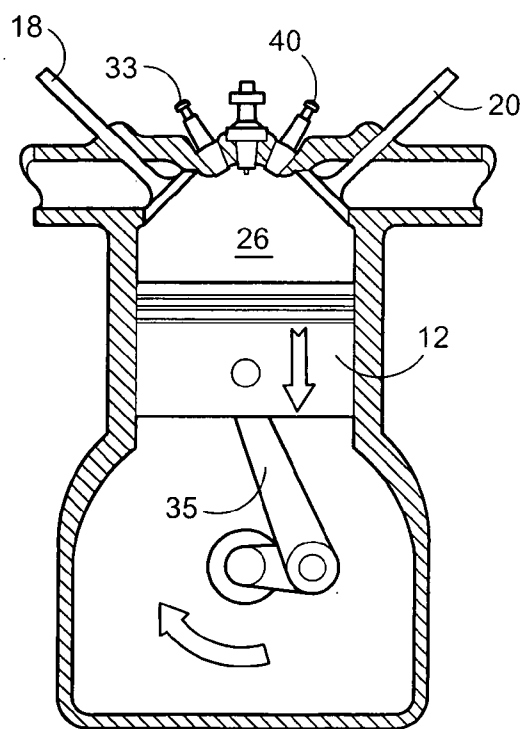


FIG. 6

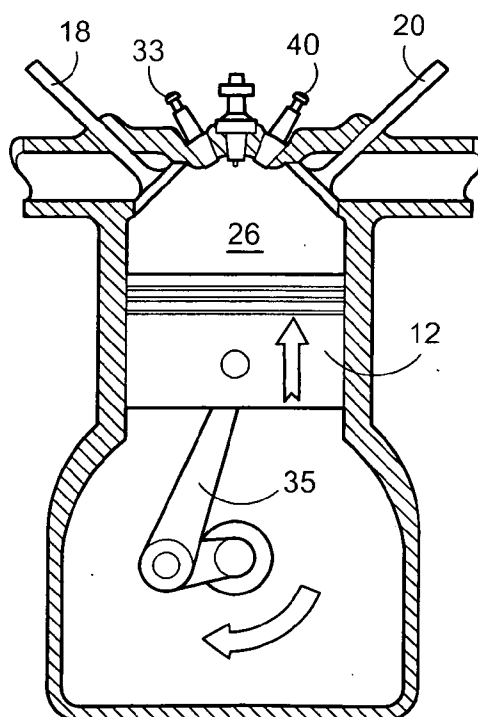


FIG. 7

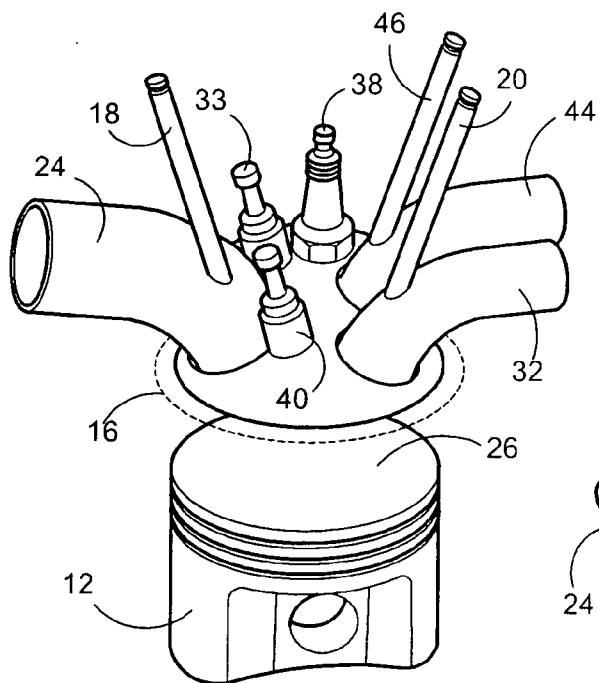


FIG. 8

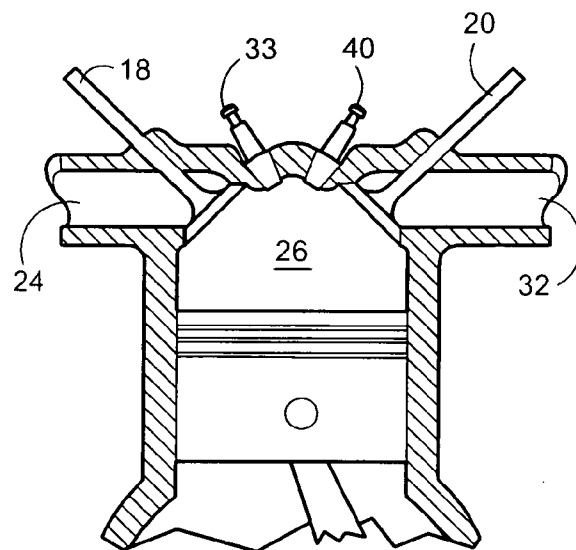


FIG. 9

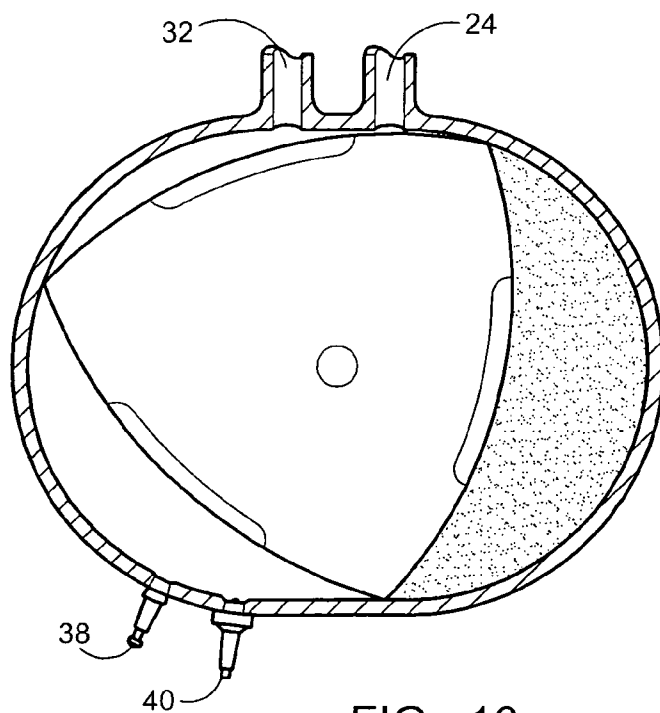


FIG. 10

METHOD AND APPARATUS FOR OPERATING AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This application claims priority from U.S. provisional application Ser. No. 60/703,394, filed Jul. 27, 2005. The present invention relates to internal combustion engines. More particularly it relates to apparatus and method of operation of an internal combustion engine for timed injection of water into a cylinder which can be employed for one or a combination of recapturing waste heat, cooling the engine, and lowering NOX emissions, by providing an extra power stroke to the engine from the expansion of the water into steam which also cools the engine internally. The design and method of operation of the device are suitable for use on any type of internal combustion engine using any type of fuel for the fuel/air mixture be it gasoline, diesel, Wankel, or other engine employing combustion of fuel to produce work from recaptured waste heat as well as a means to internally cool the engine on which it is employed to reduce or eliminate the need for a cooling system and to reduce Nox emissions caused by heated cylinder surfaces. The device may be provided as an engine already incorporating timed and metered water injection during appropriate cycles or can be added to existing internal combustion engines through the addition of parts adapted for such an improvement.

[0003] 2. Prior Art

[0004] The internal combustion engine is a heat engine wherein fuel is burned within a confined space called a combustion chamber. An exothermic reaction of a fuel with an oxidizer occurs and creates gases of high temperature and pressure, which are permitted to expand and move a piston in relation to a cylinder. Such engines provide power to perform by capturing the force of the expanding hot gases acting directly to cause movement of the pistons or rotors communicating with the combustion chamber.

[0005] Internal combustion engines powered by gasoline and diesel fuels are used throughout the world to power vehicles and equipment. Piston type gas and diesel engines reciprocate pistons engaged to crankshafts inside mating cylinders using two or four strokes per cycle of operation. Wankel or rotary engines, are arranged to rotate a triangular piston sequentially around an oval cylinder in a generally four cycle mode of operation.

[0006] Two cycle internal combustion engines generally mix lubricating oil with the gasoline or fuel used and employ only a compression stroke to compress the fuel mixture and a firing stroke subsequent to fuel ignition in the combustion chamber.

