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An overview on aircraft hydraulic system

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***Abstract*- Hydraulic systems in aircraft provide a means for the operation of aircraft components. The operation of landing gear, flaps, flight control surfaces, and brakes is largely accomplished with hydraulic power systems. Hydraulic system complexity varies from small aircraft that require fluid only for manual operation of the wheel brakes to large transport aircraft where the systems are large and complex. To achieve the necessary redundancy and reliability, the system may consist of several subsystems. Each subsystem has a power generating device (pump) reservoir, accumulator, heat exchanger, filtering system, etc. System operating pressure may vary from a couple hundred pounds per square inch (psi) in small aircraft and rotorcraft to 5,000 psi in large transports.**

Index terms- Hydraulic fluid, Hydraulic system, Hydraulic reservoirs, Hydraulic pump, Hydraulic accumulators, Hydraulic actuators

I. INTRODUCTION

The state-of-the-art in aircraft systems architectures consists of complex integration of various technologies which make up the equipment used to power and fly an aircraft in open sky. An Equipment System fulfills a major functional aspect of an aircraft and architecture is defined as overall way in which Systems are assembled within the Aircraft. In a conventional architecture (a basic schematic layout is shown in Fig. 1), the fuel is converted into power by the engines. Most of this power is expended as propulsive power (thrust) to propel the aircraft. The remainder is transmitted via, and converted into, four main forms of non-propulsive power.

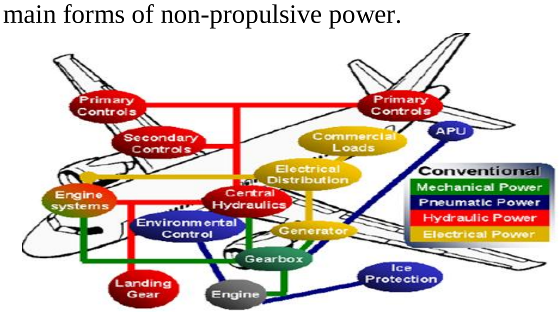

Fig. 1. Power distribution in an aircraft

Air is bled from the engine high-pressure compressor(s). This pneumatic power is conventionally used to power the Environmental Control System (ECS) and supply hot air for Wing Ice Protection System (WIPS).

A mechanical accessories gearbox transfers mechanical power from the engines to central hydraulic pumps, to local pumps for engine equipment and other mechanically driven subsystems, and to the main electrical generator.

The central hydraulic pump transfers hydraulic power to the actuation systems for primary and secondary flight control, to landing gear for deployment, retraction and braking, to engine actuation, to thrust reversal systems and to numerous ancillary systems.

The main generator provides electrical power to the avionics, to cabin and aircraft lighting, to the galleys, and to other commercial loads (entertainment systems, for example). This conventional distribution of energy is fully reflected in the way aircraft systems are classified and procured today.

II. HYDRAULIC FLUIDS

Hydraulic system liquids are used primarily to transmit and distribute forces to various units to be actuated. Liquids are able to do this because they are almost incompressible. Pascal's Law states that pressure applied to any part of a confined liquid is transmitted with undiminished intensity to every other part. Thus, if a number of passages exist in a system, pressure can be distributed through all of them by means of the liquid. Manufacturers of hydraulic devices usually specify the type of liquid best suited for use with their equipment in view of the working conditions, the service required, temperatures expected inside and outside the systems, pressures the liquid must withstand, the possibilities of corrosion, and other conditions that must be considered. If incompressibility and fluidity were the only qualities required, any liquid that is not too thick could be used in a hydraulic system. But a satisfactory liquid for a particular installation must possess a number of other properties. Some of the properties and characteristics that must be considered when selecting a satisfactory liquid for a particular system. To assure proper system operation and to avoid damage to nonmetallic components of the hydraulic system, the correct fluid must be used. When adding fluid to a system, use the type specified in the aircraft manufacturer's maintenance manual or on the instruction plate affixed to the reservoir or unit being serviced. The three principal categories of hydraulic fluids are:

1. Minerals
2. Polyalphaolefins
3. Phosphate esters

When servicing a hydraulic system, the technician must be certain to use the correct category of replacement fluid. Hydraulic fluids are not necessarily compatible.

Hydraulic systems require the use of special accessories that are compatible with the hydraulic fluid. Appropriate seals, gaskets, and hoses must be specifically designated for the type of fluid in use. Care must be taken to ensure that the components installed in the system are compatible with the fluid. When gaskets, seals, and hoses are replaced, positive identification should be made to ensure that they are made of the appropriate material.

