accumulators to meet hydraulic fluid volume requirements to actuate some hydraulically actuated devices. Additionally, it may be difficult to ascertain whether an accumulator will properly function when required, and thus, accumulators are typically assigned a relatively high probability of failure on demand.

SUMMARY

[0006] Some embodiments of the present systems are configured, through an accumulator configured to supply pressurized fluid to a hydraulically actuated device to actuate the hydraulically actuated device and a (e.g., battery powered) hydraulic pump configured to pressurize the accumulator and/or supply pressurized fluid to the hydraulically actuated device to actuate the hydraulically actuated device, to, for example, provide for multiple (e.g., redundant and/or supplementary) sources of high pressure hydraulic fluid, resistance to depth-related limitations on usable hydraulic fluid volume within the accumulator (e.g., allowing for a degree of depth independence), and/or the like.

[0007] Some embodiments of the present systems are configured, through a hydraulic power storage system, including an accumulator and a drain in fluid communication with the accumulator and configured to drain hydraulic fluid from the hydraulic power storage system, and a hydraulic pump configured to pressurize the accumulator if an internal pressure of the accumulator falls below a threshold pressure, to, for example, provide for assessable reliability of system components (e.g., the accumulator, the hydraulic pump, and/or the like) through automatic, periodic, and/or self-testing, thereby providing for a source of high pressure hydraulic fluid with a relatively low probability of failure on demand.

[0008] According to an aspect of the present invention, there is provided a system for actuating a hydraulically actuated device, the system comprising: a hydraulic power storage system including an accumulator configured to supply pressurized hydraulic fluid to a hydraulically actuated device to actuate the hydraulically actuated device, a drain in fluid communication with the accumulator and comprising a valve that is actuatable to drain hydraulic fluid from the hydraulic power storage system such that an internal pressure of the accumulator is reduced and a flow restrictor configured to reduce a flow rate of hydraulic fluid through the valve, a flow sensor configured to capture data indicative of a flow rate of hydraulic fluid through the valve of the drain; a hydraulic pump configured to pressurize the accumulator, a pressure sensor configured to capture data indicative of the internal pressure of the accumulator, an electric motor configured to be coupled to the hydraulic pump and actuate the hydraulic pump; and a processor configured to actuate the

hydraulic pump by controlling the electric motor that operates the hydraulic pump to increase the internal pressure of the accumulator if the internal pressure of the accumulator, as indicated in data captured by the pressure sensor, falls below a threshold pressure and to open the valve to drain hydraulic fluid from the hydraulic power storage system; wherein the processor is further configured to: determine a variance between a flow rate indicated in data captured by the flow sensor and a pre-determined flow rate; and actuate the valve of the drain to reduce the variance. In some embodiments, the system is configured to be coupled to a

[0014] Some embodiments comprise one or more valves in fluid communication with the hydraulic power storage system and the hydraulic pump, where the one or more valves are configured to control hydraulic fluid communication between the hydraulic power storage system and the hydraulic pump. In some embodiments, the one or more valves comprises a one-way valve configured to prevent hydraulic fluid communication from the hydraulic power storage system to the hydraulic pump.

[0015] According to another aspect of the present invention, there is a provided a method comprising: increasing, with a hydraulic pump, an internal pressure of an accumulator of a hydraulic power storage system, draining hydraulic fluid from the hydraulic power storage system, through a valve and a flow restrictor, and to at least one of a reservoir and a subsea environment such that the internal pressure of the accumulator is reduced, if the internal pressure of the accumulator falls below a threshold pressure, increasing, with the hydraulic pump, the internal pressure of the accumulator to a pressure that is above the threshold pressure, supplying, with the accumulator, pressurized hydraulic fluid to a hydraulically actuated device to actuate the hydraulically actuated device; capturing data indicative of a flow rate of the hydraulic fluid; determining a variance between the flow rate indicated in the captured data and a pre-determined flow rate; and actuating a valve to reduce the variance. In some embodiments, the hydraulic fluid comprises at least one of: sea water, desalinated water, treated water, and an oil-based fluid.

[0016] Some embodiments comprise supplying, with the hydraulic pump, pressurized hydraulic fluid to the hydraulically actuated device to actuate the hydraulically actuated device. Some embodiments comprise supplying hydraulic fluid from a reservoir to the hydraulic pump. Some embodiments comprise supplying hydraulic fluid from an above-surface hydraulic fluid source to the hydraulic pump. Some embodiments comprise supplying hydraulic fluid from a subsea environment to the hydraulic pump. Some embodiments comprise supplying hydraulic fluid from a remotely operated underwater vehicle (ROV)-mounted hydraulic fluid source to the hydraulic pump.

[0017] In some embodiments, the draining hydraulic fluid comprises draining hydraulic fluid at a pre-determined flow rate. In some embodiments, the draining hydraulic fluid comprises actuating a valve to drain hydraulic fluid from the hydraulic power storage system. In some embodiments, the draining hydraulic fluid comprises draining hydraulic fluid to the reservoir.