[0007] Four cycle piston and rotary engines as a general rule do not mix the lubrication oil with the fuel being burned. Instead, they have a compression stroke to compress a mixture of a fuel and an oxidizer such as air from the atmosphere, a firing stroke subsequent to the mixture being ignited, an exhaust stroke which voids the cylinder of hot gases while lubricating the sidewall, and subsequently an intake stroke to pull in a new volume of air and fuel into the compression chamber. This intake stroke is then followed by a compression stroke of the next cycle of operation.

[0008] Diesel engines operate much the same, however, instead of using a spark plug or other means of ignition of the fuel and air, the diesel ignites the mixture using high compression above the piston in the cylinder.

[0009] Most modern engines employ some mode of fuel injection into the combustion chamber to mix the fuel being used with the oxidizer or air, and older style engines employ a carburetor or throttle body device to mix the fuel and air prior to entry into the combustion chamber. The method and device herein may be employed with any mode of fuel communication to the combustion chamber.

[0010] A constant problem for internal combustion engines is the need to cool the piston, cylinders and cylinder heads, from the constant heat released during the combustion of the fuel inside the combustion chamber. While some smaller engines are air cooled, the majority of larger engines use water or antifreeze fluid to cool the sidewall of the engine block housing the cylinders and the cylinder heads and bleed off what is currently considered waste heat.

[0011] This waste heat, which must be communicated away from the engine, also wastes energy. It is estimated that over half the energy from fuel burned in internal combustion engines is vented as waste heat providing no power for the engine to perform work. Since engine power must generally be employed to move the fluid or air to vent the waste heat, the current mode of operation is doubly inefficient since the lost heat must be pumped or blown away using engine power that could be employed to do work.

[0012] Another problem particularly related to internal combustion engines is Nitrogen oxides, or NOX emissions from the engine. NOX is a generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO₂) along with particles in the air can often be seen as a reddish-brown layer of Smog over many urban areas and acid rain in other areas.

[0013] Nitrogen oxides form when fuel is burned at high temperatures, and a primary manmade source of such emissions into the atmosphere comes from the exhaust gasses of internal combustion engines. In order to reduce smog and acid rain and other environmental problems, the U.S. Government is continually tightening the allowable Nox emissions from internal combustion engines. Currently, Exhaust Gas Recirculation through the combustion chamber is employed to reduce combustion temperatures and thus reduce Nox emissions. However, that strategy has currently been maximized for effect and consequently other means to reduce combustion temperature are needed in the ongoing tightening of exhaust standards limiting such Nox emissions.

