

WATER-COOLED DIESEL ENGINE FOR AN OUTBOARD MOTOR

The present invention relates to a water-cooled diesel engine for an outboard motor.

5

Hitherto, 2-stroke petrol engines operable with a fuel mixture have been most popular for use in marine outboard motors, which are mounted on the stern of small-sized vessels, because this type of engine best meets the requirement for a light weight and a small size which are the essential requisites for marine outboard motors. Thus, diesel engines have been used very seldom in marine outboard motors. The current rise in the price of petroleum, however, has given rise to a demand for the use of diesel engines in marine outboard motors. It will be noted that a distinction is here drawn between an outboard "motor", by which term is intended the whole unit including engine, transmission, propellor, mounting clamp, controls, etc, and an outboard "engine" by which is intended merely the propulsion unit of an outboard motor.

10

15

The use of a diesel engine in a marine outboard motor, however, involves overcoming various problems. Namely, a diesel engine can produce only a comparatively small power per unit weight because of the need to use cast iron as the material of the cylinder block and cylinder head. In addition, the overall number of engine parts is large because the cylinder block and the cylinder head are

20

25

constructed separately from each other and joined to each other by means of bolts with a gasket interposed therebetween. In addition, the seal of the gasket tends to become imperfect.

5 An engine used in an outboard motor has to be swung manually for steering and has to be tilted up as desired. In addition, such an engine has to be carried when not on the vessel, and mounted easily. Furthermore, an outboard motor is required to have a centroid on the neutral axis thereof. Namely, if the centroid is
10 offset to the left or right, the manoeuvrability of the engine will be impaired.

In order to obviate these problems, it is necessary to meet the requirements such as minimized weight of the outboard motor unit,
15 including the engine itself, symmetry of the engine with respect to the plane parallel to the intended direction of movement, minimized height, compactness of the engine, reduction in the number of parts, simplified construction and reduced cost.

20 When a diesel engine is used for a marine outboard motor, the compactness of the engine is affected by the position of the exhaust gas outlet.

According to the present invention, there is provided an overhead
25 cam type water cooled reciprocating piston diesel engine for an

- 3 -

outboard motor, having a plurality of cylinders each having associated inlet and exhaust valves and respective fuel injector units operated by a cam shaft on a cylinder head, in which the said injector units are located on one side of a plane passing through
5 the axis of the associated cylinder parallel to the crankshaft axis and the inlet and exhaust valves and the cam shaft for the injector units are located on the other side of this plane, and in which an oil filter and a governor of the engine are disposed on opposite sides of the said plane from one another.

10

One embodiment of the invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

15 Figure 1 is a partly-sectioned side elevational view of an outboard motor having an engine embodying the present invention;

Figure 2 is a vertical sectional view of a diesel engine in accordance with the embodiment of the invention; and

20 Figure 3 is a sectional view taken along the line III-III of Figure 2.

In the accompanying drawings the same reference numerals have been used to identify the same or like components throughout.

25

In the present specification references to the orientation of the engine will be understood to relate to the engine in its intended upright position of use, on an outboard motor for a small vessel. References to left, right, front etc will be construed accordingly.

5

Referring to Figure 1, an outboard motor M has a diesel engine 2 accommodated by a cowling 1. The power of the diesel engine 2 is transmitted to a propeller 4 provided at the lower end of the body 3 of the outboard motor M to rotate the propeller 4 through a
10 vertical transmission shaft (shown by two-dot-and-a-dash line) disposed in the body 3 of the outboard motor. As the propeller 4 is rotated, a small-sized vessel on which the outboard motor is mounted is propelled to run in the direction of an arrow A. The vessel is steered as the outboard motor M is swung to the left and
15 right by means of a tiller 5 which projects forwardly from the outboard motor M.

Exhaust gas E emitted from the diesel engine 2 flows through an exhaust passage 7 in the body 3 of the outboard motor and is
20 discharged into the ambient water through an exhaust opening 7A which is positioned below the water level L during running of the vessel.

