International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 03 | March – 2025 DOI: 10.55041/ISJEM02538
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Fundamentals & Working of Aircraft Hydraulic Systems: The Lifeline of Aviation Controls

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Abstract - Hydraulic systems play a pivotal role in modern aviation, serving as the primary source of power transmission for various critical aircraft operations. This paper delves into the fundamentals and working principles of aircraft hydraulic systems, highlighting their significance as the lifeline of aviation control. It explores the basic components, fluid dynamics, and the integration of hydraulics in controlling flight control surfaces, landing gear, brakes, and other essential systems. Additionally, the paper outlines the advantages of hydraulic systems over mechanical alternatives, such as high power-to-weight ratio, reliability, and precision. By understanding the core principles and practical applications of aircraft hydraulics, this study aims to provide a comprehensive overview of how these systems ensure safety, efficiency, and operational effectiveness in aviation.

Keywords: Aircraft Hydraulic Systems, Hydraulic Power, Flight Control, Landing Gear, Fluid Dynamics, Power Transmission, Aviation Safety, Hydraulic Components.

1. INTRODUCTION

- The aircraft hydraulic system is a vital component of modern aviation, responsible for operating numerous critical functions that require significant force and precision. By utilizing the principles of fluid mechanics, hydraulic systems efficiently convert mechanical energy into hydraulic energy to control essential aircraft operations such as flight control surfaces, landing gears, aircraft braking systems, flaps.
- In an aircraft, hydraulic power offers a highly reliable and efficient means to operate systems that require substantial force but need to be compact and lightweight. With the ability to transmit power consistently and with great precision, hydraulic systems ensure smooth operation, contributing to the safety of aircraft and its components, maneuverability, and performance. Due to the importance of this system, they are designed with redundancy and high standards of reliability to meet the rigorous demands of aviation, making them a fundamental aspect of both civil and military aircraft design.
- This project on aircraft hydraulic systems is essential as it helps students build foundational knowledge of a critical component in aviation, with direct applications in aerospace engineering and maintenance. It enhances practical understanding and problem-solving skills and prepares students for careers in civil and military aviation. By studying safety, reliability, and the latest technological advancements, students gain insights into real-world systems and interdisciplinary collaboration, making it highly relevant for anyone pursuing a career in the aviation industry.
- The scope of this project includes understanding the fundamental principles and components of aircraft hydraulic systems, such as pumps and actuators, and their application in critical functions like flight controls and landing gear. It will also cover system design for efficiency and reliability, common maintenance challenges, and explore future trends like electro-hydraulic systems to improve performance and reduce weight. This ensures a thorough grasp of both theoretical and practical aspects of hydraulic systems in aviation.

2. METHODOLOGY

- Approach to Achieve Objectives: - The project will adopt a systematic approach involving literature review, component selection, system design, assembly, testing, and evaluation. Each phase will be executed sequentially, starting with foundational research to inform decisions on components and design.

- Engineering Principles, Tools, and Technologies: - The hydraulic system will be based on the principle of fluid dynamics (Pascal's law), pressure management, and actuator mechanics. Practical tools can be used like CSD-PSD, pliers, hacksaw, etc.
- Design Processes and Theoretical Frameworks: - The design process will follow the systems engineering framework, emphasizing requirements analysis, system architecture, and iterative testing. Theoretical models of hydraulic systems will guide calculations related to fluid flow, pressure drops, and actuator performance, ensuring that the system meets operational specifications.

3. WORKING

The working of an aircraft hydraulic system is based on Pascal's Law, which states that pressure applied to a confined fluid is transmitted equally in all directions. This principle enables hydraulic systems to transmit force efficiently and precisely, making them ideal for aviation applications.

- **Basic Operation**

In an aircraft hydraulic system, hydraulic fluid is pressurized using one or more hydraulic pumps. This pressurized fluid is transmitted through pipes and hoses to various actuators and control units, which convert hydraulic pressure into mechanical movement.

- **Main Components & Working Process**

The typical working cycle of an aircraft hydraulic system involves the following components:

a) Reservoir:

Stores hydraulic fluid.

Maintains fluid level and helps in heat dissipation.

b) Hydraulic Pump:

Driven by the aircraft engine or an electric motor.

It Converts mechanical energy into hydraulic energy by pressurizing the fluid.

c) Filters:

Clean the hydraulic fluid to avoid contamination and wear of components.

d) Pressure Relief Valve:

Maintains system pressure within safe limits.

Releases excess pressure to prevent damage.

e) Selector Valve / Control Valve:

Directs the flow of pressurized fluid to the required actuator.

Operated by the pilot via cockpit controls.

f) Actuators (Hydraulic Cylinders or Motors):

Convert hydraulic pressure back into mechanical force or motion.

Used to move flight control surfaces, landing gear, brakes, thrust reversers, etc.

g) Return Line:

After performing its function, fluid returns to the reservoir via a low-pressure line to be reused.

- **Step-by-Step Working**

1. Pump Activation: When input is given by the pilot to activate the pump, the hydraulic pump starts circulating fluid from the reservoir.
2. Pressure Build-Up: The fluid is pressurized and flows through filters to ensure cleanliness.
3. Valve Operation: The selector valve directs pressurized fluid to the appropriate actuator based on the command.
4. Actuation: The actuator moves in the desired direction, performing the required mechanical action (e.g., lowering landing gear and deflecting ailerons).
5. Pressure Relief & Return: Excess pressure is relieved via relief valves and fluid used in the system returns to the reservoir.

4. CONCLUSION

The Aircraft Basic Hydraulic System project effectively demonstrates the operation and functionality of hydraulic systems in aviation. By implementing a 12V electrically operated hydraulic pump, a manually controlled selector valve, and a safety pressure release valve, the project showcases the precise control of actuator movements. Testing confirmed that the system operates reliably and meets performance specifications while ensuring safety through the release valve. The project enhances understanding of hydraulic systems and provides practical insights into their design and maintenance, laying the groundwork for future advancements in aviation technology

ACKNOWLEDGEMENT

We sincerely thank Mr. Rushikesh Kapse, our project guide, for his expertise, patience, and thoughtful feedback and the Pune Institute of Aviation Technology for providing the environment to make this project a success. Our deepest thanks to Mr. Saswata Ranjan Pati, our mentor, for his constant encouragement and insightful advice that helped shape the direction of this work. We also want to thank Mr. Vilas Gavhane for his invaluable support and guidance throughout this project.

REFERENCES

- Dr. Ronald Sterkenburg "Aircraft Maintenance & Repair, 8th Edition"
  Year of publication: 2019 (McGraw-Hill Education)
  Page no. 933
  https://drive.google.com/file/d/1wvNSS8HLthb0pETqLnufle_2RcU96cYn/view
- Airframe & Powerplant MECHANICS AIRFRAME HANDBOOK
  Page no. 320
  https://www.faa.gov/documentlibrary/media/advisory_circular/ac_65-15a.pdf
- European Union Aviation Safety Agency (EASA). Part-66 Module 11: Aerodynamics, Structures & Systems. EASA Part-66 Basic Knowledge Requirements, Revision as per AMC 66.A.25.
  Page No. 393
  Year of publication: 2021 latest revision
  https://drive.google.com/file/d/1FK3hhRvsqSmm8DfQRsL9uRoH2xsq6E_P/view