

AN ELECTRIC OUTBOARD MOTOR

TECHNICAL FIELD

[0001] The present disclosure relates broadly, but not exclusively, to an electric outboard motor.

BACKGROUND OF THE DISCLOSURE

[0002] Outboard motors (OBM) have been used to propel small watercraft for decades and until recently have been powered by petrol or diesel internal combustion engines (ICE). These OBMs can range in power from as low as 1.5hp to 600hp per OBM and can move boats from small kayaks to medium-sized pleasure craft. The smallest OBMs are portable and can be removed from the boat for storage or maintenance, while those 15hp and above tend to be permanently attached to the boat. These boats can be used in lakes or rivers for sports and recreation, or on a yacht as a tender, in reservoirs/marinas/ports for commercial purposes, or for security/military operations.

[0003] Since technological advances in electric motor and battery technology, electric outboard motors (eOBMs) have become commercially feasible. Majority of the typical eOBMs are in the less than ten or greater than forty horsepower range. The smaller eOBMs have different designs from conventional ICE, in that the electric motor is in the motor, directly driving the propeller, while the larger eOBMs are typically a conventional OBM but with the ICE replaced by an electric motor, retaining the shaft and gearing system. The smaller eOBMs can be carried by one or two persons, while the larger eOBMs require a lifting device or three to four persons to install/remove.

[0004] To provide electricity to the eOBMs, manufacturers supply batteries to be used onboard the boats. These batteries and their components are typically adapted from electric vehicles (EV) and tend to be large and heavy, with moderate power density. In addition, these batteries typically use adapted land electrical connectors and components which are not fully watertight and are unsuitable for a marine environment, particularly an environment replete with briny seawater. This use of conventional land-use electrical connectors leads to unsafe exposed electrical connections that could result in injury to the user or damage to the battery. The failure of non-marine connectors also affects the reliability of the entire system and often renders conventional eOBM non-operational. For conventional smaller eOBMs, batteries may be integrated into the eOBM or connected to the eOBM via wires using connectors with relatively small pins. Installing the battery onto the eOBM may be cumbersome due to the shape of the battery.

[0005] Another issue with typical eOBMs is size. The smaller eOBMs, such as those outputting between one and three horsepower, while light and easily portable, are underpowered for use in any waters where there are light currents or waves, such as coastal or tidal waters. In situations where a boat needs to travel against the current or waves, boats using such conventional smaller eOBMs may not have enough power to make headway against the current and/or waves and might even be pushed backwards by the current or waves. However, while larger eOBMs, such as those outputting more than six horsepower, can produce enough power to make headway against currents and waves, they typically have separate larger batteries that are too large and heavy to fit onto small boats and are significantly costlier than the smaller eOBMs.

[0006] Another issue with typical eOBMs is motor inefficiencies arising from stator and rotor design. In order to maximise magnetic flux of a motor, the stator and rotor

need to be designed and manufactured to a precise specification which matches a propeller to achieve desired performance and efficiency. Conventionally, it is challenging to design and manufacture the stator and rotor to the precise specification. Further, shape and type of magnets used contribute significantly to the motor performance, and it is difficult to obtain the magnets that can provide maximum efficiency when used with the stator and rotor.

[0007] A further issue with conventional eOBMs is cooling of the electric motor and the electronic speed controller (ESC). The larger powered eOBMs require air closed or open-loop cooling or liquid closed or open-loop cooling of the ESC, as it is located above the water. This exposes the air fan to failure due to corrosion and liquid circulation failure due to pump failure or blockage of seawater and/or coolant in the cooling system tubing.

[0008] Yet a further problem is that trimming smaller conventional eOBMs is mechanically challenging because a significant portion of the overall weight of such eOBMs is located at the propeller, due to the motor and the battery. Since the tiller is not designed to be used as a lever arm, a user needs to pull the motor up from outside the boat. When there is a need to quickly raise the motor out of the water, such as presented in shallow water to avoid grounding or to avoid nets or other underwater obstacles in deeper water, the tiller interferes with the raising of the motor as it hits the boat deck before the motor can be fully raised.

[0009] Another problem is that typical eOBMs require a pair of power cables and a separate multicore data cable, in order to operate the eOBM with the battery. These power cables and data wires are typically not marine-specific connectors and do not ensure that seawater does not enter the connectors, which would result in a short-circuit or corrosion of the connector pins and sockets. Furthermore, the thin data wires are

prone to damage due to the thinner protective insulation and the thin data pins/sockets are also extremely prone to corrosion.

[0010] Throttles, tillers and transom mounts of conventional eOBMs present additional issues. Typical eOBM throttles can be rotated in both directions for ahead and astern (forward and reverse) drive which may result in situations where the user rotates the throttle in the wrong direction, resulting in an accident. As to the tiller, the typical eOBM tiller cannot be fully folded away when not in use, obstructing movement inside the rear part of the boat and also requires more storage space. For some designs, the tiller may be removable, hence there would be one additional part to handle when transporting or storing the eOBM. And, as to the transom mount, conventional eOBMs have the transom mount integrated with the main body, which makes the overall system heavier and harder to carry and manipulate when installing the eOBM on the boat or removing the eOBM from the boat.

[0011] Thus, an electric outboard motor (eOBM) that overcomes the drawbacks of conventional eOBMs while providing a portable eOBM capable of high-power, quiet and efficient watercraft operation is needed.