Referring now to Figure 2, a diesel engine 2 in accordance with the
25 invention has a crankshaft 11 provided at its upper end with a

fly-wheel 12. This engine, designed specifically for use as a marine outboard engine, is provided in a bore at the lower end of the crankshaft with an internal spline 13 by means of which the crankshaft is connected to an output shaft (not shown). In the illustrated embodiment, the engine 2 has two cylinders 14 and 15 which are arranged one above the other. Hereinafter two longitudinal median planes of these cylinders will be used for the purposes of explanation, namely a horizontal plane 0-0 (Figure 2) extending horizontally in the fore and aft direction of the engine, there being an individual such plane for each cylinder and a vertical plane 0_1-0_1 (Figure 3), which is common to both cylinders. Numerals 16 and 17 denote pistons and connecting rods, respectively.

15 A cylinder block 18 and a cylinder head 19 are formed by casting as a unit from aluminium or an aluminium-base light-weight alloy. A cooling water jacket 20 is formed in the combined cylinder block 18 and cylinder head 19, which latter are integral with each other. The cooling water is introduced by a cooling water pump (not shown) into the cooling water jacket 20. Exhaust ports 21 and intake ports 22 are formed in the cylinder head 19. The cylinder head 19 is provided also with cylindrical bosses 27 for supporting the stems 25, 26 of the exhaust valves 23 and intake valves 24, as well as cylindrical bosses 29 defining mounting holes for the fuel injection devices 28. As shown in Figure 3, an exhaust manifold 30

is integrally formed with the cylinder head 19. Each of the cylinders 14 and 15 has one exhaust valve 23 and one intake valve 24. Thus, four valves in total, that is two exhaust valves 23 and two intake valves 24 are arranged in the vertical plane with their stems lying horizontally, and are adapted to be driven by a common cam shaft 31 through valve arms 32 in a manner which will be explained later. A casing 34 defining a valve arm chamber 33 accommodating the cam shaft 31 and the valve arms 32 is fixed to one end surface of the cylinder head 19 by means of bolts (not shown).

The diesel engine 2 has a crank case 36 which can be split into two parts: namely, a first part 37 adjacent to the cylinder block 18 and a second part 38 opposite to the cylinder block 18. The first part 37 is formed as a unit with the cylinder block 18 while the second part 38 is fastened by bolts 39 to the first part 37. The plane at which two parts 37 and 38 are joined contains the neutral axis C-C of the crankshaft and is perpendicular both to the horizontal and vertical median planes 0-0 and 0_1-0_1 of the cylinders. The part 38 of the crank case is made of a material identical to or similar to that of the cylinder block 18.

A detailed description will be made hereinafter as to the construction of every portion of the diesel engine. Liners 40 presenting the sliding surfaces for the pistons 6 are made from

cast iron and are cast in the cylinder block 18. An alloy layer is formed along the boundary between the liner 40 and the cylinder block 18 and the liner 40 is joined to the cylinder block 18 through this alloy layer. As will be seen from Figure 2, the cylinder head 19 is provided therein with exhaust valves 23, intake valves 24, exhaust ports 21 and intake ports 22, so that the overall height H as measured from the explosion surface 43 to the end surface 35 is inevitably large. Furthermore, a multiplicity of ribs 55 are mounted in the cylinder head 19 so as to form walls of the cooling water jacket 20, exhaust ports 21 and intake ports 22, as well as cylindrical bosses 27 mentioned before. Thus, the cylinder head 19 itself exhibits a sufficient strength because it has a large overall height H and because it is stiffened internally by a multiplicity of cylindrical bosses 27 and ribs 55.