[0014] As such, there exists a continuing unmet need for a method and apparatus to recapture a substantial portion of the waste heat produced by conventional internal combustion engines and convert it to increased power resulting in increased work from internal combustion engines. Such a device and method should, in addition to recapturing the heat byproduct of internal combustion engines, concurrently provide cooling to the engine on which it is employed. Ideally such cooling will be provided without the need to tap power from the engine itself to drive fans and pumps thereby

increasing engine efficiency further by eliminating complicated and cumbersome liquid cooling and radiator systems. This elimination or miniaturizing of such cooling systems yields the additional benefit of weight reduction in vehicles powered by internal combustion engines thereby increasing efficiency more.

[0015] It would be additionally desirable if the device and method providing for engine cooling and a recapture of waste heat also provides a means to reduce Nox emissions from the engine on which it is employed. This reduction of Nox emissions yields great benefits to the environment.

[0016] Finally, such a device and method yielding the above benefits should be easily incorporated into internal combustion engine design and operation without substantial modification to conventional design and manufacture standards and components to thereby allow for widespread immediate adoption by manufacturers. This will allow for immediate implementation of the device and method to a wide variety of internal combustion engines to save energy and fuel while concurrently increasing power produced by the engine and reducing Nox and total aggregate emissions from such enhanced engines.

SUMMARY OF THE INVENTION

[0017] The device and method of operation herein described and disclosed, when employed upon a four-stroke engine with one power stroke during each cycle, yields a six-stroke internal combustion engine with an additional power stroke during each six stroke cycle. When adapted for employment upon a two-stroke engine with one power stroke per cycle, it yields an engine with two power strokes per cycle in a similar fashion.

[0018] The device and method is adaptable for operative employment on virtually any type of internal combustion engine to recapture conventionally wasted heat energy communicated to the engine metal and left in the combustion chamber, by the hot exhaust gases. In operation it produces an extra power stroke using that waste heat thereby doubling the power strokes during any cycle of operation on the internal combustion engine.

[0019] Further, the engine cylinders and pistons and cylinder heads, which are conventionally cooled by water or air, pumped by the engine itself, are cooled during this recapture of heat energy by the water injected into the cylinder, thereby limiting or eliminating the need for water or air cooling systems which use engine power to pump cooling fluids through or over the engine. This cooling effect not only saves weight which saps the power of the engine trying to move the weight, it also saves the power formerly taken from the engine to run the cooling system.

[0020] Additionally, the device and method herein can optionally be employed to lower combustion chamber temperatures to provide concurrent reduction in Nox emissions from the engine and help meet and even exceed new government regulations. This is especially true of diesel engines which must meet stringent reductions required by the EPA in 2007 and beyond. Through lessening of fuel used by such engines and lessening of Nox emissions, the device and method provide a great benefit to the environment.

[0021] The device and method of operation of an internal combustion engine, herein described and disclosed employs

direct water injection into the combustion chamber at timed intervals and at a measured volume to both yield an extra power stroke, and if desired, lower combustion chamber temperatures during engine operation to reduce Nox emissions.

[0022] Means for metered communication of water to the combustion chamber at the proper volume and timing is provided by high pressure injectors similar to those used modernly for fuel injection. Electronic fuel injection employs computing devices and sensors on the engine to determine the proper volume and timing of fuel to the combustion chamber. An injector, in communication with the combustion chamber then meters fuel therein to be mixed with air and thereafter ignited to produce an exothermic reaction and force from expanding gases and heat. Fuel injectors atomize the fuel by forcibly pumping it through a small nozzle under high pressure into the combustion chamber.

[0023] The device herein employs fluid injectors to meter the proper amount of fluid into the combustion chamber at the proper timing in an atomized spray therein. The fluid of choice in the current preferred mode of the device is water which may itself be recaptured once injected and turned to steam and then recycled through the fluid injectors again.

[0024] As noted above, the fluid injectors can be adapted for engagement with any type of internal combustion engine burning any fuel and having any number of cycles of each operation of pistons inside a cylinder. The injectors would either be engaged to a high pressure fluid source such as a fluid conduit communicated from a pump, or would internally generate the high pressure spray themselves. The resulting atomized or other spray of water or other fluid, would be communicated into the combustion chamber at precisely the correct moment much the same as fuel injectors time fuel communication. Properly injected into the combustion chamber, the water will turn to steam and expand under pressure to thereby recapture heat from the combustion chamber and surrounding surfaces and produce additional force or work from the engine since the pistons would double their power strokes during any engine cycle.

[0025] In engines having a four-stroke cycle, a first stroke of the cycle pulls air into the cylinder through an opened intake valve and a second stroke compresses the air as the piston advances toward the cylinder head housing the valves. The air communicated to the combustion chamber by this action can either have fuel mixed therein by components exterior to the engine, or, can have fuel injected therein by a fuel injector communicating into the combustion chamber. As the piston approaches the top of the second stroke, the fuel and air mixture is ignited by means of ignition causing an exothermic reaction. In a gasoline type engine, the means for ignition is generally a spark plug whereas in a diesel engine, the means for ignition is the compression of the fuel and air mixture to a point where it self ignites and forces the piston away from the combustion chamber from the exothermic reaction produced by the ignited fuel and air mixture.

[0026] The piston thereafter in a fourth stroke of the cycle advances toward the cylinder head and forces exhaust gases out of the combustion chamber through an open exhaust valve. The disclosed device, in operation, just prior to the peak of the fourth stroke and prior to a fifth receding stroke

of the piston, causes water to be injected into the combustion chamber using the fluid injectors. At this point in time, both the intake and exhaust valves are in a closed position, to seal the combustion chamber formed between the cylinder head, the cylinder, and the top surface of the piston. Water or another fluid those skilled in the art might employ, thereby enters the combustion chamber while it is extremely hot from the previous combustion stroke and is immediately turned to steam which expands inside the closed combustion chamber driving the cylinder downward in a second power stroke or fifth stroke of the cycle, much like the ignition of fuel in the cylinder.

