Principle Analysis and Fault Handling of MCC400A Electric Wheel Automatic Lubrication Control System

Shenglin Ding, Min Yu, Zhizhan Zhou
Dexing Copper Mine, Jiangxi Copper Corporation Limied, Dexing, Jiangxi, China

Abstract: Selecting the appropriate lubricating grease, applying the right amount of lubrication, suitable intervals, and the correct lubrication points can significantly reduce equipment maintenance and spare parts costs, while enhance the reliability of equipment operation. A well-functioning automatic lubrication system for mining dump trucks can greatly minimize friction and wear, thus extending the lifespan of bearings and mechanical components. Through in-depth analysis of the principles of the MCC400A electric wheel automatic lubrication control system and combined with on-site troubleshooting processes, we have accumulated valuable maintenance experience. This experience holds great significance for maintenance personnel to master troubleshooting techniques for automatic lubrication control systems. By understanding the system principles and analyzing the root causes of issues, we can precisely locate and resolve faults. Additionally, by leveraging modern technology effectively, we can enhance system stability and reliability, further improving equipment operational efficiency. In conclusion, optimized lubrication practices and a thorough understanding of the system will contribute significantly to the sustainable operation of equipment and reduced maintenance costs.

Keywords: Automatic Lubrication Control System; MCC400A; Electric Lubrication; Gear Oil Pump; Electromagnetic Pressure Relief Valve; Pressure Sensor

1. Introduction

With the advancement of the domestication plan for equipment within Jiangxi Copper Corporation, the Dexing Copper Mine's mining site currently possesses a total of 29 domestically-produced electric wheel units, including MCC400A (by China Metallurgical Group Jingcheng) and NTE200/240 (by North Heavy Industries). As the mainstay equipment in the mining production process, the condition of these units significantly influences the accomplishment of the mining site's overall stripping task.

In comparison to traditional lubrication methods, the automatic lubrication control system utilized in the MCC400A electric wheels offers substantial advantages [1]. This system can automatically add an appropriate amount of lubricating oil at set locations and intervals based on equipment requirements. It effectively reduces wear on articulated bearings, prolongs the service life of equipment's connecting pin shaft components, diminishes equipment downtime due to failures, lowers maintenance costs, and ensures secure equipment operation [2,3]. We conducted a comprehensive analysis of the automatic lubrication control system's principles and combined it with specific on-site troubleshooting cases to uncover the genuine causes of failures. By summarizing these cases, this paper empowers team members to grasp the repair techniques for automatic lubrication control systems, ultimately enhancing the efficiency of troubleshooting such issues.

2. Operation Process and Principle Analysis of the MCC400A Automatic Lubrication Control System

When the lubricating grease level in the storage tank is within the normal range, and the lubricating grease level signal on the HMI display screen in the cabin reads 1, pressing the manual lubrication switch (indicated by the change from 0 to 1 in the display screen's manual switch signal) or the initiation of the MCU controller's automatic lubrication cycle causes the electric lubricating oil pump motor (using a brushless DC motor) and the electromagnetic pressure relief valve to be energized simultaneously. The pressure relief valve's function is to close off the passage from the lubrication pipeline back to the storage tank [4]. The rotation of the oil pump motor drives the meshing gears in the pump body's cylinder. As the volume of the space on the gear's separation side increases, a vacuum effect is generated, creating suction and drawing in the lubricating grease into the system. Conversely, as the volume of the space on the gear's meshing side decreases, the lubricating grease is pressurized and sent through the pressure relief valve and the lubrication pipeline to the injector [5,6]. The injector injects lubricating grease to various pre-set lubrication points through a single line. When the lubrication pressure of the automatic lubrication system rises to the predetermined value (3000 psi) [7-9], the lubrication oil pressure sensor is triggered (indicated by the change from 0 to 1 in the lubrication oil pressure signal on the HMI display screen). As per the instruction from the MCU controller, the electric lubrication oil pump motor and the electromagnetic pressure relief valve will be immediately de-energized at the same time, causing the lubrication oil pump to stop working and the pressure relief valve to open the passage of the lubrication pipeline back to the storage tank, allowing pressure to be released and preparing for the next lubrication cycle.

