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Automatic Lubrication System with Blocked Outlet Reporting

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Abstract

This disclosure describes an automatic lubrication system designed to detect and report blocked lubricant outlets, thereby preventing component failure due to insufficient lubrication. The system integrates a metering block with a pressure sensing element and a control unit. By monitoring pressure fluctuations during lubrication cycles, the control unit can distinguish between normal operation, an empty lubricant reservoir, and a critically blocked outlet. This enables timely intervention, addressing the problem of invisible lubrication pathway obstructions before they lead to premature bearing wear or catastrophic equipment breakdown.

1. Technical Field

[0001] The present disclosure relates to industrial lubrication systems and, more specifically, to condition monitoring within automatic lubrication systems designed to detect and report faults in lubricant delivery pathways.

2. Technical Context

[0002] Automatic lubrication systems are employed in various industrial machinery to ensure consistent and adequate lubrication of critical components such as bearings, bushings, and gear sets. These systems typically dispense lubricant from a central reservoir to multiple lubrication points through a network of supply lines and metering devices. A significant challenge in operating such systems is the detection of blockages within the lubricant delivery paths. A blocked outlet, often occurring due to hardened grease, foreign debris, or a crimped line, can prevent lubricant from reaching its intended destination. This condition frequently remains unnoticed by maintenance personnel until the affected component experiences premature wear or catastrophic failure, leading to costly downtime and repairs. Conventional automatic lubrication systems often lack the capability to directly monitor lubricant flow at each individual lubrication point, making these blockages invisible during routine inspections.

3. System Overview

[0003] The disclosed system comprises an automatic lubricant delivery apparatus integrated with a fault detection and reporting mechanism. A lubricant reservoir (10) supplies lubricant to a pump (12), which delivers pressurized lubricant through a main supply line (14) to a metering block (20). The metering block (20) distributes discrete volumes of lubricant to multiple lubrication points (40) via individual outlet lines. A pressure sensor (26) is strategically positioned to monitor the lubricant pressure within the metering block (20) or its immediate vicinity. A control unit (30) is electrically connected to the pump (12), the pressure sensor (26), and an alarm indicator (32). The control unit (30) manages the pump's (12) operation, continuously monitors the pressure sensor's (26) output, and analyzes the pressure profile during lubrication cycles. Based on this analysis, the control unit (30) differentiates between normal operation, an empty lubricant reservoir (10), and a blocked outlet within the metering block (20) or its downstream path. Upon detection of a blocked outlet, the control unit (30) activates the alarm indicator (32) to alert operators. The overall system is depicted in FIG. 1.

4. Components

[0004]

- **Lubricant Reservoir (10):** A container designed to store lubricant, typically grease or oil, for the system. It includes an outlet port for connection to the pump (12) and may incorporate a low-level sensor (not shown) to indicate when replenishment is required.
- **Pump (12):** A positive displacement pump, such as a piston pump or gear pump, responsible for drawing lubricant from the reservoir (10) and pressurizing it for delivery through the main supply line (14). The pump (12) is controlled by the control unit (30).
- **Main Supply Line (14):** A conduit, typically a high-pressure hose or rigid pipe, connecting the pump (12) outlet to the inlet of the metering block (20).
- **Metering Block (20):** A device that receives pressurized lubricant from the main supply line (14) and accurately dispenses measured volumes of lubricant to individual outlet ports (24a, 24b, 24c). The metering block (20) can be of a progressive type, where internal pistons operate sequentially, or a parallel type, where each dispensing element operates independently. For progressive blocks, the operation of one piston is contingent on the previous one completing its stroke. The inlet port (22) of the metering block (20) is where lubricant enters.
- **Metering Block Outlets (24a, 24b, 24c):** Individual ports on the metering block (20) from which metered lubricant is discharged through secondary lines to lubrication points (40).
- **Pressure Sensor (26):** A transducer, such as a piezoresistive or strain gauge type, capable of measuring the lubricant pressure within the system. It is typically installed at the inlet port (22) of the metering block (20), as shown in FIG. 2, or integrated directly into the metering block body (20). The sensor (26) provides an electrical signal proportional to the measured pressure to the control unit (30).
- **Control Unit (30):** An electronic controller, such as a programmable logic controller (PLC) or a microcontroller, that manages the lubrication cycles. It receives pressure data from the pressure sensor (26), controls the pump (12) motor, analyzes pressure patterns, and triggers the alarm indicator (32) based on detected fault conditions.
- **Alarm Indicator (32):** A device that provides a visual (e.g., warning light) or audible (e.g., buzzer, siren) signal to alert operators of a detected fault condition. It is activated by the control unit (30).
- **Lubrication Points (40):** The components requiring lubrication, such as rolling element bearings, plain bearings, gears, or pivot points. They are connected to the metering block outlets (24a, 24b, 24c) via secondary lubricant lines.