SUMMARY

[0012] According to a first aspect, there is provided an electric outboard motor (eOBM), comprising: a propulsion module; a power supply module electrically coupled to the propulsion module; and a tiller-throttle module operably coupled to the propulsion module, the tiller-throttle module comprising a tiller, a throttle, a safety button and a restriction mechanism, wherein: a first end of the tiller is coupled to one end of a stem module; one end of the throttle is coupled to a second end of the tiller; and the safety button is coupled to the restriction mechanism and configured to engage

the restriction mechanism to limit rotation of the throttle to a predetermined throttle angle range when un-activated, wherein the safety button is further configured to release the restriction mechanism when activated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Embodiments and implementations are provided by way of example only, and will be better understood and readily apparent to one of ordinary skill in the art from the following written description, read in conjunction with the drawings, in which:

[0014] FIG. 1 is a schematic representation of an electric outboard motor (eOBM), according to an example embodiment.

[0015] FIG. 2, comprising FIGs. 2A, 2B and 2C, is a schematic representation of a propulsion module of the eOBM of FIG. 1, according to an example embodiment. FIG. 2A is a side view of the propulsion module, FIG. 2B is a side cutaway view of the propulsion module with a gearbox and FIG. 2C is a side cutaway view of the propulsion module without the gearbox.

[0016] FIG. 3, comprising FIGs. 3A and 3B, is a schematic representation of a power supply module of the eOBM of FIG. 1, according to an example embodiment. FIG. 3A is an isometric view of the power supply module and FIG. 3B is an isometric cutaway view of the power supply module.

[0017] FIG. 4, comprising FIGs. 4A, 4B, 4C, 4D and 4E, is a schematic representation of a tiller-throttle module of the eOBM of FIG. 1, according to an example embodiment. FIG. 4A is an isometric view of the tiller-throttle module wherein a tiller of the tiller-throttle module is locked at zero degree, FIG. 4B is an isometric view of the tiller-throttle module wherein the tiller is locked at 90 degrees, FIG. 4C is an isometric view of the tiller-throttle module wherein the tiller is locked at

180 degrees, FIG. 4D is an isometric cutaway view of a section of the tiller-throttle module and FIG. 4E is a side cutaway view of the section of the tiller-throttle module.

[0018] FIG. 5, comprising FIGs. 5A, 5B, 5C and 5D, is a schematic representation of a restriction mechanism of the eOBM of FIG. 1, according to an example embodiment. FIG. 5A is an isometric view of the restriction mechanism coupled to a throttle, FIG. 5B is an isometric view of an annular sleeve of the restriction mechanism, FIG. 5C is an isometric view of a pin of the restriction mechanism in a first position and FIG. 5D is an isometric view of the pin of the restriction mechanism in a second position.

[0019] FIG. 6, comprising FIGs. 6A and 6B, is a schematic representation of a propeller module of the eOBM of FIG. 1, according to an example embodiment. FIG. 6A is a front view of the propeller module and FIG. 6B is an isometric view of the propeller module.

[0020] FIG. 7, comprising FIGs. 7A and 7B, is a schematic representation of a stem module of the eOBM of FIG. 1, according to an example embodiment. FIG. 7A is an isometric view of the stem module and FIG. 7B is an isometric cutaway view of the stem module.

[0021] FIG. 8, comprising FIGs. 8A, 8B, 8C, 8D, 8E, 8F, 8G and 8H, is a schematic representation of a connector module of the eOBM of FIG. 1, according to an example embodiment. FIG. 8A is an isometric cutaway view of a female power connector of the connector module. FIG. 8B is a side cutaway view of the female power connector. FIG. 8C is an isometric view of a male power connector of the connector module. FIG. 8D is a side cutaway view of the male power connector. FIG. 8E is an isometric view of the male power connector coupled to other connectors. FIG. 8F is an isometric view of the male power connector assembled in the stem module. FIG. 8G is an isometric view

of a weather cover of the male power connector. FIG. 8H is an isometric view of the weather cover installed onto the male power connector assembled in the stem module.

[0022] FIG. 9, comprising FIGs. 9A, 9B and 9C, is a schematic representation of a transom mount module of the eOBM of FIG. 1, according to an example embodiment. FIG. 9A is an isometric view of the transom mount module at an initial operational position. FIG. 9B is an isometric view of the transom mount module at a maximum trim position. FIG. 9C is an isometric view of the transom mount module at a tilt position.

[0023] FIG. 10, comprising FIGs. 10A, 10B and 10C, is a schematic representation of a remote throttle module, according to an example embodiment. FIG. 10A is an isometric view of the remote throttle module. FIG. 10B is a partial isometric view of the remote throttle module without a display. FIG. 10C is an isometric view of the display.

[0024] FIG. 11 is a flowchart illustrating a method for powering on the eOBM, according to an example embodiment.

[0025] FIG. 12 is a flowchart illustrating a method for powering off the eOBM, according to an example embodiment.

[0026] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale.

DETAILED DESCRIPTION

[0027] Embodiments will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0028] Embodiments of the invention provide an electric outboard motor (eOBM) for a watercraft. The eOBM may be portable with a power between 1 to 3kW.

