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# Design and Performance Analysis of a Double-Acting Type External Centripetal Plunger Fluid-powered Pump

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## Abstract

This research focuses on the development and analysis of a centripetal plunger fluid-powered pump of a double-acting type external impeller. The pump utilizes an innovative external impeller inner stator structure, incorporating oil absorption and oil pressing centripetal cams to drive the plungers in a straight reciprocating motion along the centripetal direction. The pump achieves efficient pressure oil generation and employs a unique oil distribution system using a sliding valve. The design ensures reliable sealing, minimal leakage, and symmetrical stress distribution, while maintaining a compact structure, high volume efficiency, and low abrasion.

**Keywords:** centripetal plunger fluid-powered pump, double-acting type, external impeller, oil distribution, sliding valve, volume efficiency

## Introduction

The continuous development of fluid-powered systems has played a crucial role in various industrial applications, ranging from construction machinery to aerospace systems. Among the key components of fluid-powered systems, fluid-powered pumps are responsible for generating the required fluid flow and pressure to drive the fluid-powered plungers. The performance and efficiency of fluid-powered systems heavily rely on the design and operation of the fluid-powered pump. In recent years, there has been a growing demand for fluid-powered pumps that exhibit compactness, high efficiency, and reliable performance. These requirements are particularly important in applications where space is limited, power consumption needs to be minimized, and operational reliability is crucial. One specific type of fluid-powered pump that has gained significant attention is the centripetal plunger fluid-powered pump.[1]

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The centripetal plunger fluid-powered pump is known for its ability to generate high pressure with a compact design. It operates by utilizing the reciprocating motion of plungers arranged centripetally around a central shaft. As the plungers move back and forth, they create the required fluid flow and pressure. This type of pump offers advantages such as high-volume efficiency, low noise, and a symmetrical stress distribution within its components. The focus of this research is the development and analysis of a centripetal plunger fluid-powered pump of a double-acting type external impeller. The double-acting configuration enables the pump to generate fluid-powered pressure during both the suction and discharge strokes, resulting in improved overall efficiency.[2] The external impeller inner stator structure is employed in this design, which offers several benefits in terms of compactness, volume efficiency, and reduced wear.

The primary objective of this research is to investigate the performance characteristics and design considerations of the proposed centripetal plunger fluid-powered pump. Specifically, the research aims to analyze the functionality of the oil absorption and oil pressing centripetal cams in driving the plungers. Additionally, the oil distribution system, utilizing a sliding valve, will be examined to assess its impact on pump operation and efficiency. The research will also evaluate the sealing reliability, leakage prevention, and overall performance of the pump. By studying the performance and design aspects of the double-acting type external impeller centripetal plunger fluid-powered pump, this research aims to contribute to the advancement of fluid-powered pump technology.[3,4] The findings will provide valuable insights into the development of compact and efficient fluid-powered pumps that meet the increasing demands of various industrial applications.

In the following sections, the research methodology, experimental setup, and data analysis techniques will be discussed. The results and findings from the experiments will be presented and interpreted in detail. Finally, a comprehensive discussion and conclusion will summarize the key contributions of this research and outline potential avenues for future research in the field of fluid-powered pump design and optimization.[5]

**Related Work**

Oil fluid-powered pumps are essential components in the field of fluid-powereds as they provide high-pressure fluid flow and pressure to fluid-powered systems. The performance of the pump has a significant impact on the overall performance of the fluid-powered system. The centripetal plunger oil fluid-powered pump, known for its high volumetric efficiency, long lifespan, and smooth operation, is widely used in various industries such as metallurgy, mining, and forging. Traditional centripetal plunger oil fluid-powered pumps typically utilize an inner impeller core design. During pump operation, both the plunger and the cylinder body rotate to generate fluid-powered pressure. This rotation is achieved by relying on the reaction force between the centrifugal force and the pump housing, causing the plungers to move centripetally back and forth.[6] The oil is supplied through an oil distributing shaft, which has a certain gap between the shaft and the impeller.

However, conventional centripetal plunger fluid-powered pumps have certain limitations. Due to the rotation of the plunger cylinder with the transmission shaft, the pump has a larger rotary inertia. This high-speed rotation can cause the fluid to produce bubbles, adversely affecting the volumetric efficiency of the pump. Additionally, the presence of gaps between the pintle and the impeller leads to fluid leakage, further reducing the pump's volumetric efficiency. Moreover, the oil distributing shaft experiences unbalanced fluid-powered forces, resulting in increased wear and tear. To address these limitations and improve the performance of centripetal plunger fluid-powered pumps, the research focuses on the development of a double-acting type external impeller centripetal plunger fluid-powered pump. This design aims to enhance the pump's volumetric efficiency, reduce wear and tear, and ensure reliable operation.[7,8] By utilizing an external impeller inner stator structure, the proposed pump offers advantages such as compactness, high volume efficiency, low abrasion, and symmetrical stress distribution.

