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Water Quality Monitoring System Based on Water Outlet Hydroelectric Power Generation

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Abstract. With the accelerated pace of national modernization, the issue of sewage discharge in urban and rural industrial parks has attracted more and more attention. Disorderly discharge of industrial sewage by some enterprises has seriously damaged the urban and rural environment. This paper realizes the real-time monitoring of the water quality of the water outlet. In order to realize this system, firstly design a three-dimensional model of a hydroelectric power plant and simulate the water pressure of the turbine, use the GPRS module and STM32 main control chip to control the electric ball valve, and control the electric ball valve through the single-chip microcomputer to block the sewage in time. The high-level wind power generation in the plant is used to generate electricity for the cloud platform server, the GPRS module is used to upload data to the cloud platform, and the BDS positioning module is used to achieve real-time and accurate water quality monitoring in urban and rural industrial parks.

Keywords. Clean energy, Turbine modeling and simulation, cloud platform, BDS positioning module.

1. Introduction

The growing need to replace fossil fuel power generation is one of the main issues on the international public policy agenda [1]. With the acceleration of the country's modernization process, the discharge water quality of urban residents and rural production sites has attracted more and more attention. As cities gradually expand, government regulation will become more difficult and stretched. Therefore, some enterprises discharge production sewage disorderly, which seriously damages the environment of citizens and rural areas and the quality of water used by residents, which in turn affects the safety of crops. Under the epidemic, our lives are surrounded by "cloud activities". "Cloud live broadcast", "cloud recording", "cloud classroom" and even "cloud office" are all changing people's way of life. This will inevitably lead to a huge technological change in the industrial field [2]. The use of cloud platforms can promote the systematic management of government departments to a certain extent. There are many problems in the water quality detection and monitoring system that

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routinely relies on ordinary batteries. First of all, the use cycle is short, and the batteries are replaced collectively in about two years, resulting in a waste of human resources. The second is the poor adaptability to the conditions of the sewage outlet. When the condition of the sewage outlet is not good, the battery life will decrease linearly, and the information transmission system will be affected. 3. The battery is a rechargeable battery, and the pollution intensity of a waste battery is 100 times that of an ordinary dry battery. 60,000 liters of water would be seriously polluted [3]. This will cause environmental pollution, especially the pollution of water resources. At present, the research and experiments on small pipe flow power generation at home and abroad have been mature: Duan Weizhao designed a pipe flow power generation system based on the kinetic energy of the fluid in the pipe to realize the power supply of the water pipe network sensor. The designed output power is about 100 W [4]; Chen Mingji et al. integrated the micro water generator with the water meter, and used the water energy in the water supply network to supply power to the smart water meter [5]. Schoten designed a vertical axis ducted turbine with a power output of 50 W [6]. This design uses the sewage outlet hydropower to provide power for the water quality detection sensor, main control chip, electric ball valve, etc. Insufficient power supply can also be supplemented by high-rise wind power, and clean energy provides electricity. Remote monitoring system and GPS equipment to complete nearby power generation and consumption.

2. Overall Structure Design

2.1. System Platform Design

The platform of the system selected One NET, which was the only open to cloud platforms of Internet of Things of China Mobile Company. It provided a variety of ways to enter hardware devices, and could realize network connection and data communication with One NET cloud platform by using NB-IOT communication module, WIFI module and Ethernet interface[7]. Because each engineering environment was different, it needed to decided hardware devices according to the engineering environment situation. The cloud was the unify procedure center of the system, which was responsible for receiving and caching the device-side intelligent technology information technology and informatization data, and sent it to the user side; at the same time, it received and processed the user-side instructions and sent them to the device side. The cloud adopted an open One NET platform, which including device management functions such as data analysis and online supervision, and application integration functions such as rule engine and message service. It could send and get information in real time ,and trigger intelligent information push when the data was abnormal, which could virtually lessen the development cycle and lessen the development cost[8].TCP protocol could maintain long communication with the lower computer; Two-way communication, users could customize the communication data format.The platform could support upload custom scripts to parse custom data; Data points reported by storage devices; Supports custom command delivery. Data was pushed to applications.The principle block diagram of the communication between its One NET cloud platform and the GPRS module was shown in figure 1.