Advantageously, the eOBM has enough power to push the watercraft against currents and waves, yet is compact and light enough to be removed by one person from the watercraft when needed (e.g. when not in use). The eOBM uses a power supply module such as a battery module and components specifically designed and tested for a saline marine environment. A motor and an electronic speed controller (ESC) of the eOBM are located in the water with no internal liquid cooling required, resulting in a watertight system which is fully cooled by external seawater. Thus, the eOBM is fully emissions-free and advantageously produces low noise and vibration, which is important when operating in many natural water habitats. In addition, the eOBM and/or its propulsion module can advantageously be adapted to be mounted under a boat as a drive pod or integrated with a lifting foil as a foil-drive, providing a wide variety of optional uses.

[0029] FIG. 1 is a schematic representation of an electric outboard motor (eOBM) 100, according to an example embodiment. The eOBM comprises a propulsion module 200. The eOBM also comprises a power supply module 300 electrically coupled to the propulsion module 200. Further, the eOBM comprises a tiller-throttle module 400 operably coupled to the propulsion module 200, the tiller-throttle module 400 comprises a tiller, a throttle, a safety button and a restriction mechanism. A first end of the tiller is coupled to one end of a stem module 700. One end of the throttle is coupled to a second end of the tiller. The safety button is coupled to the restriction mechanism and configured to engage the restriction mechanism to limit rotation of the throttle to a predetermined throttle angle range when un-activated. In addition, the safety button is further configured to release the restriction mechanism when activated. As shown in FIG. 1, the eOBM may also comprise a propeller module 600 and a transom mount module 900. The first end of the tiller may be pivotably coupled to the one end of the

stem module 700. Further, the throttle may be rotatably coupled about the tiller such that the throttle may be rotatable about an axis of the tiller.

[0030] FIG. 2, comprising FIGs. 2A, 2B and 2C, is a schematic representation of a propulsion module 200 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 2A is a side view of the propulsion module 200, FIG. 2B is a side cutaway view of the propulsion module 200 with a gearbox and FIG. 2C is a side cutaway view of the propulsion module 200 without the gearbox. As shown in FIG. 2, the propulsion module 200 may comprise a motor 202, an electronic speed controller (ESC) 204 for controlling the motor 202, a motor shaft 206 coupled to the motor 202, a propeller shaft 208, bearing(s) 210, shaft seal(s) 212, a motor casing 214, an ESC endcap 216 and an anti-grounding fin 218. Optionally, the propulsion module 200 may also comprise a gearbox 220 (e.g. a planetary gearbox 220) and a gearbox endcap 222.

[0031] According to one embodiment, the eOBM 100 may further comprise the propeller module 600 coupled to the propulsion module 200. The propulsion module 200 may comprise the motor 202 coupled to the planetary gearbox 220 or directly coupled to the propeller module 600.

[0032] The motor 202 may be a custom designed Brushless Direct Current (BLDC) motor. The motor 202 may be coupled to a lightweight, strong and durable planetary gearbox 220 designed to provide speed and torque required to turn the propeller module 600 and generate thrust to propel the watercraft. As a non-limiting example, the planetary gearbox 220 may be made of metal. A motor stator may be fitted on the inside of the motor casing 214. This arrangement beneficially allows direct seawater cooling of the motor 202 through cooling of an external surface of the motor casing 214. The motor 202 may have field-weakening at high speed to achieve increased torque, which is necessary to propel the watercraft faster.

[0033] The motor 202 may be controlled by a multi-layered ESC 204 that enables the entire ESC 204 to be fitted on a forward end of the motor 202, without increasing a diameter of the motor casing 214. The ESC 204 may be designed to handle large currents and voltages required to turn the motor 202. The large currents and voltages can generate significant heat that needs to be quickly dissipated to allow for continuous operation at high currents. The heat can be dissipated by thermally connecting a base of the ESC 204 with an internal surface of the ESC endcap 216. The ESC endcap 216 may be fitted over a forward end of the motor casing 214, forming a watertight seal with one or more O rings (e.g. double O rings). Beneficially, the arrangement maintains structural integrity and allows access for installation and assembly. The method of fixing the ESC endcap 216 to the motor casing 214 can eliminate use of axial screws and allows relatively smaller radial screws to be used instead.

[0034] The motor casing 214 allows relatively simple and quick assembly of the motor 202 inside the motor casing 214 as well as connection of the motor casing 214 to the stem module 700. Combination of extruded and cast parts in the motor casing 214 allows for a cost effective, quick and secure connection of the motor casing 214 to the stem module 700 for safe and effective transfer of forces from the propeller module 600 to the watercraft.

[0035] The optional gearbox 220 at an aft end of the motor 202 may be integrated with the motor 202, with the motor shaft 206 entering at the front of the gearbox 220 and the propeller shaft 208 exiting at the aft of the gearbox 220. Beneficially, the gearbox 220 is silent and self-lubricating, thus does not require any maintenance. Compact design of the gearbox 220 advantageously allows the gearbox 220 to fit within the gearbox endcap 222. A watertight seal can be formed with one or more O rings, such as double O rings. Beneficially, the method of fixing the gearbox endcap 222 to

the motor casing 214 eliminates a need for axial screws and allows relatively smaller radial screws to be used instead, without compromising structural strength of the structure that transmits thrust from the propeller module 600 to the motor casing 214.