15

Referring now to Figure 3 which is a sectional view taken along the line III-III of Figure 2, the cylindrical boss 29 for the fuel injection nozzle 28 also contributes to the enhancement of the strength of the cylinder head 19. The cylindrical boss 29 extends from a position near the centre of the ceiling wall 53 at a small angle to the axis of the cylinder, so that it contributes greatly to the stiffening of the cylinder head 19. The fuel injection device takes the form of an injector unit 57 in which a fuel injection nozzle 28 and a fuel pump 56 are constructed

25

as a unit with each other. This injector unit 57, when fitted in the cylindrical boss 29 as will be explained below, serves further to increase the rigidity or strength of the cylinder head 19.

5 The construction of the injector unit 57 will be explained briefly. The injector unit 57 is composed of a fuel injection pump 56 having a body 91 and a fuel injection nozzle 28 having a sleeve 98 connected to the end of the body 91 of the fuel injection pump 56. As a plunger 93 moves reciprocatingly within a barrel 92 mounted in
10 the body 91, fuel is supplied from the fuel injection pump 56 to the fuel injection nozzle 28 through a pressurized fuel passage 94 formed in the body 91. The injector unit 57 is provided with an annular step 95 between the end portion of the body 91 and the sleeve 98. With the annular step 95 pressed onto the inner
15 peripheral step on the cylindrical boss 29, the portion of the body 91 projecting above the cylindrical boss 29 is fastened to the cylinder head 11 by means of a metal retainer 96. This also contributes to the strength of the cylinder head 19 so that the amount of deflection of the ceiling wall 53 is decreased
20 effectively.

The portion of the injector unit 57 constituting the fuel injection pump 56 has a larger diameter than the nozzle portion 28, and also

fits in the cylindrical boss 29. Therefore, the cylindrical boss 29 serves as a large reinforcement having a large diameter and, hence, contributes to the strength of the cylinder head 19.

- 5 The fuel injection nozzle 28 has a nozzle port which is opened when a high pressure is applied by the fuel delivered by the fuel injection pump 56. As stated before, in the injector unit 57, the fuel injection pump 56 and the fuel injection nozzle 28 are connected to each other solely through a short pressurized fuel
- 10 passage 94 formed in the body 91, so that the fuel pressure established in the fuel injection pump is correctly transmitted to the fuel injection nozzle 28. It is, therefore, possible to inject the fuel from the fuel injection nozzle 28 at exact correspondence to the pressure in the fuel injection pump 56 without any secondary
- 15 injection over the entire region of the variance of the fuel injection rate. Furthermore, since the pressure drop along the short pressurized fuel passage 94 is small, it is possible to obtain a high fuel injection pressure in the fuel injection nozzle 28 which in turn promotes the atomization of the injected fuel.
- 20 Furthermore, the injection from the fuel injection nozzle 28 takes place without a substantial time lag with respect to the pumping operation in the fuel injection pump 56. It is therefore possible to maintain an optimum condition for combustion and to make full use of the engine performance, partly because secondary injection
- 25 and injection time lag are avoided and partly because atomization

of the fuel is promoted. The avoidance of delay in fuel injection also contributes to improve the performance of the engine during high-speed operation. It is remarkable that these advantages are brought about with a simple construction which does not require a timer as has been found indispensable in conventional engines for
5 adjusting the timing of the fuel injection.

The end of the fuel injection nozzle 28 is exposed to the combustion chamber 45 close to the centre of the explosion surface 43, and no vortex flow chamber (pre-combustion chamber) is provided
10 in the cylinder head 19. Since the engine is of a direct injection type as stated before, it is possible to support the injector unit 57 by the full height H of the cylinder head 19. Consequently, the injector unit 57 can be held stably and the distance between the explosion surface 43 and the other end (protector 71) of the
15 injector unit 57 can be decreased to permit a reduction in the size of the engine as a whole. Thus, although the injector unit 57 inherently has a large length, it is nevertheless possible to keep the size of the engine small by designing the engine as a direct injection type engine. For comparison, if a vortex flow chamber
20 were to be formed in the cylinder head 19, the distance between the injector unit 57 and the explosion surface 43 would have to be increased by an amount corresponding to the size of the vortex flow chamber, so that the size of the cylinder head 19 and the size of the case 34 would have to be increased.

