SUMMARY

[0007] In embodiments of the present invention, there is provided a device and method of storing electrical energy near a well on the sea floor and activating well control equipment with the stored electrical energy. According to a first aspect of the present invention, there is provided a method comprising: storing electrical energy near a well on the sea floor; storing hydraulic energy near the well on the sea floor in a hydraulic energy storage tank, wherein the hydraulic energy storage tank is configured to provide stored hydraulic energy to operate a shear ram; operating a pump from the stored electrical energy to generate the stored hydraulic energy; and activating the shear ram with a combination of the stored electrical energy and the stored hydraulic ~~pressure~~ energy by: activating the shear ram with the stored electrical energy to move the shear ram a first distance; and activating the shear ram with the stored hydraulic energy to move the shear ram a second distance. Subsea actuators on sea floor equipment may include an electrical design. Subsea actuators may alternatively include a hybrid electrical/mechanical design, in which a main hydraulic power valve may be electrically controlled, allowing one or more electrically powered hydraulic pumps to operate a shear ram in combination with, or independently of, a pressurized hydraulic system. According to one embodiment, cylinders in the shear ram are moved a first distance under stored electrical power and are then moved a second distance under stored hydraulic energy, where the first distance may be the portion of a path the shear ram traverses before contacting an obstruction, such as a drill pipe.

[0008] According to the disclosure, stored electrical energy may be used to operate a pump to generate hydraulic pressure. The generated hydraulic pressure may be stored at the sea floor. In certain embodiments, hydraulic fluid may be recaptured for later use, rather than exhausting the fluid to the sea. Excess hydraulic fluid may be stored at ambient pressure near the well on the sea floor. This excess hydraulic fluid may be pressurized by the subsea pump using stored electrical energy. In one embodiment, a remotely-operated vehicle (ROV) may deliver either ambient-pressure hydraulic fluid or pressurized, hydraulic fluid. When pressurized fluid is delivered by the ROV, the hydraulic energy from the ROV, may operate a subsea pump as a generator to recharge the stored electrical energy in certain embodiments.

[0009] According to the disclosure, the device and method include a complete stand-alone power and communications system, multiple sensors, event and signature memory, closed-loop feedback on mechanical positioning, and math models of actuator processes.

CLAIMS

What is claimed is:

1. A method, comprising:

storing electrical energy near a well on the sea floor;

storing hydraulic energy near the well on the sea floor in a hydraulic energy storage tank, wherein the hydraulic energy storage tank is configured to provide stored hydraulic energy to operate a shear ram;

operating a pump from the stored electrical energy to generate the stored hydraulic energy; and

activating the shear ram with a combination of the stored electrical energy and the stored hydraulic ~~pressure~~ energy by:

activating the shear ram with the stored electrical energy to move the shear ram a first distance; and

activating the shear ram with the stored hydraulic energy to move the shear ram a second distance.

2. The method of claim 1, wherein the first distance is less than the second distance, wherein the first distance is the portion of a path the shear ram traverses before contacting an obstruction and the second distance is the distance that the shear ram traverses to shear the obstruction.

~~3. The method of claim 1, wherein the first distance is the portion of a path the shear ram traverses before contacting an obstruction.~~

43. The method of claim ~~3~~2, wherein the obstruction is the drill pipe.

~~5~~4. The method of claim 1, further comprising operating a pump from the stored electrical energy to generate the hydraulic pressure.

~~6~~5. The method of claim ~~5~~4, further comprising storing the hydraulic pressure generated by the pump.

~~7~~6. The method of claim ~~5~~4, wherein the step of storing hydraulic energy near the well on the sea floor comprises:

storing hydraulic medium at ambient pressure near the well on the sea floor; and

pressurizing the hydraulic medium with the subsea pump powered by the stored electrical energy.

~~8~~7. The method of claim ~~7~~6, further comprising receiving ambient-pressure hydraulic medium from a remotely-operated vehicle (ROV).

~~9~~8. The method of claim ~~5~~4, further comprising:

receiving pressurized hydraulic medium from a remotely-operated vehicle (ROV); and

operating the subsea pump as a generator from the received pressurized hydraulic medium to recharge the stored electrical energy.

