Title:

REVERSE UNIFLOW TWO-STROKE TURBOCHARGED DIESEL ENGINE

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Abstract:
A two-cycle turbocharged diesel engine. The engine includes one or more cylinder sleeves (12) mounted within a block (22). A cylinder head (30) encloses and seals the top of the cylinder sleeves (12) and pistons (14) are reciprocally mounted in each cylinder sleeve (12). Inlet air passes through the compression section of a turbocharger (26), an inlet port (90) in the cylinder head (30), and an inlet valve (44) into a combustion chamber (84). Fuel is injected (32) into the combustion chamber (84) and ignited. The combustion by-products flow out of the combustion chamber (84) through exhaust ports (82) located radially around the sides of the cylinder sleeves (12) and are collected by a collector ring (66) that surrounds the exhaust ports (82). The collector ring (66) directs the flow of combustion by-products through a collection manifold (72) that, in turn, directs the flow through the turbine section (96) of the turbocharger.

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Claims:
The embodiments ofthe invention in which an exclusive property or privilege is claim

1. ed are defined as follows: A twostroke internal combustion engine comprising: an engine block; a piston cylinder located within the engine block, the piston cylinder including a plurality of exhaust ports located around the periphery of the sides of the piston cylinder and extending through the sides ofthe piston cylinder; a cylinder head located at the top of the piston cylinder and forming a seal with the top of the piston cylinder, the cylinder head including an inlet port through which inlet air may flow into the piston cylinder; a reciprocating inlet valve mounted in the inlet port and movable between an open position in which the inlet valve allows air to flow through the inlet port into the piston cylinder and a closed position in which the inlet valve prevents air from flowing through the inlet port into the piston cylinder, the inlet port being the only opening through which inlet air enters the piston cylinder; a piston reciprocally mounted within the piston cylinder so that as the piston nears the bottom of its stroke within the piston cylinder, it opens the exhaust ports to allow combustion byproducts within the piston cylinder to flow out of the exhaust ports and so that as the piston moves on its upward stroke within the piston cylinder, the piston closes the exhaust ports; a fuel injection system mounted in the cylinder head to inject fuel into the interior ofthe piston cylinder; and a turbocharger having a compression section connected to the inlet port and a turbine section connected to the exhaust ports, wherein, during operation of the engine, the compression section of the turbocharger forces air into the inlet port, the inlet valve moving to its open position during the downward stroke ofthe piston after the piston has at least partially opened the exhaust ports, to allow air to flow into the top of the cylinder, thereby forcing combustion byproducts downward out of the cylinder through the exhaust ports, the combustion byproducts flow out of the exhaust ports into the compression section of the turbocharger thereby driving the turbocharger and wherein the inlet valve moves to its closed position during the upward stroke of the piston after the piston has closed the exhaust ports and wherein the fuel injection system injects fuel into the cylinder during the upward stroke of the piston, the fuel and air within the cylinder being ignited near the top of the piston's stroke, thereby driving the piston downward.
2. The engine of Claim 1, further comprising; a valve spring coupled to the inlet valve and biasing the inlet valve into the closed position; and a rocker arm rotatably coupled to the cylinder head, one end of the rocker arm being in contact with the inlet valve, the other end ofthe rocker arm being coupled to an assist spring, the assist spring and valve spring working together to resist a rotation of the rocker arm that causes the inlet valve to move from the closed position to the open position.
3. The engine of Claim 2, wherein the assist spring is mounted within a receptacle in the cylinder head and is maintained within the receptacle by a removable spring retainer such that removal of the spring retainer allows the assist spring and a push rod and a cam follower to be removed through the receptacle without removing the cylinder head.
4. The engine of Claim 1, further comprising a collector ring having a centrally located hole that allows the collector ring to be slid over the piston cylinder so that the collector ring surrounds and encloses the exhaust ports, and wherein the collector ring is thermally isolated from the structure ofthe engine block to reduce the amount of heat transfer between combustion byproducts exiting the exhaust ports and flowing through the collector ring and the structure ofthe engine block.
5. The engine of Claim 4, wherein the collector ring is maintained in place around the piston cylinder through the use of a support cylinder that surrounds the piston cylinder so as to leave a gap between the piston cylinder and the support cylinder, the upper edge of the support cylinder contacting and maintaining the collector ring in place, the lower edge of the support cylinder being coupled to the

engine block.

