Application of Internet Communications in Agricultural Electromechanical Drainage and Irrigation Pumping Station

Yanman Li¹, Kun Huang¹, Xingye Zhu² and Keji Lu²,*

¹Nari Group Corporation/State Grid Electric Power Research Institute, Nanjing, Jiangsu, China
²Research Centre of Fluid Machinery Engineering and Technology, Jiangsu University, Zhenjiang, Jiangsu, China

*Corresponding author e-mail: lukeji123@foxmail.com

Abstract. With the gradual advancement of electric energy substitution, the power consumption of agricultural electromechanical drainage and irrigation pumping station increases rapidly. It is urgent to update and transform the pumping station. Aiming at the substitution scenario of electric energy for agricultural irrigation and drainage, the technology of internet communications are combined in the application. It focuses on the design of two systems: monitoring and warning of operation conditions, and charging management of pumping stations. An electrical control cabinet integrated with power supply and control is designed by using PLC control system. This control cabinet is installed in the pump house of irrigation and drainage area. Some control terminals can be connected to it, and each terminal can be connected with a load that can work or shut down independently. These two systems store and analyse the operation conditions and electricity charge information. They also establish database and exchange data with external power supply companies and water resources management bureaus through internet communications. They are used to realize intelligent control and management. It is of great significance to establish a perfect integrated power supply control system for agricultural irrigation and drainage.

1. Introduction

Rural electric power drainage and irrigation station is the basic construction of agriculture and an important link to promote agricultural development [1-3]. Small-scale agricultural electric power drainage and irrigation stations have the advantages of small investment, quick effect and convenient installation, which play an important role in rural economic and social development [4-6]. Internet communications is a new direction of information industry after computer, internet and mobile communication network. The so-called Agricultural Internet Communications is to achieve the information acquisition of crop growth and agricultural products production through the internet communications technology [7-10]. By using various sensors or software processing platforms, people could be helped to solve the problems. In this way, agriculture will change from a human-centered mode relying on isolated machinery into a software-centered production mode.

Irrigation and drainage stations should be able to irrigate and drain during drought or floods [11-13], and electricity is its main power. Therefore, the objective of the paper is to use the internet communications technology to design an integrated power supply control system for agricultural electric drainage and irrigation. In order to ensure the pumping station more efficiently and reasonably,
it can complete the work of power supply and charging simultaneously, improving the economic benefits [14-17].

2. Overall Framework Design

The integrated power supply and control system of agricultural electric drainage and irrigation is an intelligent power supply, charging and operation condition monitoring system. It is specially developed for electromechanical drainage and irrigation pumping stations. This system combines the internet communications technology and the characteristics of electromechanical drainage and irrigation pumping station. The PLC controller is used to connect with external power grid and the network. It also carries on the analysis and storage of working condition data through advanced operating condition monitoring system, which overcomes the shortcomings of large workload and error resulting from traditional manual monitoring. To resolve the difficulty in wading meter, charging and management, it establishes the charging management system of agricultural electric drainage and irrigation. The IC card switcher is installed at the load terminal to charge electricity fee.

Figure 1 shows the overall design of integrated power supply and control equipment. In a whole irrigation and drainage area, each small irrigation and drainage field is equipped with an integrated load terminal, which can be connected with sensors that can collect soil or air moisture. Different types of pumps are installed according to the requirements of irrigation and drainage conditions. The field sensors can communicate with receivers under certain conditions to control the opening and closing of irrigation valves. It could transmit irrigation information to the central controller through wireless network. The integrated safety control system in each load terminal mainly includes leakage protection switch, electric meter and card swipe switch. Generally, one load terminal corresponds to one user, and the user finally switches the pump by swiping the card. In addition, the central control system is equipped with monitoring and early warning, and electricity charge management system. These two systems can store and analyse the operation conditions and electricity charge information. They also establish database and exchange data with external power supply companies and water resources management bureaus through Internet communications.

3. Monitoring and Early Warning System for Operating Conditions of Agricultural Electromechanical Drainage and Irrigation Pumping Station

3.1. Background and problem analysis

The renovation and rational utilization of electromechanical drainage and irrigation pumping stations have obvious positive effect on rural economic development. Therefore, it is an important link to judge the economic operation situation of pumping stations accurately. By carrying out operation monitoring and early warning work, it would promote the upgrading and the sustainable development of pumping stations.

Restricted by the traditional statistical means, the economic operation monitoring and analysis of pumping stations are being more and more difficult. It becomes hardly meet the requirements of power grid companies for real-time monitoring, analysis and early warning. The main performances are as follows. Firstly, the statistical data and operation monitoring and analysis system of mechanical and electrical drainage and irrigation pumping station lacks effective integration. For example, monthly and annual load statistics are not systematic, so the economic operation of power consumption is
difficult to monitor, analyse and judge. Secondly, most of the historical statistical data of pumping stations are stored in paper, and there is no systematic database. It is time-consuming and laborious to query and use. Thirdly, the timeliness of pump station operation monitoring is poor due to lacking software platform.

