A watercraft includes a performance mode selector which enables a rider to select normal operation of the watercraft or an economy mode operation. In the economy mode operation, the watercraft either disables cylinders or reduces fuel injection and ignition in order to limit the maximum engine speed obtained by the engine when the throttle lever is fully depressed. Additionally, the watercraft can disable cylinders or selectively reduce fuel injection or ignition when an abnormal operating parameter has been detected.
Figure 2
START

STARTER SWITCH ACTIVATED

ECONOMY MODE ON?

Y

N

NORMAL OPERATION MODE

END

CHOOSE CYLINDER D TO BE DISABLED

DISABLE CYLINDER D

Figure 4
Figure 5

198

SELECT CYLINDER D TO BE DISABLED

206

SWITCH DISABLED CYLINDER 1 → 4 → 3 → 2 → 1 FOR PREDETERMINED TIME

208

RETURN

210
Figure 4

230

232

WARNING MODE TRIGGERED

234

ENDING TIME OF FUEL INJECTION IS SET SO THAT FUEL INJECTION AMPLITUDES FITS WITHIN ONE CYCLE

236

PREDETERMINED TIME ELAPSED IN STAGE 1, 2, OR 3?

240

N ≥ PREDETERMINED ENGINE SPEED

242

RAISE TO HIGHER STAGE

244

REDUCE TO LOWER STAGE

238

END
STAGE 1

**Economy Mode**

STAGE 2

**Disable Cylinders:**
1 + 4 → 2 + 3

STAGE 3

**Disable Cylinders:**
1 + 4 + 2 → 4 + 3 + 2 → 3 + 2 + 1 → 2 + 1 + 4
START

STARTER SWITCH ON

ECONOMY MODE ON?

Y

N

NORMAL OPERATION

CYCLE SKIP

END

Figure 9
ENGINE CONTROL UNIT FOR WATER VEHICLE
PRIORITY INFORMATION

[0001] This application is based on and claims priority to Japanese Patent Application No. 2001-028536 filed Feb. 5, 2001, the entire contents of which are hereby expressly incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention generally relates to a control unit for an engine of a watercraft. More specifically, the present invention relates to a fuel control and ignition controller for the engine of a watercraft.

[0004] 2. Related Art

[0005] As personal watercraft have become popular, they have become increasingly fast. Today, certain personal watercraft are capable of speeds greater than 60 mph. To attain such speeds, these personal watercraft are driven by high power output motors.

[0006] Typically, two-cycle engines are used in personal watercraft because two-cycle engines have a fairly high power to weight ratio. One disadvantage of two-cycle engines, however, is that they produce relatively high emissions. In particular, large amounts of carbon monoxide and hydrocarbons are produced during operation of the engine. When steps are taken to reduce these emissions, other undesirable consequences typically result, such as an increase in the weight of the engine, the cost of manufacture, and/or the reduction of power.

[0007] It has been suggested that four-cycle engines replace two-cycle engines in personal watercraft. Four-cycle engines typically produce less hydrocarbon emissions than two-cycle engines while still producing a relatively high power output. Additionally, it has been suggested that fuel injected engines are more efficient and cleaner.

SUMMARY OF THE INVENTION

[0008] One aspect of the present invention includes the realization that often times riders of personal watercraft wish to drive the watercraft at a speed that is less than the maximum speed capable of the watercraft. However, because the rider must hold the throttle lever at a mid-way position with one finger, yet retain a firm grasp of the handlebars with the remaining fingers, operating a watercraft in such a manner can cause discomfort. Thus, it is desirable to allow the watercraft to operate at a speed lower than the maximum speed capable by the watercraft yet with the throttle lever in the fully depressed position. Another aspect of the invention includes the realization that often times a rider of a personal watercraft desires to operate the watercraft in the most fuel-efficient manner. For example, a rider may be unsure of the maximum range of the watercraft using the remaining fuel in the watercraft. Alternatively, a rider may be unsure of the distance to their destination. In any of these circumstances, a rider may wish to reduce the chance that the watercraft will run out of fuel before the destination is reached. Thus, it is desirable to allow a rider to choose certain operational parameters of the watercraft to match the rider’s wishes.

[0009] Yet another aspect of the invention is directed to a watercraft having a hull defining an engine compartment and an engine disposed in the engine compartment. A rider’s area is supported by the hull and a throttle lever is disposed in the rider’s area. A controller is configured to control fuel supply and ignition for engine operation. The watercraft also includes a user-operable performance mode switch having a normal operation position and an economy mode position. The controller is configured to limit engine speed through at least one of cylinder disablement, fuel injection reduction, and ignition reduction, to a predetermined engine speed which is less than the maximum rated speed of the engine when the performance mode switch is in the economy mode position.

[0010] Another aspect of the present invention is direct to a method of controlling an engine of a watercraft having an engine and a user-operable performance mode switch. The method includes determining if the performance mode switch is in a first or second position and limiting engine speed to a first predetermined speed with at least one of cylinder disablement, fuel injection reduction, and ignition reduction when the performance mode switch is in the first position.

[0011] A further aspect of the invention is directed to a watercraft having a hull defining an engine compartment and an engine disposed in the engine compartment. A rider’s area is supported by the hull and a throttle lever is disposed in the rider’s area. A controller is configured to control fuel supply and ignition for engine operation. The watercraft also includes a user-operable performance mode switch having a normal operation position and an economy mode position. Additionally, the watercraft includes means for limiting engine speed to a predetermined engine speed which is less than the maximum rated speed of the engine when the performance mode switch is in the economy mode position.

[0012] Yet another aspect of the present invention is directed to a watercraft comprising a hull defining an engine compartment with an engine disposed in the engine compartment. A controller is configured to control fuel supply and ignition for engine operation. The controller is also configured to detect an operational parameter of the engine and to disable a first cylinder of the engine when a speed of the engine is above a predetermined engine speed and when the operation parameter is outside a normal range of values. Additionally, the controller is configured to increase the number of disabled cylinders if the speed of the engine continues to be greater than the predetermined engine speed.