Experience has shown that trouble in a hydraulic system is inevitable whenever the liquid is allowed to become contaminated. The nature of the trouble, whether a simple malfunction or the complete destruction of a component, depends to some extent on the type of contaminant. Two general contaminants are:

- Abrasives, including such particles as core sand, weld spatter, machining chips, and rust.
- Non-abrasives, including those resulting from oil oxidation and soft particles worn or shredded from seals and other organic components.

To control the particulate contamination in the system, filters are installed in the pressure line, in the return line, and in the pump case drain line of each system. The filter rating is given in microns as an indication of the smallest particle size that is filtered out. The replacement interval of these filters is established by the manufacturer and is included in the maintenance manual. In the absence of specific replacement instructions, a recommended service life of the filter elements is:

- Pressure filters—3,000 hours
- Return Filters—1,500 hours
- Case drain filters—600 hours

II. HYDRAULIC SYSTEM COMPONENTS

Hydraulic Reservoirs

The hydraulic reservoirs are pressurized by bleed air through a pressurization module. The standby reservoir is connected to the system B reservoir for pressurization and servicing. The positive pressure in the reservoir ensures a positive flow of fluid to the pumps. The reservoirs have a standpipe that prevents the loss of all hydraulic fluid if a leak develops in the engine-driven pump or its related lines. The engine-driven pump draws fluid through a standpipe in the reservoir and the AC motor pump draws fluid from the bottom of the reservoir. The system A, B, and standby reservoirs are located in the wheel well area as shown in Fig. 2.

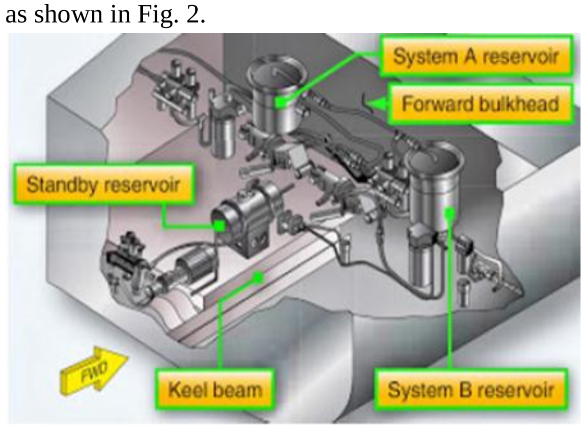

Fig. 2. Hydraulic reservoirs

Hydraulic pumps

All aircraft hydraulic systems have one or more power-driven pumps and may have a hand pump as an additional unit (Fig. 3) when the engine-driven pump is inoperative. Power-driven pumps are the primary source of energy and may be either engine driven, electric motor driven, or air driven. As a general rule, electrical motor pumps are installed for use in emergencies or during ground operations. Some aircraft can deploy a ram air turbine (RAT) to generate hydraulic power.

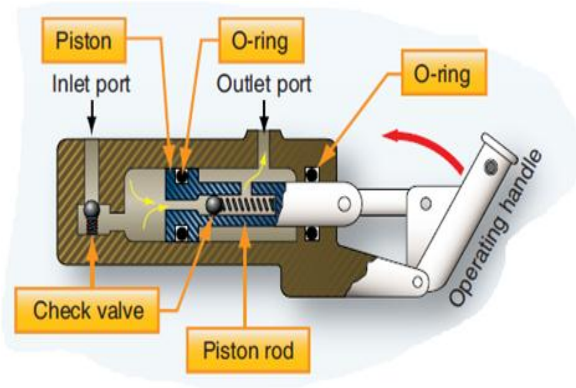

Fig. 3. Hydraulic pump

Flow control valves

Flow control valves control the speed and/or direction of fluid flow in the hydraulic system. They provide for the operation of various components when desired and the speed at which the component operates. Examples of flow control valves include: selector valves, check valves, sequence valves (Fig. 4), priority valves, shuttle valves, quick disconnect valves, and hydraulic fuses.

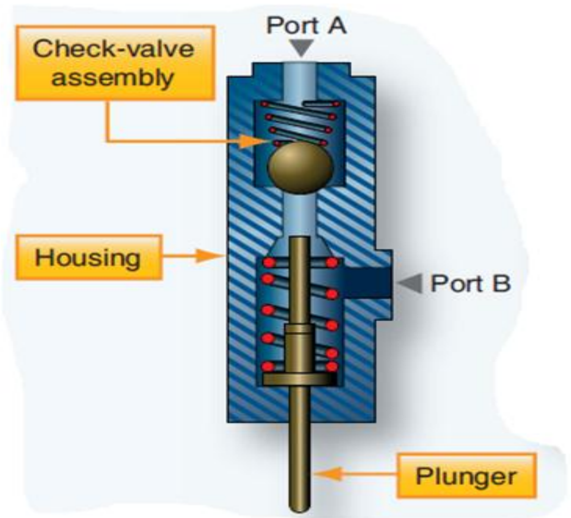

Fig. 4. Mechanically operated sequence valves

Pressure control valves

The safe and efficient operation of fluid power systems, system components, and related equipment requires a means of controlling pressure. There are many types of automatic pressure control valves (Fig. 5). Some of them are an escape for pressure that exceeds a set pressure; some only reduce the pressure to a lower pressure system or subsystem; and some keep the pressure in a system within a required range.