[0027] As the forming steam expands, it also cools the cylinder wall, cylinder head, and piston surface which define the combustion chamber. During a subsequent sixth stroke of the piston toward the cylinder head, a valve is opened to vent the steam from the combustion chamber. This valve can either be the exhaust valve whereby steam is vented to the atmosphere through the exhaust system, or, in a particularly preferred mode of the device, a third valve is provided which provides communication to a water recovery system to recapture the water from the exhausting steam and distal it back to water for reuse in the system.

[0028] Subsequent to the sixth stroke to vent steam from the combustion chamber, a new reciprocal cycle is started wherein the piston moves away from the cylinder head in the first stroke of a new six stroke cycle. Just as noted earlier, this first stroke, provides means to pull air or another oxidizer premixed with fuel or for mixture with fuel inside the combustion chamber. The oxidizer or air is communicated into the combustion chamber through the intake valve which moves to an open position during this intake stroke. Or, air may be pulled into the combustion chamber and means for injection of fuel therein may be employed to create the fuel mixture for ignition.

[0029] As noted, the steam is formed using waste heat left in the combustion chamber and communicated from the wall surfaces of the piston, cylinder, and cylinder head thereby cooling those surfaces. This cooling effect substantially lessens or eliminates the need for air or liquid cooling of the cylinders and cylinder head and the size of the radiator system which must normally be employed to eliminate the heat from the engine. The device and method thus employs the waste heat communicating with the surfaces of the combustion chamber, to create the steam to drive the piston thereby doubling the number of piston power strokes during each cycle. Where previous waste heat from the combustion of fuel and oxidizer was simply absorbed by the liquid cooling system and vented to the atmosphere, using the fluid injection system herein disclosed, a four-stroke engine can be recycled to a six-stroke engine and the waste heat used to do work by driving the piston the extra stroke during each cycle.

[0030] Further, as noted, the fluid injection system and recycling of the herein disclosed, is suitable for adaptation to any type of internal combustion engine whether it be two stroke or four stroke. The disclosed device and method herein will work with any type of fuel being provided to any type of internal combustion engine including but not limited to one or a combination of fuels such as gasoline, diesel, jet fuel, natural gas, LPG, or any other fuel and oxidizer mix used for combustion inside the combustion chamber of an internal combustion engine.

[0031] The device and method of operation of an internal combustion engine herein employs water injection at correctly timed intervals, to yield an additional power stroke to the engine. The method and components of the device can also be employed as a means for internal cooling of a conventional internal combustion engine, or to cool a highly turbo charged engine which due to the pressure boost in the oxidizer and increased fuel in the mix, tends to burn hotter. As a method providing a means for internal cooling, water is injected into the cylinder after the normal exhaust of hot waste gases to the turbo boost system. In any type of internal combustion engine, the timed and metered water injection directly into the combustion chamber not only provides an extra power stroke, it would also aid in cooling the conventional or turbo charged engines.

[0032] Additionally, because injection of water into the combustion chamber yields such an efficient means to recapture wasted heat energy for work production and remove heat from the metal surfaces of the combustion chamber, even more waste heat can be captured for work using the disclosed device and method by altering engine block and head cooling operation of the engine. Normally, water jackets are formed in the cylinder head and adjacent to cylinder walls, as a conduit for pumped fluid used to cool those components. However, since the employment of fluid injection to form steam for a second power stroke, is so effective at cooling the engine, it may be desirable to capture heat from the exhaust vented from the combustion chamber after the combustion of fuel and oxidizer therein. These extremely hot gases are currently vented to the atmosphere. However, if they were vented into conduits such as the water jackets communicating through the cylinder head, the heat from the exhaust would be communicated to the cylinder head. While not desirable on conventional engines, by heating the cylinder head to a hotter peak temperature before injection of water by the disclosed device, even more waste heat is provided to the surfaces of the combustion chamber for recapture as steam to drive the second power stroke in the engine. Therefore, an optionally preferred mode of the device, would vent the exhausting gases through the open exhaust valve through conduits formed in the cylinder head and adapted to cause heat from the exhaust to be absorbed by the cylinder head. Thereafter, the resulting steam would have more waste heat for recapture from the higher temperature cylinder head. Of course Nox emissions would also be lessened by the aforementioned short water injection during the compression stroke of the fuel and oxidizer mix.

[0033] As also noted above, the device and method herein can be employed to provide a means for reduction of Nox emission from the exhaust from internal combustion engines. The same fluid injectors and timing system providing means for metered communication of fluid such as water to the combustion chamber to form steam, can communicate a small amount of water, directly into the combustion chamber during the fuel/oxidizer compression stroke. When injected just prior to the mixture being ignited by a spark plug or compression, a significant reduction in surface temperatures of the surface forming the combustion chamber can be achieved thereby significantly reducing Nox exhaust emissions.

[0034] With respect to the above description, before explaining at least one preferred embodiment of the herein disclosed invention in detail, it is to be understood that the

invention is not limited in its application to the details of construction and to the arrangement of the components in the following description or illustrated in the drawings. While the invention and method have been described in operation in a conventional four cycle engine operation, they can be employed just as easily in a two-stroke engine operation and such is anticipated. Further, while operationally described using an igniter such as a spark plug for ignition, the device works equally well where the mode of ignition is compression alone as on diesel engines. Further, the invention herein described is capable of other embodiments and of being practiced and carried out in various ways which will be obvious to those skilled in the art. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

[0035] As such, those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present disclosed device. It is important, therefore, that the claims be regarded as including such equivalent construction and methodology insofar as they do not depart from the spirit and scope of the present invention.