Direct injection offers also the following advantage. Namely, in an engine having a vortex flow chamber, a heavy thermal load is imposed on the inner surface of the communication passage between the vortex flow chamber and the combustion chamber 45 during
5 propagation of the flame from the former to the latter. By contrast, in a direct injection type engine having no vortex flow chamber, no local thermal stressing takes place in the cylinder head 19 nor in the cylinder block 18. Therefore, the cylinder head 19 and the cylinder block 18 are never damaged by heat even though
10 they are made from aluminium or an aluminium alloy having small resistance to heat.

Aluminium or its alloys exhibit a high heat conductivity at the cost of small resistance to heat. Therefore, the heat transferred
15 to the cylinder head 19 and the cylinder block 18 from the combustion chamber 45 can be delivered promptly to the cooling water in the cooling water jacket 20, so that the cylinder block 18 and the cylinder head 19 are protected against overheating. Thus, the engine is protected against thermal damage even in this
20 respect.

The piston 16 is provided in the top surface thereof with a recess which defines a part of the combustion chamber 45. When the piston 16 is positioned at the top dead centre in its stroke, the portions
25 of the top surface of the piston other than the central recess

closely approach the explosion surface 43 or the rounded corner around the explosion surface 43 without leaving any substantial gap or clearance.

- 5 The explosion surface 43 may be conically concave although it is flat in the described embodiment. In this way, it is possible to enhance the strength of the cylinder block 18 and the cylinder head 19 because of the greater strength of the arch structure formed by the cylinder block 18 and the cylinder head 19 in the illustrated
- 10 cross-section, that is the arch structure constituted by the side walls of the cylinder block 18 and the ceiling portion provided by the cylinder head 19.

- The following explanation relates to the mechanism for actuating
- 15 the fuel injection pump 56, as well as the exhaust valve 23 and the intake valve 24 (Figure 3 shows only the valve 24). Besides the cam shaft 31 and the valve arms 32 which were mentioned before, the valve arm chamber 33 accommodates a valve arm 59 for the fuel injection pump 56. In addition, valve stems 25 and 26 of the
- 20 exhaust valve 23 and the intake valve 24 respectively, as well as the fuel injection pump 56, project from the cylinder head 19 into the casing 34. The valve stems 25 and 26 are located, for example, on the left side of the vertical longitudinal median plane O_1-O_1' , that is the plane containing the axis of the cylinder, the terms
- 25 "left" and "right" will be understood in relation to the normal

orientation of the engine as illustrated in the drawings, in which,
in Figure 2, the engine is shown in an upright orientation viewed
from the left, so that forward motion is from right to left as
indicated by the arrow A of Figure 2, which indicates the direction
5 of motion of a vessel having the engine fitted thereto.

The ends of the valve stems 25 and 26 are located comparatively
close to the head end surface 35. The valve stems 25 and 26 are
provided at their ends with protectors 60 which are contacted by
10 adjusting screws 62 held in position on respective ends of the
valve arms 32 by means of lock nuts 61. Each valve arm 32 is
provided at its intermediate portion with a tappet 63 adapted to be
actuated by a cam 64 on the cam shaft 31. Four valve arms 32 are
supported at their other ends by a common valve arm shaft 65 which
15 is vertical and supported by the case 34. The valve arm shaft 65
is offset leftwardly from the longitudinal vertical median plane
 O_1-O_1 , and the outer peripheral surface thereof is somewhat spaced
from the end surface 35 of the cylinder head 19. The axis 65a of
this shaft is nearer the end surface 35 of the cylinder head 19
20 than the protectors 60 on the ends of the valve stems by a distance
of about 2 to 3 mm (about 1/3 of the valve lift) when the valves
are closed.