These shortcomings restrict the level of operation monitoring, prediction and early warning of electromechanical drainage and irrigation pumping stations. It is urgent to find new means to break through the difficulties. Based on the above analysis, it is an effective way to establish a unified platform for economic operation monitoring and early warning system of pumping stations by using internet communications technology. Through the construction of operation monitoring and early warning system platform, the historical statistical data of pumping stations are combined and integrated.

3.2. Structure design of operation monitoring and early warning system

The platform of economic operation monitoring and early warning system for electric load of drainage and irrigation pumping stations can be composed of seven subsystems and five-layer architecture. The seven subsystems are statistical information database, enterprise network direct reporting, economic operation monitoring and analysis, economic operation prediction and early warning, economic operation quality evaluation, information sharing service, unified portal and comprehensive query display subsystem, respectively. The five-layer architecture are hardware layer, data layer, application layer, presentation layer and user layer are from bottom to top. Figure 2 shows the overall functional framework of this system.

![Figure 2. Framework of operation condition monitoring and early warning system](image)

Statistical information database subsystem is the basic support subsystem of the whole system platform, providing data and platform support for other business functions and subsystems. The enterprise network direct reporting subsystem is the enterprise data acquisition subsystem of the system platform. It realizes the data direct reporting function for electromechanical drainage and irrigation pumping stations under the network environment. The economic operation monitoring and analysis subsystem is the core function subsystem of the system platform. Through this subsystem, it can monitor and analyse the overall situation of the economic operation of electricity in pumping stations. It could monitor and analyse the daily, monthly and annual operation of the system. The economic operation prediction and early warning subsystem is a pioneering subsystem. According to the regularity, periodicity and self-characteristics of operation conditions, the prediction and early warning model can be established. The economic operation quality evaluation subsystem is an important functional subsystem. At present, the focus of electromechanical drainage and irrigation pumping station is to improve the quality of operation conditions. The information sharing service subsystem is the information content management subsystem of the system platform. It mainly achieves the following five functions, the collection of pumping station information; the management
and publication of information; the comprehensive query and browsing function of information; the push function of information; the information exchange with power supply companies and local water industry management departments. The unified information portal and the integrated query display subsystem is located in the presentation layer of the economic operation monitoring and warning system. It is the platform for realizing the interactive service between application subsystems and users, and the window for the centralized display and integrated query of information resources in each application subsystem.

4. Power Supply and Electricity Charge Management System of Agricultural Electromechanical Drainage and Irrigation Pumping Station

4.1. Background and problem analysis

Traditional charging method is that electricity fees are collected by section collectors and handwritten receipts are used. Due to the lack of advanced payment methods, problems such as difficulty in paying fees and missing charges are becoming increasingly apparent. With the renovation of agricultural electromechanical drainage and irrigation pumping stations and the further adjustment of power supply layout, the existing charge management system can hardly meet the needs. By integrating internet communications technology into the operation and management, electric charge measurement, collection and analysis of data statistics are realized. The intelligent information processing can ensure the accuracy and reliability of data, and save manpower and material resources, which could reduce operating costs and improve economic benefits.

Therefore, it is imperative to develop and use a set of comprehensive power and charge management software. The electricity charge management system can realize the automatic transmission of electricity charge data from user meters, pump station charge management office, and power grid corp. This system should be able to analyse the whole power supply charge situation at any time. It would be expected to ensure the dynamic management of the charging work, and master the actual situation of power supply.

4.2. Structure design of power supply and electricity charge system

The hierarchical relationship of the watt-hour meter: the export meter of the power grid company--the main acceptance meter of the substation--the distribution meter of the distribution substation--the user meter. Due to the existence of power and line loss in transmission lines, it will lead to the mismatch of power consumption at the outlet of power supply. The business process relationships of each department are shown in figure 3.

![Business flow chart of power charging system](image)

**Figure 3.** Business flow chart of power charging system

The business section is responsible for the charge management of each drainage and irrigation area. The finance section is responsible for the financial account management of the collection of the power supply and electricity charge of the whole pumping station. The business steps are carried out in a monthly cycle, including the meter reading and input--business section accounting and issuing--the charge inputting of each department--account conformation by finance section. The monthly data of electricity charge is uploaded to the database of the system. While sharing the data, the relevant departments supervise and cooperate with each other to ensure the normal operation of the electricity charge system. The database of power supply charge management system is set up in the business section, which is managed by a special person designated by the business section. Through the
advance payment, meter machine reading and user meter, each irrigation and drainage area can realize the automatic updating of user's electricity data and the printing of charging bills. Figure 4 shows the overall framework of the power charge management system.