[0036] It is an object of this invention to provide a method of operation of an internal combustion engine wherein water is injected into its combustion chamber to power a second power stroke during the cycle of the internal combustion engine.

[0037] It is another object of this invention to provide a method of operation of an internal combustion engine wherein water is injected into its combustion chamber to provide a means to recapture wasted heat energy from the engine and convert it to power.

[0038] It is a further object of this invention to provide a method of operation of an internal combustion engine wherein water is injected into its combustion chamber to provide a means for internal cooling of the engine.

[0039] It is another object of this invention to provide an internal combustion engine having means for water injection into a combustion chamber which provides a timed and metered fluid flow to form steam therein to power a second power stroke during the cycle of an internal combustion engine.

[0040] It is a further object of this invention to provide an internal combustion engine with a water injection system adaptable to employment on any internal combustion engine to recapture previously wasted heat from the combustion chamber to do work thereby increasing engine efficiency and power.

[0041] It is another object of this invention to provide such a device and method to employ steam to drive a second power stroke on an engine cycle which will also lessen or eliminate the need for air or fluid cooling of the engine.

[0042] It is a further object of this invention to provide such an engine operation design that will be easily adapted and employed at existing manufacturing plants and factories producing internal combustion engines.

[0043] It is an additional object of this invention to provide an engine and method of operation of an internal

combustion engine, that is adaptable to any type of internal combustion engine using any number of cycles and any type of fuel to produce a second power stroke from a timed water injection and cool the engine.

[0044] An additional object of this invention is to provide an engine design and method of operation that may be retrofitted to currently existing four stroke and two stroke engines.

[0045] Yet another object of this invention is the provision of such a device using water to generate a second power stroke with steam that also may be employed to lower the combustion chamber temperature during combustion of fuel and oxidizer to thereby provide means for reduction of Nox emissions from the engine.

[0046] A still further object of this invention is a method of operation and device to recapture waste heat from exhaust gases by communicating them into the surfaces of the engine by venting exhaust gases through conduits which conduct heat into those surfaces thereby providing additional waste heat for recapture through steam formation for a second drive stroke during each engine cycle.

[0047] Further objects of the invention will be brought out in the following part of the specification, wherein a detailed description is for the purpose of fully disclosing the invention without placing limitations thereon.

BRIEF DESCRIPTION OF DRAWING FIGURES

[0048] FIG. 1 depicts a side view of a piston at an upper position in the cylinder during an intake stroke wherein fuel and air are communicated into the combustion chamber.

[0049] FIG. 2 is a side view of the piston during an upward compression stroke inside the cylinder to compress the fuel and air mixture.

[0050] FIG. 3 depicts a side view of the piston in a first power stroke subsequent to ignition of the mixture of fuel and oxidizer in the combustion chamber.

[0051] FIG. 4 shows the piston traveling toward the cylinder head subsequent to the end of the first power stroke of FIG. 3 with the exhaust valve open to vent exhaust gasses.

[0052] FIG. 5 depicts the cylinder at or just prior to top dead center of the exhaust stroke and all valves communicating with the combustion chamber closed wherein water is injected into the combustion chamber.

[0053] FIG. 6 shows the downward travel of the piston in the cylinder of a second power stroke in the cycle powered by steam formed in the combustion chamber.

[0054] FIG. 7 depicts the beginning of the final upward stroke of the cycle wherein the steam will be exhausted from the combustion chamber through the exhaust port to the atmosphere or through a separate steam exhaust port and through a condenser to allow reuse of the water.

[0055] FIG. 8 shows an embodiment of the device having three valves communicating through the cylinder head thereby providing a separate steam exhaust port and communicating conduit for exhausting steam for recapture and reuse.

[0056] FIG. 9 depicts a diesel cylinder having direct fuel injection and the device engaged to communicate a metered amount of water to the combustion chamber.

[0057] FIG. 10 shows the device engaged on a rotary type engine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

[0058] As shown in FIGS. 1-10 the device employs a novel manner to both cool and increase the power and economy of an internal combustion engine through a recapture of waste heat. In FIG. 1 there is shown a side sliced view of a piston 12 positioned toward an upper position in the cylinder 14 adapted for reciprocated engagement with the piston 12. During a conventional intake stroke of a two or four-cycle engine, the piston 12 moves away from the cylinder head 16 which provides the engagement point for the intake valve 18 and the exhaust valve 20. The intake valve translates to open and close the valve head portion 21 in a seat 22. The intake valve 18 thus controls communication of the intake manifold 24 with the combustion chamber 26. Likewise the exhaust valve 20 translates to engage and disengage a head portion 28 with an exhaust seat 30 and control communication of the combustion chamber 26 with the exhaust manifold 32.

[0059] Conventionally, fuel is communicated to the combustion chamber through the intake manifold 24 with the oxidizer such as air, or through a means for injection of fuel to the combustion chamber 26 such as fuel injector 33. The device 10 and method herein anticipate all such means for communication of fuel into the combustion chamber and any fuel that may be employed including but not limited to gasoline, diesel, natural gas, hydrogen, or other fuels employed to produce the explosion in the combustion chambers of internal combustion engines. In most reciprocating internal combustion engines a rod 35 is operatively engaged between the piston 12 and a crankshaft 34 to convert the reciprocating motion of the piston 12 to rotational motion for work.

