March 2024

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1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Axial piston pumps achieve variable displacement through a mechanism involving an angled swash plate and pistons arranged around it. Here's a breakdown:

- **Swash Plate:** This is a flat plate positioned at an angle relative to the drive shaft. The pistons connect to the swash plate via a slipper or yoke.
- **Pistons:** These are cylindrical plungers that slide within a cylinder block. Their movement creates the pumping action.

By tilting the swash plate, the angle between the piston axis and the cylinder block axis changes. This angle variation directly affects the piston stroke length:

- **Zero Angle:** When the swash plate is perpendicular to the drive shaft (zero angle), the pistons move straight up and down with minimal stroke. This results in the least amount of fluid displacement per rotation.
- **Increased Angle:** Tilting the swash plate creates an angle between the piston and cylinder axes. As the angle increases, the piston stroke length grows. This allows for a larger volume of fluid to be drawn in and expelled per rotation.

This mechanism allows for smooth adjustment of the pump's output flow rate. By controlling the swash plate angle, the pump can vary its displacement from zero to maximum, delivering a wide range of flow rates within the system.

Nov 2023

Nov 2023

1. Describe, with the aid of sketches, the operating principle of an axial variable delivery hydraulic pump. (10)

An axial variable displacement hydraulic pump uses a combination of pistons, a cylinder block, and a swash plate to convert rotational input from a drive shaft into variable fluid flow. Here's a breakdown of its operation:

Components:

- **Drive Shaft:** Rotates to provide power to the pump.
- **Cylinder Block:** Contains cylindrical chambers where pistons reside.
- **Pistons:** Cylindrical plungers that slide within the cylinder block, creating the pumping action.
- **Swash Plate:** A flat plate angled relative to the drive shaft. Pistons connect to the swash plate through a slipper or yoke.

Operating Principle:

1. **Rotation:** The drive shaft rotates, causing the cylinder block and pistons to rotate along with it.
2. **Angled Swash Plate:** The swash plate is not perpendicular to the drive shaft, but tilted at a specific angle.
3. **Piston Movement:** Due to the angle of the swash plate, the pistons move in an axial direction (parallel to the drive shaft) as they rotate with the cylinder block. The piston stroke length depends on this angle.
4. **Intake and Discharge:** During each rotation:
    - On one side of the cylinder block, the pistons tilt inwards (due to the swash plate angle), increasing their volume and creating a low-pressure zone. Hydraulic fluid flows from the reservoir to fill this space (intake).
    - On the opposite side, the pistons tilt outwards, decreasing their volume and creating a high-pressure zone. This pushes fluid out of the pump towards the hydraulic system (discharge).

Variable Displacement:

The key to variable flow lies in the swash plate angle. This angle can be adjusted through external controls (hydraulic, mechanical, or electrical) depending on the pump design.

- **Minimum Angle:** When the swash plate is nearly perpendicular to the drive shaft (minimal angle), the piston stroke length is minimal. This results in a low volume of fluid being drawn in and expelled per rotation (low flow rate).
- **Increased Angle:** Tilting the swash plate to a greater angle increases the piston stroke length. This allows for a larger volume of fluid to be moved per rotation, leading to a higher flow rate.

By controlling the swash plate angle, the pump can adjust its displacement (volume of fluid delivered per rotation) and consequently, the flow rate delivered to the hydraulic system. This allows for precise control over actuator speed and force in applications like construction equipment, mobile machinery, and industrial automation.

June 2023

June 2023

1. Describe, with the aid of a sketch, the operation of a variable delivery axial piston pump. (10)

Nov 2018 3rd

Nov 2018 23rd

1. Describe, with the aid of a sketch, the operation of a variable delivery axial piston pump. (10)

Nov 2018 3rd

Nov 2018 23rd

1. Describe, with the aid of a sketch, the operation of a variable delivery axial piston pump. (10)

Core Components:

- **Drive Shaft:** Provides rotational power to the pump.
- **Cylinder Block:** A fixed housing containing cylindrical bores where pistons reside.
- **Pistons:** These are axial pistons, meaning their movement is parallel to the drive shaft axis. They convert rotary motion into reciprocating motion for pumping.
- **Swash Plate:** A flat disc positioned at a variable angle relative to the drive shaft axis. Pistons connect to the swash plate via a slipper or yoke, allowing them to tilt.
- **Distribution Valve/Plate:** This component directs fluid flow within the pump between the high-pressure and low-pressure sides based on piston position.