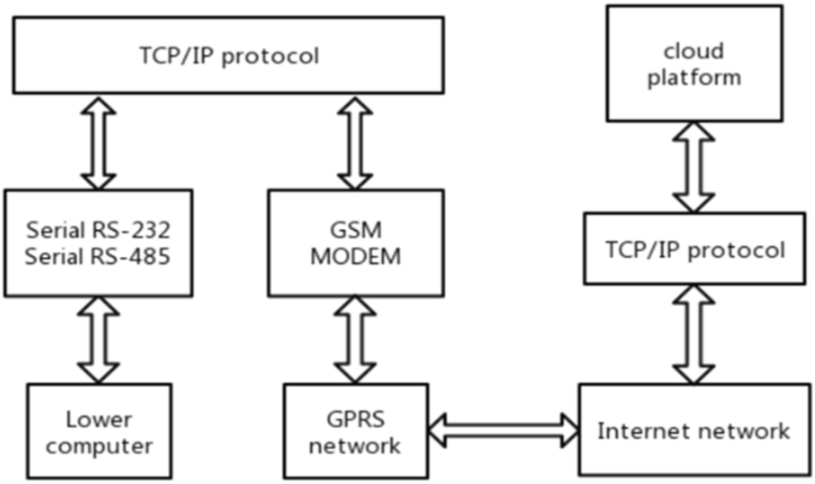

Figure 1. Block diagram of communication between One NET cloud platform and GPRS module

2.2. The Choice of Wireless Transmission

This design used GPRS wireless transmission technology to realize. General Packet Radio Service (GPRS) was shorted for General Packet Radio Service technology. It was a data communicated mode based on Packet switch transmission developed on the basis of the GSM system of the second generation of mobile communication. It provided wide area, seamless and direct Internet wireless IP connection[9].GPRS had the advantages of large transmission area, low cost, and no need to buy any communication facilities, only needed to use the communication base station built by the communication service provider, you could ensure the real-time transmission of data, for the industrial zone established far away from the city center could also achieve communication through the support of the three operators, so the signal coverage was wide. This design chooses SIM800A, this chip was connected to 4.2V working voltage. The RX and TX two serial ports of the main control chip STM32 were connected to the RXD and TXD pins of the SIM800A chip, and the control could be completed by using the AT command. The SIM800A startup and reset circuit were shown in figure 2.

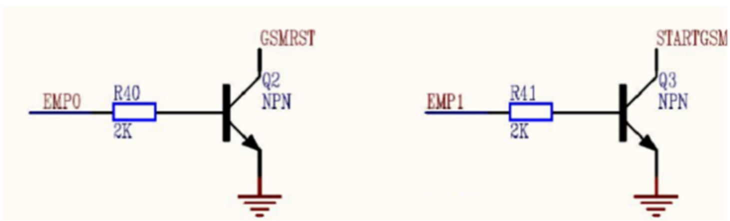

Figure 2. SIM800A startup and reset circuit

2.3. Design of Water Flow Control

Flow control modular included the master control chip and electric ball valve, its purpose was that when the factory drain excess water quality situation could in time according to the main control chip set threshold to control electric ball valves, realized the sewage of truncation. The chief control chip choose STM32F103C8T6, and the data sent from the water standard sensor and then sent to the STM32 microcomputer through A\D (digital-to-analog converter). The threshold program was written in the STM32 microcomputer, that progress to make corresponding reference for the control. Once the threshold was exceeded, The single-chip microcomputer sent pulses to control the electric ball valve to realize timely blocking of factory sewage. Among them, STM32 minimum system schematic diagram was shown in figure 3.

