

Research on Intelligent Operation and Maintenance Technology for Industrial Wastewater Treatment

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Abstract: With the rapid progress of industrialization, the problem of industrial wastewater treatment is becoming increasingly severe and urgently needs to be solved. Intelligent operation and maintenance technology provides innovative solutions for industrial wastewater treatment by integrating cutting-edge technologies such as the Internet of Things, cloud computing, big data analysis, and artificial intelligence. This article will deeply analyze the practical application, prominent advantages, challenges, and future development directions of intelligent operation and maintenance technology in industrial wastewater treatment, with the aim of providing useful references and inspirations for research and practice in this field.

Keywords: Industrial wastewater; Intelligent operation and maintenance; Internet of Things; Cloud computing; Big data analysis; artificial intelligence.

1. Introduction

With the continuous expansion of industrial activities, the discharge of industrial wastewater is increasing, and the pressure on the environment is also increasing. Traditional treatment methods often rely on a large amount of manpower and physical and chemical processes, which not only consume resources but also have limited treatment effects, making it difficult to meet increasingly strict environmental standards. Intelligent operation and maintenance technology integrates advanced information technology to achieve real-time monitoring, intelligent analysis, and automatic adjustment of industrial wastewater treatment processes, significantly improving treatment efficiency, reducing operating costs, and achieving more accurate and efficient management through data-driven decision support. Therefore, researching and promoting the application of intelligent operation and maintenance technology in industrial wastewater treatment has important practical significance for promoting environmental protection and sustainable development[1].

Intelligent operation and maintenance technology can monitor the sewage treatment process in real time, optimize resource allocation, improve treatment efficiency, and reduce operating costs. At the same time, it can also provide data support for decision-makers, helping with environmental protection and sustainable development[2].

2. Overview of Intelligent Operation and Maintenance Technology

2.1. Internet of Things Technology

The Internet of Things technology utilizes various sensors and other related devices to collect real-time key data during the wastewater treatment process, and transmits this data to the cloud for in-depth analysis and processing. These data cover multiple aspects such as water quality parameters and equipment operation status, providing a solid foundation for intelligent operation and maintenance. Through these sensor devices, we can monitor key water quality parameters such as chemical oxygen demand (COD), biochemical oxygen

demand (BOD), pH value, turbidity, temperature, etc. in sewage in real time. At the same time, equipment status monitoring includes information on pump station operation, valve switch status, pipeline pressure, and flow rate. The real-time collection and transmission of these data enable operation and maintenance personnel to timely understand the operating status of the system, respond quickly to various emergencies, and thus improve the efficiency and reliability of the entire sewage treatment system[3].

After transmitting these data to the cloud, deep mining and processing of the data can be carried out through big data analysis and artificial intelligence algorithms. For example, through comparative analysis of historical data, the maintenance cycle of equipment can be predicted, preventive maintenance can be carried out in advance, and sudden failures can be avoided. In addition, real-time data analysis can optimize treatment processes, improve treatment efficiency, reduce energy consumption, and achieve more environmentally friendly and economical wastewater treatment. The application of IoT technology in wastewater treatment provides powerful data support for intelligent operation and maintenance through real-time collection and transmission of various key data, making the entire treatment process more efficient, intelligent, and sustainable[3].

2.2. Cloud computing technology

Cloud computing technology, with its powerful data storage and computing capabilities, provides strong support for large-scale data processing and analysis tasks. Through this advanced technology, the massive data collected by IoT devices can be efficiently stored and processed, providing a solid foundation and strong guarantee for intelligent operation and maintenance. Cloud computing platforms can flexibly expand resources to meet the needs of various complex scenarios, ensuring real-time and accurate data processing. In addition, cloud computing also has a powerful data security mechanism that can effectively prevent data leakage and loss, providing users with a reliable data storage and computing environment. Through cloud computing technology, enterprises can achieve centralized management and intelligent analysis of data, further improving operational

efficiency and decision-making quality, and promoting rapid business development[4].