Operational Cycle:

1. **Rotation and Angled Pistons:** The drive shaft rotates, causing the cylinder block and pistons to spin. Due to the swash plate angle, the pistons undergo a combined rotary and axial motion.
2. **Intake Stroke:** On one side of the cylinder block, the pistons tilt inwards (because of the swash plate angle). This increases their volume, creating a low-pressure zone. Hydraulic fluid from the reservoir flows through an inlet port and into the cylinder bore to fill this space (suction phase).
3. **Sealing and Trapping:** As the piston continues to rotate, the slipper/yoke slides within the swash plate, transitioning the piston from the intake stroke to the discharge stroke. The distribution valve/plate isolates the inlet port, trapping the ingested fluid within the cylinder bore.
4. **Discharge Stroke:** The continued rotation and swash plate angle cause the pistons to tilt outwards, decreasing their volume. This generates a high-pressure zone within the cylinder bore. The trapped fluid is forced out through an outlet port and into the hydraulic system (discharge phase).
5. **Continuous Pumping:** This cycle of intake, sealing, and discharge continuously occurs for each piston as the shaft rotates, delivering a continuous flow of hydraulic fluid.

Variable Displacement Mechanism:

The crux of variable flow lies in the swash plate angle. This angle can be adjusted by external control mechanisms (hydraulic, mechanical, or electrical) depending on the pump design.

- **Minimal Angle:** When the swash plate is nearly perpendicular to the shaft (zero angle), the piston stroke length is minimal. This results in a low volume of fluid displacement per rotation, leading to a low flow rate.
- **Increased Angle:** Tilting the swash plate to a greater angle increases the piston stroke length. This allows for a larger volume of fluid to be displaced per rotation, resulting in a higher flow rate.

Control Mechanisms (Examples):

- **Pressure Compensator:** This device automatically adjusts the swash plate angle to maintain a constant system pressure.
- **Load-Sensing Control:** This system adjusts the swash plate angle based on the external load on the hydraulic actuator, optimizing power delivery.
- **Joystick Control:** In operator-controlled applications, a joystick input can mechanically or electronically adjust the swash plate angle for precise flow control.

By dynamically controlling the swash plate angle, the pump regulates its displacement and tailors the flow rate to meet the specific demands of the hydraulic system. This enables efficient operation and precise control over actuator performance in various engineering applications.

June 2020

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1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Nov 2018

Nov 2018

1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Axial piston pumps achieve variable displacement through a clever mechanism involving a swash plate and pistons arranged around it. Here's a breakdown focusing on the key aspects relevant to an engineering exam:

Key Players:

- **Drive Shaft:** Rotates to provide power to the pump.
- **Cylinder Block:** Stationary housing with cylindrical bores where pistons reside.
- **Pistons:** These are axial pistons, meaning their movement is parallel to the drive shaft axis.
- **Swash Plate:** A flat disk positioned at a variable angle relative to the drive shaft axis. Pistons connect to the swash plate via a slipper or yoke, allowing them to tilt.

Varying Displacement with Swash Plate Angle:

1. **Swash Plate Angle:** The angle of the swash plate directly affects the piston stroke length.

2. **Zero Angle:** When the swash plate is perpendicular to the drive shaft (zero angle), the pistons move almost straight up and down with minimal stroke. This results in the **lowest** displacement (volume of liquid moved per rotation).
3. **Increased Angle:** Tilting the swash plate creates an angle between the piston and cylinder block axes. As the angle increases, the piston stroke length grows. This allows for a **larger volume** of fluid to be drawn in and expelled per rotation, leading to higher displacement.

Control Mechanisms (Examples):

- **Hydraulic/Mechanical/Electrical Input:** Depending on the pump design, an external control system adjusts the swash plate angle. This control system can be:
  - **Pressure compensator:** Maintains constant system pressure by adjusting the angle.
  - **Load-sensing control:** Optimizes power delivery by adjusting the angle based on external load.
  - **Joystick control:** Allows for operator control of flow rate by adjusting the angle mechanically or electronically.