~~10~~9. The method of claim 1, wherein the step of storing hydraulic energy near the well on the sea floor comprises returning hydraulic medium to be re-used in the ~~well control equipment~~shear ram.

~~11~~10. The method of claim 1, further comprising:

receiving data from a sensor near the well; and

activating the ~~well control equipment~~shear ram based on data received from the sensor.

~~12~~11. The method of claim ~~11~~10, wherein data is wirelessly received from a sensor near the well.

~~13~~12. The method of claim ~~11~~10, further comprising:

recording data from the sensor for a period of time;

comparing the recorded data to at least one of a predetermined event signature and a historical event signature; and

determining an event has occurred based on the step of comparing.

~~14~~13. The method of claim ~~11~~10, further comprising determining the state of health of a blowout preventer (BOP) containing the ~~well control equipment~~shear ram.

~~15~~14. The method of claim ~~14~~13, further comprising indicating the state of health of a blowout preventer (BOP) containing the ~~well control equipment~~shear ram.

~~16~~15. An apparatus, comprising:

a shear ram;

a subsea electrical power supply coupled to the shear ram and configured to operate the shear ram;

a hydraulic reservoir;

a hydraulic line coupled to the hydraulic reservoir and coupled to the shear ram, the hydraulic line configured to operate the shear ram in combination with the subsea electrical power supply; and

a control system configured to perform steps comprising:

operating the subsea electrical power supply to move the shear ram a first distance; and

operating the hydraulic actuator to move the shear ram a second distance.

~~17~~16. The apparatus of claim ~~16~~15, further comprising:

a hydraulic valve; and

a hydraulic actuator coupled to the hydraulic valve;

wherein the control system is coupled to the hydraulic actuator and coupled to the subsea energy storage system electrical power supply, the control system being configured to operate the ~~well control equipment~~shear ram with electrical energy from the subsea electrical power supply and hydraulic energy from the hydraulic line.

~~18~~17. The apparatus of claim ~~17~~16, in which the control system comprises a control board having a memory and a processor.

~~19~~18. The apparatus of claim ~~17~~16, further comprising a sensor coupled to the control system, in which the control system is configured to activate the shear ram based, at least in part, on data received from the sensor.

~~20~~19. The apparatus of claim ~~19~~18, in which the sensor is wirelessly coupled to the control system.

~~21~~20. The apparatus of claim ~~19~~18, in which the sensor comprises as least one of a humidity sensor, a temperature sensor, a pressure sensor, a vibration sensor, an accelerometer, and a flow sensor.

~~22~~21. The apparatus of claim ~~17~~16, in which the control system is further configured to:

record data from the sensor for a period of time;

compare the recorded data to at least one of a predetermined event signature and a historical event signature; and

determine an event has occurred based on the step of comparing.

~~23~~22. The apparatus of claim ~~22~~21, further comprising an indicator configured to display the state of health of a component of the shear ram.

~~24~~23. The apparatus of claim ~~16~~15, in which the subsea electrical power supply is configured to independently operate the shear ram.

~~25~~24. The apparatus of claim ~~16~~15, further comprising a subsea pump coupled to the hydraulic line and coupled to the subsea electrical power supply, the subsea pump configured to generate hydraulic pressure in the hydraulic line from energy in the subsea electrical power supply.

~~26~~25. The apparatus of claim ~~25~~24, in which the hydraulic reservoir comprises an ambient-pressure hydraulic reservoir, and in which the subsea pump is configured to pressurize hydraulic medium of the ambient-pressure hydraulic reservoir to operate the hydraulic line.

~~27~~26. The apparatus of claim ~~25~~24, further comprising a port configured to receive ambient-pressure hydraulic medium from a remotely-operated vehicle.

~~28~~27. The apparatus of claim ~~25~~24, further comprising a port configured to receive pressurized hydraulic medium from a remotely-operated vehicle (ROV), in which the subsea pump is configured to operate as a generator to recharge the subsea electrical power supply from the received pressured hydraulic medium.

~~29~~28. The apparatus of claim ~~17~~16, in which the shear ram is wirelessly coupled to the control system.