2.3. Big Data Analysis Technology

Big data analysis technology has powerful capabilities to conduct in-depth mining and comprehensive analysis of massive amounts of data. Through this technology, we can reveal the inherent correlations and potential regularities between data. These findings not only help us better understand the information behind the data, but also provide scientific decision-making basis for intelligent operation and maintenance. Through big data analysis, we can optimize processing techniques, improve equipment configuration, and thus enhance overall operational efficiency and equipment performance. The application of this technology enables enterprises to more accurately predict and respond to various complex situations, ensuring the efficiency and stability of the production process.

2.4. Artificial Intelligence Technology

Artificial intelligence technology encompasses a variety of advanced methods and algorithms, including key technologies such as machine learning and deep learning. These technologies can intelligently analyze and predict the large amount of data generated during the wastewater treatment process, thereby helping us better understand and control the treatment process. Through the application of artificial intelligence technology, wastewater treatment systems can achieve automated control, dynamically adjust based on real-time data and predicted results, and optimize the treatment process. This intelligent processing method not only improves processing efficiency, but also significantly enhances processing accuracy, ensuring the quality and effectiveness of wastewater treatment[5].

3. Application of Intelligent Operation and Maintenance Technology in Industrial Wastewater Treatment

3.1. Real time monitoring and warning system

Intelligent operation and maintenance technology can continuously monitor key water quality parameters and equipment operation status during wastewater treatment by establishing a real-time monitoring and warning system. This system utilizes advanced sensors and data analysis technology to ensure real-time monitoring of every step, thereby achieving comprehensive control over the entire processing process. Once the system detects any abnormal situation, such as exceeding water quality parameters or abnormal equipment operation, it will immediately issue a warning signal. These warning signals are quickly transmitted to operation and maintenance personnel through various communication methods, ensuring that they can obtain information in a timely manner. After receiving the warning signal, the operation and maintenance personnel can quickly take corresponding measures, carry out timely processing and adjustment, to prevent the problem from further deteriorating, and ensure the stable operation of the sewage treatment system and the safety of the environment. Through this approach, intelligent operation and maintenance technology not only improves processing efficiency, but also greatly reduces the risks and losses caused by equipment failures or water quality issues.

3.2. Remote Control and Automation Adjustment

Intelligent operation and maintenance technology achieves remote control and management of equipment and systems through advanced information technology and automation methods. This technology can automatically adjust various parameters and equipment status during the processing based on real-time data and pre-set rules. Through this approach, intelligent operation and maintenance technology ensures the stability and efficiency of the processing, greatly reducing the frequency of manual intervention and the risk of misoperation. Specifically, intelligent operation and maintenance technology utilizes sensors, the Internet of Things, and big data analysis to monitor the real-time operating status and environmental conditions of devices. The system will automatically adjust the working parameters of the equipment and optimize the operation process based on these data, combined with preset rules and algorithms. For example, in industrial production, intelligent operation and maintenance technology can automatically adjust key parameters such as temperature, pressure, and flow rate on the production line, ensuring the stability of the production process and consistency of product quality[6].

In addition, intelligent operation and maintenance technology can continuously optimize and adjust preset rules through machine learning and artificial intelligence algorithms, making the operation of devices and systems more intelligent and efficient. This technology not only improves the operational efficiency of the equipment, but also reduces reliance on manual operations, lowering the risks and losses caused by human errors. Intelligent operation and maintenance technology achieves efficient and stable operation of equipment and systems through remote control and automated adjustment functions, significantly improving production efficiency and safety, and bringing huge economic benefits and competitive advantages to enterprises.

3.3. Data analysis and optimization decision-making

Intelligent operation and maintenance technology has powerful data analysis capabilities, which can comprehensively and deeply analyze various data in the process of wastewater treatment. By carefully sorting and interpreting data, this technology can identify bottlenecks and potential problems in the processing, providing strong support for optimizing the processing flow. Intelligent operation and maintenance technology can not only detect problems, but also provide specific optimization suggestions based on analysis results, helping to improve the operational efficiency and processing quality of the entire processing system[7].