![Overall framework of power supply and charge management system](image)

**Figure 4.** Overall framework of power supply and charge management system

The power supply and charge system uses C/S structure to realize data management in the local area network, and FTP service to upload or download data between the system and irrigation and drainage areas in the metropolitan area network. The system software takes the three structures as the basic framework of the whole system: management statistics unit, electricity charge unit and equipment maintenance unit. It can realize the three-level organization and management of sections, pumping stations and irrigation and drainage districts. It can also set up the network of meters and equipment according to the actual distribution of users. Each unit is both clear and interrelated, which can achieve a comprehensive and scientific management.

5. Conclusion

The integrated power supply control system of agricultural electricity, drainage and irrigation designed in this paper has many advantages. It can mainly achieve the following objectives: firstly, Through intelligent construction and transformation on the equipment in drainage and irrigation area, the load status in the area could be real-time monitored and controlled; the operation data could be comprehensive analysed; the power grid operation could be optimized by reducing peak load. Secondly, the charging management system of agricultural electric drainage and irrigation is established to solve the problem of electricity fee return. In general, employing the idea and technology of internet communications, this integrated power supply and operation monitoring system platform has broad application prospects.

6. Acknowledgments

This work was financially supported by 2017 State Grid Scientific Project Research and application of typical scenario optimization interaction in electric energy substituting and power grid regulation and support technology.

References

[1] Huang J F. Discussion on energy-saving design for renovation and renovation of small drainage and irrigation pumping station [J]. Science & Technology Vision, 2017(36):224+241.
[2] Xu D, Li Y N, Gong S H, Zhang B Z. Experiment on sweet pepper nitrogen detection based on near infrared reflectivity spectral ridge regression [J]. J Drain Irrig Mach Eng, 2019, 37(1): 63-72.
[3] Zhu X Y, Chikangaise P, Shi W D, Chen W H, Yuan S Q. Review of intelligent sprinkler irrigation technologies for remote autonomous system [J]. Int J Agric & Biol Eng, 2018, 11(1): 23-30.
[4] Wang H. Operation status and management measures of small-sized pumping stations in rural
areas [J]. Modern Agricultural Science and Technology, 2013(03):229+232.

[5] Dong B. Research on key technologies of energy-saving for small pumping station system [D]. Yangzhou University, 2013.

[6] Hu G, Zhu X Y, Yuan S Q, Zhang L G, Li Y F. Comparison of ranges of fluidic sprinkler predicted with BP and RBF neural network models [J]. J Drain Irrig Mach Eng, 2019, 37(3): 263-269.

[7] Yue Y J, Yue X F, Zhong Y Y. Research progress on system structure and key technology of agricultural Internet of Things [J]. Journal of Agricultural Science and Technology, 2019, 21(04): 79-87.

[8] Zhu J L. Research on agricultural IOT technology based on public cloud platform [J]. Modern Information Technology, 2019, 3(06): 159-160+163.

[9] Tang L D, Yuan S Q, Qiu Z P. Development and research status of water turbine for hose reel irrigator. J Drain Irrig Mach Eng, 2018, 36(10): 963-968.

[10] Lu J, Cheng J. Numerical simulation analysis of energy conversion in hydraulic turbine of hose reel irrigator JP75 [J]. J Drain Irrig Mach Eng, 2018, 36(5): 448-453.

[11] Zhu J. Safe Operation and Maintenance Management of Electric Power Drainage and Irrigation Station [J]. Science and Technology, 2016, 26(30): 182

[12] Tian K, Zhu X Y, Wan J H, Bao Y. Development and performance test of lateral move irrigation system. J Drain Irrig Mach Eng, 2017, 35(4): 357-361.

[13] Zhang M, Zhao W X, Li J S, Li Y F. Fertigation uniformity and evaporation drift losses of center pivot irrigation system [J]. J Drain Irrig Mach Eng, 2018, 36(11): 1125-1130.

[14] Lu M Y, Lu K J, Hu G, Zhu X Y. Experiment on hydraulic performance of type SD-03 pop-up sprinkler. J Drain Irrig Mach Eng, 2018, 36(11): 1120-1124.

[15] Xiang Q J, Xu Z D, Chen C. Experiments on air and water suction capability of 30PY impact sprinkler. J Drain Irrig Mach Eng, 2018, 36(1): 82-87.

[16] Playán E, Salvador R, Faci J M. Day and night wind drift and evaporation losses in sprinkler solid-sets and moving laterals [J]. Agric Water Manag, 2005, 76(3): 139-159.

[17] Wrachien D D, Lorenzini G. Modelling jet flow and losses in sprinkler irrigation: overview and perspective of a new approach [J]. Biosystems Engineering, 2006, 94(2): 297-309.