[0036] The propeller shaft 208 may have double bearing and/or double seal arrangement. This arrangement can ensure a watertight seal with a rigid support for the propeller shaft 208 which can be subjected to strong axial and radial forces and vibrations. The seal(s) can be custom designed to withstand high temperatures and be resistant to seawater.

[0037] One or more sacrificial anodes such as anti-galvanic corrosion zinc anodes can be fixed at the motor casing 214 (e.g. at an end of the motor casing 214). Advantageously, this allows easy periodic replacement of the sacrificial anodes as the sacrificial anodes are consumed, especially in sea water.

[0038] FIG. 3, comprising FIGs. 3A and 3B, is a schematic representation of a power supply module 300 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 3A is an isometric view of the power supply module 300 and FIG. 3B is an isometric cutaway view of the power supply module 300. In some implementations, the power supply module 300 may be a battery module.

[0039] The power supply module 300 may comprise a battery pack 302, a battery management system (BMS), a State of Charge (SOC) indicator for indicating available battery capacity, a display module 304, a charging port 306 for charging the battery pack 302, a battery case 308 with a carry handle 310 for handling the power supply module 300, a guide track 312 for easy coupling of the power supply module 300 and the stem module 700, and a battery secure slot 314 for securing the power supply module 300 in position. In some embodiments, the BMS may be integrated with the battery pack 302. The battery case 308 may be watertight. The display module 304 may

comprise a trip computer. As shown in FIG. 3B, a female power connector 802 may be coupled to the power supply module 300.

[0040] The battery pack 302 may comprise battery cells, which can be OEM battery cells. The battery cells may be built into a pack that fits overall battery requirements of performance, capacity, weight and size.

[0041] The BMS may control the battery cells and interface with the ESC 204 of the propulsion module 200 to ensure that the battery cells and the BMS are operating within design limits. The BMS can also provide a low voltage power supply to the eOBM 100 to power the trip computer, while not providing full power to the ESC 204. On a condition that a kill switch is in place, the trip computer may be triggered to send a signal to the BMS to provide full power. The trip computer may send another signal to the ESC 204 to allow operation.

[0042] The power supply module 300 may be configured to be electrically coupled to a renewable energy source. As a non-limiting example, the renewable energy source may be a solar power source. Accordingly, the BMS may be designed to allow the renewable energy source and/or one or more external batteries of larger capacity to be connected to advantageously extend range and endurance of the eOBM and hence the watercraft. A detachable adapter may be used to connect the one or more external batteries to the eOBM 100. The detachable adapter may not comprise battery cells. However, the detachable adapter may comprise an electronic control board, such as a BMS.

[0043] The display module 304 may have a power switch or an on/off switch 316. The display module 304 may indicate remaining capacity of the battery pack 302 and alarm(s) from the BMS. Upon activation of the power switch or on/off switch 316, power may be provided to the display module 304 and the trip computer. Activation of

the power switch or on/off switch 316 can be performed by pressing and holding a button of the power switch or on/off switch 316 for a predetermined duration. As mentioned above, the trip computer may send the signal to the BMS to provide full power when the kill switch is in place. The screen on the display module 304 may light up and the system may become ready for operation when the kill switch is in place.

[0044] Power-data connector(s) such as the female power connector 802 may be custom designed to meet requirements of a single connector for both power and data, and maintain watertightness when connected.

[0045] The battery case 308 may be a molded plastic watertight case. The molded plastic watertight case ensures that the battery pack 302 is always dry and remains relatively cool under the sun. In contrast, temperature of a metal case can be high under the sun. The carry handle 310 disposed at the top of the power supply module 300 and/or a side handhold disposed at one or both of the sides of the power supply module 300 advantageously make carrying the power supply module 300 more ergonomic. Further, safer handling of the power supply module 300 is ensured, particularly when on the water.

[0046] As shown in FIG. 3A, the display module 304 is mounted on the top of the power supply module 300 to provide a user with necessary information. When the eOBM 100 is used with a remote throttle module, the display module 304 can be incorporated into the remote throttle module to provide the user with the same information. The display module 304 may comprise a screen, the trip computer, component(s) for obtaining the user's input and a display case. The component(s) for obtaining the user's input can be one or more waterproof buttons that allow the user to change settings on the screen. The one or more waterproof buttons may use vibration/capacitive as a mode of direct activation. The display case may be watertight.

[0047] The screen may be a high-daylight visibility transmissive type, with a waterproof bonded face plate, in order to achieve a clear digital display of data such as the watercraft speed and range, a power level, a battery level and alarm(s).

[0048] The trip computer can comprise a processor, a memory, a GPS and other electronic components. The trip computer may be connected to the ESC 204, the BMS, local throttle(s) and the remote throttle module. The trip computer may be connected to the remote throttle module via communication protocols such as CANBUS.

[0049] The processor of the trip computer can be a custom designed processor with one or more functions such as logging data from the ESC 204, the BMS and the GPS. Non-limiting examples of the data from the ESC 204 can be motor rpm, throttle information, motor and ESC temperatures and alarms. Non-limiting examples of the data from the BMS can be voltage, current, remaining capacity of the battery pack 302, battery cells information and BMS temperatures and alarms. Non-limiting examples of the data from the GPS can be speed over ground and time. Another function of the trip computer can be processing data to be displayed on the screen. Non-limiting examples of the data can be the watercraft speed and range in different units, the power level, the battery level and the alarm(s). Yet another function of the trip computer can be executing safety feature(s). A further function of the trip computer can be providing access such as Bluetooth link(s) to a user device such as a mobile application for diagnostic and remote troubleshooting.