If, within a lubrication cycle, the control system fails to detect the triggering of the lubrication oil pressure sensor even after 5 minutes of operation (pressure value not reaching 3000 psi), the lubrication warning light on the HMI display screen in the cabin will flash, accompanied by an alarm from the buzzer, alerting the driver to promptly report for maintenance.

3. Common Failures of the MCC400A Automatic Lubrication Control System

Handling common failures of the MCC400A electric wheel's automatic lubrication control system can be achieved by observing the lubricating oil pressure gauge and various I/O signals on the cabin's HMI display screen. These signals include lubricating oil level signals, lubricating oil pressure signals, control signals for the lubricating oil pump motor and electromagnetic pressure relief valve, among others. This approach allows for a swift identification of the faulty components and their locations, breaking away from relying solely on electrical instrument measurements for diagnosing and addressing faults. This significantly enhances the efficiency of troubleshooting such issues [10]. Below is a compilation of common failures and potential causes for the automatic lubrication control system of the MCC400A electric wheel.

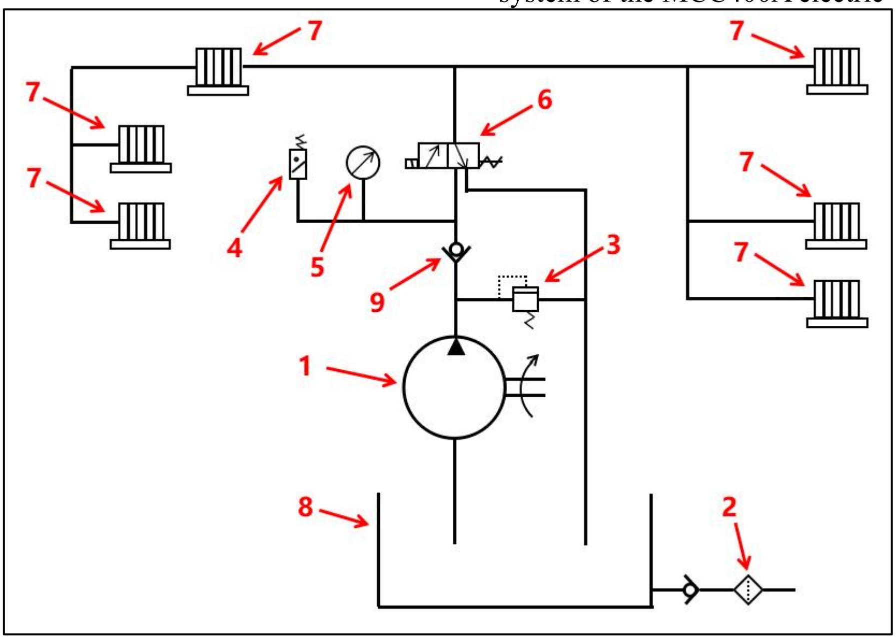

Figure 1. MCC400A Automatic Lubrication Control System Mechanical Schematic Diagram (1.Electric Lubricating Oil Pump; 2.Filter; 3.Safety Valve; 4.Lubricating Oil Pressure Sensor; 5.Lubricating Oil Pressure Gauge; 6.Electromagnetic Pressure Relief Valve; 7.Single Line Oiler; 8.Oil Tank; 9.Oil Check Valve)

