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DESIGN AND FABRICATION OF HYDRAULIC TEST RIG FOR MANUAL RIGGING OF AIRCRAFT HYDR AULIC SYSTEM

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ABSTRACT

The proposed test rig is meant for testing of hydraulic elements used in aircraft except pump & actuators. It is used to check the performance of the hydraulic elements for pre-installation check before mounting on the aircraft. Line replacement units used in the light combat aircraft have important role to transfer pressure energy and fluid from pump to actuators.

The test rig design involved design of hydraulic circuit, selection of hydraulic elements, design of test rig which include mechanical items like test bed test stand, test chamber & hydraulic elements mounting bracket etc.

The test rig will be capable of testing the various hydraulic elements on distinguish pressure and flow.

Keywords: *DTD 585, LRUs, NRV, PRV, PSI.*

I. INTRODUCTION

The Hydraulic test rig which is also known as second line test rig will be used by the second line servicing bay for conducting the pre-installation (PI) checks for the line re-placement units (LRUs) with landing gear, flight control system and electrical LRUs which are operated by hydraulic power. The PI check up is the sub set of the accepted test procedure or production acceptance test and the pressure testing for the LRUs. The Hydraulic test rig will also have provision for delivering high pressure at lower flow rates for conducting proof pressure testing of LRUs and very high pressure at low flow rates for conducting static pressure testing of hydraulic tubes and hoses this Hydraulic test rig will also be have provision of hand pump.

LRUs are used in the aircraft for proper flight and motion control. There are many small valves, flow control valves, pressure control valve, direct operated or pilot operated valves used in aircraft. Apart from these, there are temperature sensors, pressure gauges and flow meter devices. These all type of valves and sensors are mounted in between the pressure lines.

There are two independent hydraulic systems in the aircraft which operate at 3,000 lb/sq, in (210 kg/cm^2) using OM15 (DTD.585) hydraulic fluid. Identical *Vickers Sperry Rand* bent-axis variable delivery engine-driven pumps are used to power both systems. The pumps arc, however, driven at different speeds so that, at maximum engine speed, 8 gal/min (36 lit/min) are available for No. 1 system while 4¾ gal/min. (21 lit/min) are available for No. 2 system. These two systems are truly independent in that there is no point where oil can transfer from one to the other.

II. METHODOLOGY

Test rig for test of hydraulic elements requires skills like design of machine elements, machine tool design practices and hydraulic systems of machine tools, machining data together with standard mathematical and basic engineering reference data. Here in the test rig there are two different test stands with different test facility. Each test stand is meant for testing hydraulic valves and under carriage jack assemblies. In all the two cases we have provided the mounting block facilities with L-bracket and guide ways for the mounting of different valves and different under carriage jack assemblies. The hydraulic circuit was designed for the test rig which is capable of testing line replacement unit at 280 bar pressure and 200 flow rates.

The test rig is having the facility to connect all the line replacement units with power pack for that there is inbuilt hydraulic circuit. In first testing chamber for testing of different valves is consist of LRUs test stand, mounting block and variable test parameters which can be measure during test and we can vary the test parameters including flow rate and pressure.

In second test chamber is available for under carriage jack assemblies, boot strap reservoir as well as accumulators. For under carriage jack we have made arrangement linear guide way with mounting box where we can clamp under carriage jacks. Also these are mounted on the mounting block. Inside the chamber quick disconnect couplers are available for both pump pressure line as well as return line. Here we have mounted one hand pump on the front of stand with pressure capacity 250 bars. Here we can connect those sensors with test elements during the test. This chamber is also equipped with various sensors and gauges.

III. DESIGN OF HYDRAULIC TEST RIG

1. Reservoir
2. Isolation valve
3. Hydraulic pump
4. Low or High pr switch.
5. NRV
6. Filter
7. Selection valve 1
8. Selection valve 2
9. Pressure gauge(HP)
10. Suction line 1
11. Suction line 2