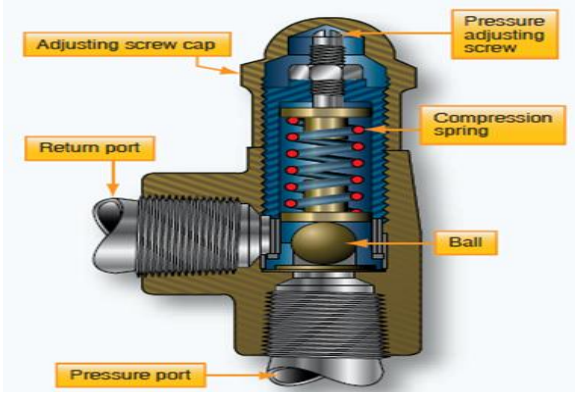

Fig. 5. Pressure relief valve

Hydraulic pressure must be regulated in order to use it to perform the desired tasks. A pressure relief valve is used to limit the amount of pressure being exerted on a confined liquid. This is necessary to prevent failure of components or rupture of hydraulic lines under excessive pressures. The pressure relief valve is, in effect, a system safety valve.

Actuators

An actuating cylinder transforms energy in the form of fluid pressure into mechanical force, or action, to perform work. It is used to impart powered linear motion to some movable object or mechanism. A typical actuating cylinder consists of a cylinder housing, one or more pistons and piston rods, and some seals. The cylinder housing contains a polished bore in which the piston operates, and one or more ports through which fluid enters and leaves the bore. The piston and rod form an assembly. The piston moves forward and backward within the cylinder bore, and an attached piston rod moves into and out of the cylinder housing through an opening in one end of the cylinder housing. Seals are used to prevent leakage between the piston and the cylinder bore and between the piston rod and the end of the cylinder. Both the cylinder housing and the piston rod have provisions for mounting and for attachment to an object or mechanism that is to be moved by the actuating cylinder as shown in Fig. 6.

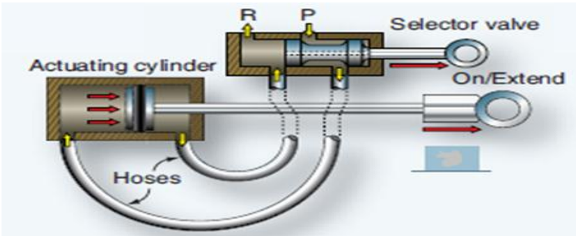

Fig. 6. Linear actuator

Hydraulic motor

Piston-type motors are the most commonly used in hydraulic systems. They are basically the same as hydraulic pumps except they are used to convert hydraulic energy into mechanical (rotary) energy. Hydraulic motors are either of the axial inline or bent-axis type. The most commonly used hydraulic motor is the fixed-displacement bent-axis type (Fig. 7). These types of motors are used for the activation of trailing edge flaps, leading edge slats, and stabilizer trim. Some equipment uses a variable-displacement piston motor where very wide speed ranges are desired. Although some piston-type motors are controlled by directional control valves, they are often used in combination with variable-displacement pumps. This pump-motor combination is used to provide a transfer of power between a driving element and a driven element. Some applications for which hydraulic transmissions may be used are speed reducers, variable speed drives, constant speed or constant torque drives, and torque converters.

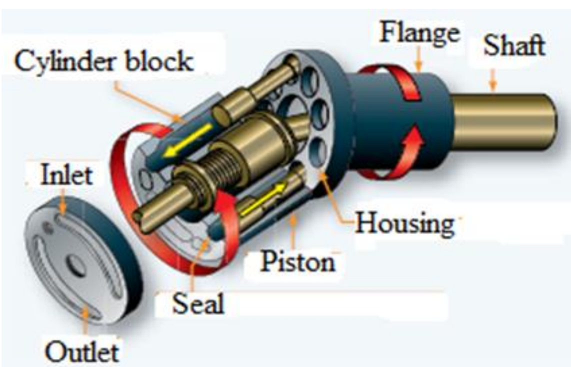

Fig. 7. Bent axis piston motor

Some advantages of hydraulic transmission of power over mechanical transmission of power are as follows:

- Quick, easy speed adjustment over a wide range while the power source is operating at a constant (most efficient) speed
- Rapid, smooth acceleration or deceleration
- Control over maximum torque and power
- Cushioning effect to reduce shock loads
- Smoother reversal of motion

Ram Air Turbine (RAT)

The RAT is installed in the aircraft to provide electrical and hydraulic power if the primary sources of aircraft power are lost. Ram air is used to turn the blades of a turbine that, in turn, operates a hydraulic pump and generator. The turbine and pump assembly is generally installed on the inner surface of a door installed in the fuselage. The door is hinged, allowing the assembly to be extended into the slipstream by pulling a manual release in the flight deck. In some aircraft, the RAT automatically deploys when the main hydraulic pressure system fails and/or electrical system malfunction occurs (Fig. 8).