[0013] An additional aspect of the present invention is directed to a method of controlling a watercraft engine. The method includes detecting an operational parameter of the engine, disabling a first cylinder if a speed of the engine is above a predetermined speed, and increasing the number of disabled cylinders if the engine speed continues to be higher than the predetermined speed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other features, aspects and advantages of the present invention will now be described with reference to the drawings of a preferred embodiment, which embodiment is intended to illustrate and not to limit the invention, and in which figures:
FIG. 1 is a side elevational view of the watercraft constructed in accordance with the present invention, with certain components such as an engine and a jet propulsion device shown in phantom;

FIG. 2 is a schematic illustration of the engine included in the watercraft shown in FIG. 1, the left-hand side of FIG. 2 showing a partial sectional view of one cylinder of the engine, the lower right-hand corner of FIG. 2 including an electronic control unit of the engine, and the upper-right hand corner illustrating a portion of the fuel supply system;

FIG. 3 is an enlarged rear elevational view of a control panel on the watercraft shown in FIG. 1; and

FIG. 4 is a block diagram illustrating a control routine for controlling the engine illustrated in FIG. 2, including a normal operation mode and an economy operation mode;

FIG. 5 is a control routine for performing part of the economy mode operation illustrated in FIG. 4;

FIG. 6 is a block diagram illustrating a control routine for performing another part of the economy mode operation illustrated in FIG. 4;

FIG. 7 is a block diagram illustrating a warning mode control routine for controlling the engine illustrated in FIG. 2;

FIG. 8 is a schematic representation of three stages of operation available in the warning mode routine illustrated in FIG. 7;

FIG. 9 is a block diagram of a modification of the control routine illustrated in FIG. 4 including a normal operation mode portion and an economy mode operation portion;

FIG. 10 is a block diagram of a portion of the economy mode operation portion illustrated in FIG. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

With reference now to FIGS. 1-3, an overall configuration of a personal watercraft 10 is described below. An arrow F shown in FIG. 1 indicates a forward direction of the watercraft 10.

The watercraft 10 includes an engine 12 and a hull 14 formed with a lower hull section 16 and an upper deck section 18. Both hull sections 16, 18 may be constructed of, for example, molded fiberglass reinforced resin or a sheet molding compound. The hull section 16, 18 may, however, be constructed from a variety of other materials selected to make the watercraft lightweight and buoyant. The lower hull section 16 and upper hull section 18 are coupled together to define an internal cavity 20. A gunwale 22 defines an intersection of the lower and upper hull section 16, 18.

The hull 14 extends longitudinally and thereby generally defines a longitudinal axis (not shown). Along the longitudinal axis, in a direction from bow to stern of watercraft 10, the watercraft 10 includes a bow portion 24, a hatch cover 26, a control mast 28, and a rider’s area 30.

In the illustrated embodiment, the bow portion 24 of the upper hull section 18 slopes upwardly and an opening 32 is provided through which a rider can access the internal cavity 20. The hatch cover 26 is detachably affixed (e.g., hinged) to the bow portion 24 so as to cover the opening 32.

The control mast 28 extends upwardly to support the handlebar 34. The handlebar 34 is provided primarily for controlling the direction in which the watercraft 10 travels. Grips (not shown) are formed at both ends of the bar 34 to aid the rider in controlling the direction of travel, and maintaining his or her balance on the watercraft 10. The handlebar 34 also carries other control devices such as, for example, a throttle lever (not shown) used to control a running condition of the engine 12, described in more detail below with reference to FIG. 4.

The rider’s area 30 is defined primarily by a seat assembly 36. The seat assembly 36 is formed of a seat pedestal 38 which is defined by a portion of the upper deck portion 18. The pedestal 38 extends longitudinally along the hull and is shaped so that it can be straddled by a rider. Additionally, the pedestal 38 includes an access opening (not shown) through which a user can access the engine compartment 20.

The seat assembly 36 also includes a seat cushion 40 which is supported by the pedestal 38. Preferably, the seat 40 substantially seals the access opening when installed on the pedestal 38 so as to prevent water from entering the engine compartment 20. Additionally, foot areas are formed on each side of the seat assembly 36.

Preferably, the watercraft 10 includes at least one ventilation duct (not shown) for allowing atmospheric air to flow into the engine compartment 20 as well as allowing air from inside the engine compartment 20 to flow out to the atmosphere. Except for the ventilation ducts, the engine compartment 20 is substantially sealed during operations so as to prevent water from invading the engine compartment 20.

A jet pump 42 propels the watercraft 10. The jet pump 42 is mounted at least partially within a tunnel 44 formed on the underside of the lower hull section 18. The tunnel 44 has a downward facing inlet portion 46 opening towards the body of water in which the watercraft 10 is operating. A jet pump housing 48 is disposed within a portion of the tunnel 44 and communicates with the inlet port 46. An impeller 50 is supported within the housing 48.

An impeller shaft 52 extends forwardly from the impeller and is connected to a driveshaft 54 with a flexible coupling 56. The driveshaft 54 is driven by the engine 12.

The rear end of the housing 48 defines a discharge nozzle 58. A steering nozzle (not shown) is affixed to the discharge nozzle 58 pivotally for movements above a steering access which extends generally vertically. The steering nozzle through a bowden-wire assembly, for example, so that the rider can pivot the steering nozzle.

As the engine 12 drives the driveshaft 54 and thus the impeller shaft 52, the impeller is thereby rotated within the housing 48. The pressure generated in the housing 48 by the impeller 50 produces a jet of water that is discharged through the discharge nozzle 58 and the steering nozzle. This water jet propels the watercraft in a forward direction, as
indicated by the arrow F. The rider can move the steering nozzle with the handlebar 34 when he or she desires to turn the watercraft 10.

[0037] Preferably, the watercraft 10 also includes a reverse bucket 60. The reverse bucket 60 is pivotally mounted relative to the discharge nozzle 58 so as to pivot about a generally horizontal axis. The reverse bucket 60 is shaped such that when it is placed in its full downward position, as illustrated in Fig. 1, water discharged from the discharge nozzle 58 will be directed downwardly and forwardly so as to cause reverse movement of the watercraft 10. In its upright position (not shown), the reverse bucket 60 allows the water to be discharged rearwardly from the discharge nozzle 58 and thus propel the watercraft in a forward direction F.

[0038] With reference to Fig. 2, the engine 12 operates on a four-stroke combustion principle. The engine 12 includes cylinder block 62. The cylinder block defines at least one cylinder bore 64 therein. Preferably, the cylinder block 62 defines a plurality of cylinder bores 64 spaced from each other in a fore to aft direction along the longitudinal axis of the watercraft 10. Preferably, the cylinder block 62 defines four cylinder bores 64. Thus, the engine 12 is preferably an L-4 (in-line four cylinder) type engine. The illustrated engine 12, however, merely exemplifies one type of engine that may include preferred embodiments of the anti-theft system. Engines having other numbers of cylinders, having other cylinder arrangements, other cylinder orientations (e.g., upright cylinder banks, V-type, and W-type) and operating on other combustion principles (e.g., crankcase compression two-stroke, diesel and rotary) are all practicable.