[0050] FIG. 4, comprising FIGs. 4A, 4B, 4C, 4D and 4E, is a schematic representation of a tiller-throttle module 400 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 4A is an isometric view of the tiller-throttle module 400 wherein a tiller of the tiller-throttle module is locked at zero degree, FIG. 4B is an isometric view of the tiller-throttle module 400 wherein the tiller is locked at 90 degrees,

FIG. 4C is an isometric view of the tiller-throttle module 400 wherein the tiller is locked at 180 degrees, FIG. 4D is an isometric cutaway view of a section of the tiller-throttle module and FIG. 4E is a side cutaway view of the section of the tiller-throttle module. The tiller-throttle module 400 may be configured to steer the watercraft and control speed of the watercraft.

[0051] As mentioned above, the tiller-throttle module 400 comprises a tiller 402, a throttle 404, a safety button 406 and a restriction mechanism. The tiller 402 can rotate and lock in vertical up and vertical down positions to provide flexibility in operation, transport and storage. According to an embodiment, the tiller 402 may be configured to rotate between zero and 180 degrees about the one end of the stem module 700 and further configured to lock at 180 degrees for trimming or tilting the motor 202, 90 degrees when in operation and/or trimming the motor 202, and zero degree for handling the eOBM 100. The tiller 402 can be rotated upwards and locked at 180 degrees to act as a lever arm to trim or tilt the motor 202 to an optimum trim or raise it when in shallow water. When the watercraft is at anchor or when not in use, the tiller 402 can be rotated to and locked at 180 degrees, freeing up space at an aft of the watercraft for movement or other activities. When handling the eOBM 100 such as carrying the eOBM 100 by hand or transporting the eOBM 100 by vehicle, the tiller 402 can be rotated downwards and locked at zero degree to act as a carrying handle and to provide a compact volume. Beneficially, this minimises storage space required. The ability to rotate the tiller 402 180 degrees advantageously eliminates a need to dismantle the tiller 402 from the eOBM 100, which also eliminates a need to constantly connect and disconnect data cable(s). The user also need not constantly check that no loose parts are lost.

[0052] According to one embodiment, the throttle 404 may comprise an encoder configured to detect a throttle angle and transmit a corresponding throttle angle signal

to the propulsion module 200. The encoder may comprise an integrated power converter that allows the throttle 404 to accurately detect the throttle angle associated with changes in a throttle level, and transmit the corresponding throttle angle signal to the ESC 204 of the propulsion module 200.

[0053] As mentioned above, the safety button 406 is coupled to the restriction mechanism and configured to engage the restriction mechanism to limit rotation of the throttle 404 to a predetermined throttle angle range when un-activated. In some implementations, the predetermined throttle angle range may be zero to 45 degrees in a first throttle direction. In other words, the throttle 404 can freely rotate in a forward direction up to 45 degrees.

[0054] The safety button 406 may be disposed at a free end of the throttle 404. As mentioned above, the safety button 406 is configured to release the restriction mechanism when activated. On a condition that the restriction mechanism is released, a maximum rotation of the throttle 404 can be 90 degrees in the first throttle direction and/or 45 degrees in a second throttle direction. The second throttle direction may be opposite the first throttle direction.

[0055] In order to increase speed of the watercraft, the safety button 406 can be activated while rotating the throttle 404 further from 45 degrees to 90 degrees in the first throttle direction. This advantageously prevents accidental acceleration of the watercraft. Further, the safety button 406 can be activated to rotate the throttle 404 in the second throttle direction to reverse the watercraft. This advantageously prevents accidental reversal. In contrast, conventional ICE OBMs typically only allow throttle rotation in one direction, and a gear lever needs to be pulled to change into reverse gear. Hence, the present invention improves efficiency of operating the eOBM 100. The safety button 406 may be activated by depressing it.

[0056] As shown in FIG. 4D and FIG. 4E, the throttle 404 may comprise a neutral spring mechanism 408 configured, e.g. biased, to return the throttle angle to zero degree on a condition that no force is applied on the throttle 404. The neutral spring mechanism 408 advantageously prevents unintentional movement and automatically returns the throttle angle to zero degree when the user releases the throttle 404. Further, a throttle friction twist ring can be tightened to achieve required throttle feedback for a more constant throttle level.

[0057] FIG. 5, comprising FIGs. 5A, 5B, 5C and 5D, is a schematic representation 500 of the restriction mechanism of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 5A is an isometric view of the restriction mechanism coupled to a throttle 404, FIG. 5B is an isometric view of an annular sleeve of the restriction mechanism, FIG. 5C is an isometric view of a pin of the restriction mechanism in a first position and FIG. 5D is an isometric view of the pin of the restriction mechanism in a second position. In some implementations, the restriction mechanism may comprise an annular sleeve 502 surrounding and coupled to at least a portion of the throttle 404, the annular sleeve 502 having a first inner surface 504 and a second inner surface 506. The restriction mechanism may also comprise a pin 508 coupled to and movable by the safety button 406 into engagement with the first inner surface 504 and disengagement with the second inner surface 506 when the safety button 406 is un-activated, and disengagement with the first inner surface 504 and engagement with the second inner surface 506 when the safety button 406 is activated.