12. Stand by pressure line
13. PRV(low pressure)
14. Pressure gauge (LP)
15. Sample valve
16. Pressure line

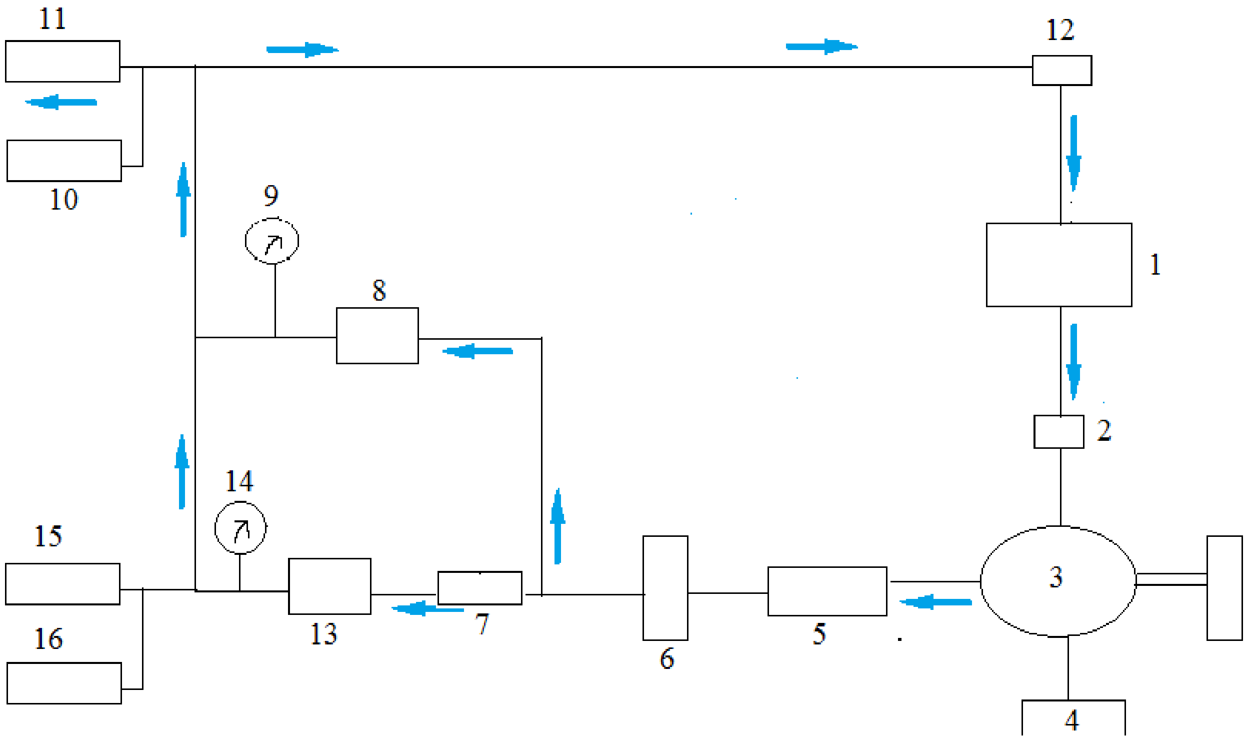

Fig.1 Hydraulic circuit

3.1 DESCRIPTION

3.1.1 HYDRAULIC RESERVOIR

The unit consists of a cylinder which houses a piston and piston rod assembly and which is closed by an air end cover at one end and by a fluid end cover at the other. The fluid end cover is formed with a hollow stem containing a gland through which passes the piston rod. The piston is bolted to one end of the piston rod, the other end being enlarged into a head, fitted with seals, which slides inside the end cover stem to serve as the high pressure piston. The piston rod also contains two spring loaded plungers which depress two switch operating plungers at certain positions of the piston.

A switch housing to which is bolted two switch bracket assemblies is attached to the end of the end cover stem by a ring nut and circlip. The switch housing also accommodates the two concentric spring loaded plungers; the outer one actuating the level sensing indicator switch and the inner one actuating the refill indicator switch. The inner plunger is attached to a reset button which protrudes through the end of the housing.

3.1.2 HYDRAULIC FILTERS

Palmer High Pressure Filter: The main high pressure filter assembly comprises of four sub-assemblies, and is capable of filtering OM-15 to a degree of 5 microns absolute.

a) Filter Head

This houses four threaded ports, of which, only three are in current use. It receives an inlet and outlet adaptor union, a pressure loss indicator assembly, and the fourth port blanked off, but it can be utilised to 'hand' the filter for an outlet/Filter Head.

b) Pressure Loss Indicator

Often referred to as the Clogging Indicator Assembly, and consists of a magnetic piston held against a pole piece by a spring. On the other side of the pole piece is a RED warning button held onto the pole piece by magnetic force (North and South Pole together). A light spring tends to push the button away from the pole piece, and a bi-metallic, sleeve around the RED warning button prevents it from moving when the oil temperature is below a pre-determined figure.

c) Filter Bowl

The filter bowl houses the filter element, and screws into the filter head. Fitted between the filter head and bowl are two sealing rings. Due to the construction of the filter element it should only be necessary to hand tighten the filter bowl into the filter head for servicing procedures.

d) Filter Element

The filter element is made up of finely woven stainless steel wire cloth pleated across its length to form fins. The fins are welded together and secured in end plates forming a cylinder. One end plate accommodates a threaded made portion allowing the element to be screwed into the filter bowl and the opposite end plate has a hollow boss to allow a flow of filtered fluid into the system.