5. Operation

[0005] The system operates through a series of timed lubrication cycles managed by the control unit (30).

[0006] **Start-up and Normal Cycle:** When a lubrication cycle is initiated, the control unit (30) activates the pump (12). The pump (12) draws lubricant from the reservoir (10) and delivers it under pressure to the main supply line (14) and into the metering block (20) via its inlet port (22). As lubricant flows into the metering block (20), internal pistons within the block begin to displace, dispensing lubricant from the outlets (24a, 24b, 24c) sequentially in the case of a progressive block, or simultaneously in the case of a parallel block. During this phase, the pressure sensor (26) continuously transmits pressure readings to the control unit (30). For a progressive metering block, the pressure typically rises to an operating pressure (e.g., 80 to 250 bar) and remains relatively stable as pistons cycle, showing minor fluctuations as each piston completes its stroke. Once the required volume of lubricant has been dispensed or a set time has elapsed, the control unit (30) deactivates the pump (12). The pressure in the system then gradually drops as the residual pressure dissipates through the distribution lines and lubrication points. The control unit (30) monitors the entire pressure profile, including the rate of pressure rise, the peak pressure, the duration of the high-pressure phase, and the rate of pressure decay.

[0007] **Fault Detection - Blocked Outlet:** If one of the metering block outlets (24a, 24b, 24c) or its associated secondary line becomes blocked, the internal resistance to lubricant flow increases significantly. During a pump (12) activation, the pressure measured by the pressure sensor (26) will rise much more rapidly and reach a significantly higher peak pressure than during normal operation (e.g., exceeding 300 bar). For a progressive metering block, a blockage will prevent subsequent pistons from moving, causing the pressure to spike and remain high until the pump (12) is stopped, as the lubricant has no path to relieve the pressure. The control unit (30) is programmed with pressure thresholds and time limits. If the pressure exceeds a predetermined upper threshold (e.g., 280 bar) within a specified time (e.g., 2 seconds) during the pump-on phase, or if the pressure fails to drop sufficiently after the pump (12) is switched off, the control unit (30) identifies this as a blocked outlet condition.

[0008] **Fault Detection - Empty Reservoir:** An empty lubricant reservoir (10) presents a different pressure signature. When the pump (12) activates with an empty reservoir, it attempts to draw lubricant but instead draws air or very little lubricant. Consequently, the pressure measured by the pressure sensor (26) will either remain very low (e.g., below 10 bar) or will fail to rise above a minimum operating threshold (e.g., 50 bar) within the expected time frame. The control unit (30) distinguishes this from a blocked outlet because a blocked outlet causes an *overpressure* condition, whereas an empty reservoir causes an *underpressure* or *no-pressure* condition. If the pressure remains below a lower threshold (e.g., 40 bar) for a specified duration during the pump-on phase, the control unit (30) identifies this as an empty reservoir condition. Some systems may incorporate a low-level sensor in the reservoir (10) as a primary indicator, but pressure analysis provides a secondary confirmation or primary detection if no such sensor is present.