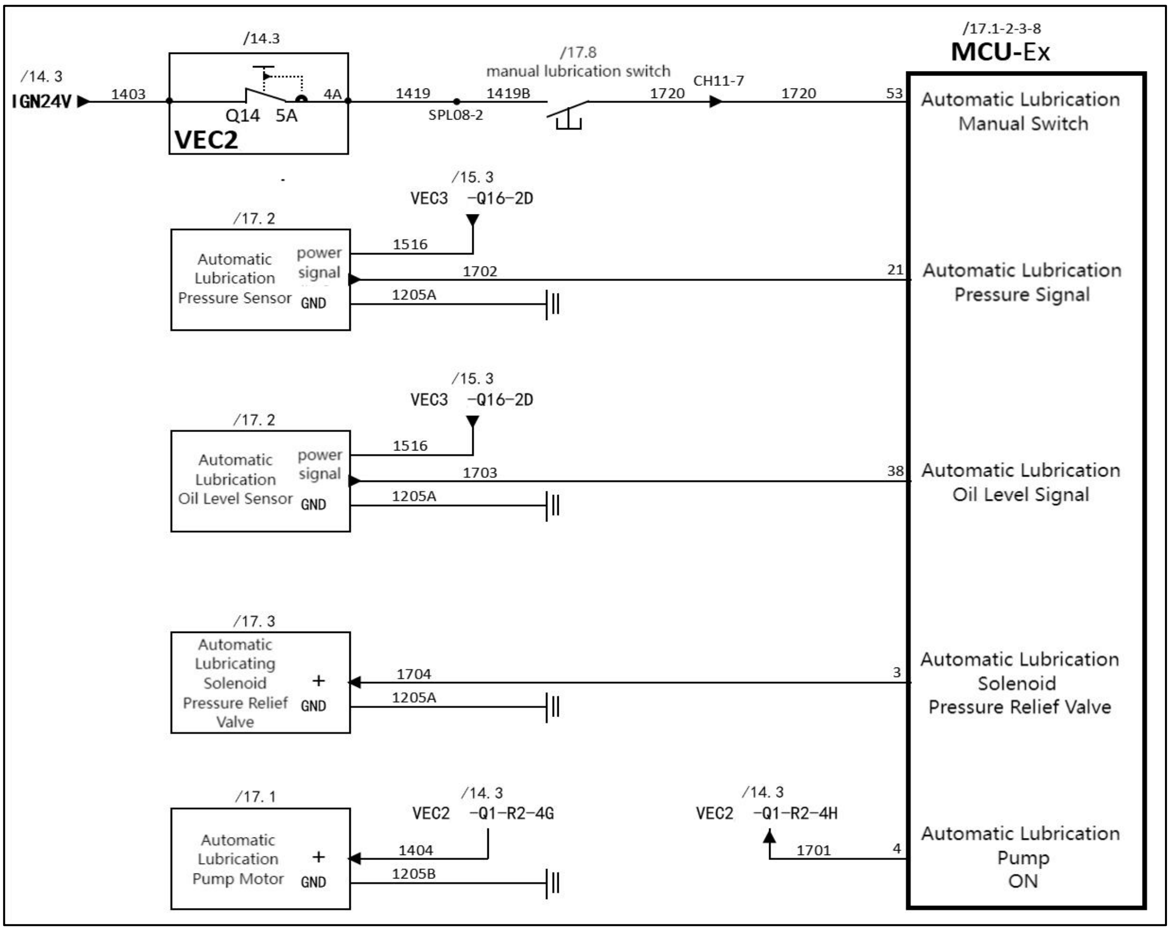

Figure 2. MCC400A Automatic Lubrication Control System Electrical Schematic Diagram

3.1. The Oil Pump Motor Does not Rotate During the Lubrication Cycle

The causes of the failure include: faults in the oil pump motor power supply and wiring, faults in the lubricating oil level sensor and its wiring (or insufficient lubricating grease capacity in the storage tank), faults in the lubricating oil pressure sensor and its wiring, damage to the oil pump motor itself.

3.2. The Oil Pump Motor Keeps Rotating During the Lubrication Cycle

The causes of the failure include: faults in the lubricating oil pressure sensor and its wiring, malfunction of the lubricating oil pump (unable to build pressure), sticking of the electromagnetic pressure relief valve spool and faults in the electromagnetic valve wiring, malfunction of the safety valve, faults in the lubrication pipeline (leaks), malfunction of the single-line injector.

3.3. The System Does not Release Pressure at the End of the Lubrication Cycle

The causes of the failure include: sticking of the electromagnetic pressure relief valve spool and faults in the electromagnetic valve wiring, sticking of the oil outlet check valve, etc.