6. The engine of Claim 4, wherein the collector ring is maintained in place through the use of at least one threaded cylindrical nut, the threaded cylindrical nut being threaded onto the piston cylinder adjacent the collector ring in order to maintain the collector ring in position.
7. The engine of Claim 4, further comprising a cylindrical wedge that is placed between the edge ofthe collector ring and the piston cylinder, the wedge being driven between the collector ring and the piston cylinder through the use of the threaded cylindrical nut in order to maintain the collector ring in place around the piston cylinder.
8. The engine of Claim 1, fiirther comprising a piston rod and a piston pin, the piston rod being rotatably attached to the piston pin and the piston pin being attached to the interior ofthe piston without forming holes in the sides ofthe piston.
9. A twostroke internal combustion turbocharged engine comprising an engine block; a piston cylinder located within the engine block, the piston cylinder including a plurality of exhaust ports located around the peripheral sides of the piston cylinder and extending through the piston cylinder; a piston reciprocally mounted within the piston cylinder so that as the piston nears the bottom of its stroke it opens the exhaust ports to allow combustion by¬ products to flow out of the exhaust ports and so that as the piston moves upward within the cylinder, it closes the exhaust ports; a cylinder head located at the top of and forming a seal around the top of the piston cylinder, the cylinder head including an inlet port through which inlet air may flow into the piston cylinder; a reciprocating inlet valve mounted in the inlet port and movable between an open position in which the inlet valve allows air to flow through the inlet port into the piston cylinder and a closed position in which the inlet valve prevents air from flowing through the inlet port into the piston cylinder; a rocker arm rotatably coupled to the cylinder head, one end ofthe rocker arm being in contact with the inlet valve; a push rod having opposing ends, one end of the push rod being in contact with the end ofthe rocker arm opposite the inlet valve, the other end of the push rod including a cam follower that contacts and follows a lobe on a cam; a valve spring coupled to the inlet valve to bias the inlet valve into the closed position; and an assist spring coupled to the cylinder head and the end of the rocker arm opposite the inlet valve, wherein the assist spring and valve spring work together to rotate the rocker arm and inlet valve to the closed position and wherein the push rod moves the rocker arm against the biasing force of both the assist spring and the valve spring to move the inlet valve from the closed position to the open position.
10. The engine of Claim 9, further comprising a collector ring that includes an opening sized to allow the collector ring to be slid up over the piston cylinder so that the collector ring encloses the exhaust ports so as to direct combustion by¬ products flowing through the exhaust ports out ofthe engine block.
11. The engine of Claim 9, fiirther comprising a turbocharger, the turbine section ofthe turbocharger being connected to the collector ring to allow combustion byproducts leaving the collector ring to drive the turbocharger, the compression section ofthe turbocharger being connected to the inlet port.
12. The engine of Claim 9, further comprising a fuel injector positioned to inject fuel into the piston cylinder, and wherein fuel is injected into the piston cylinder during the upward stroke of the piston, after the piston has closed the exhaust ports and after the inlet valve moves to the closed position.
13. A valve system for an internal combustion engine, the valve system comprising: a cylinder head having an inlet port through which inlet air enters the engine; a valve movably mounted within the inlet port so as to move between an open position in which gases may flow through the inlet port and a closed position in which the inlet valve prevents gases from flowing through the inlet port; a biasing spring coupled to the inlet valve and biasing the inlet valve into the closed position; a push rod having

opposing ends, one end of the push rod contacting and following lobes ofa cam; a rocker arm rotatably coupled to the cylinder head, the rocker arm having one end positioned to contact the inlet valve and an opposite end positioned to contact the end ofthe push rod opposite the cam; and a valve assist spring coupled to the cylinder head and positioned to contact and bias the end ofthe rocker arm contacting the push rod to assist the biasing action of the valve spring, wherein rotation of the rocker arm by the push rod against the biasing action of the valve spring, and the assist spring moves the valve from the closed position to the open position.

14. A piston for use in a twocycle engine, the piston comprising: a piston configured to move reciprocally within a cylinder sleeve of the two cycle engine; the interior ofthe piston including one or more mounting flanges; and a piston pin located within the interior of the piston, the piston pin being mounted to the interior ofthe piston at the flanges using at least one fastener, wherein the piston pin is mounted within the interior of the piston without the use of holes passing through the sides ofthe piston.
15. The piston of Claim 14, wherein the flanges include Vshaped grooves and wherein the piston pin includes correspondingly Vshaped lands that are received within the Vshaped grooves.

Description:
REVERSE UNIFLOW TWO-STROKE TURBOCHARGED DTESEL ENGINE

Field ofthe Invention The present invention relates to two-stroke engines and more specifically to two-stroke turbocharged diesel engines. Background ofthe Invention

Four-cycle diesel engines are widely used for applications in the trucking and heavy hauling business due to their relatively large power output, reasonable fuel consumption, and high reliability. However, as the long haul trucking industry has become more competitive, an ever greater emphasis is being placed on fuel consumption, engine reliability, and engine maintenance requirements. The increasingly stringent requirements placed on current diesel engines have revealed a number of shortcomings in current engine configurations.

One ofthe shortcomings of current four-cycle diesel engines is a relatively low ratio of power output to weight. Another shortcoming of current four-cycle diesel engine configurations is ease of maintenance. Currently, engine breakdowns often require repairing the diesel engine in the vehicle in which it is installed due to the difficulty in removing and replacing the engine in the vehicle. While installed in the vehicle, the mechanic has limited access to critical parts of the engine. Thus, repair procedures take a great deal of time and expense. Often, the vehicle can be in the repair station for days, leaving the vehicle operator without a means of creating income.