[0058] In particular, when the safety button 406 is un-activated, the pin 508 may be at the first position as shown in FIG. 5C such that the throttle 404 is prevented from rotating beyond the first inner surface 504. The position of the first inner surface 504 may correspond to the predetermined throttle angle range. When the safety button 406

is activated, such as depressed, the pin 508 may be moved to the second position as shown in FIG. 5D such that the throttle 404 is not prevented from rotating beyond the first inner surface 504; in other words, there is clearance for the throttle to rotate beyond the predetermined throttle angle range. Accordingly, the throttle 404 can rotate further when the safety button 406 is activated.

[0059]

[0060] FIG. 6, comprising FIGs. 6A and 6B, is a schematic representation of a propeller module 600 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 6A is a front view of the propeller module 600 and FIG. 6B is an isometric view of the propeller module 600. The propeller module 600 may comprise a propeller 602. The propeller 602 may be customised to match motor characteristics to achieve desired performance. In some implementations, one or more sacrificial anodes 604 are disposed at the propeller module 600. The one or more sacrificial anodes 604 may be disposed at an end of the propeller 602. Beneficially, the sacrificial anodes 604 protect a shaft from galvanic corrosion. As a non-limiting example, the sacrificial anodes 604 may be zinc anodes.

[0061] FIG. 7, comprising FIGs. 7A and 7B, is a schematic representation of a stem module 700 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 7A is an isometric view of the stem module 700 and FIG. 7B is an isometric cutaway view of the stem module 700. The stem module 700 may be coupled to the propulsion module 200 and the power supply module 300 and may comprise a steering lock 702. The stem module 700 may also comprise a stem 704, a connector block 706, a kill switch 708, a tiller latch 710, a battery latch 712, a battery pin guide 714, a steering end stop 716, a steerer tube 718 and a mounting pivot 720. The connector block 706 may

be a cast connector block. As shown in FIG. 7B, a male power connector 804 may be coupled to the stem module 700.

[0062] The stem 704 may comprise extruded fairing over the steerer tube 718. The fairing may comprise an extrusion profile designed to be hydrodynamically efficient and structurally strong. Further, the fairing may be designed in parts for assembly without exposed screws.

[0063] The steerer tube 718 may connect the motor 202 to the transom mount module 900 for transfer of thrust from the propeller module 600. The steerer tube 718 may also connect the motor 202 to the tiller 402 through the connector block 706 and throttle 404. Wires or cables from the ESC 204 can pass through the steerer tube 718. The steerer tube 718 may be sealed at both ends, making it and the motor casing 214 watertight.

[0064] Steering friction can be adjusted on the transom mount module 900 to allow for fine adjustment of force required to turn the motor 202 to steer the watercraft. If it is too light, the watercraft may be unable to hold a steady course, while if it is too tight, the user may have difficulties steering the watercraft quickly.

[0065] The connector block 706 at the top of the stem module 700 can connect the stem 704 to the tiller 402. The connector block 706 may house the male power connector 804 and the mounting pivot 720. The power supply module 300 may be installed onto the connector block 706, engaging the male power connector 804. The connector block may also house the kill switch 708, the battery latch 712, the tiller latch 710, the battery guide pin 714 and the steering end stop 716.

[0066] The mounting pivot 720 may provide a single action installation of the eOBM 100 on the transom mount module 900, while firmly engaging the transom mount module 900 for complete transfer of thrust from the propeller module 600 to the

watercraft, particularly when changing directions between forward and astern. A single action lever can unlock or disengage the mounting pivot 720 for easy and quick removal of the eOBM 100, while ensuring that it is secured firmly to the transom mount module 900 when the eOBM 100 is installed.

[0067] The steering lock 702 can be used to lock the eOBM 100 in a center steering position when the watercraft is steered using its own rudder. The steering lock 702 may have a unitary body and may be configured to lock the eOBM 100 in a center steering position when rotated to a predetermined locking angle. A lock latch of the steering lock 702 may not have any removable parts and can be self-locking with a single twist, eliminating a need for loose locking pins that can fall out or be lost.

[0068] FIG. 8, comprising FIGs. 8A, 8B, 8C, 8D, 8E, 8F, 8G and 8H, is a schematic representation of a connector module 800 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 8A is an isometric cutaway view of a female power connector 802 of the connector module 800. FIG. 8B is a side cutaway view of the female power connector 802. FIG. 8C is an isometric view of a male power connector 804 of the connector module 800. FIG. 8D is a side cutaway view of the male power connector 804. FIG. 8E is an isometric view of the male power connector 804 coupled to other connectors. FIG. 8F is an isometric view of the male power connector 804 assembled in the stem module 700. FIG. 8G is an isometric view of a weather cover 806 of the male power connector 804. FIG. 8H is an isometric view of the weather cover 806 installed onto the male power connector 804 assembled in the stem module 700. The connector module 800 may be a composite power-data harness which protects data wires and terminates them in one multi-purpose connector which houses both power and data pins/sockets.