The cam shaft 31 is positioned to the rear of the valve arm 32,
25 that is on the side remote from the end surface 35, and to the left

side of the lock nut 61. The shaft 66 for the valve arm 59 extends vertically on the right hand side of the central plane 0_1-0_1 , and is disposed to the right of the cam shaft 31. The shaft 66 is also supported by the valve arm chamber casing 34. Two valve arms 59
5 (only one of them is shown) are carried at their intermediate portions by the common shaft 66 and are each provided at one end with a respective cam follower 67 in contact with the rear side of an associated cam 68 on the cam shaft 31. Adjusting screws 70 are fixed to the other ends of the valve arms 59 and held in place by
10 means of lock nuts 69. The ends of the adjusting screws 70 contact the protectors 71 on the ends of the plungers 93. The adjusting screws 70 are located to the right of the longitudinal vertical median plane 0_1-0_1 of the cylinders. Each injector unit is inclined to this plane 0_1-0_1 and approaches it towards the end of
15 the fuel injection nozzle 28.

An opening 72 is formed in the rear wall of the valve arm chamber casing 34 so as to extend from the right end towards the left end portion of the rear wall. A cover 73 for closing the opening 72 is
20 secured by bolts 74 to the casing 34. A lever-type decompression mechanism 75 is secured to the left of the case 34. The decompression mechanism 75 is for manually operating valves into opening positions when the engine is to be started. The valve arm 32 is provided with an arm 76 which is adapted to be actuated by
25 the decompression mechanism 75.

In the engine structure described above, the rotation of the cam shaft 31 causes cams 64 to actuate exhaust valves 23 and intake valves 24 through the action of valve arms 32 and, at the same time, the cam 68 actuates the plunger 93 of the fuel injection pump 56 through the action of the valve arm 59. The operation of the exhaust valves 23, the intake valves 24 and the fuel injection pump 56 can be adjusted by varying the positions of the adjusting screws 62 and 70. Since the adjusting screw 70 and the lock nut 69 face the opening 72 in the valve arm casing 34, access to them can be easily gained for adjustment through the opening 72 by removing the cover 73. The adjusting screws 62 and lock nuts 61 are also accessible for adjustment through the opening 72 via a gap between the cam shaft 31 and the shaft 66 because these shafts are on opposite sides of the adjusting screws 62 and lock nuts 61.

15

As shown in Figure 2, the cam shaft 31 is supported at both ends and at an intermediate portion by the casing 34. For each of the cylinders 14 and 15, the cams 64 for actuating the valves and the cam 68 for actuating the fuel injection pump are spaced vertically along the camshaft 31, with the cam 68 being positioned at the same level as the horizontal longitudinal median plane 0-0. To the lower end of the camshaft 31 is connected a pump shaft 79 of a lubricating oil pump 78 which is fastened to the lower side of the casing 34 by means of bolts (not shown). The inlet of the lubricating oil pump 78 communicates with an oil pan (not shown)

20

25

through an oil passage drilled through the casing 34, the cylinder head 19 and the cylinder block 18. The oil pan is formed by a case which encases the output shaft (not shown) extending downwardly from the lower end of the crankshaft 11. The outlet of the
5 lubricating oil pump 78 is connected to every portion of the engine through an oil passage (not shown) drilled through the casing 34, the cylinder head 19 and the cylinder block 18.

- 17 -

The upper end portion of the cam shaft 31 projects above the casing 34. A pulley 81 fixed to the projecting part of the upper end of the cam shaft 31 is drivingly connected to another pulley 82 fixed to the upper portion of the crankshaft 11 by means of a timing belt 83. A generator 84 is connected to the fly-wheel 12 above the pulley 82. A ring gear 85 on the outer periphery of the fly-wheel 12 is adapted to be driven by a starter 86 secured to a portion 30 of the crank case 36. An oil filler duct 87 projecting obliquely upwardly is attached to the upper portion of the bottom wall (front wall) of the crank case 36. A governor 88 is attached to the cylinder block 18 while a fuel injection rate increasing device 89 which operates during starting up of the engine is secured to the cylinder head 19. The governor 88 is adapted to be driven through the timing belt 83. The governor 88 and the fuel injection rate increasing device 89 are connected to the plunger 93 of the fuel injection pump 56 shown in Figure 3 through a lever mechanism 90.