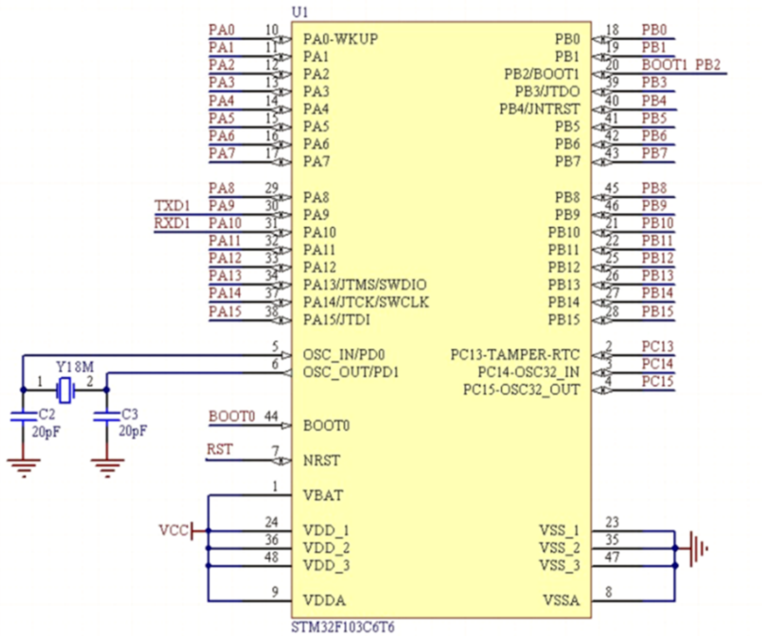

Figure 3. STM32 minimum system principle diagram

2.4. Modeling and Simulation of Hydroelectric Power Plants

Based on the water outlet, hydroelectric power generation included water flow turbine generators, wind generators, unload a benelux machine, controllers and batteries. The main function of the unload a benelux machine was to prevent the battery from overcharging was equivalent to unloading the excess electricity. The shortcomings could also be supplemented by high-rise wind power generation, and green energy could be used to supply power to the remote monitoring system equipment. In the design of the hydroelectric generator in this article, when the turbine in the hydroelectric generator was fixed, we needed to consider the number of turbines. Since electricity was generated at the drain outlet, because the drain outlet contains more impurities, the number of turbine blades should be less. All choose 5 blades to prevent foreign matter from blocking the hydroelectric turbine. It used SOLIDWORKS software to design the three-dimensional model of the water turbine. First, the impeller model was established by SOLIDWORKS software. Second, use internal mass properties to estimate. Third, set the model material to be ordinary steel, and its density was 7800 kg/m3 [10]. The three-dimensional model of the turbine was shown in figure 4.

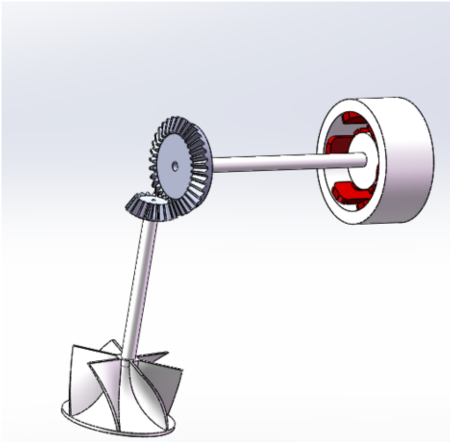

Figure 4. Turbine three-dimensional model

Based on fluid mechanics, the finite element analysis software ANSYS was used as the tool of calculation and analysis, and the hydraulic turbine model was designed in line with the established goal. The specific steps are as follows:

- The mesh division module in the fluid mechanics calculation software was selected and the whole module was divided into small modules with different structures and shapes, which could not overlap each other. Since most modules are irregular, the mesh size, shape, and uniformity were different during the meshing phase. The number of specific division should be determined according to the performance of the computer and the experimenter's requirements for the accuracy of the calculation results. Generally speaking, the commonly used mesh shape has tetrahedron, and other geometric shapes. In general, the smaller the overall grid, the more accurate the results of calculation and analysis.