Generally, high output diesel engines have used a turbocharged, reciprocating four-stroke engine configuration. Although some two-stroke turbocharged diesel

engine configurations have been used in the past, such engines are not currently, generally or commercially accepted. Two-stroke diesel engines by their nature tend to operate at elevated temperatures when compared to similar power four-stroke engines. In the past, such elevated temperatures have required complex cooling systems to maintain the engine at acceptable operating temperatures. Such cooling systems add to both the expense and complexity of the engine. In addition, current two-stroke engines tend to have difficulty meeting emission control standards . One of the reasons current two-stroke engines have difficulties meeting emission standards, is the production of unburned hydrocarbons caused by poor oil control. One of the causes of such poor oil control is the interface in between the piston pin and the piston. In prior engines, the piston pins pass through apertures in the side of the piston. The interface between the piston pin and the apertures tends to serve as a container for unburned oil. During operation ofthe engine, such unburned oil passes out through the exhaust ports, thus, resulting in emissions of unburned hydrocarbons. As can be seen from the discussions above, there exists a need in the industry for improved high performance diesel engines capable of meeting the demands of the heavy haul trucking industry. The present invention is directed towards fulfilling this need.

Summary ofthe Invention The present invention is a reverse uniflow two-stroke turbocharged diesel engine. The engine includes an engine block having one or more piston cylinders located within the block. Each piston cylinder includes a plurality of exhaust ports that extend through the sides ofthe piston cylinder. The top of each piston cylinder is sealed by a cylinder head that includes an inlet port through which inlet air may enter each ofthe piston cylinders. A reciprocating inlet valve is mounted within each ofthe inlet ports and is movable between an open position in which air may flow into the piston cylinder and a closed position in which air is prevented from flowing into the cylinder. A piston is reciprocally mounted within each of the piston cylinders so that as the piston nears the bottom of its downward stroke it opens the exhaust ports to allow combustion by-products to flow downward within the piston cylinder and out through the exhaust ports. As the piston moves on its upward stroke, it covers and closes the exhaust ports. A fuel-injection system is mounted in the cylinder head to inject fuel into the interior of the piston cylinder as the piston cylinder approaches its maximum extension. The engine also includes a turbocharger. The compression section of the turbocharger is connected to the inlet ports and the turbine section of the turbocharger is connected to the exhaust ports ofthe engine. During operation of

the engine, inlet air enters the top ofthe piston cylinders through the inlet ports. Fuel is then injected into the piston cylinders and the mixture of fuel and air is compressed by the upward stroke of the piston. As the piston reaches the top of its upward stroke, the fuel and air mixture is ignited by the compression induced heating, in the case of a diesel engine or by an ignition system, forcing the piston downward . After the piston moves downward a sufficient amount to begin opening the exhaust ports, the inlet valve is opened allowing air from the compression section of the turbocharger to flow into the top of the cylinder in order to force the combustion by ¬ products down and out ofthe piston cylinder through the exhaust ports. In accordance with other aspects of the invention, the engine includes a valve spring coupled to the inlet valve and the cylinder head. The valve spring biases the inlet valve into a closed position. A rocker arm is rotatably coupled to the cylinder head and one end of the rocker arm is placed in contact with the inlet valve. The other end of the rocker arm is coupled to an assist spring so that the assist spring assists the biasing force of the valve spring. Both the assist spring and the valve spring resist any rotation ofthe rocker arm to open the inlet valve. The assist spring is mounted within a receptacle in the cylinder head and is maintained within the receptacle by a removable spring retainer, such that removal of the spring retainer allows the assist spring and a push rod and cam follower to be removed through the receptacle without removing the cylinder head.

In accordance with still other aspects of the invention, the engine includes a collector ring having a centrally-located hole that allows the collector ring to be slid over the piston cylinder. The collector ring is slid over the piston cylinder so that the collector ring surrounds and encloses the exhaust ports. The collector ring is also thermally isolated from the structure of the engine block in order to reduce the amount of heat transfer between hot combustion by-products exited in the exhaust ports and the structure of the engine block. The collector ring is maintained in place through the use of either a support cylinder that surrounds the piston cylinder or a threaded cylindrical nut. The support cylinder is placed around the piston cylinder so that it leaves a gap in between the piston cylinder and support cylinder. The upper edge ofthe support cylinder contacts and maintains the cylinder ring in place while the lower edge of the support cylinder is coupled to the engine block. If the cylindrical nut is used, it is threaded onto the piston cylinder adjacent the collector ring in order to maintain the collector ring in position. The present invention has a number of advantages over prior diesel engines.

First, by using a two-cycle engine configuration, the present invention provides a

power stroke with each revolution ofthe piston, thus increasing the power to weight ratio of the engine over similar four-cycle designs. However, unlike prior two-cycle diesel engines, the present invention does not require complex, expensive or maintenance prone cooling systems. The invention manages the inlet air and combustion by-products so that only cool intake air flows through the cylinder head. The combustion by-products flow downward out through the exhaust ports in the side ofthe cylinder sleeve. The present invention is thus able to maintain the cylinder head at relatively low temperatures. In addition, the present invention's use of an exhaust collection system allows the present invention to collect the combustion by-products and remove them from the engine while helping to thermally isolate them from the structure of the engine block. Therefore, the present invention allows the operating temperatures of the engine to be reduced. This allows the engine of the present invention to function without the complex and maintenance prone cooling systems that characterize prior two-cycle turbocharged diesel engines. The configuration of the present invention simplifies the number of parts and complexity of the engine while increasing reliability and easing maintenance.