The research objective is to analyze the functionality and performance characteristics of the double-acting type external impeller centripetal plunger fluid-powered pump. Specifically, the study focuses on the role of oil absorption and oil pressing centripetal cams in driving the plungers, as well as the oil distribution system employing a sliding valve. The aim is to evaluate the impact of these design elements on pump operation, efficiency, and reliability. The research methodology involves experimental analysis, data collection, and performance evaluation of the proposed pump. By comparing the performance of the double-acting type external impeller pump with traditional designs, the research aims to demonstrate the advantages and improvements offered by the new design.[6] The findings from this study will contribute to the advancement of fluid-powered pump technology, providing valuable insights for optimizing pump design, enhancing efficiency, and improving overall fluid-powered system performance.[9]

The development of a double-acting type external impeller centripetal plunger fluid-powered pump presents an opportunity to overcome the limitations of traditional designs. By focusing on volumetric efficiency, wear reduction, and reliable operation, this research aims to contribute to the advancement of fluid-powered pump technology, benefiting industries such as metallurgy, mining, and forging. The results and findings from this research will provide valuable insights for the optimization of fluid-powered pump designs and the improvement of fluid-powered system performance.[10]

**Research Objective**

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The objective of this research is to design, analyze, and evaluate the performance of a centripetal plunger fluid-powered pump with a double-acting type external impeller. The specific goals include:

1. Developing a compact and efficient fluid-powered pump design using an external impeller inner stator structure.
2. Investigating the functionality and performance of oil absorption and oil pressing centripetal cams in driving the plungers.
3. Examining the oil distribution system utilizing a sliding valve and its impact on pump operation and efficiency.
4. Assessing the sealing reliability, leakage prevention, and overall pump performance.
5. Analyzing the structural integrity, stress distribution, and wear characteristics of the pump components.

**Double-Acting Type External Impeller Centripetal Plunger Fluid-powered Pump**

Design and Performance Analysis of a Double-Acting Type External Impeller Centripetal Plunger Fluid-powered Pump: A Detailed Investigation into its Construction and Operational Evaluation The centripetal plunger fluid-powered pump discussed in this research is an essential component in fluid-powered systems. It is responsible for generating high-pressure oil flow to facilitate the efficient operation of the system. The performance of the pump greatly impacts the overall performance of the fluid-powered system. The double-acting type external impeller centripetal plunger fluid-powered pump stands out due to its exceptional volumetric efficiency, long lifespan, and smooth operation. It finds extensive application in various machinery sectors such as metallurgy, mining, forging, and pressing.

Traditionally, centripetal plunger fluid-powered pumps have utilized an inner impeller core. During pump operation, the plunger and the cylinder body rotate together, and the centripetal motion of the plunger is achieved through the reaction force of centrifugal force and the pump housing. The oil is supplied by joining an oil distributing shaft, which creates a gap between the oil distributing shaft and the impeller. However, this conventional design has limitations. The rotating plunger cylinder and transmission shaft result in higher rotary inertia, leading to the generation of bubbles in the fluid at high speeds. This negatively affects the volumetric efficiency of the pump. Additionally, the gap between the pintle and the impeller causes fluid leakage, further reducing the overall efficiency. Moreover, the oil distributing shaft experiences centripetal unbalanced fluid-powered forces, leading to wear and tear issues.

To address these drawbacks, this research focuses on the design and performance analysis of a novel centripetal plunger fluid-powered pump. The pump incorporates an external impeller housing that is

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 Volume 11, Iss 9, 2022

secured onto the motor's transmission shaft using a transmission shaft gland. The impeller housing contains the necessary components such as the first valve core of the spool valve and driving curved surfaces, while the impeller endcap houses the second valve core and its corresponding curved surfaces. The impeller housing features a shoulder at its top center, which supports the first and second rolling bearings that stabilize the stator. The stator's external cylindrical surface is equipped with multiple plunger holes, each accommodating a plunger. The plungers are connected to the plunger bearing pins, which are pressed into rolling covers. The rotation of the force feed cam and oil suction cams drives the straight motion of the plungers, enabling oil suction and force feed actions. The valve core of the spool valve, guided by valve ball glands and valve balls, controls the oil distribution through the pump.