[0069] In one embodiment, the eOBM may further comprise the connector module 800. The connector module 800 may comprise the female power connector 802 and the male power connector 804. The female power connector 802 may be coupled to the power supply module 300 and may comprise a plurality of sockets 810. The male power connector 804 may be coupled to the stem module 700 and may comprise a plurality of pins 814 configured to insert into the plurality of sockets 810. The plurality of pins 814 may be more than 4.5mm in diameter. The female power connector 802 and the male power connector 804 may have specially designed pins 814 and sockets 810 that are equally and adequately sized to resist corrosion and breaking. This is in contrast to typical smaller pins and sockets used in conventional eOBMs, which are more prone to corrosion and breaking. For example, the plurality of pins 814 may be 4.9mm in diameter.

[0070] The female power connector 802 and the male power connector 804 can be power-data connectors and may be of IP67 rating to prevent seawater from entering the female power connector 802 and the male power connector 804 during use. The connector module 800 can advantageously eliminate entrained water in the female power connector 802 and the male power connector 804, hence preventing short circuit or corrosion.

[0071] As shown in FIG. 8B, the female power connector 802 may comprise wire terminals 808, sockets 810 and a connector case 812. As shown in FIG. 8D, the male power connector 804 may comprise pins 814, sealing posts 816, O rings 818 disposed at the sealing posts 816, wire terminals 820 and a connector case 822. In some implementations, the male power connector 804 may comprise a plurality of sealing elements coupled to the plurality of pins 814. When the pins 814 are inserted into the sockets 810, the sealing elements are configured to maintain watertightness between

the sockets 810 and pins 814. The plurality of sealing elements can be the sealing posts 816.

[0072] As shown in FIG. 8E, the other connectors coupled to the male power connector 804 can be separate smaller connectors such as a throttle/remote throttle module connector 824 and a kill switch connector 826.

[0073] In some implementations, the eOBM may further comprise the weather cover 806 detachably coupled to the male power connector 804. The weather cover 806 may be configured to cover each of the plurality of pins 814. The weather cover 806 can cover each individual pin 814, advantageously protecting the pins 814 from the elements, such as rain or seawater, when the power supply module 300 is not connected.

[0074] FIG. 9, comprising FIGs. 9A, 9B and 9C, is a schematic representation of a transom mount module 900 of the eOBM 100 of FIG. 1, according to an example embodiment. FIG. 9A is an isometric view of the transom mount module 900 at an initial operational position. FIG. 9B is an isometric view of the transom mount module 900 at a maximum trim position. FIG. 9C is an isometric view of the transom mount module 900 at a tilt position.

[0075] The eOBM 100 may further comprise a transom mount module 900 configured to couple the eOBM 100 to a transom of a watercraft. The transom mount module 900 may comprise an inner mount body 902 and an outer mount body 904. The inner mount body 902 may comprise a lever 906 and may be configured to rotate about the outer mount body 904 on a condition that the lever 906 is released. The transom mount module 900 may further comprise a mounting receiver 908, mount clamps 910, a pivot latch 912, a kick-up lever 914 and a steering friction adjuster 916.

[0076] The outer mount body 904 may provide a frame for the inner mount body 902 to transmit thrust from the stem module 700 to the transom mount module 900 while

the inner mount body 902 remains able to rotate to adjust a trim angle or for beaching. The lever 906 can be a single action lever that advantageously allows the inner mount body 902 to rotate across a full rotation angle range about the outer mount body 904, hence allows for fuss-free rotation of the eOBM 100, without a need to release other latches or levers. In contrast, a typical eOBM has two levers or require a pin to be removed in order to trim a motor.

[0077] The transom mount module 900 may comprise a mounting part configured to be detachably coupled to the stem module 700. The mounting part may be a mounting receiver 908 which beneficially allows for quick engagement of the stem module 700. The pivot latch 912 can prevent accidental release of the stem module 700 from the transom mount module 900. The mounting receiver 908 can be rotated up to 60 degrees for easy installation and removal of the stem module 700 by one person. The mount clamps 910 can secure the transom mount module 900 to a transom board of the watercraft.

[0078] FIG. 10, comprising FIGs. 10A, 10B and 10C, is a schematic representation of a remote throttle module 1000, according to an example embodiment. FIG. 10A is an isometric view of the remote throttle module 1000. FIG. 10B is a partial isometric view of the remote throttle module 1000 without a display 1002. FIG. 10C is an isometric view of the display 1002.

[0079] The remote throttle module 1000 may comprise a remote throttle case 1004, the display 1002, a kill switch 1006 and single/twin levers 1008. The remote throttle case 1004 may use the display module 304 and kill switch of the local display and mid tiller. The display 1002 may comprise one or more buttons 1010 to obtain the user's input. The remote throttle case 1004 may be watertight to protect internal components.

The single/twin levers 1008 may comprise trigger lock(s) 1012 for locking the single/twin levers 1008 in place.

[0080] The remote throttle module 1000 can have a single lever 1008 with a single encoder, for single or synchronised twin eOBM operation. The lever 1008 can be pushed forward for forward thrust or pulled backwards for reverse thrust. In some implementations, remote throttle module 1000 can have split levers 1008 for independent twin eOBM operation.

[0081] A charger for the power supply module 300 may be a DC charger using domestic or on-board AC power supply. The charger may have built-in safety features to prevent over and under voltage charging.

[0082] FIG. 11 is a flowchart 1100 illustrating a method for powering on the eOBM, according to an example embodiment. At step 1102, a user connects a battery and the eOBM. At step 1104, the user presses an on/off button on the battery. At step 1106, a low power line turns ON while a main power line remains OFF.