The present invention's valving system also creates advantages over prior valving systems. The invention's use of both a valve spring and assist spring allows the valve system to react more quickly than prior art designs using a single valve spring. The invention thus allows the maximum speed of the engine to increased, resulting in an increased ratio of power to weight. The design of the present invention's valving system also allows the cam followers, rods, rocker arms, and valve springs to be replaced without removing the entire cylinder head and breaking down the engine. Thus, failed parts may be more rapidly and easily replaced when compared to prior engine designs.

The present invention's use of a piston pin contained within a smooth walled piston also produces advantages over prior designs. The invention's elimination of bores passing through the sides ofthe piston helps to prevent oil from passing through the interface between the piston pin and piston and out through the exhaust ports. Thus, the present invention reduces engine emissions of unburned hydrocarbons.

Brief Description ofthe Drawings The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes belter understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a partial cross-section through a two-cycle turbocharged diesel engine according to the present invention;

FIGURE 2 is an exploded view of the inlet valving system according to the present invention; FIGURE 3 is an exploded view of an exhaust collection system according to the present invention;

FIGURE 4 is a cross-section illustrating an alternate embodiment of the exhaust collection system;

FIGURE 5 is a cross-section through a piston according to the present invention;

FIGURE 6 is a perspective view ofthe piston pin of FIGURE 5.

Detailed Description ofthe Preferred Embodiment

The present invention is an improved turbocharged two-cycle engine 10. The preferred embodiment of the invention is described below with respect to a turbocharged two-cycle diesel engine. However, the present invention is not limited to diesel engines and may be used for two-cycle internal combustion engines of other kinds, such as spark ignition engines.

In the description that follows, the features of the invention are described in detail. However, features of the engine 10 not described below are readily understood by individuals of ordinary skill in the art of engines, turbocharged engines and turbocharged diesel engines. For example, engine fuel injection systems and oil cooling systems are readily understood by those in the art and are thus not discussed below.

The preferred embodiment is discussed with respect to two cylinders of the engine 10, however, an engine according to the invention can have 2, 4, 6, 8, etc., pistons. Similarly, an engine according to the invention can be configured in either an in-line, flat or V configuration without departing from the scope ofthe invention. The basic structure and operation of the engine 10 is discussed below. Some of the individual components ofthe engine 10 are subsequently discussed in more detail. The preferred embodiment of the engine 10 (FIGURE 1) includes an engine block 22, piston cylinder sleeves 12, pistons 14, connecting rods 16, a weighted crankshaft 18, a camshaft 19, connecting rod caps 20, an oil pan 23, an exhaust collection system 24 (FIGURE 3), a turbocharger 26, and an inlet valving system 28

(FIGURE 2). The engine 10 also includes a cylinder head 30, inlet and exhaust ducting 34 and 102, fuel injectors 32, and an associated fuel injection system (not shown), oil cooling system (not shown), lubrication system (not shown), etc.

The inlet valving system 28 (FIGURE 2) includes a cam follower 38, a push rod 40, a rocker arm 42, an inlet valve 44, a valve spring 46, a spring retainer 48, a valve assist spring 50, a spring pin 52, a pivot boss 54, upper and lower pivot boss retaining brackets 56 and 58, a rocker arm bolt 60 and nut 61, a rocker arm cover 62, and an assist spring retainer 64. The exhaust collection system 24 (FIGURE 3) includes the cylinder sleeves 12, exhaust collection rings 66, support cylinders 68, mounting brackets 70, and an exhaust collection manifold 72.

In the preferred embodiment of the invention, each cylinder sleeve 12 is mounted within the upper portion of engine block 22 (FIGURE 1). As well known in the art, the use of separate cylinder sleeves 12 (as opposed to cylinders formed as part of an integral casting) allows the sleeves to be removed and replaced, thus increasing engine life. Each cylinder sleeve 12 includes radially outward extending upper 74 and Iower 80 flanges. The upper and lower flanges 74 and 80 are configured to rest upon correspondingly sized recesses in upper and lower flanges 75 and 76 (FIGURE 1) cast within the structure ofthe engine block 22. Methods of designing, manufacturing and press fitting cylinder sleeves 12 within engine blocks 22 are well understood by those of ordinary skill in the art.

Each cylinder sleeve 12 includes a plurality of exhaust ports 82 that are spaced around the circumference of the cylinder sleeve. In the preferred embodiment, the exhaust ports 82 are sized and configured to maximize the flow of emission by¬ products out of the exhaust ports during operation of the engine 10 as described in more detail below.

The pistons 14 are reciprocally mounted within the cylinder sleeves 12 as illustrated in FIGURE 1. Each piston 14 is rotatably attached to a connecting rod 16 through the use ofa piston pin 81 as described in more detail below. Each connecting rod 16 extends downward from the center ofthe piston 14 and is rotatably attached to the crankshaft 18 using the connecting rod caps 20. The connecting rods 16 are attached to the crankshaft 18 such that the crankshaft may rotate within a bearing formed between the connecting rods 16 and the caps 20. The configuration of the pistons 14, connecting rods 16, caps 20 and crankshaft 18 allow the pistons 14 to move reciprocally up and down within the cylinder sleeves 12 as the crankshaft 18 rotates in a manner well known in the art.

