SYSTEMS AND METHODS FOR PROVIDING BACK-UP HYDRAULIC POWER FOR AIRCRAFT, INCLUDING TANKER AIRCRAFT

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to U.S. Provisional Application 60/689,129, filed Jun. 8, 2005 and incorporated herein by reference.

TECHNICAL FIELD

The present invention is directed generally toward systems and methods for providing back-up hydraulic power for aircraft, including tanker aircraft. In particular aspects of the invention, such power can be provided to a refueling device, e.g., a refueling boom actuator.

BACKGROUND

In-flight refueling (or air-to-air refueling) is an important method for extending the range of aircraft traveling long distances over areas having no feasible landing or refueling points. Although in-flight refueling is a relatively common operation, especially for military aircraft, the aircraft to be refueled (e.g., the receiver aircraft) must be precisely positioned relative to the tanker aircraft in order to provide safe engagement while the fuel is dispensed to the receiver aircraft. The requirement for precise relative spatial positioning of the two rapidly moving aircraft makes in-flight refueling a challenging operation.

There are currently two primary systems for in-flight refueling. One is a hose and drogue system, which includes a refueling hose having a drogue disposed at one end. The hose and drogue are trailed behind the tanker aircraft once the tanker aircraft is on station. The pilot of the receiver aircraft then flies the receiver aircraft to intercept and couple with the drogue for refueling. Another existing system is a boom refueling system. The boom refueling system typically includes a rigid boom extending from the tanker aircraft with a probe and nozzle at the distal end. The boom also includes airfoils controlled by a boom operator stationed on the refueling aircraft. The airfoils allow the boom operator to actively maneuver the boom with respect to the receiver aircraft, which flies in a fixed refueling position below and aft of the tanker aircraft.

Another challenge associated with tanker aircraft stems from the fact that the tanker aircraft deploy the hose and/or boom during refueling operations. If the hydraulic system that powers actuators used to deploy and retract the hose and/or boom fail, the aircraft must rely on a redundant system to stow these devices before landing. Accordingly, tanker aircraft typically include redundant systems that provide this capability. However, a drawback with such redundant systems is that they add weight and complexity to the tanker aircraft and can accordingly reduce the range of the aircraft and/or the overall operational efficiency of the aircraft.

FIG. **4** is a schematic illustration of a portion of an aircraft hydraulic system **10** that is used on existing aircraft, including tanker aircraft. The hydraulic system **10** can provide hydraulic power to an aircraft parking brake **12**. Accordingly, the hydraulic system **10** can provide power to the brake **12** via a simple accumulator **30** after hydraulic pressure has been depleted. A control valve **18** controls the application of hydraulic fluid to the brake **12**. The pressurized hydraulic fluid is provided by an aircraft hydraulic supply line **13** (via a check valve **15**) and returned via an aircraft hydraulic return line **14**. The accumulator operates against pressure provided by a gas charge **17** so as to store energy for use when the aircraft is powered down. In other installations, a similar (simple) accumulator can be used to store hydraulic power for high demand periods. While the foregoing hydraulic system is suitable for its intended use, it does not address the weight and complexity associated with redundant systems described above.

SUMMARY

The following summary is provided for the benefit of the reader only, and does not limit the invention. Aspects of the invention are directed generally to aircraft systems. One such system can include a hydraulic fluid source, a hydraulic supply line coupled to the hydraulic fluid source, a hydraulic return line coupled to the hydraulic fluid source, and a hydraulic aircraft actuator coupled between the hydraulic supply line and the hydraulic return line. The system can further have a fluid energy storage device that includes a self-displacing accumulator coupled to at least one of the hydraulic supply line and the hydraulic return line, and a first valve coupled between the fluid energy storage device and the hydraulic supply line and/or the hydraulic return line. The first valve can prevent or at least restrict a flow of hydraulic fluid from the fluid energy storage device to at least one of the hydraulic supply line and the hydraulic return line. The system can still further include a second, control valve coupled between the fluid energy storage device and the actuator. The control valve can be changeable between a first configuration (e.g., a closed position) in which the control valve at least restricts fluid flow between the energy storage device and the actuator, and a second configuration (e.g., an open position) in which the control valve allows a flow of fluid to the actuator at least sufficient to operate the actuator.

In particular embodiments, the system can further include a controller coupled to the control valve to move the control valve between the closed position and the open position. The controller can be a manual controller, a partially automated controller, or a fully automated controller coupled to a sensor to automatically open the control valve in response to a sensed reduction in system performance.

In still further particular embodiments, the system can further include a tanker aircraft carrying the hydraulic supply line, the hydraulic return line, the hydraulic actuator, the fluid energy storage device, the first valve, and the control valve. The system can also include a refueling device carried by the tanker aircraft. The hydraulic actuator can be coupled to the refueling device to move the refueling device between a stowed position and a deployed position. Accordingly, the fluid energy storage device can provide a redundant energy source for controlling the refueling device actuator (or other aircraft actuator) when a selected condition (e.g., a reduction in hydraulic system performance) occurs.

The invention is also directed toward methods for operating an aircraft system. In one embodiment, such a method can include pressurizing an aircraft hydraulic system and storing hydraulic energy provided by the hydraulic system in a fluid energy storage device that includes a self-displacing accumulator. The method can further include actively preventing (or at least restricting) energy stored in the fluid energy storage device from returning to the rest of the hydraulic system during a first phase of operations, and, during a second phase of operations, actively releasing energy stored in the fluid energy storage device to at least one actuator of the aircraft. In