[0039] A piston 66 is slidably disposed in each cylinder bore 64. A cylinder head member 68 is affixed to the upper end of the cylinder block 62. The cylinder head member 68 closes the upper ends of the cylinder bores 64 and thereby defines four combustion chambers 70 along with the respective cylinder bores 64 and pistons 66.

[0040] A crankcase member (not shown) is affixed to the lower end of the cylinder block 62 to close the respective lower ends of the cylinder bores 64 and to define a crankcase chamber. A crankshaft 72 is rotatably connected to the pistons 66 through connecting rods 74 and is journalized at least partially within the crankcase. That is, the connecting rods 74 are rotatably coupled with the piston 66 and with the crankshaft 72.

[0041] The cylinder block 62, the cylinder head member 68, and the crankcase member, together define an engine body 76. The engine body 76 preferably is made of an aluminum-based alloy. In the illustrated embodiment, the engine body 76 is arranged in the engine compartment 20 to position the crankshaft 72 generally parallel to the longitudinal axis of the watercraft 10. Other orientations of the engine body 76, of course, are also possible (e.g., with a transverse or vertical crankshaft).

[0042] With reference to Fig. 1, engine mounts 78 extend from both sides of the engine body 76. The engine mounts 78 preferably include resilient portions made of, for example, a rubber material so that vibrations from the engine 12 are attenuated. The engine 12 is preferably mounted on a hull liner (not shown) that forms part of the lower hull section 16.

[0043] The engine 12 preferably is lubricated with oil housed in an oil tank (not shown). Preferably, the engine 12 includes a dry—sump lubrication system which, using plural oil pumps, circulates oil from the oil tank through a plurality of oil galleries defined within the engine body 76. The circulation path of the oil preferably passes through an oil filter (not shown) mounted on the engine body 76.

[0044] The engine 12 also includes an air induction system configured to guide air into the combustion chamber 70. In the illustrated embodiment, the air induction system includes at least one intake runner 78 for each combustion chamber 70 defined within the engine 12. Preferably, the intake runners 78 have an inlet end connected to an air plenum (not shown) disposed within the engine compartment 20. The outlet ends 80 of the intake runner 78 are connected to intake ports 82 defined on an outer surface of the cylinder head member 68. An internal air passage 84 extend from the inlet ports 82 to the combustion chamber 70.

[0045] The induction system also includes at least one throttle valve 86. Preferably, there is one throttle valve 86 for each intake runner 78. Each of the throttle valves 86 comprise a plate member 88 which defines a butterfly type valve with an interior surface of the intake runner 78. A throttle valve shaft 90 extends through the intake runner to rotatably support the plate 88. A portion of the runner 78 which supports the throttle valve shaft 90 can also be referred to as a “throttle body”. The throttle valves 86 are connected to the throttle lever which is pivotally mounted on the handlebar 34. Thus, a rider can manipulate the throttle valve 86 by moving the throttle lever.

[0046] With continued reference to Fig. 2, the internal intake passages 84 are opened and close by intake valves 92. When the intake valves 92 are open, air from the intake runner 78 flows into the combustion chamber 70, during a downward movement of the piston 66.

[0047] In operation, the engine 12 draws air from the engine compartment 20 into the combustion chamber 70 during the downward movement of the piston 66. The throttle valve 86 controls the amount of air flowing into the intake runners 78 and eventually entering the combustion chamber 70. When the throttle valves 86 are closed, only a small amount of air enters each combustion chamber 70. Preferably, the throttle valves 86 are configured to allow a predetermined amount of air to flow through the intake runner 78 into the combustion chamber 70 when they are fully closed. Alternatively, one or a plurality of idle air passages (not shown) can be included which allows an idle amount of air to bypass the throttle valves 86 and flow into the combustion chambers 70.

[0048] The engine 12 also includes an exhaust system configured to guide burnt fuel charges from the combustion chamber 70 to the atmosphere. Exhaust gases are discharged from the combustion chamber 70 during upward movement of the piston 66. The exhaust gases travel out of the combustion chamber 70 into an internal exhaust gas passage 94 defined in the cylinder head member 68. The exhaust gases then travel out through an exhaust port (not shown) and through plurality of exhaust pipes, mufflers, and other components to the atmosphere.

[0049] At least one exhaust valve 96 opens and closes during the operation of the engine 12 and controls the flow of exhaust gases from the combustion chamber 70 into the exhaust passage 94.
An intake camshaft 98 and an exhaust camshaft 100 are provided to control the opening and closing of the exhaust valves 96 and the intake valves 92, respectively. The camshafts 98, 100 extend generally horizontally and parallel with each other. The camshafts 98, 100 have cam lobes that act against the valves 92, 96 at predetermined timings to open and close the respective internal passages 84, 94. The camshafts 98, 100 are journaled on the cylinder head member 68 and are driven by the crankshaft 72 via a camshaft drive unit (not shown).

With continued reference to FIG. 2, the engine 12 also includes a fuel injection system 102. The fuel injection system includes at least one fuel injector 104 for each combustion chamber 70. Each of the fuel injectors 104 includes an injection nozzle exposed to a portion of the airflow path into the combustion chamber 70. In the illustrated embodiment, the fuel injectors 104 are mounted in the intake runners 78 and are oriented so as to inject the fuel into an airflow flowing through the respective intake runners 78 towards the intake ports 84.

A main fuel supply tank (not shown) preferably is disposed in the engine compartment 20. Fuel is drawn from the fuel tank by a first low pressure pump (not shown) through a fuel line. The first low pressure pump pumps the fuel to a vapor separator assembly 104 through a fuel line (not shown). A float valve 106 is disposed within the vapor separator so as to maintain a uniform level of fuel contained within the vapor separator 104.

A high pressure fuel pump 108 preferably is disposed within the vapor separator 104 and pressurizes fuel within the vapor separator 104. The high pressure fuel pump 108 is connected with the fuel injectors 104 through a fuel delivery conduit 110. Preferably, the conduit 110 itself forms a fuel rail connecting the fuel injectors 104 with the high pressure fuel pump 108.