Also, as well known in the art, the piston 14 is slidably mounted within the cylinder sleeve 12 through the use of upper compression rings 77 and Iower oil rings 78. The compression rings 77 form a seal between the top of the piston 14 and the interior wall of the cylinder sleeve 12, thus preventing air or combustion by-

products from moving between the piston and cylinder sleeve. Similarly, the oil rings 78 form a seal between the lower portion of the piston 14 and the interior of the cylinder sleeve 12, thus preventing oil within the oil pan 23 from moving between the piston 14 and cylinder sleeve 12. The cylinder head 30 is placed on the top of and attached to the engine block 22 using removable fasteners (not shown). The bottom of the cylinder head 30 contacts and forms a seal around the top of the upper flanges 74 of the cylinder sleeves 12. In the preferred embodiment, a gasket (not shown) formed of steel or other appropriate gasket material is placed between the cylinder head 30 and flanges 74 in order to ensure an air and gas tight seal. The bottom of the cylinder head 30, top of the pistons 14 and interior walls of the cylinder sleeves 12 define combustion chambers 84.

The cylinder head 30 includes air inlet ports 90 to allow air to flow through the cylinder head into the combustion chambers 84 as described in more detail below. The inlet ports 90 are offset so that they open into one side of the combustion chambers 84. A cylindrical valve seat 92 is located in the cylinder head 30 at the opening ofthe inlet port 90 into the combustion chamber 84. The opposite end o the inlet port 90 is connected to the compression section 94 of the turbocharger 26 through the use of inlet ducting 34. The inlet valve 44 is reciprocally mounted within the cylinder head 30 and inlet port 90 such that it moves between an open position (shown in FIGURE 1) in which air may flow through the input port 90 and into the combustion chamber 84 and a closed position (not shown) in which the inlet valve contacts and forms a seal on the valve seat 92. The structure and operation of the inlet valve 44 is discussed in more detail below.

The collection rings 66 (FIGURE 1) are slid over the bottom of the cylinder sleeves 12 so that the collection rings surround the exhaust ports 82 (FIGURE 1) as discussed in detail below. The collection rings 66 are configured to collect the flow of combustion by-products exiting the exhaust ports 82. The collection rings 66 direct the flow of combustion by-products through the collection manifold 72 (FIGURE 3) which in turn directs the flow of combustion by-products through a turbine section 96 of the turbocharger 26. After flowing through the turbine section 96, the combustion by-products flow out through exhaust ducting 102.

The fuel injectors 32 are mounted within the cylinder head 30 and extend through the structure ofthe cylinder head into the combustion chambers 84. The fuel injectors 32 are connected to the fuel injection system (not shown) The fuel injection

system is configured in a manner well known in the art to inject fuel through the fuel injectors 32 into the combustion chamber 84 at the appropriate point in the stroke of the pistons 14. Depending upon the design of the engine 10, a glow plug or spark ignition system (not shown) may also be located in the cylinder head 30. The basic operation of the engine 10 will now be described. Once the engine 10 is started, the pistons 14 move upward within the cylinder sleeves 12 as illustrated by arrow 100 (FIGURE 1). As the pistons 14 move upward, they close and seal the exhaust ports 82, thus sealing the bottom ofthe combustion chambers

84. As the pistons 14 continue to move upward, the inlet valves 44 move upward into a closed position, sealing the top ofthe combustion chambers 84. Fuel is then injected into the sealed combustion chambers 84 through the use ofthe fuel injectors 32. As a piston 14 continues to move upward, the mixture of fuel and air within the combustion chamber 84 is compressed until it ignites or until the mixture is ignited by an ignitor or glow plug. Once the fuel and air mixture is ignited, the resulting expansion of gases forces the pistons 14 downward. As the pistons 14 move downward, they force the connecting rods 16 downward, thus driving the crankshaft 18 in a circular motion as well known in the art. As the pistons 14 continue to move downward, the tops ofthe pistons move past the tops of the exhaust ports 82, thus opening the exhaust ports. This allows the combustion by-products within the combustion chambers 84 to flow out of the combustion chambers, through the exhaust ports 82 and into the collector rings 66 (FIGURE 3).

The collector rings 66 direct the combustion by-products through the exhaust manifold 72 and into the turbine section 96. The combustion by-products drive the turbine section 96 of the turbocharger, which in turn drives the compression section 94 ofthe turbocharger. The compression section 94 ofthe turbocharger takes ambient air flowing through air ducting 104, compresses it, and forces it through the air ducting 34 into the inlet ports 90. Thus, the compression section 94 of the turbocharger 26 produces a back pressure on the inlet valve 90. As the pistons 14 move downward and begin to open the exhaust ports 82, the inlet valves 44 move to the open position in which the pre-loaded air within the inlet ports 90 is allowed to flow into the combustion chambers 84. The flow of air through the inlet ports 90 fills the combustion chambers 84 from the top to the bottom, thus forcing any combustion by-products within the combustion chambers out through the exhaust ports 82. The inlet valves 44 remain open until the pistons 14 finish the downward stroke and move upward and close the exhaust ports 82. The operation of

the engine 10 continues as described above. Fuel is loaded into the combustion chambers 84, compressed, and ignited in a continuous two-cycle operation.