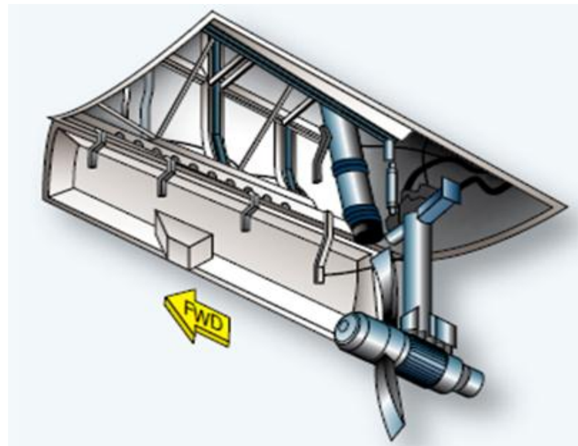

Fig. 8. Ram air turbine

Power Transfer Unit (PTU)

The PTU is able to transfer power but not fluid. It transfers power between two hydraulic systems. Different types of PTUs are in use; some can only transfer power in one direction while others can transfer power both ways. Some PTUs have a fixed displacement, while others use a variable displacement hydraulic pump. The two units, hydraulic pump and hydraulic motor, are connected via a single drive shaft so that power can be transferred between the two systems. Depending on the direction of power transfer, each unit in turn works either as a motor or a pump.

III. CONCLUSIONS

Hydraulic systems have many advantages as power sources for operating various aircraft units; they combine the advantages of light weight, ease of installation, simplification of inspection, and minimum maintenance requirements. Hydraulic operations are also almost 100 percent efficient, with only negligible loss due to fluid friction. Furthermore, an aircraft hydraulic system is a very high performance system with a high risk both in human life and financial cost when failures occur while in flight. Therefore, efficient control must be a major concern to the aircraft designers and maintenance personnel associated with the hydraulic systems on aircraft.

REFERENCES

[1] Yamaguchi A. Studies on the characteristics of axial plunger pumps and motors. Bull JSME 1966;9(34):305–27.
[2] Yamaguchi A, Tanioka Y. Motion of pistons in piston-type hydraulic machines. Bull JSME 1976;19(130):402–19.
[3] Edge KA, Darling J. Cylinder pressure transients in oil hydraulic pumps with sliding plate valves. Proc Instn Mech Engrs, Part B 1986;200(12):45–54.
[4] Axin M, Eriksson B, Krus P. Flow versus pressure control of pumps in mobile hydraulic systems. Proc Inst Mech Eng I J Syst Control Eng 2014;228(4):245–56.
[5] Chao Q, Zhang J, Xu B, Chen Y, Ge YZ. Spline design for the cylinder block within a high-speed electro-hydrostatic actuator pump of aircraft. Meccanica 2018;53(1–2):395–411.
[6] Gao F, Ouyang XP, Yang HY, Xu X. A novel pulsation attenuator for aircraft piston pump. Mechatronics 2013;23 (6):566–72.
[7] Li L, Lee KM, Ouyang XP, Yang HY. Attenuating characteristics of a multi-element buffer bottle in an aircraft piston pump. Part C J Mech Eng Sci 2015;46(1):1–13.
[8] Ma JM, Ruan LY, Fu YL, Ke B, Chen J, Qi XY, et al. Research on current situation and methods of accelerated life test of aircraft hydraulic pump — a review on method of accelerated lifetime test for aircraft hydraulic pump. Chin Hydrau Pneumatics 2015;6:6–12.
[9] Robert WM. High-pressure hydraulics for the A380. Overhand & Maintenance 2005;18(6):43–5.
[10] Wang S, Tomovic M, Liu H. Commercial aircraft hydraulic systems. Shanghai: Elsevier; 2016.
[11] SAE international. Commercial aircraft hydraulic systems. Warrendale (PA): Aerospace, A-6A1 Commercial Aircraft Committee; 2015 Sep. Report No.: Air5005A.
[12] Wu HQ, He ZW, Liu Y, Ding YL. Design life of modern commercial aircraft. Aeronaut Sci Technol 2003(5);33–5.