A fuel return conduit 112 connects the fuel injectors 104 and/or the fuel rail 110 with the vapor separator 104. Excess fuel that is not injected by the injectors 104 returns to the vapor separator 104 through the conduit 112. A pressure regulator (not shown) can be provided so as to communicate with either the fuel supply conduit 110 or the fuel return conduit 112 to limit the pressure of the fuel delivered to the fuel injectors 104. The flow generated by the return of unused fuel from the fuel injectors aids in cooling the fuel injectors 104.

The timing and duration of fuel injection from the fuel injectors 104 are controlled by an electronic control unit (ECU) 114. Preferably, each of the fuel injectors 104 are controlled by an electronic solenoid (not shown) which opens a valve at the discharge end of the fuel injector 104. The ECU 114 communicates with the solenoids on the fuel injectors 104 through a fuel injection communication line 116. Thus, the ECU 114 signals the solenoids on the fuel injectors 104 to open according to a timing determined by the ECU 114 and for duration also determined by the ECU 114.

The engine 12 also includes an ignition system. The ignition system includes at least one sparkplug 118 for each of the combustion chambers 70. The sparkplugs 118 are mounted such that an electrode of the sparkplug 118 is exposed to the respective combustion chamber 70. The sparkplugs 118 ignite an air fuel charge at a timing determined by the ECU 116 so as to cause the air fuel charge to burn therein. For this purpose, the ignition system includes an ignition coil (not shown) interposed between the sparkplugs 118 and the ECU 114. The ECU 114 controls the operation of the coil through an ignition control line 120.

The engine 12 also preferably includes an AC generator (not shown) for generating electrical power. Additionally, the watercraft 12 preferably includes a battery 122 (FIG. 4) for powering the ECU, as well as other components discussed in greater detail below, during the starting of the engine 12. The battery 122 is recharged with electrical energy from the AC generator.

As noted above, the ECU 114 controls engine operations including fuel injection from the fuel injectors 104 and firing of the sparkplugs 118, according to various control maps stored in the ECU 114. In order to determine appropriate control scenarios, the ECU 114 utilizes such maps and/or indices stored within the ECU 114 in reference to data collected from various sensors.

Any type of desired control strategy can be employed for controlling the time and duration of fuel injectors from the injectors 104 and the timing for firing sparkplugs 118; however, general discussion of some engine conditions that can be sensed and some of the ambient conditions that can be sensed for engine control will follow. Typically, fuel supply control strategies are configured to create stoichiometric air/fuel charges in the combustion chambers 70. Additionally, the watertank 10 preferably includes a rev limiter configured to limit the speed of the engine to a speed that is approximately the maximum rated speed of the engine 12. It is to be understood, however, that those skilled in the art will readily understand how various control strategies can be employed in conjunction with the components of the invention.

The control for the air/fuel ratio preferably includes a feedback control system. Thus, an oxygen sensor 124 is mounted so as to detect a residual amount of oxygen in the combustion products at a time when the exhaust valve 96 opens. An air/fuel data line 126 connects the oxygen sensor 124 with the ECU 114, and thus conducts a signal indicative of the air/fuel ratio to the ECU 114.

With continued reference to FIG. 2, an engine speed sensor 128 is configured to detect a speed of the crankshaft 72 and produces a signal indicative of the speed of rotation of the crankshaft 72. An engine speed data line 130 connects the engine speed sensor 128 with the ECU 114.

Preferably, at least one crank angle position sensor 132 is provided for each combustion chamber 70. Each crank angle position sensor 132 is positioned around the crankshaft 72 so as to produce a signal indicative of the position of the crankshaft 72. Each crank angle position sensor 132 is connected to the ECU 114 with a crank angle position data line 134.

An engine temperature sensor 136 is connected to the cylinder block 62 so as to detect the temperature of coolant flowing through a water jacket disposed within the cylinder block 62. The engine temperature sensor 136 produces a signal indicative of the temperature of the coolant and transmits the signal to the ECU 114 via an engine temperature data line 138.
A fuel level sensor 140 is connected to the vapor separator 104 so as to detect a level of fuel within the vapor separator 104. The fuel level sensor 140 produces a signal indicative of the level of fuel within the vapor separator 104 and transmits this signal to the ECU 114 via a fuel level data line 142.

Although not illustrated, the ECU 114 can control the low pressure fuel pump in accordance with the signal received from the fuel level sensor 140 so as to maintain a uniform level of fuel within the vapor separator 104.

The engine can also include an intake air pressure sensor 144 disposed in the induction system. Preferably, at least one air pressure sensor 144 is disposed in one of the intake runners 78 so as to detect an air pressure therein. The air pressure sensor 144 is configured to produce a signal indicative of the air pressure within the intake runner 78 and transmits this signal to the ECU via an air pressure data line 146.

At least one air temperature sensor 148 is also preferably disposed in one of the intake runners 78 so as to detect an air temperature therein. The air temperature sensor 148 produces a signal indicative of the air temperature within the intake runner 78 and transmits the signal to the ECU 114 via an air temperature data line 150.

A throttle position sensor 152 is configured to detect an opening amount of the throttle valve 86. In the illustrated embodiment, the throttle valve position sensor 152 is configured to detect an angular position of the throttle valve shaft 90 and produce a signal indicative of the angular position of the throttle valve shaft 90. The signal from the throttle valve position sensor 152 is transmitted to the ECU 114 via the throttle valve position data line 154.

The sensed conditions disclosed above are merely some of those conditions which may be sensed and applied for control of fuel injection and ignition. It is, of course, practical to provide other sensors such as, for example, without limitation, a knock sensor, a watercraft pitch sensor, an atmospheric temperature sensor, an atmospheric pressure sensor, a fuel pressure sensor, in accordance with the various control strategies.

The ECU 114 processes the detected signals from each sensor based upon a control strategy. The ECU 114 forwards control signals to the fuel injectors 104, sparkplugs 118, and the fuel pumps including the high pressure fuel pump 108 (via the high pressure control pump line 109) for their respective control.

With reference to FIG. 3, the gauge panel 160 also includes performance mode switch 180. The performance mode switch 180 has two positions; one corresponding to a normal operation mode and one corresponding to an economy operation mode, thereby allowing a user to switch the watercraft 10 between a normal operation mode and an economy operation mode.

With reference to FIG. 4, a performance mode control routine 190 is illustrated. At step 192, the routine 190 begins. For example, the routine 190 can run at all times when the watercraft 10 is operating. As such, the ECU 114 can be configured to run the control routine 190 at all times when power is supplied to the ECU 114. Optionally, the ECU 114 can be configured to run the routine 190 only when the engine 12 is running. After the routine 190 starts in step 192, the routine 190 moves to step 194.