As will be seen from Figure 3, the governor 88 is disposed rearwardly of the crank case 36 and on the right of the cylinder block 18. A lubricating oil filter 100 is disposed on the left side of the cylinder block 18. As explained before, the fuel injection pump 56 is mounted in the cylinder head 19 as a unit with the fuel injection nozzle 28. Thus, in the illustrated embodiment of the invention the fuel injection pump 56 is carried on the

5 cylinder head 19, while the governor 88 and the lubricating oil filter 100 are carried on the cylinder block 18. Therefore, the engine as a whole exhibits a substantially oval or egg-like form when viewed from the upper side as shown in Figure 3, which shape is quite suitable for use as a marine outboard engine. Needless to say, the engine as a whole is covered by a cowling 1 (Figure 1) of the outboard motor M.

10 An air intake pipe 101 is connected at one end to the intake port 22 on the right side of the cylinder head 19 while the other end is open near the forward end of the crank case 36. The air intake pipe 101 extends along the right side of the cylinder block 18 and the crank case 36 and the inlet end portion thereof turns round to the front side of the crank case 36 to reach a position near the
15 longitudinal vertical median plane O_1-O_1 . By adopting such a long air intake pipe, it is possible to enhance the intake inertia effect to improve the performance of the engine.

As has been described, since the intake pipe 101 extends along the
20 right side of the crank case 36 and since the starter 86 is positioned on the left side slightly forwardly of the crank case 36, it is possible to obtain a certain rough balance and approximate symmetry of the engine as a whole with respect to the longitudinal axis thereof. Furthermore, a certain balance and
25 symmetry within the valve arm casing 34 is attained as can be seen

from Figure 3 by positioning the injector unit 57 inclined to the right while the cam shaft 31 and the valve arms 32 are disposed to the left.

- 5 The arrangement of the parts of the engine of the described embodiment may be inverted with respect to the neutral axis of the engine. The invention does not exclude an arrangement in which the portion 37 of the crank case 36 is formed separately from the
- 10 cylinder block 18, and the invention can be embodied as an engine having more than three cylinders. It is also possible to provide a vortex flow chamber (pre-combustion chamber) within the cylinder block 18.
- 15 This Specification is divided from British Patent application No. 83.31011 (Serial No. 2142087) which contains a disclosure of the invention defined in this Specification.



- 20 -

CLAIMS

1. An overhead cam type water cooled reciprocating piston diesel engine for an outboard motor, having a plurality of cylinders each having associated inlet and exhaust valves and respective fuel injector units operated by a cam shaft on a cylinder head, in which the said injector units are located on one side of a plane passing through the axis of the associated cylinder parallel to the crankshaft axis and the inlet and exhaust valves and the cam shaft for the injector units are located on the other side of this plane, and in which an oil filter and a governor of the engine are disposed on opposite sides of the said plane from one another.
2. A water-cooled diesel engine as claimed in Claim 1, in which an intake pipe is disposed on the said one side of the said plane, the said intake pipe having one end connected to an inlet port formed in the cylinder head and the other end open adjacent a part of the crankcase remote from the cylinder head.
3. A water-cooled diesel engine as claimed in Claim 2, in which an oil filter opening is formed in the crankcase in a position opposite the said cylinder block, and a starter is positioned adjacent the crankcase on the opposite side of the oil filter opening from the said other end of the intake pipe.

32



4. A water-cooled diesel engine substantially as hereinbefore described with reference to and as shown in the accompanying drawings.