The present invention overcomes a number ofthe disadvantages of prior diesel engines. First, by using a two-cycle configuration, the present invention increases the power to weight ratio ofthe engine. The present invention also eliminates the cooling problems normally associated with current two-cycle engines. As explained above, the configuration ofthe invention allows only relatively cool air from the compression section 94 of the turbocharger 26 to flow through the cylinder head 30. The hot combustion by-products flow directly out of the exhaust inlets 82, into the collection rings 66 and out through the exhaust manifold 72. The configuration ofthe engine 10 ofthe invention thus allows the cylinder head 30 to be maintained at a relatively cool temperature during operation of the engine. This configuration allows the cylinder head 30 to be formed of aluminum or other fairly low temperature tolerant materials. In addition, the complex, costly and often maintenance prone cooling systems present in other two-cycle turbocharged diesel engines are eliminated.

It is important to thermally isolate the structure of the engine block 22 from the combustion by-products in order to maintain the engine block at relatively low temperatures when compared to prior two-cycle engines. In order to thermally isolate the engine block 22 from the hot combustion by-products, the present invention uses the collector rings 66 and the associated mounting structure including the support cylinders 68 (FIGURE 3), mounting brackets 70, and collection manifold 72.

Each collection ring 66 has a generally U-shaped cross section and a centrally located circular opening 104. The circular opening 104 allows each collection ring 66 to be slid up over a cylinder sleeve 12 so that the U-shaped cross section of the collection ring encloses the exhaust ports 82. As best seen in FIGURE 1, the exterior wall 106 of the cylinder sleeve surrounding the exhaust ports 82 is thicker than the Iower portion ofthe cylinder sleeves. In addition, the exterior wall 106 slopes slightly outward from bottom to top as the thickness ofthe cylinder sleeve 12 increases.

The circular opening 104 is sized so that the collector ring 66 slides upward over the cylinder sleeve 12 until the bottom wall 108 (FIGURE 3) of the collector ring engages the slanted wall 106 of the cylinder sleeve 12, thus preventing the collector ring from moving upward any fiirther. In the preferred embodiment, a space 109 (FIGURE 1) is maintained between the upper surface 1 10 (FIGURE 3) of the collector ring 66 and the structure ofthe engine block 22. This space 109 helps to prevent heat transfer between the collector ring 66 and the structure of the engine block 22. In order to further reduce the amount of heat transfer between the collector

ring 66 and the engine block 22, thermal insulation (not shown) can be placed within the space 109 and around the collector ring.

Each collector ring 66 is maintained in place around the exhaust ports 82 and cylinder sleeve 12 through the use ofa support cylinder 68. Each support cylinder 68 is sized to surround the lower portion of the cylinder sleeves 12 while maintaining a gap 112 (FIGURE 1) between the cylinder sleeves and the support rings 68. The upper edge ofthe support ring 68 contacts the lower surface 108 (FIGURE 3) of the collection ring 66. The lower edge of the support ring 68 contacts and is supported on the mounting bracket 70. As illustrated in FIGURES 1 and 3, each support bracket 70 includes an upward extending circular ring or step 1 14 that extends into the interior ofthe support cylinder 68. The step 114 contacts the inner surface ofthe support cylinder 68 and prevents the support cylinder from moving laterally on the mounting bracket 70.

Each mounting bracket 70 is attached to the engine block 22 through the use of fasteners (not shown) that extend through holes 1 16 (FIGURE 3) in the mounting bracket 70 and are received within correspondingly sized recesses (not shown) in the structure of the engine block 22. The mounting bracket 70 prevents the support cylinder 68 and its associated collector ring 66 from moving downward on the cylinder sleeve, while the interference fit between the cylinder sleeve 12 and inner edge ofthe collector ring 66 prevents the collector ring from moving upward.

The collector rings 66 direct the flow of combustion by-products exiting the exhaust ports 82 around the cylinder sleeve 12 and out through an opening 1 1 1 on one side of each collector ring. The collector rings 66 are attached to the collection manifold 72 through the use of fasteners that extend through the collection manifold and are received within the collector rings 66. The collection manifold in turn collects the combustion by-products flowing out of the various cylinders of the engine and directs them through the compression section 96 ofthe turbocharger as described.

The configuration of the exhaust collection system 24 (FIGURE 3) helps to thermally isolate the collector rings 66 from the structure of the engine block 22 and cylinder sleeve 12 During operation of the engine 10, the combustion by-products raise the temperature of the collector rings 66 to highly elevated temperatures. However, the collector rings 66 are thermally isolated from the engine block 22, thus reducing the amount of heat transferred between the combustion by-products and the structure ofthe engine block. The combustion by-products may be further thermally isolated from the engine block 22 by placing insulation within the gap 1 12 between the support cylinder 68 and

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the cylinder sleeve 12 and surrounding the exterior of the support cylinder 68 . Through the use of the exhaust collection system 24 of the present invention, the preferred embodiment maintains the cylinder head 30 and engine block 22 at temperatures of approximately 180°F during operation of the engine. Isolated hotspots on the engine block 22 and cylinder head 30 could be up to 40°F higher.