- Then was to had good model divided into common definition in fluid mechanics software, such as in the actual process should abide by the principle of energy and momentum conservation, the calculation process also to abide by these theorems and principles, in the case of there was need to take into account the energy exchange, must be set in the software related position, if the failure to deal with in the process, It will directly lead to the following calculation results had an impact.

- Then discrete processing, that was already set before the good initial and boundary conditions into each division on the good small independent unit, previously set divided on the value and then the surface of the value of the fine grid was consistent, before the final calculation should also be set according to the actual demand calculation accuracy, the number of iterations, such as set value, The selection of appropriate values also had a certain impact on the calculation.

- After all the above steps are completed normally, the simulation calculation can be carried out. After the calculation and analysis starts, the engineer only needs to wait patiently for the calculation results. The general model could get the results after a few hours of calculation. Computational fluid dynamics software provides a variety of different results display query methods, after simple post-processing, engineers can view the data they need[11].

FLUENT software was used in this paper, and the detailed steps were shown in figure 5.

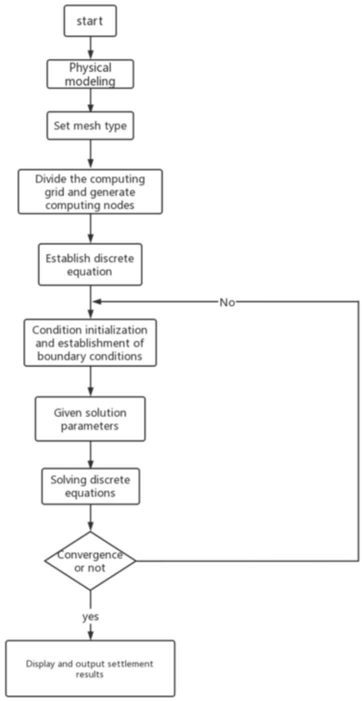

Figure 5. CFD computational fluid mechanics detailed solution steps

Based on the numerical simulation of flow field, the head loss H, output N and efficiency η of the turbine can be calculated to predict the hydraulic performance of the turbine[12].

The working H head of the turbine is：

$$H = \left(z_1 + \frac{p_1}{\rho g} + \frac{\alpha_1 v_1^2}{2g}\right) - \left(z_2 + \frac{p_2}{\rho g} + \frac{\alpha_2 v_2^2}{2g}\right) \quad (1)$$

z1 and z2 are the relative position heights (m) of the inlet and outlet of the turbine runner respectively; P1 and P2 are the relative pressures of import and export respectively. ρ is the density of water, 1 kg /m3; V1 and V2 are the inlet and outlet velocity (m/s) respectively; G is the acceleration of gravity, 9.81 m/s2, α is the coefficient of kinetic energy heterogeneity of section.

After the mesh was divided, the FLUENT module was used for material selection, fluid domain and solid domain assignments, inlet, outlet and wall boundary conditions setting, initialization, step size setting and step size setting, etc. Whether the step size setting was reasonable directly affects the realization of the final calculation results and the simulation calculation time. In this simulation, the step size was set as 500, and then, the solution was carried out, and finally convergence was achieved. The simulation cloud diagram was shown in figure 6.