[0009] **Alarm Activation and Cycle Monitoring:** Upon detecting either a blocked outlet or an empty reservoir condition, the control unit (30) immediately activates the alarm indicator (32). The alarm (32) may be accompanied by a specific code or message indicating the nature of the fault. The control unit (30) may also stop the pump (12) to prevent damage. The control unit (30) continuously monitors the completion of each lubrication cycle. If a cycle is interrupted, if the pressure profile deviates from expected norms, or if the pump (12) runs for an excessive duration without reaching the expected pressure or completing its discharge, these conditions are also flagged as potential faults. The alarm is designed to be actionable, prompting maintenance personnel to investigate and rectify the identified problem.

6. Example Embodiments

[0010] **Embodiment 1** In this embodiment, a progressive metering block (20) is employed, serving three lubrication points (40a, 40b, 40c). The pressure sensor (26) is directly mounted into the inlet port (22) of the metering block (20). The control unit (30) is programmed to expect a pressure rise to approximately 150 bar within 3 seconds of pump (12) activation, followed by a stable pressure plateau for 5-10 seconds, and then a pressure decay to below 10 bar within 15 seconds after pump shutdown. A blocked outlet is detected if the pressure exceeds 280 bar during the pump-on phase, or if the pressure does not decay below 20 bar within 30 seconds after pump shutdown. An empty reservoir is detected if the pressure remains below 40 bar for the entire 10-second pump-on duration. The alarm indicator (32) comprises a red flashing light and a local audible buzzer.

[0011] **Embodiment 2** This embodiment utilizes a parallel metering block arrangement where each dispensing element operates independently. A single pressure sensor (26) is installed in the main supply line (14) just upstream of the metering block (20). The control unit (30) monitors the pressure during a fixed pump (12) run time, for example, 20 seconds. In this configuration, a blocked outlet in one of the parallel lines may cause a less dramatic pressure spike than in a progressive system, but it will still result in an elevated average pressure during the dispense cycle compared to normal operation (e.g., a sustained pressure above 200 bar instead of the expected 120 bar). The control unit (30) learns the normal pressure profile for a given number of active outlets. An empty reservoir is detected if the pressure does not reach 50 bar within 5 seconds of pump (12) activation. The alarm indicator (32) communicates fault status via a networked interface to a central maintenance system.

[0012] **Embodiment 3** This embodiment features a large system with multiple progressive metering blocks (20a, 20b, 20c), each feeding a distinct group of lubrication points. Each metering block is equipped with its own pressure sensor (26a, 26b, 26c). The control unit (30) individually monitors the pressure profile of each metering block (20). This allows for localization of the blockage to a specific metering block, thereby narrowing down the area for maintenance investigation. The control unit (30) stores historical pressure data for each block, allowing for trend analysis. If a consistent pattern of slightly elevated pressure is observed over several cycles for a particular block, even if not immediately triggering a hard alarm, it can indicate an incipient blockage or increased resistance, triggering a pre-warning signal.

7. Alternative Configurations

[0013] Instead of a single pressure sensor at the metering block inlet, multiple pressure sensors could be distributed throughout the main supply line (14) or even within specific galleries of the metering block (20) for more granular fault localization. For very large systems, a flow sensor (not shown) could be incorporated in conjunction with the pressure sensor (26) to provide additional data for fault diagnosis, such as detecting leaks. The control unit (30) could be integrated into the pump (12) assembly or housed separately. The alarm indicator (32) may be a simple local light, a networked message to a supervisory control and data acquisition (SCADA) system, or a direct SMS alert to maintenance personnel. The pressure sensor (26) could be replaced by a pressure switch that triggers at a specific high-pressure threshold, providing a simpler, binary indication of overpressure, though without the detailed diagnostic capability of a proportional sensor.