An alternative embodiment of the exhaust collection system 24 is show in FIGURE 4. In the alternative embodiment, the inner edge 120 of the top of the collector ring 66 is beveled from top to bottom. A deformable cylindrical seal 122 is placed between the internal support flange 75 of the engine block 22 and the upper surface of the collector ring 66. A seal is established between the edge 120 of the collector ring 66, the side of the cylinder sleeve 12 and the lower surface of the support flange 75 by pressing the collector ring 66 upwardly until it contacts and deforms the deformable seal 122. The deformable seal 122 is formed of an appropriate seal material capable of withstanding the high temperatures present during operation of the engine. In the preferred embodiment, the deformable seal 122 is formed of a metal such as copper. However, the seal material is influenced by the material from which the cylinder block is cast, and thus may differ in alternate embodiments ofthe invention.

The collector ring 66 is pressed upward and maintained in position around the cylinder sleeve 12 through the use of a cylindrical wedge 124 and two interlocking nuts 126 and 128. The inner edge 130 of the bottom surface 131 of the collector ring 66 is beveled from bottom to top. The cylindrical wedge 124 has a smooth interior surface beveled to fit against the exterior surface of the wall 106 of the cylinder sleeve 12. The exterior surface 132 of the cylindrical wedge 124 is beveled so that the top of the wedge is narrower than the bottom of the wedge. The wedge 124 is slid upward in between the inner edge 130 of the collector ring 66 and the wall 106 of the cylinder sleeve 12. The exterior surface of the wall 106 is threaded to allow the interlocking nuts 126 and 128 to be placed over the cylinder sleeve 12 and threaded upward onto the wall 106. The first interlocking nut 126 is threaded upward until the cylindrical wedge 124 and collector ring 66 are moved upward a sufficient distance to form a seal between both the upper and Iower surfaces of the collector ring 66 and the exterior surfaces of the cylinder sleeve 12. The second interlocking nut 128 is then threaded on to the wall 106 until the second nut locks against the first locking nut 126. In a manner similar to that described with respect to the preferred embodiment, the collector ring 66 is thermally isolated from the cylinder block 22 thus

minimizing the amount of heat transfer between the combustion by-products exiting the exhaust ports 82 and the engine block 22. Thermal insulation can be placed around the collector rings 66 in order to further thermally isolate the combustion by ¬ products from the surrounding engine structure. The structure of the inlet valving 28 is now described by reference to

FIGURE 2. According to the invention, a replaceable cam follower 38 is removably slid over the Iower end of he push rod 40. The cam follower 38 includes a circular recess 150 that is sized to accept the lower end ofthe circular rod 40. The Iower end of the cam follower 38 also includes a rotatably mounted bearing 152 that contacts and follows the lobes of the cam shaft 19 during operation of the engine 10, as illustrated in FIGURE 1. The upper end ofthe rod 40 contacts and is received within a concave lower surface 154 (FIGURE 1) on one end ofthe rocker arm 42.

As illustrated in FIGURE 1, the rocker arm 42 is rotatably mounted within a chamber in the top of the cylinder head 30 through the use of the pivot boss 44 and upper and Iower support brackets 56 and 58. The pivot boss 54 is cylindrical and is rotatably received within a correspondingly sized cylindrical bore 151 passing laterally through the center of the rocker pin 42. The upper and Iower brackets 56 and 58 include circular cutouts 160 and 162 that are sized to allow the upper and lower brackets to fit over and hold the pivot boss 54. The pivot boss 54, upper and Iower brackets 56 and 58, and rocker arm 42 are attached to the cylinder head 30 through the use of a fastener 60 and nut 61 that extends through a hole in the cover plate 62, upper and Iower brackets 56 and 58, pivot boss 54 and rocker arm 42, and is received in a receptacle in the cylinder head 30.

The end of the rocker arm 42 opposite the rod 40 includes a rotatably mounted inlet valve bearing 162. The inlet valve bearing 162 contacts the top end of the valve stem 166, as illustrated in FIGURE 2. As the rocker arm 42 pivots clockwise as illustrated by arrow 170 in FIGURE 1, the bearing 162 contacts and pushes the inlet valve 44 downward away from the valve seat 92, thus allowing air to flow through the inlet port 90 and into the combustion chamber 84. As the rocker arm 42 moves counterclockwise, the inlet valve 44 is biased upward into the closed position by the valve spring 46. The valve spring 46 is placed over the upper end of the valve stem 166 and maintained in place on the inlet valve 44 by the spring retainer 48. The spring retainer 48 is placed over the valve stem 166 on top of the valve spring 46 and is received within a retaining slot 172 on the inlet valve 44 in a manner well known in the art. In addition to biasing the inlet valve 44 into the closed

position, the valve spring 46 also biases the rocker arm counterclockwise as illustrated in FIGURE 1.