In the step 194 of the illustrated embodiment, the routine 190 begins after a starter switch 134 has been activated. For example, a starter switch 134 is mounted on the handlebar 134. The starter switch can be in the form of a button which is connected to a starter motor. The starter motor can be connected to the crankshaft 72 of the engine 12 so as to crank the engine in a starting operation. After the starter switch has been activated, the routine 190 moves on to a decision step 196.

In the decision step 196, it is determined if the watercraft 10 is in the economy mode. For example, the ECU 114 can sample a signal from the performance mode switch 180. If the signal detected by the ECU 114 indicates that the performance switch 180 is in the economy mode position, the routine 190 moves to the step 198.

In the step 198, a cylinder D is chosen to be disabled. The operation performed in step 198 is disclosed in greater detail below with reference to FIG. 5. After the step 198, the routine 190 moves to step 200.

In the step 200, the cylinder or cylinders D identified in the step 198 are disabled. The operation performed in the step 200 is disclosed in greater detail below with reference to FIG. 6. After the step 200, the routine 190 moves to the step 202 in which the routine 190 ends. However, the ECU 114 can be configured to re-run the routine 190 at all times when the engine is operating. Alternatively, the routine 190 can include a return from the step 202 to the step 192.

With reference to the step 196, if it is determined that the economy mode is not activated, the routine 190 moves to step 204.

In the step 204, the fuel injection and the ignition systems of the engine 12 are operated in a normal mode. For example, the ECU 114 can control fuel injection and ignition according to any known control strategies. Preferably, the strategy used is configured to provide a stoichiometric air/fuel ratio to the combustion chamber 70, under all running conditions. After the step 204, the routine 190 moves to the step 202.

With reference to FIG. 5, the step 198 of the routine 190 is illustrated as three steps 206, 208, and 210. However, one of ordinary skill in the art will appreciate that the routine 198 can be broken down into other numbers of steps.

The routine 198 begins when, as noted above, it is determined that the watercraft 10 is in economy mode in step 196 (FIG. 4). Thus, the beginning of the routine 198 begins with step 206 in order to select a cylinder D to be disabled. After the step 206, the routine 198 moves on to step 208.

In the step 208, the cylinder D to be disabled is switched. In the illustrated embodiment, initially, the cylinder disabled is Cylinder No. 1. Cylinder No. 1 remains the selected cylinder to be disabled for a predetermined amount of time. The next time the routine 198 reaches step 208, Cylinder No. 4 is disabled for the pre-determined period of time. Similarly, as the routine 198 returns to the step 208, Cylinder No. 3 is disabled for a predetermined time, then Cylinder No. 2 is disabled for a predetermined period of
time. Following the disablement of Cylinder No. 2 for a predetermined time, Cylinder No. 1 is again disabled for the predetermined time. After the step 208, the routine 198 moves to the step 210.

[0082] In the step 210, the routine 198 returns to the step 206 and repeats.

[0083] With reference to FIG. 6, the step 200 is illustrated as the routine for disabling the cylinder D chosen in the step 198. The routine 200 is initiated at a step 212 when the routine 190 reaches the step 200, as noted above. After the routine 200 has been initiated, the routine 200 moves to the step 214.

[0084] In the step 214, it is determined whether the ignition advance value presently dictated by the ECU 114 is greater than or equal to a predetermined economy mode ignition advance. For example, the ECU 114 can compare the ignition advanced presently used to control the timing of the firing of the sparkplugs 118 with a predetermined ignition advance calibrated for use in a mode where cylinders in the engine 12 are disabled. If it is determined that the present ignition advance is greater than or equal to the economy mode, the routine 200 moves to a step 216.

[0085] In the step 216, the present ignition advance being applied to the timing of the firing of the sparkplugs 118 is set to equal the predetermined economy mode ignition advance. Thus, for example but without limitation, the ECU 114 can change the presently applied ignition advance to the predetermined economy mode advance. After the step 216, the routine 200 moves on to step 218. Similarly, if the present ignition advance is not greater than or equal to the economy mode ignition advance, in the step 214, the routine moves directly to the step 218.

[0086] In the step 218, it is determined whether the present engine speed N is greater than or equal to a predetermined maximum economy mode speed N_{max}. For example, the ECU 114 can sample the output from the engine speed sensor 128 and compare the corresponding speed to a predetermined maximum economy mode speed N_{max}. In the illustrated embodiment, the predetermined maximum economy mode speed N_{max} can be set to approximately 8300 rpm. However, one of skill in the art will recognize that the maximum economy mode speed can be set to numerous other engine speeds. If it is determined that the engine speed N is greater than or equal to the maximum economy mode speed N_{max}, the routine 200 moves to step 220.

[0087] In the step 220, fuel injection is stopped for all cylinders. For example, the ECU 114 can stop sending any signals to the fuel injectors 104. Thus, combustion in all of the combustion chambers 70 will immediately stop. However, under the momentum of the moving components within the engine 12, the crankshaft 72 will continue to rotate. After the step 220, the routine 200 moves to a step 222.

[0088] In the step 222, the routine 200 returns to the step 212 and repeats.

[0089] With reference to the step 218, if it is determined that the present engine speed N is not greater than or equal to the predetermined maximum economy mode speed N_{max}, the routine 200 moves to a step 224.

[0090] In the step 224, it is determined whether the present engine speed N is greater than or equal to a predetermined cylinder disable start speed N_{cyl}. For example, the ECU 114 can sample the output of the engine speed sensor 128 and compare the corresponding engine speed to a predetermined engine speed N_{cyl} at which cylinder disablement is to start. Preferably, the cylinder disable start speed N_{cyl} is sufficiently high such that a sudden disablement of one cylinder will not interrupt the smooth operation of the engine 12. In the illustrated embodiment, the cylinder disable start speed N_{cyl} is approximately 8000 rpm. If it is determined, in the step 224, that the present engine speed is greater than or equal to the cylinder disable start speed N_{cyl}, the routine 200 moves to a step 226.

[0091] In the step 226, fuel injection is stopped to the Cylinder No. D determined in the step 198 of the routine 190. For example, but without limitation, the ECU 114 can stop sending fuel injection control signals to the fuel injectors 104 corresponding to the Cylinder No. D. Thus, the remaining cylinders will continue to operate even though combustion will cease in the Cylinder No. D. After the step 226, the routine 200 moves to the step 222 and thus repeats.