8. Parameter Variations

Parameter	Realistic Range	Effect of Increase	Effect of Decrease
Pump operating pressure	80 to 250 bar	Higher force available to clear minor obstructions; increased stress on components.	Reduced ability to push lubricant through lines; lower stress on components.
Blocked outlet pressure threshold	250 to 400 bar	Requires more severe blockage to trigger alarm; reduces false alarms from minor fluctuations.	More sensitive to blockages; increased risk of false alarms from normal pressure transients.
Empty reservoir pressure threshold	20 to 60 bar	Requires lower pressure to be sustained for detection; may delay alarm if reservoir is nearly empty.	More sensitive to low lubricant conditions; may trigger alarm prematurely if pump struggles slightly.
Pump-on duration	5 to 60 seconds	Delivers more lubricant per cycle; increases time for fault detection; higher energy consumption.	Delivers less lubricant per cycle; faster fault detection; lower energy consumption.
Lubricant viscosity	NLGI 000 to NLGI 2	Higher viscosity increases system pressure and resistance; slower flow; harder to pump.	Lower viscosity reduces system pressure; faster flow; easier to pump; potential for leakage.
Alarm delay	0.5 to 5 seconds	Prevents nuisance alarms from momentary pressure spikes; delays critical fault notification.	Faster alarm response; increased likelihood of false alarms from transient conditions.

9. Additional Implementations

[0015] The disclosed system can be adapted for use with various types of lubricants, including oils, greases, and synthetic compounds, provided the pump (12) and metering block (20) are compatible with the lubricant's viscosity and chemical properties. The control unit (30) can incorporate adaptive learning algorithms that baseline the normal pressure profile over time, allowing it to adjust fault detection thresholds as system wear or ambient conditions change. For applications requiring specific fault identification, the control unit (30) can be configured to differentiate between a blockage in the metering block (20) itself versus a blockage in a downstream secondary line by analyzing the rate of pressure rise and the maximum achieved pressure against known characteristics of each type of fault. Furthermore, the system can be integrated with predictive maintenance platforms, where pressure data, cycle counts, and alarm events are logged and analyzed to forecast potential failures before they occur, enabling proactive maintenance scheduling. The control unit (30) can also be configured to perform a system purge function, where the pump (12) operates at a higher pressure or for an extended duration in an attempt to clear minor blockages before a full alarm is triggered.