[0060] Upon completion of the intake cycle of the piston 12 a compression cycle is provided wherein the piston 12 moves toward the cylinder head 16 in a compression stroke of the piston cycle to compress the fuel and air mixture communicated to the combustion chamber 26 in the upper end of the cylinder 14 adjacent to the cylinder head 16. This is shown in FIG. 2 wherein the piston 12 is moving toward the cylinder head 16 compressing the volume of the combustion chamber 26. During this cycle, the intake valve 18 and exhaust valve 20 are seated thereby sealing the combustion chamber 26.

[0061] The compressed air and fuel mixture is ignited once the piston 12 reaches a point sufficiently close to the cylinder head 16 to compress the fuel mixture thereby producing heat and force from the exothermic reaction. Means for ignition of the fuel mixture in most gasoline engines is provided by a spark plug 38 and in most diesel type engines by compression itself. Rotary engines such as the Wankel, while not depicted herein, function much the same as a reciprocating piston engine shown in that there are conventional four cycles to the piston and as such, the device 10 and method herein may be deployed upon a rotary engine also.

[0062] Upon ignition of the fuel mixture as shown in FIG. 3 the piston 12 travels in a direction away from the cylinder

head 16 in a first power stroke using the force of the fuel ignition to force the piston 12. Thereafter as shown in FIG. 4 the piston 12 will travel toward the cylinder head 16 and the exhaust valve 20 will open and provide communication between the combustion chamber 26 and the exhaust manifold 32 to vent the exhaust gases from the combustion chamber 26.

[0063] It is at this point the device 10 and method disclosed herein, provide utility to the user in the form of a second power stroke of the piston 12 during the cycle of piston reciprocation inside the cylinder 22. As shown in FIG. 5, once the exhaust has been vented from the combustion chamber 26, both the intake valve 18 and exhaust valve 18 move to the closed position thereby sealing the combustion chamber 26. With the piston 12 at, or just past, top dead center, water 39 or another fluid adapted to turn to steam, is communicated to the hot combustion chamber 26 using means for metered communication such as fluid injector 40.

[0064] It should be noted that the combustion chamber 26 during the metered injection of fluid therein to form steam, may be pressurized through piston compression of exhaust gases in a fashion similar to that noted earlier for the fuel mixture, or, it can be unpressurized as shown in FIG. 5, subsequent to venting of the exhaust gases depicted in FIG. 4. The current favored mode of the operation of the device 10 vents the exhaust as shown in FIG. 4 and then communicates fluid to the compression chamber 26. However, closing both valves 18 and 20 during the stroke shown in FIG. 4, will allow for the very hot exhaust gases to stay in the compression chamber 26 under pressure when the liquid is communicated therein, increasing the heat that might be recaptured. Currently, experimentation has shown that venting the gases and communicating fluid to the combustion chamber 26 to turn to steam, to be the most preferred mode of operation.

[0065] The rapid expansion of the steam in the combustion chamber 26, once the water 39 is communicated thereto, provides a second power stroke to the reciprocation cycle of the piston 12 which is shown in FIG. 6. This extra or second power stroke doubles the number of power strokes during the reciprocal cycle of the piston 12 and energy for this second power stroke is provided by waste heat which is normally transmitted out of the cylinder through coolant in passages 42 running through the engine and cylinder head 16. Thus, the device 10 and method capture this waste heat to make steam to drive the piston 12 through the extra power stroke of the reciprocal cycle. Further, making steam from the communicated water 39 provides means to cool without an external radiator or fan or pump to move fluid or air through the device to cool it.

[0066] Once the piston 12 completes the second power stroke of the cycle, it will move toward the cylinder head 16 in a final stroke of the cycle to vent the steam from the combustion chamber 26. As depicted in FIG. 7, where only intake and exhaust manifolds are employed, the steam would be vented through the exhaust manifold 32 when the exhaust valve 20 opens.

[0067] However, in a particularly preferred mode of the device 10 shown in FIG. 8, a steam exhaust conduit 44 would communicate with the intake manifold 26. A reciprocating third valve 46 would operate in the same fashion as the intake valve 18 and exhaust valve 20 by engaging

between an open position and closed position. In this embodiment employing the third valve 46, during the final stroke of the cycle, the piston 12 moves toward the cylinder head 16 wherein the third valve 46 will open and allow the steam in the combustion chamber 26 to be vented to the steam exhaust conduit 44. Also in this preferred mode of the device, the steam exhaust conduit 44 will communicate the steam to a cooling chamber or other means to cool the steam and change it back to water which will be recycled and used to supply the fluid injector 40.

[0068] The fluid injector 40 would either generate its own pressure to inject the fluid into the combustion chamber 26 or will be in sealed communication with a pressurized fluid supply which will draw the fluid from an onboard reservoir. Steam recaptured through the steam exhaust conduit 44 and cooled will become reclaimed water thereafter communicated back to the reservoir. By recycling the water when the device 10 is employed on an automobile or other device which moves, a smaller water supply is required than if the steam is simply ejected into the atmosphere through the exhaust manifold 32 as noted earlier as the other mode of operation of the device 10. However, if the size of the water supply is not an issue or the engine is stationary and need not carry a supply of water to generate steam, then the two valved embodiment may be sufficient for the user. Consequently while the third valve 46 mode of the device is more preferable, either mode of operation will still provide the benefits of heat recapture of formerly wasted heat from an internal combustion engine.

[0069] Also, the depiction in FIG. 8 shows both a fuel injector 33 and a fluid injector 40 and consequently only air would be drawn through the intake manifold 24 in this mode of operation of the device. However, the means to communicate fuel into the combustion chamber, as noted above, might also be through the intake manifold 24 in a carbureted or throttle body injection type system, and the fuel injector 33 may not be required for the device to still yield the recapture of waste heat for energy.