3.4. Oil pump Motor Rotates too Fast During Lubrication Cycle

The causes of the failure include: insufficient lubricating grease capacity in the storage tank, sticking of the electromagnetic pressure relief valve spool and faults in the electromagnetic valve wiring, etc.

3.5. Lubrication Cycle System Builds Pressure too Quickly

The causes of the failure include: sticking of the oil outlet check valve, faults in the lubrication pipeline (blockage), sticking of the electromagnetic pressure relief valve spool and faults in the electromagnetic valve wiring, incomplete pressure relief at the end of the previous lubrication cycle, etc.

4. On-site Troubleshooting and Analysis of MCC400A Automatic Lubrication Control

System

By conducting on-site troubleshooting and analysis of MCC400A's automatic lubrication control system failures, one can gain a comprehensive understanding of the maintenance techniques for the automatic lubrication control system.

4.1. Troubleshooting Case Step 1

During the operation of electric wheel #115, the lubrication failure warning light flashed, indicating an issue. Upon on-site inspection, it was found that the equipment's connection pin shaft area was poorly lubricated. Upon reviewing the maintenance records, it was discovered that this issue had occurred recently as well. With the key switch turned on in a static state, the lubricating oil level sensor signal on the cabin's HMI display screen was 1 (indicating normal grease capacity in the storage tank). Pressing the manual lubrication switch, the lubrication oil pressure gauge installed on the electric pump assembly was observed. The system's lubrication pressure quickly reached the preset value of 3000 psi and continued to rise. However, the lubrication pressure switch did not respond (the lubrication oil pressure sensor signal on the display screen remained at 0), and the lubrication oil pump motor and pressure relief valve did not de-energize.

4.2. Troubleshooting Case Step 2

Steps were taken to address the issue. The key was turned off, and an inspection of the lubrication oil pressure sensor and its wiring revealed no obvious abnormalities. Upon removing the plug of the pressure sensor, pin corrosion was observed. After replacing the sensor plug, the key was turned on, and the manual lubrication switch was pressed. The system's lubrication pressure rapidly reached the preset value within 1-2 seconds. The lubrication oil pressure switch activated, and both the lubrication oil pump motor and the electromagnetic pressure relief valve were de-energized simultaneously.

4.3. Troubleshooting Case Step 3

Through analysis, it was determined that the lubrication test conditions described above mostly met the system control requirements. However, the identified issue (corrosion of the lubrication oil pressure sensor plug) would primarily lead to elevated lubrication system pressure, causing over-lubrication, and it wouldn't result in poor lubrication of the equipment's connection pin shaft area. Moreover, based on past maintenance experiences, under normal circumstances, the lubrication system pressure wouldn't reach the preset value of 3000 psi within 1-2 seconds. Therefore, there was likely another fault point in the lubrication system.

After a recheck, it was found that after the electromagnetic pressure relief valve de-energized, the lubrication oil pressure gauge pointer did not return to zero but consistently remained at 2300-2500 psi. Furthermore, during the process of removing the lubrication oil pump's outlet pipe, it was observed that there was significant residual pressure in the lubrication system. This indicated that there was a fault in which the system was unable to fully release pressure at the end of the lubrication cycle. As a result, in the subsequent cycle, the lubrication oil pressure quickly reached the system's preset value. During the inspection of the electromagnetic pressure relief valve, it was discovered that the spool was stuck. The spool was disassembled, cleaned, and reinstalled.

With the key turned on and the manual lubrication switch pressed again for testing, it was observed that the lubrication oil pressure needed 30-50 seconds to reach the system's preset value within each lubrication cycle. Additionally, after the lubrication oil pressure switch activated and the electromagnetic pressure relief valve de-energized, the lubrication oil pressure gauge pointer instantly returned to zero, indicating normal operation. As a result, the troubleshooting was completed.

4.4. Troubleshooting Case Summary

If the aforementioned issue of the electromagnetic pressure relief valve spool being stuck had not been promptly identified and addressed, it could have led to prolonged poor lubrication of the equipment's connection pin shaft components. In this scenario, the automatic lubrication control system might not have indicated a lubrication fault, which could have not only impacted the safe operation of the equipment but also posed a potential risk of residual pressure causing harm during maintenance procedures.