[0083] At step 1108, a trip controller of a display module turns ON and receives battery information such as SOC and BMS information. An ESC receives sufficient power to only turn on control systems but not a power system. At step 1110, a kill switch is activated, and a hall sensor is triggered and sends a signal for a trip computer to activate the battery and the ESC. At step 1112, the power line is active so the ESC receives full power and receives an activation signal via CANBUS from the kill switch and sends ESC data to the trip computer. At step 1114, the eOBM is ready for operation.

[0084] FIG. 12 is a flowchart 1200 illustrating a method for powering off the eOBM, according to an example embodiment. At step 1202, a kill switch is removed (e.g. the kill switch is no longer depressed). At step 1204, an ESC stops receiving its activation signal and commands zero rpm and the hall sensor is deactivated, deactivating the BMS

of the battery. At step 1206, the ESC then stops receiving power and the eOBM stops. The trip controller, however, is still powered.

[0085] The eOBM 100 may have options for higher and lower power models which, with slight modifications to the system architecture of the current design to accommodate the smaller or larger motors. The battery pack 302 capacity can also be adjustable to match the motor power. Smaller capacity battery packs 302 may be suitable for lower powered motors for ease of handling without compromising a duration of use. A larger power motor will require more power to operate with reasonable range, so multiple larger batteries can be utilized.

[0086] Different propeller 602 designs for each motor 202 facilitate different use scenarios such as high speed, low speed high thrust, or low speed trolling. Also, the remote throttle module 1000 can have other variants for installation on different watercrafts. For example, a side mounted remote throttle lever(s) with a separate display unit may be mounted on the watercraft's console.

[0087] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. For example, parameters such as shape of the individual modules may vary depending on the application for optimizing performance. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. An electric outboard motor (eOBM), comprising:
 - a propulsion module;
 - a power supply module electrically coupled to the propulsion module; and
 - a tiller-throttle module operably coupled to the propulsion module, the tiller-throttle module comprising a tiller, a throttle, a safety button and a restriction mechanism, wherein:
 - a first end of the tiller is coupled to one end of a stem module;
 - one end of the throttle is coupled to a second end of the tiller; and
 - the safety button is coupled to the restriction mechanism and configured to engage the restriction mechanism to limit rotation of the throttle to a predetermined throttle angle range when un-activated, wherein the safety button is further configured to release the restriction mechanism when activated.
2. The eOBM of claim 1, further comprising a propeller module coupled to the propulsion module, wherein the propulsion module comprises a motor coupled to a planetary gearbox or directly coupled to the propeller module.
3. The eOBM of claim 1, wherein the stem module is coupled to the propulsion module and the power supply module and comprises a steering lock.
4. The eOBM of claim 3, wherein the steering lock has a unitary body and is configured to lock the eOBM in a center steering position when rotated to a predetermined locking angle.

5. The eOBM of claim 2, wherein the tiller is configured to rotate between zero and 180 degrees about the one end of the stem module and further configured to lock at 180 degrees for trimming the motor, 90 degrees when in operation and zero degree for handling the eOBM.
6. The eOBM of claim 1, wherein the throttle comprises an encoder configured to detect a throttle angle and transmit a corresponding throttle angle signal to the propulsion module.
7. The eOBM of claim 1, wherein the predetermined throttle angle range is zero to 45 degrees in a first throttle direction.
8. The eOBM of claim 7, wherein on a condition that the restriction mechanism is released, a maximum rotation of the throttle is 90 degrees in the first throttle direction and/or 45 degrees in a second throttle direction, wherein the second throttle direction is opposite the first throttle direction.
9. The eOBM of claim 1, wherein the restriction mechanism comprises:
 - an annular sleeve surrounding and coupled to at least a portion of the throttle, the annular sleeve having a first inner surface and a second inner surface; and
 - a pin coupled to and movable by the safety button into engagement with the first inner surface when the safety button is un-activated, and disengagement with the first inner surface and engagement with the second inner surface when the safety button is activated.

10. The eOBM of claim 6, wherein the throttle comprises a neutral spring mechanism which is biased to return the throttle angle to zero degree on a condition that no force is applied on the throttle.

11. The eOBM of claim 1, further comprising a transom mount module configured to couple the eOBM to a transom of a watercraft, wherein the transom mount module comprises an inner mount body and an outer mount body, and wherein the inner mount body comprises a lever and is configured to rotate about the outer mount body on a condition that the lever is released.

12. The eOBM of claim 11, wherein the transom mount module comprises a mounting part configured to be detachably coupled to the stem module.

13. The eOBM of claim 1, further comprising a connector module, the connector module comprising a female power connector and a male power connector, wherein:

the female power connector is coupled to the power supply module and comprises a plurality of sockets;

the male power connector is coupled to the stem module and comprises a plurality of pins configured to be inserted into the plurality of sockets; and

optionally, the plurality of pins are more than 4.5 mm in diameter.

14. The eOBM of claim 13, wherein the male power connector comprises a plurality of sealing elements coupled to the plurality of pins, and wherein when the pins are

inserted into the sockets, the sealing elements are configured to maintain watertightness between the sockets and pins.

15. The eOBM of claim 13, further comprising a weather cover detachably coupled to the male power connector, wherein the weather cover is configured to cover each of the plurality of pins.