10. Figures

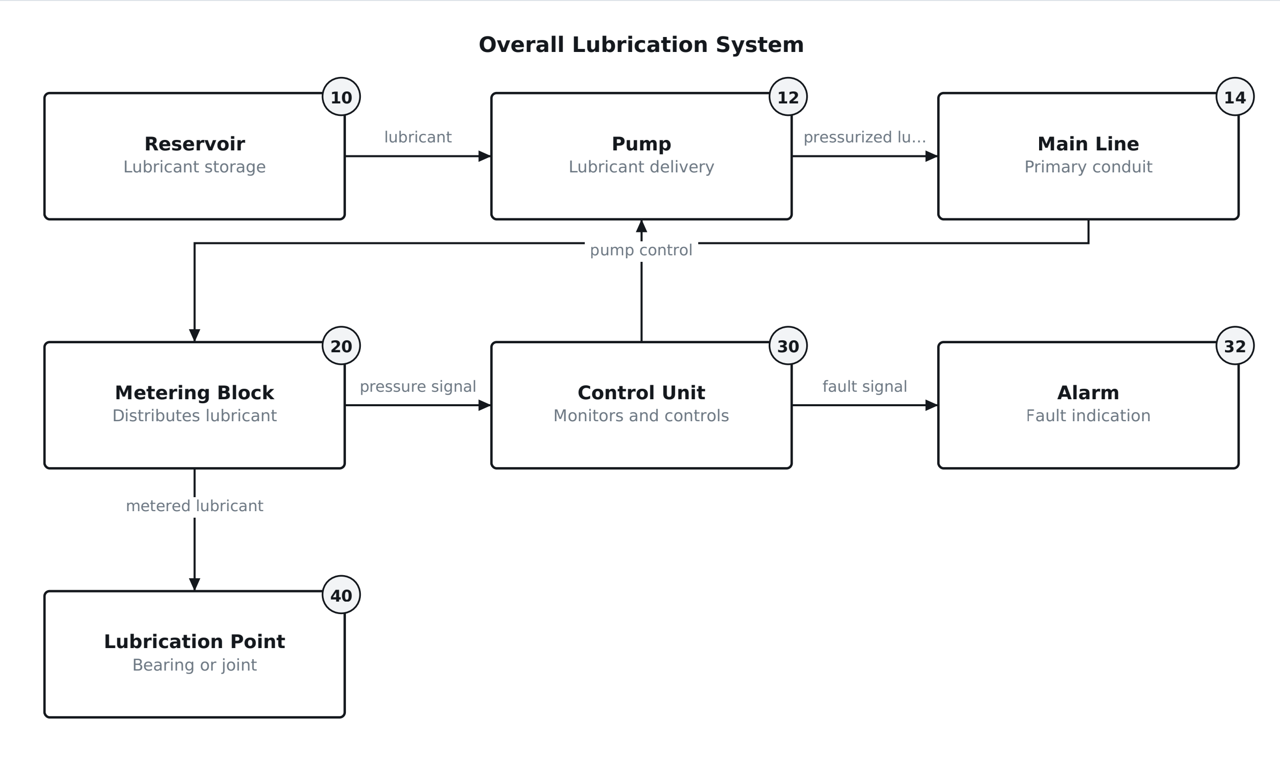

FIG. 1 This figure illustrates the principal components and flow paths of the automatic lubrication system. PNG

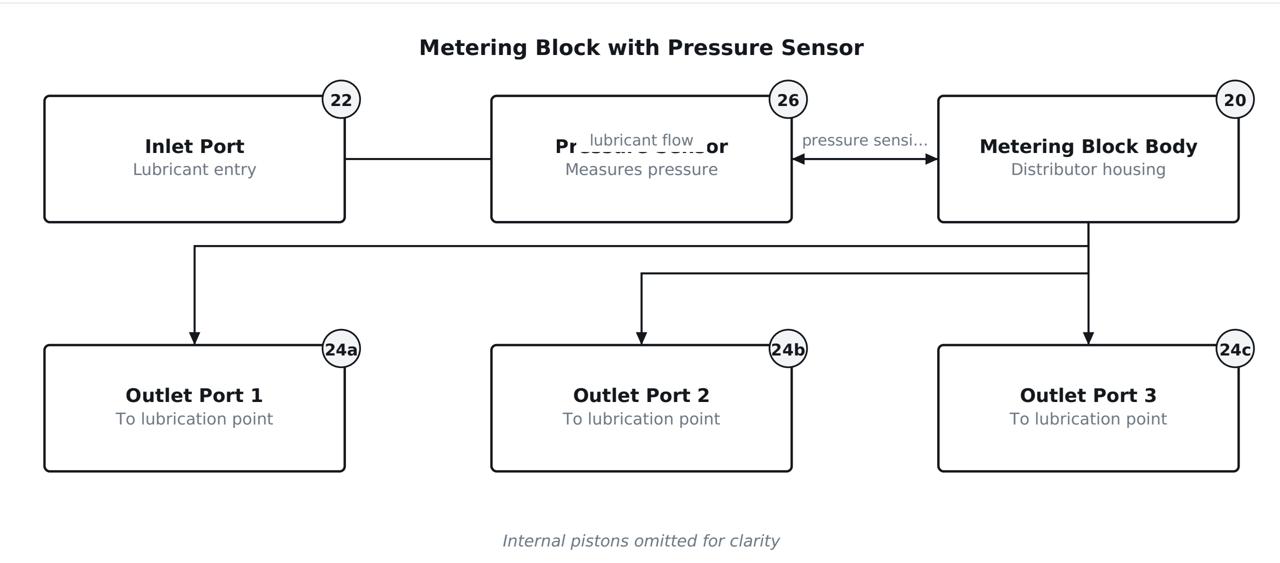

FIG. 2 This figure details the internal arrangement of a progressive metering block and its integrated pressure sensor. PNG

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