[0070] Additionally, the depictions of the drawings show a piston driven engine which employs a spark plug 38 as the means for ignition of the fuel mixture. As noted above, the spark plug 38 would not be required for the device 10 when employed on a diesel engine which uses compression as a means for ignition of the fuel mixture. Still further, the drawings and explanation of operation above, discuss the device 10 and method employed with a four cycle engine with four reciprocating strokes of the piston 12 and when employed, yield the extra power stroke using waste heat. However, the device and method can just as easily be employed with a two-cycle engine changing it to a two-cycle engine with an extra power stroke by communicating water or other liquid into the combustion chamber of the two cycle engine on the stroke of the piston 12 subsequent to the fuel being ignited by a spark plug 38. This would yield the second power stroke in the cycle using waste heat to provide the power to move the piston 12.

[0071] In another optional mode of the device 10, additional waste heat can be captured for use to generate steam from water 39 communicated into the combustion chamber 26 by venting the exhaust gases into passages 42 formed internally in the cylinder head 16. Conventionally these passages 42 provide a fluid conduit for the cooling system to

pump fluid therethrough for cooling. However, since the device 10 cools the combustion chamber 26 and surrounding metal components in making the steam to recapture waste heat, the passages 42 may be employed to communicate hot exhaust gases into the metal parts forming the cylinder 16 and cylinder head 16 to heat them. This would store the heat from the hot exhaust gases in the metal parts of the engine and allow it to be additionally reclaimed by the device 10 to generate steam making the resulting engine even more efficient.

[0072] Finally, singularly or in combination with steam generation and waste heat recapture, the device 10 and method of operation of an internal combustion engine herein may be employed to provide a means for cooling combustion chamber surface temperatures during burning of the fuel mixture to thereby provide means for reduction of Nox emissions in the exhaust gases from the combustion chamber 26. When employed for this additional utility, the fluid injectors 40 will provide a timed metered communication of fluid such as water 39 to the combustion chamber 26 during the fuel/oxidizer compression stroke. When injected just prior to the fuel mixture being ignited by a spark plug or compression, a significant reduction in surface temperatures of the cylinder head 16 and other surface forming the combustion chamber 26 is achieved to significantly reducing Nox exhaust emissions from internal combustion engines and especially diesel engines. An additional water supply may be necessary when this extra injection of water is employed since it will be exhausted with the exhaust gases.

[0073] As noted above, the engine may be manufactured as a new component with the appropriate fuel intake means and water injection means engaged with each cylinder. The engine would employ the water injection noted above for any of the noted objects of waste heat recapture, internal cooling, or Nox reduction. Or, it is envisioned that existing internal combustion engines may be retrofitted through the addition of fluid injectors to inject water into each cylinder and a control means to control the timing thereof to produce an extra power stroke. In a retrofit, the timing of the valve opening and closing of the cylinder would also be adjusted to provide the steam stroke and/or Nox reduction, and/or internal cooling in the above described manner.

[0074] While all of the fundamental characteristics and features of the method of operation of an internal combustion engine to recapture waste heat as steam and internally cool the engine, as well as an internal combustion engine apparatus having these qualities of operation, have been shown and described herein, with reference to particular embodiments thereof, a latitude of modification, various changes and substitutions are intended in the foregoing disclosure and it will be apparent that in some instance, some features of the invention may be employed without a corresponding use of other features without departing from the scope of the invention as set forth. It should also be understood that various substitutions, modifications, and variations may be made by those skilled in the art without departing from the spirit or scope of the invention. Consequently, all such modifications and variations and substitutions are included within the scope of the invention as defined by the following claims.

What is claimed is:

1. An internal combustion engine having a plurality of strokes of a piston during a cycle of operation, comprising:

at least one piston reciprocating inside of a cylinder;

said piston having an intake stroke;

means to communicate a fuel and an oxidizer into said cylinder;

said piston having a compression stroke whereby said fuel and oxidizer are compressed in a fuel mixture in said combustion chamber;

means to ignite said fuel mixture;

said piston having a first power stroke during said cycle of operation caused by ignition of said fuel mixture;

said piston having an exhaust stroke subsequent to said first power stroke;

means to communicate water directly into said combustion chamber subsequent to commencement of said exhaust stroke whereby steam is formed in said combustion chamber from a said water; and

said piston having a second power stroke during said cycle of operation caused by expansion of said steam.

2. The internal combustion engine of claim 1 additionally comprising:

said piston having a second exhaust stroke during said cycle of operation whereby said steam is purged from said compression chamber to a steam exhaust conduit;

said steam exhaust conduit communicating with a means to condense said steam to form reclaimed water therefrom; and

means to communicate said reclaimed water to a reservoir supplying said water to said means to communicate water directly into said combustion chamber.

3. The internal combustion engine of claim 1 additionally comprising:

said means to communicate water substantially directly into said combustion chamber subsequent to commencement of said exhaust stroke using residual heat energy communicated from combustion chamber to convert said water to steam thereby additionally providing means to cool said engine internally through elimination of residual heat energy.

4. The internal combustion engine of claim 1 additionally comprising:

said means to communicate water directly into said combustion chamber having a second water communication cycle; and

said second water communication cycle communicating water into said combustion chamber immediately prior to said ignition of said fuel mixture; and

said water thereby providing means for reduction of NOx exhaust gases from said engine by preventing overheating of surfaces defining said combustion chamber.

5. An internal combustion engine comprising:

a cylinder, a cylinder head, and a piston reciprocating in said cylinder, and a combustion chamber defined by said cylinder head, said cylinder said piston;

a fuel injection device for injecting fuel directly into the combustion chamber,

means to ignite said fuel and cause a combustion thereof;

said combustion communicating a force to said piston causing a first power stroke of said piston;

a water injection device for communicating a water injection directly into said combustion chamber subsequent to said combustion to thereby produce steam from said water injection and residual heat in said combustion chamber; and

said steam communicating a second force to said piston said second force causing a second power stroke of said piston.