[0092] With reference to the step 224, if it is determined that the present engine speed is not greater than or equal to the cylinder disable start speed N_{cyl}, the routine 200 moves directly to the step 222 and repeats.

[0093] In operation, with reference to FIGS. 4-6, when the performance mode switch 180 is in the normal operation mode, the watercraft 10, and in particular the ECU 114, will control fuel supply and ignition in a normal operation mode. As noted above, preferably the control strategy utilized by the ECU 114 in a normal operation mode is configured to provide a stoichiometric air/fuel ratio to the combustion chamber 70 under all running conditions.

[0094] However, if the performance mode switch 180 is switched to the economy mode, as illustrated in the routine 190, the ECU 114 will limit engine speed by disabling a cylinder. For example, as illustrated in FIG. 5, initially Cylinder No. 1 will be chosen to be disabled in the step 198. Thus, in the step 200 (FIG. 6) fuel injection to Cylinder No. 1 will stop. However, it should be noted that fuel injection to Cylinder No. 1 will be stopped only when the engine speed is above the cylinder disable start speed N_{cyl}. Additionally, it should be noted that all fuel injection is stopped when the present engine speed is above the maximum economy mode speed N_{max}. Thus, in operation, the engine speed N will be maintained between the max economy mode speed N_{max} and the cylinder disable start speed N_{cyl}.

[0095] In the illustrated embodiment, the preferred maximum economy mode speed N_{max} is 8300 rpm and the predetermined cylinder disable start speed N_{cyl} is 8000 rpm. Thus, when the performance mode switch 180 is in the economy mode position, the engine 12 will be maintained at speeds between 8000 and 8500 rpm when the throttle lever is fully depressed. Thus, a rider can maintain a speed that is lower than the maximum speed of the watercraft 10 while the throttle lever is fully depressed. As such, the rider will be more comfortable when operating the watercraft for extended periods of time at speeds less than the maximum attainable by the watercraft 10. Additionally, the engine 12 will consume less fuel since fuel injection will be stopped.

[0096] An additional benefit of the routine 190 is that the cylinder that is disabled in the step 226 is changed regularly.
during the operation. In particular, in the step 198, as illustrated in FIG. 5, the cylinder that is disabled in the step 226 is continuously changed. As shown in the step 208 (FIG. 5) the cylinder to be disabled is selected for only a predetermined time period. As the routine 198 repeats, the chosen cylinder changes after each predetermined time period elapses. Thus, the cylinders are less likely to suffer from problems associated with improper lubrication or thermal stresses which may arise from one cylinder, i.e., the disabled cylinder, dropping to a temperature lower than the temperature of the other cylinders.

[0097] Optionally, the predetermined cylinder disable start speed \( N_{\text{sd}} \) can be set at a low speed, thereby allowing the disablement of a cylinder at any engine speed. In this mode, operation of the engine \( 12 \) with a reduced number of cylinders begins from a low speed operation of the engine. Thus, there is no transition from four-cylinder operation to three-cylinder operation. In this case, the throttle position and the engine speed presents a more linear or proportional relationship.

[0098] With reference to FIG. 7, a warning routine 230 is illustrated as a block diagram. The routine 230 begins at a step 232 in which the warning mode is triggered. For example, the warning mode can be triggered when a hydraulic pressure of the lubricating system falls below a predetermined value, or if the engine temperature of the engine \( 12 \) is elevated above a predetermined temperature. The ECU 114, for example but without limitation, can sample the temperature of the coolant with the engine coolant temperature sensor 136 and compare the corresponding temperature with a predetermined maximum safe engine operating temperature \( T_{\text{max}} \). In lieu or in addition to this, the ECU 114 can sample an output from a lubricant pressure sensor (not shown) and compare the corresponding pressure with a predetermined minimum lubricant pressure \( P_{\text{min}} \). Thus, if the engine temperature is above the predetermined maximum engine temperature \( T_{\text{max}} \), or if the lubricant pressure falls below the predetermined minimum lubricant pressure \( P_{\text{min}} \), the warning mode routine 230 is triggered and the routine 230 moves to a step 234.

[0099] In the step 234, the ending time for fuel injection is set so that the amplitude of fuel injection fits within one cycle. After the step 234, the routine 230 moves to a step 236.

[0100] In the step 236, it is determined whether a predetermined time has elapsed during a corresponding warning mode stage. The warning mode stages are disclosed in greater detail below with reference to FIG. 8. If it is determined that the predetermined time has not elapsed in the step 236, the routine 230 moves to a step 238 and ends. However, the ECU 114 can be configured to continually re-run the routine 230 during operation of the engine \( 12 \). Alternatively, the routine 230 can include a return from the step 238 to the step 232.

[0101] If it is determined that a predetermined time has elapsed in the corresponding warning mode stage, the routine 230 moves to a step 240.

[0102] In the step 240, it is determined whether the present engine speed \( N \) is greater than a predetermined engine speed. For example, a predetermined safe engine speed \( N_s \) can be saved into a memory within the ECU 114. Thus, the ECU 114 can sample the output of the engine speed sensor 128 and compare this speed with the predetermined engine speed \( N_s \). If it is determined that the present engine speed is greater than or equal to the predetermined engine speed \( N_s \), the routine 230 moves to a step 242.

[0103] In the step 242, the warning mode stage active in the step 236 is raised to the next higher stage. For example, discussed in greater detail below with reference to FIG. 7 and FIG. 8, the ECU 114 can disable an additional cylinder and thereby further reduce the engine speed. After the step 242, the routine 230 moves to the step 238 and repeats as noted above.

[0104] If, in the step 240, it is determined that the present engine speed is not greater than or equal to the predetermined engine speed, the routine 230 moves to a step 244.

[0105] In the step 244, the warning mode stage is reduced. For example, the ECU 114 can activate a previously disabled cylinder. After the step 244, the routine 230 moves to the step 238 and repeats as noted above.

[0106] With reference to FIG. 8, the three warning mode stages noted above with reference to the step 236 are represented schematically therein. As shown in FIG. 8, the warning mode stage 1 is the same as the economy mode described above with reference to FIGS. 4-6. The stage 2 warning mode requires that two cylinders be disabled. For example, either Cylinder Nos. 1 and 4 or 2 and 3 are disabled for the predetermined time period set forth in the step 236.

[0107] The stage 3 warning mode requires that three cylinders be disabled during the predetermined time period set forth in the step 236. In the stage 3 mode operation, the cylinders are grouped in four ways so that three cylinders are disabled each time the selected disabled cylinders are changed. Accordingly, each time the selected disabled cylinders are changed, there is a different combination of disabled cylinders so as to prevent damage, as noted above.

