

Aircraft Servo Control Hydrostatic Transmission System

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ABSTRACT

This report gives the details about the layout of closed-loop hydraulic energy- regenerative system for hydrostatic transmission drive using hydraulic accumulator and its modeling. This report discussed about the introduction of closed-circuit, hydrostatic transmission drive and hydraulic accumulator. The system was based on a closed-loop hydrostatic transmission and used a hydraulic accumulator as the energy storage system fabricated in a novel configuration to recover the kinetic energy without any reversion of the fluid flow. The proposed system was modeled based on its physical attributes. The accumulator is used in a novel way to recover the kinetic energy without reversion of fluid flow. Both variable displacement hydraulic pump/motors are used when the system operates in the flow coupling configuration so as to enable it to meet the difficult requirements of some industrial and mobile applications. This paper presents the introduction, mathematical modeling and review of the engineering and mechanics of all the components used in the developed hydraulic system. The experimental results indicated that the designed system was effective and that the round trip recovery efficiency varied from 22% to 59% for the test bench.

KEYWORDS: Hydraulic Systems, Hydrostatic Transmission, Energy Regeneration, Servo Control, Hydraulic Accumulator, Aircraft Systems.

1. INTRODUCTION

The increasing attention to comfort, automation and drivability is pushing the driveline technology to ever complex solutions, such as power-shift or continuously variable transmissions [14]. Between these, the hydro mechanical solution seems promising for heavy duty vehicle, due to the reliability and the capability of transferring high power. Energy conservation has become increasingly important due to increases in fuel prices and environmental pollution [9]. Energy-saving systems based on hybrid concepts have been studied to reduce energy consumption and exhaust emissions from cars, trucks, earth movers and construction machines [15]. A hydraulic system is considered energy-saving system if it has one of the following capabilities. First, it must improve the efficiency of the primary power source of a system, which may be an electric motor or an internal combustion engine in industrial and mobile applications, respectively. Next, it must be a regenerative system that is able to recover energy during deceleration or while a load is lowered [8]. For

instance, a system regenerates a vehicle's kinetic energy dissipated by heat transfer via a friction brake during deceleration. The efficiency of the system should also be high over a wide operating range. For example, traditional hydraulic systems using flow valves with fixed displacement are inefficient in cases where the desired velocity and load vary over a wide range, since the excess flow is dissipated via relief valves.

2. CLOSED-CIRCUIT HYDRAULIC SYSTEM

In closed circuit the hydraulic fluid is recirculate between the hydraulic pump and hydraulic motor. This basic hydraulic circuit consists of two circuits; one is main circuit and another one is charge or make-up circuit. The main circuit consists of a prime mover, one bidirectional variable displacement pump, one bidirectional fixed displacement motor, two check valves to supply the fluid into the main circuit in lower pressure side and one pressure relief valve [10]. A pressure relief valve is also used for safety

How to cite this paper: Mahabub Sultan | Nazmul Hasan Anik Chawdhuy | Nikunjun Sarker Akash "Aircraft Servo Control Hydrostatic Transmission System" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-10 | Issue-2, April 2026, pp.506-508, URL: www.ijtsrd.com/papers/ijtsrd107013.pdf



IJTSRD107013

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purpose. If the pressure at the main circuit is exceeds to the outlet pressure of pump then relief valve open and all fluid goes to the tank through pressure relief valve to prevent the damaging of motor, main circuit and charging circuit otherwise valve remain closed as shown in the fig.1 internal leakage is also shown.

3. HYDROSTATIC TRANSMISSION SYSTEM

A hydrostatic transmission system is a drive or transmission system that uses pressurized hydraulic fluid to drive hydraulic machinery. The term hydrostatic refers to the transfer of energy from flow and pressure, not from the kinetic energy of the flow [3]. A hydraulic drive system consists of three parts: The generator (hydraulic pump), driven by an prime mover (electric motor, a combustion engine or a windmill) and the motor (hydraulic motor or hydraulic cylinder) to drive the machinery. There are valves, filters, piping are also used to guide and control the system [5].

4. HYDRAULIC ACCUMULATOR

A hydraulic accumulator is a pressure storage reservoir in which a non-compressible hydraulic fluid is held under pressure by an external source. The external source can be a spring, a raised weight, or a compressed gas [7]. An accumulator enables a hydraulic system to cope with extremes of demand using a less powerful pump, to respond more quickly to a temporary demand, and to smooth out pulsations. It is a type of energy storage device. Compressed gas accumulators, also called hydro-pneumatic accumulators. A compressed gas accumulator consists of a cylinder with two chambers that are separated by an elastic diaphragm, a totally enclosed bladder, or a floating piston. One chamber contains hydraulic fluid and is connected to the hydraulic line. The other chamber contains an inert gas under pressure (typically nitrogen) that provides the compressive force on the hydraulic fluid. Inert gas is used because oxygen and oil can form an explosive mixture when combined under high pressure. As the volume of the compressed gas changes, the pressure of the gas (and the pressure on the fluid) changes inversely. Existing hydraulic accumulator designs are large and heavy due to the need for two storage tanks and do not have the high energy density needed for many applications.

5. PROPOSED HYDRAULIC CIRCUIT

5.1. Description of proposed system

This consists of seven check valves (non-return valves), in which five valves (CV3.1, CV3.2, CV3.3, CV3.4, CV3.5) are used to provide the fluid to the lower pressure line and two check valves (CV1, CV2) are used to provide unidirectional flow. Two pressure relief valves (RV1, RV2) for safety purpose when flow pressure exceeds the setting pressure of pressure

relief valves. It also has one variable displacement bidirectional hydraulic pump (P1), driven by electric motor, and one variable displacement bidirectional hydraulic pump/motor set (PM2), which work as a hydraulic pump for one direction and as a hydraulic motor for another direction. It has one 4/2 direction control valve (4-ports, 2-position V1) and one 2/2 direction control valve (2-ports, 2-position V2) which are used to change the direction of flow and both of them are spring-solenoid operated. This system also has two accumulators (HA1, HA2). One of them is works as energy saving-releasing device and other acts as hydraulic tank. IT has a flywheel which acts as load.

5.2. Working principle

Hydraulic pump P1 requires the full range of its displacement, -1 to 1, while hydraulic pump/motor PM2 uses only its 0 to 1 of its displacement. Hydraulic pump/motor PM2 is powered by either hydraulic pump source P1 or the high-pressure hydraulic accumulator HA1. By controlling the two directional valves V1 and V2, the system is able to operate in distinct configurations [11].

6. SIMULATION AND RESULTS

From a number of literatures review the following experimental, simulation curve show the validation of hydraulic energy-saving system.

7. CONCLUSION

This paper has presented a comprehensive overview of a closed-loop hydraulic energy-regenerative system. The system's design, incorporating a novel configuration of a hydraulic accumulator, demonstrates significant potential for energy savings in industrial and mobile applications. The mathematical modeling and simulation results, validated by experimental data, confirm the effectiveness of the proposed system. The round trip recovery efficiency, ranging from 22% to 59%, highlights the practical viability of this technology. Future work will focus on optimizing the control strategies and exploring the application of this system in a wider range of aircraft servo control scenarios.

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