5. Insufficient Design of MCC400A Automatic Lubrication Control System and Suggestions

for Improvement

During routine maintenance and troubleshooting, it has been observed that there are certain design deficiencies in the MCC400A automatic lubrication control system. Specifically, the lubrication oil pressure sensor is installed at the outlet of the lubrication oil pump, enabling it to monitor only the lubricating grease pressure at that specific location. In the event of blockages occurring at points such as the electromagnetic pressure relief valve or the lubrication pipeline connecting to the injector, the control system might not detect the fault. This can potentially lead to inadequate equipment lubrication, posing a safety risk.

It is recommended that the equipment manufacturer consider installing a lubrication oil pressure sensor at the rear axle housing of the vehicle. This would broaden the monitoring scope of the control system to encompass lubrication pressure across various critical points, helping to address this limitation and enhance the system's fault detection capabilities.

6. Conclusion

The article has conducted a comprehensive study and analysis of the operation and principles of the MCC400A electric wheel's automatic lubrication control system. It has also summarized common failures associated with the automatic lubrication control system. Additionally, the article addresses encountered issues with the system, outlining the process of diagnosis, troubleshooting, and summarizing insights gained from these experiences.

Furthermore, the article points out certain design deficiencies within the control system. Specifically, it highlights how the placement of the lubrication oil pressure sensor solely at the lubrication oil pump's outlet limits its ability to detect blockages in critical areas like the electromagnetic pressure relief valve or the lubrication pipeline connected to the injector. This situation can lead to inadequate equipment lubrication and potential safety hazards.

As a solution, the article recommends the equipment manufacturer consider installing a lubrication oil pressure sensor at the rear axle housing. This adjustment would expand the control system's monitoring range, overcoming the current limitation and enhancing its ability to detect faults.

In summary, the article provides an in-depth exploration of the MCC400A electric wheel's automatic lubrication control system, addressing its operation, common failures, and practical insights for troubleshooting. It also offers valuable suggestions for improving the system's design, aiming to enhance its overall performance and safety.

References

[1] Zhong, W.B., Wang, G.Q., & Shi, J. (2007). Development of On-Line Automatic Lubrication Control System for Large-Scale Continuous Operation Equipment. Coal Mining Machinery, 28(02), 138-140.

[2] Zhang, X.M. (2014). Application of S7-200 in Automatic Control System of Ball Mill High Pressure Lubricating Station. Electrical Technology, (04), 39-40.

[3] Xie, N.F. (2002). Application of Automatic Lubrication of Oil Injectors and System Control Loops. Mechanical Research and Application, (01), 18-19.

[4] Yin, Y.C., & Gao, Y. (2005). A New Theory of Working Principle of Hydraulic Gear Pump. Mechanical Engineering and Automation, (01), 59-60.

[5] Cheng, L., Zheng, Q., & Yang, Y.F., et al. (2013). Design of Automatic Lubricating System for Open Gear Transmission Mechanism. Machinery, (02), 54-59.

[6] Hou, Q.P. (2019). Innovation of Centralized Automatic Lubricating System in Loading Station. Petrochemical Technology, 26(12), 141-142.

[7] Chang, L., & He, J.Q. (2022). Mechanical Grab Non-powered Automatic Lubrication System. Port Technology, (12), 35-58.

[8] Cheng, J., & Liu, B. (2020). Design of Energy-saving Control Method for Automatic Lubrication System of CNC Machine Tool. Machine Tools and Hydraulics, 48(11), 125-127.

[9] Zhang, W.Q. (2013). Investigation and Treatment of Common Faults of Automatic Lubrication System of Large Mining Electric Wheel. China Mining Engineering, 42(04), 51-54.

[10] Chen, L., & Gao, X.B. (2017). PLC-based Conveyor Chain Automatic Lubrication Control System. Equipment Management and Maintenance, (01), 91-93.