3.1.3 PRESSURE SWITCH

The pressure switch comprises a base and pressure plate assembly with a diaphragm that deflects under pressure to operate a mechanism controlling the contacts of a micro switch connected to a three-pole electrical plug on the case.

The pressure switch operates to make with a fall in hydraulic pressure of 1550 +- 155 psi. A pressure is applied to the base, the diaphragm deflects to raise the operating pin in the pressure plate and rotate the operating arm about the pivots against the spring tension. As the operating arm is pivoted the operating screw is lowered until the microswitch is actuated. Conversely, as the applied pressure is reduced, the operating arm rotates under the spring load and raises the operating screw to actuate the microswitch at the specified operating pressure setting.

3.1.4 SERVICES ISOLATION VALVE

The body of the unit houses two valves i.e. a piston type valve and a pilot valve, both connected by fluid ways to pipe adapters which provide for connection purposes.

The valve is spring loaded against a sealed seat to close off the flow of fluid to connection P2 when the solenoids is de-energized, and is housed in a guide which is provided with holes for the passage of fluid and retained in the body by a sealed end cap.

The pilot valve assembly comprises of a spring, filter, two sealed valve seats and a spacer shimmed for fitted spring length and ball movement. A push rod locates through the spacer and the outer valve seat to contact a ball valve which operates between the seats. Centrally surmounting the pilot valve assembly is a solenoid, retained by four cap screws, with its armature screw abutting a spring loaded rod which it depresses to contact the pilot valve push rod and actuate the pilot valve when energized.

3.1.5 SAMPLING VALVE

The valve mainly comprises a body, a sampling plug and a shut-off valve. A labyrinth assembly is used to reduce the velocity of the drawn-off fluid and, to ensure that the labyrinth is not blocked by large particles of foreign matter; a filter is used at the inlet.

3.1.6 HAND PUMP

The swiveling of the operating handle about its pivot pins causes displacement of the piston inside the pump body.

The piston retraction causes an increase of volume of the chamber (a). This results in creating a vacuum in this chamber and the suction, through A, of an amount of fluid, through the inlet valve which is lifted. The ball valve is held against its seat by its retaining spring.

During this suction phase, the volume of the chamber (b) decreases and the fluid contained in this chamber is expelled towards the service port B.

At the end of the ‘retraction’ stroke, the piston abuts the pump body. The inlet valve is applied against its seat by the action of the retaining spring.

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3.1.7 PRESSURE RELIEF VALVE

The body of the unit comprises a centre bore which accommodates all the basic components. Externally, it features two taped orifices for its connection, on one hand to the hydraulic system to be protected (orifice A), on the other hand, to the installation reservoir (orifices B).

3.1.8 NON-RETURN VALVES

Non-return valves are all basically similar, varying mainly in size of thread for pipe connections in order to cater for different diameter piping. Each unit comprises a spring-loaded poppet valve housed in a body and an end fitting, external fluid leakage at the joint being prevented by a trapped 'O' ring seal. Arrowheads on alternate flats of the body indicate the direction of fluid flow. A label affixed to the end fitting bears the cure date of the seal fitted

3.1.9 PIPE COUPLINGS AND UNIONS

The joint is obtained by the swaging action of the nut which compresses the collar and forces the projections into the surfaces of the pipe.

The conical ends of the collar engaging with the corresponding countersinks of the union body and nut, ensures the rightness of the joint.

The first operation in making the joint is the anchorage of the collars on the pipes.

The penetration of the projections on the collars requires an initial swaging action by the nuts. The torque required to remake the joint is considerably less than the initial swaging action.

When the joint is broken the collar remains fixed to the pipe and retains the nut on the pipe.

IV. OPERATING PARAMETERS OF RIG

SL NO.	COMPONENTS	PARAMETERS
1	HYD. PUMP	PRESSURE RANGE: 0 P.S.I -4500 P.S.I
2	TANK	CAPACITY: 100LTS
3	FILTER	MESH FILTER OF RANGE: 0-4MICRONS
4	SAMPLING VALVE	FLOW RATE: 50-150cm^3/min
5	LOW PRESSURE GAUGE	PRESSURE RANGE: 0 -750 P.S.I
6	HIGH PRESSURE GAUGE	PRESSURE RANGE: 750-4500 P.S.I
7	PRV (HIGH PRESSURE)	MAX. PRESSURE O/P : 3600 P.S.I
8	PRV (LOW PRESSURE)	MAX. PRESSURE O/P : 750 P.S.I