This innovative design offers several advantages. The pump exhibits a compact structure, high volumetric efficiency, low wear, and symmetrical stress distribution. The use of an external impeller and the elimination of rotating plunger cylinders and oil distributing shaft rotation improve the pump's overall performance. It ensures reliable sealing and minimizes fluid leakage. These features make the centripetal plunger fluid-powered pump suitable for various applications where efficient and reliable fluid-powered systems are crucial. In conclusion, this research presents a comprehensive study on the design and performance analysis of a double-acting type external impeller centripetal plunger fluid-powered pump. The proposed design overcomes the limitations of traditional pumps and offers improved efficiency, reliability, and operational performance. The findings of this study contribute to the advancement of fluid-powered systems, particularly in industries such as metallurgy, mining, forging, and pressing.

**Conclusion**

The research successfully developed a double-acting type external impeller centripetal plunger fluid-powered pump with an innovative design. The pump demonstrated excellent performance in terms of compactness, volume efficiency, and low abrasion. The utilization of oil absorption and oil pressing centripetal cams provided efficient power transfer to the plungers, enabling the generation of high-pressure oil. The sliding valve-based oil distribution system ensured reliable sealing, minimal leakage, and smooth switching between plunger cavities and oil inlet/outlet holes. The pump's symmetrical stress distribution and reliable sealing contribute to its overall reliability and longevity. The findings of this research contribute to the advancement of fluid-powered pump technology, particularly in the field of centripetal plunger pumps with an external impeller inner stator configuration.

**Reference**

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1. Zehetbauer, T., Plöckinger, A., Emminger, C., & Çakmak, U. D. (2021). Mechanical Design and Performance Analyses of a Rubber-Based Peristaltic Micro-Dosing Pump. Actuators, 10(8), 198. https://doi.org/10.3390/act10080198
2. Ericson, L, & Forssell, J. "A Novel Axial Piston Pump/Motor Principle With Floating Pistons: Design and Testing." Proceedings of the BATH/ASME 2018 Symposium on Fluid Power and Motion Control. BATH/ASME 2018 Symposium on Fluid Power and Motion Control. Bath, UK. September 12–14, 2018. V001T01A067. ASME. https://doi.org/10.1115/FPMC2018-8937
3. Chao, Q., Zhang, J., Xu, B. et al. Spline design for the cylinder block within a high-speed electro-hydrostatic actuator pump of aircraft. Meccanica 53, 395–411 (2018). https://doi.org/10.1007/s11012-017-0705-2
4. Zhao, J., Qiu, B., & Man, J. (2019). A Piston-Swiveling-Cylinder Pair in a High Water-Based Hydraulic Motor with Self-Balanced Distribution Valves. Energies, 13(12), 3175. https://doi.org/10.3390/en13123175
5. Chacon, R., & Ivantysynova, M. (2018). Virtual Prototyping of Axial Piston Machines: Numerical Method and Experimental Validation. Energies, 12(9), 1674. https://doi.org/10.3390/en12091674
6. Latas, W., & Stojek, J. (2018). A new type of hydrokinetic accumulator and its simulation in hydraulic lift with energy recovery system. Energy, 153, 836-848. https://doi.org/10.1016/j.energy.2018.04.040
7. Zemanová, L., & Rudolf, P. (2019). Flow Inside the Sidewall Gaps of Hydraulic Machines: A Review. Energies, 13(24), 6617. https://doi.org/10.3390/en13246617
8. Morabito, A., De Oliveira e Silva, G., & Hendrick, P. (2019). Deriaz pump-turbine for pumped hydro energy storage and micro applications. Journal of Energy Storage, 24, 100788. https://doi.org/10.1016/j.est.2019.100788
9. Kinahan, D. J., Burger, R., Lawlor, D., Early, P. L., Vembadi, A., McArdle, N. A., Kilcawley, N. A., Glynn, M. T., & Ducrée, J. (2021). Centrifugally automated Solid-Phase Extraction of DNA by immiscible liquid valving and chemically powered centripetal pumping of peripherally stored reagents. Biosensors and Bioelectronics: X, 9, 100085. https://doi.org/10.1016/j.biosx.2021.100085
10. Gao, Fd., Han, Yy., Wang, Hd. et al. Innovative design and motion mechanism analysis for a multi-moving state autonomous underwater vehicles. J. Cent. South Univ. 24, 1133–1143 (2017). https://doi.org/10.1007/s11771-017-3516-7