In the present invention, the biasing action ofthe valve spring 46 is assisted by the biasing action of an assist spring 50. The assist spring 50 is mounted within a cylindrical receptacle 180 in the cover plate 62 directly over the end of the rocker arm 42 opposite the inlet valve 44. The assist spring 50 is maintained within the receptacle 180 in the cover plate 62 by the retaining cap 64. The retaining cap 64 is threaded into the upper end of the receptacle 180. The lower end of the assist spring 50 surrounds and contacts a rocker arm pin 52. The rocker arm pin 52 is also located within the receptacle 180 and extends downward into a concave recess 182 on the end ofthe rocker arm 42 directly above the rod 40. The assist spring 50 is placed under compression by the retaining cap 64 in order to bias the rocker arm 42 counterclockwise as illustrated in FIGURE 1.

As the cam 19 rotates, the lobes of the cam push the cam follower 38 and rod 40 upward. The upward movement of the rod 40 rotates the rocker arm 42 clockwise, as illustrated by 170, against the biasing force of both the assist spring 50 and the valve spring 46. As the cam 12 continues to rotate, the cam follower and rod 40 move downward to follow the lobes ofthe cam. The downward movement of the cam follower 38 and rod 40 is assisted by the biasing force provided by both the assist spring 50 and the valve spring 46.

The invention's use of both a valve spring 46 and an assist spring 50 in combination with a rocker arm 42 produces a number of advantages over prior valve systems. First, the use of both a valve spring 46 and an assist spring 50 allows a greater biasing force to be produced while reducing the force produced by the valve spring 56 as compared to similar systems using a single valve spring. This in turn allows the size and mass of the valve spring 46 to be reduced. The reduced size and mass of the valve spring 46 allows the inlet valve 44 to operate at higher speeds. The use of both the assist spring 50 and valve spring 46 also allows a larger, stronger and heavier rod 40, cam follower 38, and rocker arm 42 to be used without effecting the valve system's performance. The increased structural integrity of the rod 40, cam follower 38 and rocker arm 42 help to increase the reliability and decrease the maintenance ofthe inlet valving.

The present invention's use of the cover plate 62, and retaining cap 64 also results in maintenance advantages over prior engine designs The most common failure in the valving systems of current large diesel engines is a failure of a cam follower. In the present invention, should a cam follower 38 fail, the retaining cap 64 can be removed. The rocker arm 42 can then be rotated clockwise and the assist spring 50, rocker arm pin 52, rod 40 and cam follower 38 removed by pulling them upward out of the receptacle 180. The cam followers can thus be replaced without removing the cylinder head 20 as required in prior engine designs. Should a rocker arm 42, or valve spring 44 fail, they can be replaced by removing the cover plate 62 without removing the entire cylinder head 30.

The structure of the piston 14 will now be described by references to FIGURES 5 and 6. Although pistons of an ordinary design may be used in the present invention, a piston according to the invention results in additional advantages. In prior piston designs, the piston is connected to the connecting rod through the use of a piston pin that extends through a bore passing through the sides of the piston. The interface in between the piston pin and the piston allows oil to move through the interface. In the present invention, such oil migration can then pass through the exhaust ports 82 as the piston 14 moves reciprocally up and down within the cylinder sleeve 12. This oil migration can result in undesirable engine exhaust emissions. As oil-scrapping efficiency of both compression and oil rings has improved, the primary source of oil exposed to the ports of a two-cycle engine has become the interface in between the piston pin and the piston. The problem of oil migration is minimized in the piston 14 ofthe present invention by eliminating the bore through the sides of the piston 14.

As illustrated in the cross section of FIGURE 5, the exterior surface of the piston 14 of the invention does not include any bores through the sides of the piston 14. Instead, the piston pin 81 is attached to support shoulders 190 on the interior of the piston 14. As seen in FIGURE 5, the support shoulders 190 are formed integrally within the piston casting and include a V-shaped grooved mounting surface 191. The piston pin 81 includes corresponding V-shaped lands 193 on each end. The V-shaped lands 193 on the piston pin 81 are placed into the V-shaped grooved mounting surface 191 on the support shoulders 190. The piston pin 81 is attached to the support shoulders 190 through the use of fasteners 192 that pass through opposing bores in the piston pin 81 and are received within correspondingly sized threaded bores in the support shoulders 190,

In the preferred embodiment, the V-shaped lands 193 on the piston pin form an approximately 90° wedge. This configuration allows the sideward reaction forces of the piston on the cylinder to be carried by the piston pin 81 while the fasteners 192 serve primarily to retain the piston pin in the piston on the initial downward stroke of the piston . Although the preferred embodiment incorporates the piston o the present

invention in a two-cycle diesel engine, the invention could be used in other two-stroke or four-stroke engines.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention. For example, although the preferred embodiment of the invention is described with respect to the use of a single inlet valve 44, multiple inlet valves could be used in each cylinder of the engine. In addition, the arrangement of the valving system could be reconfigured in order to accommodate an overhead cam configuration.

Previous Patent: STRATIFIED CHARGE ENGINE

Next Patent: FLOATING PISTON, PISTON-VALVE ENGINE