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Research on the IoT Structure for the Intelligent Monitoring System of Chinese Liquor Solid Fermentation Pit

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Abstract

In view of the problems existing in traditional Chinese liquor manufacturers, such as single solid fermentation pit temperature measurement technology, non-continuous recording, subjective measurement error and environmental damage. For the above solid fermentation pit problems, how to build an effective liquor solid fermentation pit IoT monitoring system is a problem that must be solved. In this paper, firstly, WSN is introduced into the construction of the monitoring system of the fermentation pit, and the fermentation information of the pit is collected by wireless sensing nodes. Secondly, the information is uploaded to the regional collection nodes by radio frequency, and then transmitted to the base station by the collection nodes. Last, the workshop monitoring platform processes the information from the base station, and the workshop technicians can get the fermentation information of the pit to adjust it which can guarantee the quality of liquor production.

Keywords

IoT, Wireless Sensor Network, liquor solid pit.

1. Introduction

At present, in some traditional liquor manufacturers of China, the solid fermentation pit temperature measurement technology still relies on workers to plug in and out the thermometers with a length of about two meters. However, there are many pits in the distillery and frequent plugging in and out of the thermometers will not only waste a lot of manpower and time, but also the entry and exit of the thermometers will damage the fermentation environment and affect the fermentation process. In addition, the inaccuracy of the temperature measurement data can be caused by the different depth and position of the input and the subjective reading factors of the workers. Therefore, the backward measuring devices and methods, as well as the addition of extra measuring labor, all of these factors affect the quality and output of liquor.

Although the automation and information system have been introduced into the production process of modern distillery, the above problems have not been solved from the fundamental point of view. At present, there are two main ways to collect the temperature of liquor pits: one is manual collection, in which the thermometer is inserted into the pits by the distillery workers, this method consumes human time and the accuracy is not high; the other one is the wiring automatic temperature measurement mode, in which multiple thermometers are inserted into the pit and fixed, and then the temperature is transmitted to the computer through the cable, but the cable is required to be densely distributed around the pits with high cost and low safety, and it is not applicable.

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Wireless sensor network (WSN), the core technology of internet of things (IoT) technology application [1-3], is very suitable for solving this monitoring problem of traditional distilleries. WSN does not need any additional wiring, which is easy to install, stable and reliable, and has good maintainability and expansibility [4-8]. Without changing the existing workflow and mode, it can realize the automatic collection of environmental data and the state switch of production process, and the user can use the monitoring system to realize the automatic alarm and query of production status in the brewing process. For the above problems, how to effectively build a liquor solid fermentation pit IoT monitoring system is a problem that must be solved. In this paper, WSN is introduced into the construction of the monitoring system of the pit, where the fermentation information of the pit is collected by wireless sensing nodes, the information is uploaded to the regional collection node by radio frequency and transmitted to the base station by the collection node, and then the workshop monitoring platform processes the information from the base station, and the workshop technicians can get the fermentation information of the pit to adjust it which can guarantee the quality of liquor production.

2. Structure Design of IoT Monitoring System

Based on the internet of things technology, the intelligent monitoring system structure of liquor solid pit is designed, which takes computers, communication equipment and measurement and control units as the basic tools. It provides a basic platform for real-time data collection, switch state monitoring and remote management and control of fermentation parameters in the pit of the distillery. It can form a complex monitoring system with detection and control equipment. The system mainly adopts hierarchical distributed computer network structure, which is generally divided into three layers: monitoring management layer, network communication layer and field device layer,see Figure 1.

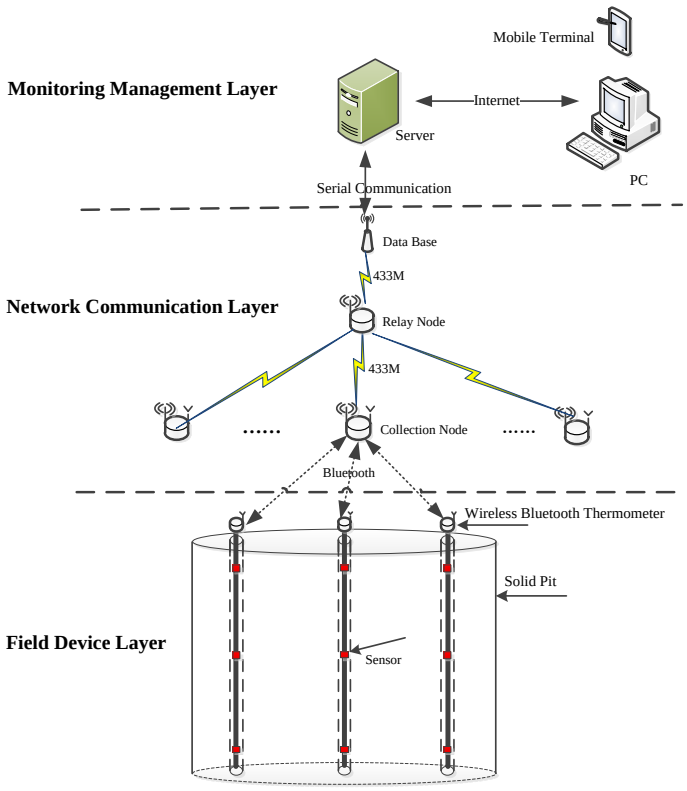

Figure 1. IoT Structure

a) Monitoring management layer

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The monitoring management layer is the direct window of human-computer interaction and the upper part of the system. It is mainly composed of system software and necessary hardware equipment, such as industrial computer, printer, UPS power supply, etc. The monitoring system software has a good human-computer interface, which can calculate, analyze and process all kinds of data and information collected on site, and reflect the operation status of the site by means of graphics, digital display, sound, etc.