[0108] In stage 3, the disabled cylinders are grouped as follows: Cylinder Nos. 1, 4 and 5, Cylinder Nos. 4, 3 and 2, Cylinder Nos. 3, 2 and 1, and Cylinder Nos. 2, 1 and 4. After the cylinders have been disabled in these groups, each grouping is disabled for predetermined time period set forth in the step 236.

[0109] In operation, when the warning mode of the routine 230 is triggered by an insufficient lubricant pressure or an excessive engine temperature, cylinders are disabled in order to maintain the engine speed end below a predetermined value. Initially, the warning mode routine 230 operates the engine in the economy mode disclosed above with reference to FIGS. 4-6. However, if at this step 240 it is determined that the present engine speed \( N \) is greater than or equal to a predetermined engine speed, the routine 230 increases the stage of the warning mode to thereby disable additional cylinders.

[0110] For example, if the warning mode has already been triggered and the routine 230 is running in stage 1, and it is determined that the present engine speed \( N \) is greater than or equal to the predetermined engine speed at the step 240, the routine 230 will raise the warning mode stage to stage 2 and eventually return to the step 236. The engine \( 12 \) will continue to run in a stage 2 mode, i.e., two cylinders will be disabled, either Cylinder Nos. 1 and 4 or Cylinder Nos. 2 and
3. One of these groups of two cylinders would be disabled until the predetermined time period elapses in the step 236.

[0111] Similarly, if the engine speed $N$ is again determined to be greater than the predetermined engine speed in the step 240, the routine 230 will increase the warning mode stage to stage 3 and thus disable three cylinders at a time.

[0112] With reference to FIG. 9, a modification of the economy mode of routine 190 is illustrated therein and referred to generally by the reference numeral 250. The routine 250 starts at steps 252 and 254. The initiation of the routine 250 can be the same as the initiation of the routine 190 described above with reference to steps 192 and 194. After the step 254, the routine 250 moves to step 256.

[0113] In the step 256, it is determined if the performance mode switch 180 is in the economy mode position. If it is determined that the performance mode switch 180 is not in the economy mode position, the routine 250 moves to step 258.

[0114] In the step 258, the engine 12 of the watercraft 10 is operated in accordance with a normal operation mode. As discussed above, with reference to the step 204 (FIG. 4), the ECU 114 preferably controls the operation of fuel injection and ignition so as to provide a stoichiometric air/fuel ratio in the combustion chamber 70 under all running conditions. After the step 258, the routine 250 moves to a step 260 and repeats, similar to the step 202 of the routine 190.

[0115] If, in the step 256, it is determined that the performance mode switch 180 is in the economy mode position, the routine 250 moves to a step 262.

[0116] In the step 262, the routine 250 performs a cycle skipping routine 264 illustrated in FIG. 10. The routine 264 begins at a step 266 which is triggered when the routine 250 reaches the step 262. After the step 266, the routine 264 moves to a step 268.

[0117] In the step 268, it is determined if the present engine speed $N$ is greater than or equal to a predetermined engine speed $N_{50}$ at which fuel injection and ignition are generally reduced by 50%. For example, the predetermined engine speed $N_{50}$ can be set at an engine speed which is too high for the present economy mode operation. A presently preferred predetermined engine speed $N_{50}$ is about 5700 rpm. In operation, for example but without limitation, the ECU 114 can sample the output from the engine speed sensor 128 and compare the corresponding speed to the predetermined engine speed $N_{50}$. If it is determined that the present engine speed $N$ is greater than or equal to the predetermined engine speed $N_{50}$, the routine 264 moves to a step 270.

[0118] In the step 270, fuel injection and ignition are reduced by 50%. For example, but without limitation, the ECU 114 can control the fuel injectors 104 and the sparkplugs 118 so as to inject fuel and ignite an air fuel mixture in the combustion chambers 70 once for every four revolutions of the crankshaft 72. Typically, in a four-stroke engine, an air fuel charge is combusted once for every two revolutions of the crankshaft 72. Thus, an air fuel charge is combusted in a particular combustion chamber 70 at only half the frequency of normal operation. By reducing fuel injection and ignition as such, the engine speed will drop.

[0119] After the step 270, the routine 264 moves to a step 272 and ends. However, the ECU 114 can be configured to repeat the routine 264 continuously during operation of the engine 12. Alternatively, the step 272 can include a return to the step 266 so that the routine 264 repeats.

[0120] With reference to the step 268, if it is determined that the engine $N$ is not greater than or equal to the predetermined engine speed $N_{50}$, the routine 264 moves to a step 274.

[0121] In the step 274, it is determined if the present engine speed $N$ is greater than or equal to a second predetermined engine speed $N_{25}$. For example, the predetermined engine speed $N_{25}$ can be set to an engine speed at which it is desired to reduce fuel injection and ignition by 25% when the engine 12 is run in the economy mode. In a presently preferred embodiment, the engine speed $N_{25}$ is approximately 5000 rpm. If it is determined that the present engine speed $N$ is greater than the predetermined engine speed $N_{25}$, the routine 264 moves to a step 276.

[0122] In the step 276, fuel injection and ignition are reduced by 25%. For example, but without limitation, the ECU 114 can be configured to cause the fuel injectors 108 to inject fuel and to cause the sparkplugs 118 to spark only three times for every eight revolutions of the crankshaft 72. As such, the fuel injection and ignition are reduced by 25%, i.e., there are 25% fewer ignitions of air fuel charges in the combustion chamber 70. After the step 276, the routine 264 moves to the step 272 and repeats.

[0123] With reference to the step 274, if the present engine speed $N$ is not greater than or equal to the predetermined engine speed $N_{25}$, the routine 264 moves to a step 278.

[0124] In the step 278, it is determined whether the present engine speed $N$ is greater than or equal to a third predetermined engine speed $N_{55}$. For example, the predetermined engine speed $N_{55}$ can be set to an engine speed at which it is desired to reduce only fuel injection, but not ignition, by 25%. In a presently preferred embodiment, the third predetermined engine speed $N_{55}$ can be set to approximately 4800 rpm. If it is determined that the present engine speed $N$ is greater than or equal to the third predetermined engine speed $N_{55}$, the routine 264 moves to a step 280.