Through the application of intelligent operation and maintenance technology, it is possible to optimize and adjust process parameters, ensuring a more efficient and stable processing. Meanwhile, by making reasonable adjustments to the device configuration, the operational efficiency of the equipment can be further improved, and unnecessary energy consumption and resource waste can be reduced. These optimization measures can not only significantly improve the quality of wastewater treatment, but also effectively reduce operating costs, achieving a dual improvement in economic and environmental benefits.

3.4. Intelligent Device Management and Maintenance

Intelligent operation and maintenance technology can comprehensively manage and maintain sewage and wastewater treatment equipment through advanced intelligent means. This technology utilizes real-time monitoring systems to continuously track the status of equipment, enabling rapid detection of potential equipment failures and issues. Through this approach, the operations team can take timely measures to ensure the normal operation of equipment and avoid production interruptions or environmental pollution caused by malfunctions. In addition, intelligent operation and maintenance technology can provide accurate equipment maintenance plans and suggestions based on the operating data and historical maintenance records of the equipment. This not only helps to extend the service life of the equipment, but also effectively reduces maintenance costs and unnecessary maintenance expenses. Through this approach, enterprises can achieve more efficient and economical equipment management, ensuring the long-term stable operation of wastewater treatment equipment.

4. The Advantages and Challenges of Intelligent Operation and Maintenance Technology in Industrial Wastewater Treatment

4.1. Advantages

Improve processing efficiency: By adopting intelligent operation and maintenance technology, various links in the processing process can be monitored in real time, potential problems can be discovered and solved in a timely manner, thereby optimizing the entire processing flow. This technology can not only improve the efficiency of the processing process, but also ensure the quality of the processing results, further enhancing the overall work efficiency.

Reduce operating costs: Smart operation and maintenance technology can significantly reduce labor costs and energy consumption by optimizing resource allocation and achieving automated control. Through intelligent scheduling and management, unnecessary resource waste is reduced, effectively lowering overall operating costs and improving the economic efficiency of the enterprise.

Improving management efficiency: The comprehensive data analysis and visualization display functions provided by intelligent operation and maintenance technology enable managers to have a more intuitive understanding of the operation status of the processing process. Through these detailed data and charts, managers can quickly identify the problem and develop corresponding optimization strategies, thereby improving overall management efficiency.

Assisting environmental protection: Smart operation and maintenance technology can effectively reduce pollutant emissions by improving processing efficiency and accuracy. This not only helps to protect the environment and reduce damage to natural resources, but also promotes the sustainable development of enterprises and makes positive contributions to achieving environmental protection goals.

4.2. Challenge

Data security and privacy protection: In the application process of intelligent operation and maintenance technology, it is inevitable to involve the collection, processing, and transmission of a large amount of sensitive data. To ensure the security and privacy of this data, a series of effective measures must be taken. This includes but is not limited to the application of encryption technology, strict management of access control, and security measures during data storage and transmission. Only in this way can we fully leverage the advantages of intelligent operation and maintenance technology while ensuring user privacy, and improve the overall performance and reliability of the system.

Technology integration and standardization: The development of intelligent operation and maintenance technology cannot be separated from the integration and standardization between different technologies and devices. At present, compatibility issues between different manufacturers and devices remain an urgent challenge that needs to be addressed. In order to ensure the compatibility and stability of the system, it is necessary to develop unified technical standards and interface specifications. This not only facilitates seamless integration between different devices and systems, but also promotes the healthy development of the entire industry. By promoting standardization, maintenance costs of the system can be reduced, operational efficiency can be improved, and more stable and reliable services can be provided to users.

Technical training for operation and maintenance personnel: The widespread application of intelligent operation and maintenance technology has raised higher requirements for operation and maintenance personnel. They not only need to have solid professional knowledge, but also need to master the application ability of various new technologies and tools. Therefore, it is particularly important to provide systematic technical training and skill enhancement for operation and maintenance personnel. This includes regular training courses, practical exercises, and skill certification. Through these training measures, operation and maintenance personnel can continuously improve their professional competence and technical level, thereby better addressing various challenges in intelligent operation and maintenance, ensuring the efficient operation and stable maintenance of the system.