6. An internal combustion engine comprising:

a cylinder, a cylinder head, and a piston reciprocating in said cylinder, and a combustion chamber defined by surfaces of said cylinder head, said cylinder said piston;

a fuel injection device for injecting fuel directly into the combustion chamber,

means to ignite said fuel and cause a combustion;

said combustion causing a first power stroke of said piston;

a water injection device for communicating a portion of water directly into said combustion chamber;

said portion being injected in a timed injection;

said timed injection immediately prior to said combustion; and

said portion providing means to reduce a rise in temperature of said surfaces from heat from said combustion, thereby providing means to reduce Nitrogen oxides exhausted from said combustion chamber.

7. The internal combustion engine of claim 6 wherein:

said timed injection being injected after said combustion;

said portion being converted to steam by residual heat in and conductive to said combustion chamber; and

said steam providing a second power stroke to said engine.

8. The internal combustion engine of claim 6 wherein:

a second said portion being injected after said combustion;

said second portion being converted to steam by residual heat in said combustion chamber; and

said steam providing a second power stroke to said engine.

9. The internal combustion engine of claim 7 additionally comprising:

said piston having a steam exhaust stroke after said second power stroke whereby said steam is purged from said compression chamber to a steam exhaust conduit;

said steam exhaust conduit communicating with a means to condense said steam to form reclaimed water therefrom; and

means to communicate said reclaimed water to a reservoir supplying said water to said water injection device.

10. The internal combustion engine of claim 8 additionally comprising:

said piston having a steam exhaust stroke after said second power stroke whereby said steam is purged from said compression chamber to a steam exhaust conduit;

said steam exhaust conduit communicating with a means to condense said steam to form reclaimed water therefrom; and

means to communicate said reclaimed water to a reservoir supplying said water to said water injection device.

11. The internal combustion engine of claim 5 additionally comprising

passages formed in at least said cylinder head; and

said exhaust stroke of said piston venting at least a portion of exhaust gases formed by ignition of said fuel mixture into said passages, whereby said cylinder head is increased in temperature by conduction of heat from said exhaust gases, thereby providing an increase in said residual heat available in said combustion chamber to form said steam.

12. The internal combustion engine of claim 5 additionally comprising

said piston having an exhaust stroke subsequent to said first power stroke whereby gases formed by said combustion are vented from said combustion chamber;

passages formed in at least said cylinder head; and

said exhaust stroke of said piston venting at least a portion of said gases formed by said combustion into said passages, whereby said cylinder head is increased in temperature by conduction of heat from said gases, thereby providing an increase in heat energy conductive from said cylinder head to said combustion chamber to form said steam.

13. The internal combustion engine of claim 7 additionally comprising

said piston having an exhaust stroke subsequent to said first power stroke whereby gases formed by said combustion are vented from said combustion chamber;

passages formed in at least said cylinder head; and

said exhaust stroke of said piston venting at least a portion of said gases formed by said combustion into said passages, whereby an increase in temperature is imparted to said cylinder head by a conduction of heat from said gases, thereby providing an increase in heat energy conductive from said cylinder head to said combustion chamber to form said steam.

14. The internal combustion engine of claim 8 additionally comprising

said piston having an exhaust stroke subsequent to said first power stroke whereby gases formed by said combustion are vented from said combustion chamber;

passages formed in at least said cylinder head; and

said exhaust stroke of said piston venting at least a portion of said gases formed by said combustion into said

passages, whereby an increase in temperature is imparted to said cylinder head by a conduction of heat from said gases, thereby providing an increase in heat energy conductive from said cylinder head to said combustion chamber to form said steam.

15. A method of operating an internal combustion engine having at having at a cylinder, a cylinder head, and a piston reciprocating in said cylinder, a combustion chamber defined by surfaces of said cylinder head, said cylinder said piston; a fuel injection device, an ignition device; and a water injection device, to achieve a second power stroke of said engine from steam, comprising the steps of:

activating said fuel injection device to communicate fuel into said combustion chamber;

activating said ignition device to ignite said fuel to cause a combustion resulting power stroke of said piston; and

subsequent to said power stroke of activating said water injection device to communicate water into said combustion chamber whereby steam is formed resulting in a steam-powered second power stroke.

16. The method of claim 15 including the additional steps of:

activating said water injection device to communicate water into said combustion chamber just prior to said second step, whereby combustion chamber temperatures are lowered subsequent to said combustion.

17. The method of claim 15 including the additional steps of:

venting gases formed by said combustion into conduits formed in said cylinder head; and

allowing said gases to increase cylinder head temperature whereby available heat energy to form said steam is recaptured from said gases.

18. The method of claim 15 employed upon an engine not having a water injection device communicating with said combustion chamber comprising the additional step of:

installing said water injection device in operative communication with said combustion chamber.

19. The method of claim 15 including the additional steps of:

reducing or eliminating external cooling of said engine by an engaged cooling system; and

allowing said water communicated by said water injection device, to internally cool said engine.

20. The internal combustion engine of claim 5 additionally comprising:

a turbo charger engaged to an air intake conduit communicating with said combustion chamber, said turbo charger communicating a pressurized air supply to said combustion chamber;

said fuel injection device injecting said fuel in an increased fuel volume to form a fuel mixture relative to said pressurized air supply; and

said water injection device adapted to provide said water injection at a timing and a volume to internally cool said combustion from an increased temperature caused by said pressurized air supply and fuel.