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Development of a two-dimension Hydraulic-Driven-Assistance Electro-Hydraulic Equitable Reverting Valve

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Abstract

This research focuses on the design and development of a novel two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve. The valve incorporates a valve body, valve core, valve sleeve, linear electro-mechanical converter, and compressive-torsional coupling. The key innovation lies in the coaxial connection of the valve core, compressive-torsional coupling, and linear electro-mechanical converter. The valve's functionality includes high flow rate, high working pressure, and Equitable control capability in zero-pressure (pressure loss) conditions. Through the integration of hydraulic power-assistance and electro-hydraulic technology, this valve offers enhanced performance and versatility.

Keywords: two-dimension valve, Hydraulic-Driven-Assistance, electro-hydraulic, Equitable Reverting valve, flow rate, working pressure, Equitable control, zero-pressure conditions.

Introduction

Hydraulic systems play a crucial role in various industrial applications, ranging from heavy machinery to aerospace systems.[1] The ability to control hydraulic systems accurately and efficiently is of utmost importance for ensuring optimal performance and productivity. In this regard, Equitable valves have emerged as key components, enabling precise regulation of fluid flow and pressure.[2] However, traditional Equitable valves often face limitations in terms of flow rate, working pressure, and Equitable control functionality under zero-pressure conditions. [1]To address these limitations, this research focuses

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on the development of a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve.

This valve incorporates innovative design elements, such as a valve core, valve sleeve, linear electro-mechanical converter, and compressive-torsional coupling, to achieve enhanced performance and versatility. The aim is to create a valve that combines the high flow rate and working pressure characteristics of conventional pilot-control type electro-hydraulic Equitable valves with the Equitable control functionality of direct-actuated Equitable valves, even in zero-pressure conditions.[2] The demand for high flow rate and working pressure in hydraulic systems arises from applications requiring large-scale power transmission. Conventional Equitable valves often struggle to meet these demands, limiting their effectiveness in high-power systems. The proposed two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve addresses this limitation by incorporating a hydraulic power-assistance mechanism. This mechanism ensures that the valve can handle high flow rates and working pressures while maintaining precise control.

Moreover, the ability to achieve Equitable control in zero-pressure conditions is a significant advantage in hydraulic systems. In certain situations, such as during power loss or pressure drop, maintaining Equitable control becomes challenging. The two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve overcomes this challenge by employing a unique design that enables Equitable control even when there is no pressure present. This feature enhances the valve's reliability and functionality in critical applications where precise control is essential.[3] The design of the two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve revolves around the coaxial connection of the valve core, compressive-torsional coupling, and linear electro-mechanical converter. This configuration ensures efficient transfer of force and motion, enabling seamless operation of the valve.[4] The valve core, compressive-torsional coupling, and linear electro-mechanical converter work in tandem to facilitate precise Equitable control and power assistance, resulting in improved overall performance.

The research objective of this study is to design and develop a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve that combines the advantages of high flow rate and working pressure found in traditional pilot-control type electro-hydraulic Equitable valves, while also providing Equitable control functionality in zero-pressure conditions. By achieving this objective, the proposed valve offers a comprehensive solution for applications requiring both high power transmission and precise control.[5] The significance of this research lies in its potential to enhance the efficiency and reliability of hydraulic systems in various industries. The improved performance of the two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve can lead to increased productivity, reduced energy consumption, and improved safety in hydraulic applications. Additionally, the valve's ability to provide Equitable control even under zero-pressure conditions opens

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up new possibilities for system design and operation.[6] This research presents a novel approach to overcome the limitations of traditional Equitable valves by developing a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve.

The integration of a valve core, linear electro-mechanical converter, and compressive-torsional coupling in a coaxial configuration enables the valve to offer high flow rate, high working pressure, and Equitable control functionality in zero-pressure conditions. This research has the potential to significantly enhance the performance and capabilities of hydraulic systems across various industries, paving the way for more efficient and reliable applications.

Related Work

The electrohydraulic servo system, developed in the mid-20th century, has revolutionized various industrial sectors due to its ability to combine the power-weight ratio and rigidity of hydraulic systems with the signal transmission and processing advantages of electronic technology.[3] This technology found successful applications in critical industries such as aerospace, automatic weapons, steel production, power generation, and more.[4] However, there is a growing need to further integrate electronic technology into hydraulic power transmission systems to achieve continuous and automated control in energy transfer processes, meeting the higher-level requirements of industrial technological advancements.[5]

Traditional hydraulic transmission systems often fall short in meeting these requirements due to limitations in controlling fluid flow precisely and efficiently. Electro-hydraulic Equitable valves, on the other hand, have gained significant attention as they provide an optimal balance between switch-type hydraulic valves and electrohydraulic control.[6] These valves can easily integrate with electronic control devices, allowing for seamless computing and processing of input and output signals, thus enabling complex control functions.[7] Additionally, electro-hydraulic Equitable valves offer advantages such as resistance to pollution, cost-effectiveness, and faster response times. Consequently, they have found widespread applications across industrial sectors, including ceramic floor brick pressure machines, steel rolling with constant tensile control, fatigue life testing of pressurized containers, hydraulic lift motion and control systems, metal-cutting machine tool control, rolling mill pressure control systems, hydraulic presses, tube benders, and plastic injection machines.[8]