[0018] The term “coupled” is defined as connected, although not necessarily directly, and not necessarily mechanically; two items that are “coupled” may be unitary with each other. The terms “a” and “an” are defined as one or more unless this disclosure explicitly requires otherwise. The term “substantially” is defined as largely but not necessarily wholly what is specified (and includes what is specified; e.g., substantially 90 degrees includes 90 degrees

CLAIMS

1. A system for actuating a hydraulically actuated device, the system comprising:

a hydraulic power storage system including:

an accumulator configured to supply pressurized hydraulic fluid to a hydraulically actuated device to actuate the hydraulically actuated device; and

a drain in fluid communication with the accumulator and comprising:

a valve that is actuatable to drain hydraulic fluid from the hydraulic power storage system such that an internal pressure of the accumulator is reduced; and

a flow restrictor configured to reduce a flow rate of hydraulic fluid through the valve;

a flow sensor configured to capture data indicative of a flow rate of hydraulic fluid through the valve of the drain;

a hydraulic pump configured to pressurize the accumulator;

a pressure sensor configured to capture data indicative of the internal pressure of the accumulator;

an electric motor configured to be coupled to the hydraulic pump and actuate the hydraulic pump; and

a processor configured to actuate the hydraulic pump by controlling the electric motor that operates the hydraulic pump to increase the internal pressure of the accumulator if the internal pressure of the accumulator, as indicated in data captured by the pressure sensor, falls below a threshold pressure and to open the valve to drain hydraulic fluid from the hydraulic power storage system;

wherein the processor is further configured to:

determine a variance between a flow rate indicated in data captured by the flow sensor and a pre-determined flow rate; and

actuate the valve of the drain to reduce the variance.

2. The system of claim 1, wherein the processor is configured to deactivate the hydraulic pump if the internal pressure of the accumulator, as indicated in data captured by the pressure sensor, rises above a second threshold pressure.

3. The system of claim 1, wherein the accumulator comprises a bladder-type accumulator and/or a piston-type accumulator.

4. The system claim 1, wherein the valve of the drain is configured to drain hydraulic fluid from the hydraulic power storage system at a pre-determined flow rate.

5. The system of claim 1, comprising a flow sensor configured to capture data indicative of a flow rate of hydraulic fluid through the valve of the drain.

6. The system of claim 1, wherein the valve of the drain is configured to drain hydraulic fluid from the hydraulic power storage system to a subsea environment.

7. The system of claim 1, comprising:

a reservoir configured to supply hydraulic fluid to the hydraulic pump;

wherein the valve of the drain is configured to drain hydraulic fluid from the hydraulic power storage system to the reservoir.

8. The system of claim 1, wherein the flow restrictor comprises an orifice.

9. The system of claim 1, wherein the hydraulic pump comprises a subsea hydraulic pump.

10. The system of claim 1, comprising:

one or more valves in fluid communication with the hydraulic power storage system and the hydraulic pump;

wherein the one or more valves are configured to control hydraulic fluid communication between the hydraulic power storage system and the hydraulic pump.

11. The system of claim 10, wherein the one or more valves comprises a one-way valve configured to prevent hydraulic fluid communication from the hydraulic power storage system to the hydraulic pump.

12. A method comprising:

increasing, with a hydraulic pump, an internal pressure of an accumulator of a hydraulic power storage system;

draining hydraulic fluid from the hydraulic power storage system, through a valve and a flow restrictor, and to at least one of a reservoir and a subsea environment such that the internal pressure of the accumulator is reduced;

if the internal pressure of the accumulator falls below a threshold pressure, increasing, with the hydraulic pump, the internal pressure of the accumulator to a pressure that is above the threshold pressure;

supplying, with the accumulator, pressurized hydraulic fluid to a hydraulically actuated device to actuate the hydraulically actuated device;

capturing data indicative of a flow rate of the hydraulic fluid;

determining a variance between the flow rate indicated in the captured data and a pre-determined flow rate; and

actuating the valve to reduce the variance.

13. The method of claim 12, comprising supplying, with the hydraulic pump, pressurized hydraulic fluid to the hydraulically actuated device to actuate the hydraulically actuated device.

14. The method of claim 12, wherein the draining hydraulic fluid comprises draining hydraulic fluid at the pre-determined flow rate.

15. The method of claim 12, comprising:

supplying hydraulic fluid from a reservoir to the hydraulic pump;

wherein the draining hydraulic fluid comprises draining hydraulic fluid to the reservoir.

16. The method of claim 12, comprising supplying hydraulic fluid from a subsea environment to the hydraulic pump.

17. The method of any of claims 12-16, comprising supplying hydraulic fluid from a remotely operated underwater vehicle (ROV)-mounted hydraulic fluid source to the hydraulic pump.