Benefits of Variable Displacement:

- **Adjustable Flow Rate:** By controlling the swash plate angle, the pump can deliver a wide range of flow rates to meet the varying demands of the hydraulic system. This improves efficiency and allows for precise control over actuator performance.
- **Energy Saving:** When lower flow rates are required, the pump can adjust its displacement to avoid unnecessary energy consumption.

By understanding the relationship between swash plate angle and piston stroke length, you can grasp how axial piston pumps achieve variable displacement and cater to the dynamic flow requirements in hydraulic systems.

Nov 2020

Nov 2020

1. With reference to a pressure compensated variable displacement, swash plate pump, explain FOUR different possible causes of reduction in performance.

Note: The filter has been cleaned, the system is in good condition and there are no visual signs. (10)

Question 1. Although the question clearly states that the system is in good condition, many give low / high viscosity, air etc. Many give worn pistons but no explanation as to why the performance is affected – unless they explain I can't award marks. Few appear to understand what a pressure compensated pump is or how it maintains a constant pressure output hence no faults regarding this are given, whereas many appear to believe that the swash angle is externally set.

Here are four possible causes of a reduction in performance in a pressure-compensated variable displacement, swash plate pump, assuming a clean filter and a system in good condition with no visual signs of damage:

1. **Internal Leakage:**

- Worn components within the pump can lead to internal leakage.
- This leakage allows fluid to bypass the intended flow path, reducing the pump's ability to generate pressure and flow.

- Worn components may include:
    - **Piston rings or valve plates:** Worn or damaged rings or plates can allow leakage between the high-pressure and low-pressure sides of the pump.
    - **Swash plate bearing:** Excessive wear in the swash plate bearing can cause internal leakage around the swash plate.
    - **Control valve components:** Wear in the control valve spool or sleeve can lead to leakage within the pressure compensation mechanism.

2. **Internal Friction:**

- Increased friction within the pump can cause a performance reduction.
- This can be caused by:
    - **Sticking components:** Sealing surfaces or valve components that stick due to wear, debris, or varnish buildup can increase friction and reduce pump efficiency.
    - **Tight clearances:** Manufacturing tolerances or wear may cause tighter clearances between moving parts, leading to increased friction.
    - **Improper lubrication:** Insufficient or incorrect viscosity of the hydraulic fluid can lead to increased friction within the pump.

3. **Swash Plate Control Issues:**

- Problems with the swash plate control mechanism can affect pump performance.
- Potential causes include:
    - **Sticking or malfunctioning control valve:** A faulty control valve may not respond properly to pressure changes, leading to an inability to maintain the desired swash plate angle and flow output.
    - **Worn or damaged linkage:** Wear in the linkage between the control valve and the swash plate can lead to imprecise control of the swash plate angle and reduced pump efficiency.
    - **Pressure relief valve malfunction:** A malfunctioning pressure relief valve may not properly regulate system pressure, leading to excessive internal pressure and reduced pump performance.

4. **Air Entrapment:**

- Air trapped within the pump can cause performance issues like erratic operation, reduced flow, and spongy control response.
- Air can enter the system through:
    - **Suction line leaks:** Leaks in the suction line can allow air to be drawn into the pump.
    - **Low fluid level in the reservoir:** Insufficient fluid level in the reservoir can lead to air being drawn into the pump inlet.
    - **Improper bleeding procedures:** Incomplete air bleeding during system maintenance can leave air pockets trapped within the pump.

Diagnosing the cause of the performance reduction requires further investigation. This may involve:

- **Monitoring system pressure and flow:** Analyzing pressure and flow readings can help identify if the issue is related to pressure generation, flow delivery, or internal leakage.
- **Checking for abnormal noises:** Unusual noises can indicate internal wear, sticking components, or air entrainment.
- **Reviewing system operating conditions:** Verifying proper system temperature, fluid level, and cleanliness can help rule out external factors.

By systematically examining these potential causes, technicians can identify the root cause of the performance reduction and implement appropriate corrective actions.