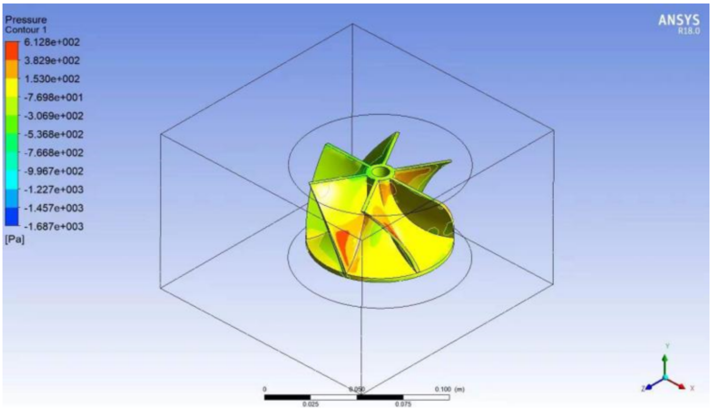

Figure 6. The simulation of cloud

2.5. BDS RNSS Positioning Module

As one of the world's four major navigation systems, BDS is a satellite navigation system independently constructed and operated by China with an eye to the needs of national security and economic and social development. It is an important space infrastructure in China. By the end of 2018, the BDS-3 basic system was completed and provided global services, and BDS-3 services are available to all parts of the world, including the Belt and Road countries and regions [13]. In recent years, BDS has been widely applied in the fields of mass application, smart city, transportation, public security, disaster reduction and relief, agriculture and fishery, precision machine control, timing service and so on [14].The positioning module of Beidou RNSS (Radio Navigation Satellite System) is used to receive Satellite Radio Navigation signals, independently complete the distance measurement with at least four satellites, calculate the user's position, speed and Navigation parameters, and obtain the user's position, time, speed and other information [15]. In this design, the UM220-IV Beidou positioning module produced by Hexincom is used, which supports the dual positioning system of Beidou navigation satellite system and global positioning system, or the single positioning system of Beidou navigation satellite system. Under the dual system, the accuracy can reach 2.5m CEP, the velocity measurement accuracy is 0.1m/s, the vertical positioning accuracy is 5m CEP, and the tracking sensitivity can reach -161dbm. Um220-iv module input signal is LVTTL, so the connection with the MCU does not need level conversion. The circuit of Beidou positioning module is shown in figure 7.

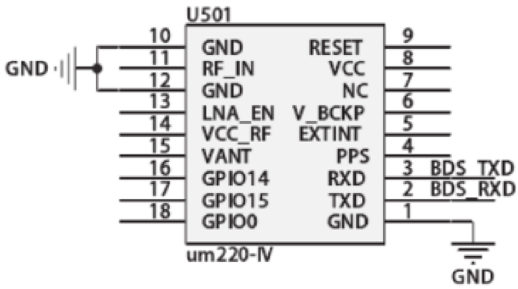

Figure 7. BDS positioning module circuit diagram

3. Conclusion

The water quality monitoring system based on the hydroelectric power generation of the water outlet described in this design supplies power to the main control chip and electric ball valve through the electricity generated by the hydro turbine generator, and supplies power to the system server through the wind generator on the roof of the office building of the factory. A variety of water quality sensor networks collect data on the water quality of factory sewage outlets in urban and rural areas, and can timely transmit data to the Internet through GPRS network and store in the cloud background, and use monitoring terminals to access the data in the cloud platform. The normal water quality index, the pre-written threshold program in the main control chip controls the electric ball valve to block the outflow of sewage in time. The structure diagram of the water quality monitoring system based on water outlet hydropower generation is shown in figure 8.

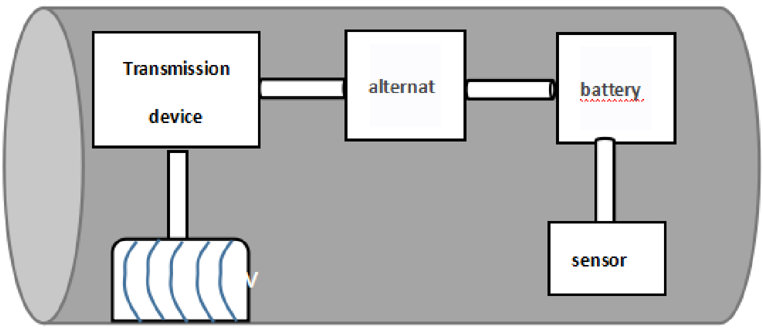

Figure 8. Based on the schematic diagram of water quality detection of drainage outlet hydroelectric power generation

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