[0125] In the step 280, fuel injection is reduced by 25%, but ignition is not reduced. For example, the ECU 114 can signal the fuel injector 104 to inject fuel only three times for every eight revolutions of the crankshaft 72. As such, fuel injection generally is reduced by 25%. After the step 280, the routine 264 moves to the step 272 and repeats.

[0126] In operation, when a rider operates the watercraft 10 with the performance mode switch 180 in the economy mode position, the maximum engine speed of the engine 12 can be maintained within a range of approximately 4800 to 5700 rpm with the throttle lever fully depressed. Thus, a rider can maintain a low speed for an extended period of time without having to hold the throttle lever in an intermediate position. Additionally, because the fuel injection and ignition reduction only occurs at speeds above the third predetermined engine speed $N_{55}$, initial or off-the-line acceleration is not effected. Finally, it is to be noted that by reducing fuel injection and/or ignition as described above with reference to FIG. 10, mechanical failures associated with cylinders that have been disabled for extended periods is avoided.
Although the present invention has been described in terms of a certain embodiment, other embodiments apparent to those of ordinary skill in the art also are within the scope of this invention. Thus, various changes and modifications may be made without departing from the spirit and scope of the invention. For instance, various components may be repositioned as desired. Moreover, not all of the features, aspects and advantages are necessarily required to practice the present invention. Accordingly, the scope of the present invention is intended to be defined only by the claims that follow.

What is claimed is:

1. A watercraft comprising a hull defining an engine compartment, an engine disposed in the engine compartment, a rider’s area supported by the hull, a throttle lever disposed in the rider’s area, a controller configured to control fuel supply and ignition for engine operation, a user-operable performance mode switch having a normal operation position and an economy mode position, the controller being configured to limit engine speed through at least one of cylinder disablement, fuel injection reduction, and ignition reduction, to a predetermined engine speed which is less than the maximum rated speed of the engine when the performance mode switch is in the economy mode position.

2. The watercraft according to claim 1, wherein the controller is configured to disable a cylinder for a predetermined time, then change the disabled cylinder to a different cylinder.

3. The watercraft according to claim 1, wherein the engine includes at least a first and second cylinders, the controller being configured to disable the first cylinder for a predetermined time, then enable the first cylinder and disable the second cylinder after the predetermined time has elapsed.

4. The watercraft according to claim 1, wherein the controller is configured to determine whether an operational parameter of the engine is outside a range of normal operational values, and to limit engine speed through at least one of cylinder disablement, fuel injection reduction, and ignition reduction, to a predetermined engine speed which is less than the maximum rated speed of the engine when the operational parameter is outside the range of normal operational values.

5. The watercraft according to claim 4, wherein the operational parameter is engine temperature and the range of normal operational values is the normal operating temperature of the engine.

6. The watercraft according to claim 4, wherein the controller is configured to increase at least one of the number of disabled cylinders, the reduction of fuel injection, and the reduction of ignition when a second operational parameter of the engine exceeds a predetermined value.

7. The watercraft according to claim 6, wherein the second operational parameter is a speed of the engine.

8. The watercraft according to claim 1, wherein the engine includes a plurality of cylinders, the controller being configured to group the cylinders into at least two groups and to alternately disable the groups of cylinders when the performance mode switch is in the economy mode position.

9. The watercraft according to claim 1, wherein the controller is configured to reduce fuel injection frequency by a first factor when a speed of the engine exceeds the first predetermined engine speed.

10. The watercraft according to claim 9, wherein the controller is configured to reduce fuel injection frequency by a second factor, which is less than the first factor, when the speed of the engine exceeds a second predetermined speed.

11. A method of controlling an engine of a watercraft having an engine and a user-operable performance mode switch, the method comprising determining if the performance mode switch is in a first or second position, limiting engine speed to a first predetermined speed with at least one of cylinder disablement, fuel injection reduction, and ignition reduction when the performance mode switch is in the first position.

12. The method as set forth in claim 11, wherein the step of cylinder disablement comprises supplying fuel to the first cylinder and preventing the supply of fuel to a first cylinder for a predetermined time.

13. The method as set forth in claim 12 additionally comprising supplying fuel to the first cylinder and preventing the supply of fuel to the second cylinder after the predetermined time period has elapsed.

14. The method as set forth in claim 11, wherein the step of fuel injection reduction comprises reducing the frequency of fuel injection such that fuel is not supplied to a cylinder during an intake stroke of a piston reciprocating in the cylinder.

15. The method as set forth in claim 11, wherein the step of fuel injection reduction comprises reducing the frequency of fuel injection below the frequency of fuel injection used during normal operation.

16. A watercraft comprising a hull defining an engine compartment, an engine disposed in the engine compartment, a rider’s area supported by the hull, a throttle lever disposed in the rider’s area, a controller configured to control fuel supply and ignition for engine operation, a user-operable performance mode switch having a normal operation position and an economy mode position, and means for limiting engine speed to a predetermined engine speed which is less than the maximum rated speed of the engine when the performance mode switch is in the economy mode position.

17. A watercraft comprising a hull defining an engine compartment, an engine disposed in the engine compartment, a controller configured to control fuel supply and ignition for engine operation, the controller being configured to detect an operational parameter of the engine and to disable a first cylinder of the engine when a speed of the engine is above a predetermined engine speed and when the operation parameter is outside a normal range of values, the controller also being configured to increase the number of disabled cylinders if the speed of the engine continues to be greater than the predetermined engine speed.

18. The watercraft as set forth in claim 17 wherein the controller is configured to decrease the number of disabled cylinders when the engine speed is below the predetermined engine speed.

19. The watercraft as set forth in claim 17, wherein the controller is configured to disable a second cylinder and enable the first cylinder after a predetermined time has elapsed.

20. The watercraft as set forth in claim 17, wherein the operational parameter of the engine is a temperature of the engine.
21. A method of controlling a watercraft engine comprising detecting an operational parameter of the engine, disabling a first cylinder if a speed of the engine is above a predetermined speed, and increasing the number of disabled cylinders if the engine speed continues to be higher than the predetermined speed.

22. The method as set forth in claim 21 additionally comprising decreasing the number of disabled cylinders when the engine speed is below the predetermined engine speed.

23. The method as set forth in claim 21 additionally comprising disabling a second cylinder and enabling the first cylinder after a predetermined time has elapsed.

24. The method as set forth in claim 21, wherein disabling the first cylinder comprises preventing fuel supply to the first cylinder.

25. The method as set forth in claim 21 wherein detecting an operational parameter comprises detecting a temperature of the engine.

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