5. Case Study of Intelligent Operation and Maintenance Technology in Industrial Wastewater Treatment

5.1. Case 1: Application of Intelligent Operation and Maintenance System in a Chemical Plant

The chemical plant adopts an intelligent operation and maintenance system for real-time monitoring and optimization of the wastewater treatment process. By collecting data such as water quality parameters and equipment status, the system can promptly detect and handle abnormal situations, improving processing efficiency and quality. At the same time, the system can also provide equipment maintenance plans and suggestions, reducing repair costs. After a period of operation, the wastewater treatment efficiency of the chemical plant has increased by

more than 20%, and the operating costs have been reduced by about 15%.

5.2. Case 2: Smart Transformation Project of a Sewage Treatment Plant

The sewage treatment plant has undergone intelligent transformation, establishing real-time monitoring and warning systems, remote control and automation adjustment systems, etc. Through renovation, the treatment efficiency and quality of the sewage treatment plant have been significantly improved, and operating costs have been reduced by nearly 20%. At the same time, intelligent operation and maintenance technology also provides scientific data support for decision-makers, helping with environmental protection and sustainable development.

6. The Future Development Direction of Intelligent Operation and Maintenance Technology In Industrial Wastewater Treatment

6.1. Technological Innovation and Development

In the future, intelligent operation and maintenance technology will continue to develop to a higher level. Through technological innovation and research and development, solve current technological bottlenecks and problems, and improve the stability and accuracy of the system. At the same time, more new application scenarios and solutions will be explored to meet the needs of different industries and fields.

6.2. Standardization and normalization

With the widespread application of intelligent operation and maintenance technology, it will promote the formulation and improvement of relevant standards and specifications. This will help solve the integration and standardization issues between different technologies and devices, and improve the compatibility and stability of the system. Meanwhile, standardization and normalization will also promote the popularization and promotion of technology, reduce application barriers and costs.

6.3. Enhancement of Intelligence and Automation Level

In the future, intelligent operation and maintenance technology will pay more attention to the improvement of intelligence and automation. By introducing more advanced artificial intelligence algorithms and models, more accurate prediction and control of the wastewater treatment process can be achieved. At the same time, automation regulation and remote control functions will be strengthened to reduce the risk of manual intervention and misoperation, and improve processing efficiency and accuracy.

6.4. Application of Sustainable Development and Environmental Protection Concepts

The development of intelligent operation and maintenance technology will pay more attention to the application of sustainable development and environmental protection concepts. By optimizing the processing technology and equipment configuration, energy consumption and pollutant emissions can be reduced, and the impact on the environment

can be minimized. At the same time, more green and low-carbon solutions will be explored to contribute to environmental protection and sustainable development.

6.5. Cross disciplinary Integration and Innovation

In the future, intelligent operation and maintenance technology will be more deeply integrated and innovated with technologies in other fields. For example, the integration with intelligent manufacturing, smart cities and other fields will promote the coordinated development of industrial wastewater treatment with intelligent manufacturing, urban management and other fields. This will help build a smarter, more efficient, and environmentally friendly industrial wastewater treatment system.

7. Conclusion and Prospect

This article explores the application, advantages, challenges, and future development directions of intelligent operation and maintenance technology in industrial wastewater treatment. Through case analysis, this article demonstrates the practical effects of intelligent operation and maintenance technology in improving processing efficiency, reducing operating costs, and enhancing management efficiency. At the same time, this article also points out the challenges and future development directions of current technology. Looking ahead, intelligent operation and maintenance technology will play a more important role in the field of industrial wastewater treatment. With the continuous innovation and improvement of technology, intelligent operation and maintenance technology will promote the intelligent transformation and sustainable development of the industrial wastewater treatment industry. At the same time, cross disciplinary integration and innovation will bring more development opportunities and challenges to intelligent operation and maintenance technology. Therefore, we should actively pay attention to and promote the development of intelligent operation and maintenance technology, strengthen technology research and application practices, and make greater contributions to environmental protection and sustainable development. At the same time, it is necessary to strengthen policy guidance and standard setting, promote the popularization and standardized development of technology. Only in this way can we jointly build a smarter, more efficient, and environmentally friendly industrial wastewater treatment system.

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