9	ISOLATION VALVE	FLOW RATE: 50-150cm3/min
10	N R V	PROOF PRESSURE LIMIT: 3000P.S.I
11	SUCTION SERVICE VALVE HOSE	INTERNAL DIA. 10-12mm
12	PRESSURE SERVICE VALVE HOSE	INTERNAL DIA. 5mm
13	SELF LOCKING FOR SUCTION LINE	WORKING PRESSURE: 50 P.S.I
14	SELF LOCKING FOR PRESSURE LINE	WORKING PRESSURE: 300 P.S.I
15	STANDBY PRESSURE LINE	PRESSURE RANGE: 0-4500 P.S.I
16	OIL LEVEL INDICATER	MECHANICAL TYPE (ANALOG)
17	4 WAY UNION 3WAY UNION	SIZE: 19-21mm

V. MAINTENANCE SCHEDULE AND SAFETY PRECAUTION OF RIG

5.1 PREDICTIVE MAINTENANCE:

5.1.1 Sampling test:

In this sampling test take the fluid used in rig through sampling valve by opening knob collect the fluid to 100 ml container and then passed to patch testing

The purpose of sampling test is to rectifying the impurities present in the hydraulic fluid.

The sampling test is done in every 7 days.

5.1.2 Check the condition of hydraulic fluid:

The fluid used in the aircraft is to DTD 585 this fluid may get contaminated with impurities added which might have been resultant due to wear and tear of moving parts during normal course of action.

5.1.3 Pointer movement of gauges:

The gauges are used in the rig indicates the pressure build inside the system show through pointer. The pointer may fluctuate during the operation. This due to dryness.

5.2 PERIODIC MAINTENANCE

5.2.1 Leakage:

In hydraulic rig there may be chances of leakages in Hose, unions, connectors etc.

By isolating joints connections using Teflon tape etc.

5.2.2 Rig maintenance:

The rig maintained is conducted in every 30 days in this there are chances in damage of mesh filters inside the system since it services constantly.

The hand pump is used to pressurize the system by manually. In this the hand pump may tighten since its service by supplying lubricating oils.

The main part of the system is the pressure gauge. Due to high pressure /low pressure inside the system and sudden releasing the pressure it may chance to error in the gauges since the calibration of gauge is to be required.

5.3 CARRY OUT ALL OF THE FOLLOWING DURING THE TESTING OF THE HYDRAULIC SYSTEM

- ✓ Obtain and use the appropriate documentation (such as job instruction, aircraft hydraulic system test procedure, quality control documentation, history sheets, flight logbook, aircraft standards and specification)
- ✓ Adhere to procedures or system in place for risk assessment, personal protective equipments and other relevant safety regulations and procedure to realize a safe system of work.
- ✓ Provide and maintain a safe working environment for testing activities.
- ✓ Obtain clearance to work on the aircraft and observe all relevant safety procedures.
- ✓ Obtain the correct tools and equipment for the activity and check that they are in a safe, tested and useable condition and within current calibration date.
- ✓ Ensure that isolation procedures are followed and that safe working distance procedures are set up.
- ✓ Carry out the test, using the specified techniques and procedures.
- ✓ Returns all tools and equipments to the correct location on completion of the testing activities.
- ✓ Leave the aircraft and work area in safe and appropriate condition, free from foreign object debris on completion of the activities.

VI. CONCLUSION

This project can be concluded that,

All equipment of Hydraulic Test Systems features the Improved Closed Loop system. This unique system ensures that the oil in the entire hydraulic system of the aircraft is continuously and automatically cleaned, degassed and dehumidified during hydraulic testing. As a result of this the handling features of the aircraft and the safety in the air will improve, but also the hydraulic system of the aircraft is protected against wear and tear and corrosion due to air and moisture.

By using our multifunctional test Rig, whereby a number of GSE functions are combined in one compact device, costs, weight and savings on space on the logistics footprint up to 70% are realized.

The use in practice of the test equipment by a number of prominent defence organisations has shown that the test and cleaning system of Hydraulic Test Systems results in an increased availability of the aircraft or helicopter compared with using traditional GSE's.

This can be attributed to the application of the Improved Closed Loop system, as a result of which unscheduled maintenance to the aircraft is avoided and the hydraulic system is being protected against wear and corrosion.

Hydraulic Test Systems guarantees high operational reliability and low maintenance costs under all circumstances. This has to do with the thorough and solid design of our rig and the high-quality components. We use non-corrodible materials such as aluminium and stainless steel. Our test equipment is very compact and yet all components are easily reachable for maintenance.

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