In ratio control systems, electro-hydraulic Equitable valves serve as the electro-hydraulic conversion and power amplification elements, playing a vital role in system performance. The most significant characteristic of electro-hydraulic Equitable valves is the use of Equitable electromagnets as electromechanical converters. Equitable electromagnets offer advantages over other types of torque motors, such as moving-iron and moving-coil, due to their simpler and more reliable structure, the use of common materials, ease of manufacturing, and the ability to generate higher power and displacement. Equitable electromagnets can drive pilot valves and serve as the low-power output stage of direct drivers.[9]

However, certain limitations remain, such as the limited output force of Equitable electromagnets due to magnetic saturation, which restricts their application in high-pressure and high-discharge scenarios.[10] To overcome the limitations posed by hydraulic power impact and enhance the flow capacity of hydraulic valves, pilot control technology has emerged as the fundamental approach. Leading control, pioneered by American engineer Harry Vickers in 1936, was introduced to address the pressure control issues in mass flow systems by using a pilot valve to control static pressure and drive the main valve plug. By exploiting the hydraulic power generated as the hydraulic thrust flows through the valve port, leading control effectively eliminates adverse effects on main valve plug motion and control.

This approach has been widely adopted in the design of various hydraulic valves, enabling high-pressure and large-discharge control in hydraulic systems. Electro-hydraulic Equitable valves have also incorporated the principles of servovalve design, utilizing pilot control and leading control concepts to achieve precise and efficient control.[10] The integration of electronic technology and hydraulic systems through electro-hydraulic Equitable valves has played a significant role in enhancing control capabilities in various industries.

However, challenges such as magnetic saturation limitations and hydraulic power impact persist. This research aims to develop a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve that addresses these challenges by combining the advantages of high flow rate, working pressure, and Equitable control functionality. The proposed valve design, with its coaxial connection of the valve core, compressive-torsional coupling, and linear electro-mechanical converter, aims to overcome limitations and improve the overall performance of hydraulic systems.

Research Objective

The objective of this research is to design and develop a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve that combines the advantages of high flow rate and working pressure found in traditional pilot-control type electro-hydraulic Equitable valves, while also providing Equitable control functionality in zero-pressure conditions. The valve's innovative design, incorporating a linear electro-mechanical converter and compressive-torsional coupling, aims to improve overall performance and operational capabilities.

Development of a two-dimension Hydraulic-Driven-Assistance Electro-Hydraulic Equitable Reverting Valve

The two-dimension hydraulic booster electro-hydraulic Equitable Reverting valve is a device that helps increase the power of hydraulic systems. It consists of a valve body, a spool, a valve pocket, a linear electromechanical converter, and a pressure-to-torsion coupling. The valve pocket is located inside the valve body, and the spool is installed to rotate within the valve pocket. The left end of the valve body has a cover, and the right end has another cover. What makes this valve special is that it also includes a linear electromechanical converter and a coupling that converts axial pressure into torsional force. The spool, pressure coupling, and linear electromechanical converter are all connected in a line. The output shaft of the linear electromechanical converter is fixedly connected to the input end of the pressure coupling, while the output end of the pressure coupling is fixedly connected to the right end of the spool. The left end of the spool, the valve pocket, and the left cover form a sensitive cavity.

Within the sensitive cavity, the spool has a pair of pressure holes and a pair of low-pressure holes on its land surface. On the inner surface of the valve pocket, outside the sensitive cavity, there is a pair of symmetric passages. One end of each passage is connected to the sensitive cavity, while the other end covers the area between the adjacent pressure holes and low-pressure holes.

The pressure coupling consists of two sections, a supported spring, a reed, a fixed plate, and a proportion electromagnet output shaft. The second section of the pressure coupling is attached to the output shaft of the proportion electromagnet. One end of the reed is connected to the second section, while the other end is connected to the first section of the pressure coupling. The reed is supported in the center by the supported spring. The second section of the pressure coupling is connected to the right cover plate using a pin. In simpler terms, the two-dimension hydraulic booster electro-hydraulic Equitable Reverting valve is a device that helps increase the power of hydraulic systems. It consists of several components, including a valve body, a spool, and a valve pocket. It also includes a linear electromechanical converter and a coupling that converts pressure into twisting force. These components work together to control the flow of hydraulic fluid and enhance the performance of the system.

Conclusion

In this study, we have successfully developed a two-dimension Hydraulic-Driven-Assistance electro-hydraulic Equitable Reverting valve that offers a unique combination of features. By integrating a valve core, linear electro-mechanical converter, and compressive-torsional coupling in a coaxial configuration, the valve demonstrates enhanced functionality. It provides high flow rate, high working pressure, and Equitable control capabilities in zero-pressure conditions. The valve's design presents a promising solution for applications requiring precise control of hydraulic systems, where both power

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assistance and Equitable control are essential. Further experimental validation and optimization are recommended to assess its performance under various operating conditions.

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