Monitoring host is used for data collection, processing and data forwarding, which can provide data interface for system internal or external and carry out system management, maintenance and analysis.

UPS ensures the normal power supply of computer monitoring system, and ensure the normal operation of monitoring management equipment in case of power supply problem of the whole system.

b) Network communication layer

As shown in Figure 1, the network communication layer includes data collection nodes, relay nodes and base station node, these nodes all are based on 433M RF communication. Through a reasonable network topology matching and route coordination, the collection and transmission of solid-state fermentation pit data can be completed smoothly.

Collection node has integrated functions of Bluetooth communication and 433M RF communication. According to the communication characteristics of the Bluetooth module hc-05, the communication distance is about 10 m, which can effectively cover six pits. Therefore, each collection node is responsible for collecting the pit data of the coverage area through Bluetooth communication and sends the data to the designated relay node through 433M RF communication after compression processing.

Relay node is responsible for collecting the data of the covered area collection nodes and sending it to the base station after compression processing.

Base station only receives the data of the relay nodes, and the received data is uploaded to the PC upper computer through the RS232 level conversion.

c) Field device layer

The field device layer is a data acquisition terminal, which is composed of a distributed I/O controller with high reliability and Fieldbus connection to upload the stored fermentation parameter data to the data center.

As shown in Figure 1, the field device layer of the IoT monitoring system designed in this paper is a wireless temperature measuring rod based on Bluetooth technology. Each temperature measuring rod can obtain the temperature data of the upper, middle and lower layers of the pit evenly, and then send it to the upper collection node through Bluetooth communication after compression processing. Each pit can be equipped with three temperature measuring rods according to the needs.

3. System Network Mode

LAN (local area network): the system uses WSN to form a LAN in the workshop and all the collected monitoring data are transmitted by wireless.

WAN (Wide area network): the LAN in each workshop is connected to the superior management center through the Internet to realize the unified management in a large area, which can remotely monitor and display the fermentation information of each workshop pit.

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4. Design of Monitoring System

Monitoring system software: on the basis of the data acquisition platform, the control software reserves the communication interface to upload the data collected by the monitoring system to the data center. The input and output interface of the software is friendly, with the functions of data statistics, storage, display, upload, etc.

①I/O interface design, including serial port setting, user management, equipment management, user input, data display, etc.

②Adopt serial communication mode (as shown in Figure 2), unify the data package structure and realize the real-time communication between monitoring software and wireless nodes, including networking information and real-time transmission data.

③Access database is used to store user information (including user name and password), serial port information (including serial port name, baud rate, etc.), and equipment data collected by WSN nodes (including equipment address and corresponding data, such as temperature, humidity, etc.).

④Realize data query function by different conditions, such as query by date, query by node number, etc.

⑤In order to facilitate the user's operation and accurately reflect the plane position of nodes in the workshop and the pits environment, the software can download the map and input the exact position of nodes.

⑥Realize the function of data statistics. According to the collected data records, consider the statistical analysis of the data, such as drawing the temperature change curve or humidity change curve of a node.

Figure 3 is the flow chart of background software data display design.

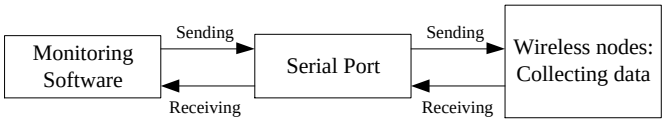

Figure 2. Data transmission flow chart

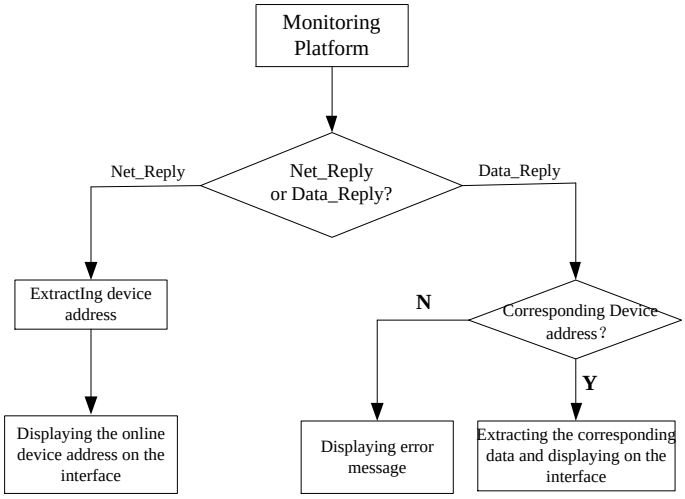

Figure 3. Flow chart of data display

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5. Design of Monitoring System

5.1. System Characteristics

a) The system adopts the wireless network communication mode, which does not change the original lines and additional wiring in the room and area and does not make any transformation to the existing energy consuming equipment, so the engineering installation and maintenance of the IoT system are simple and convenient.

b) The system adopts modular structure, simple structure, strong expansion function, and can meet the future needs of users conveniently.

c) System has energy consumption monitoring, temperature centralized control and energy-saving operation management functions.

d) Users can freely choose the functions and components that are suitable for their own needs. If the needs will change in the future, users can easily expand or modify the functions and components.

5.2. System Functions

a) The fermentation parameters such as pit temperature, humidity, PH value, dissolved oxygen concentration, CO2 concentration, alcohol concentration and temperature outside the pit are collected in real time and transmitted to the plant monitoring platform, which makes statistics and analysis of energy consumption data and uploads it to the superior monitoring center.

b) Realize the real-time monitoring and network management of the parameters such as pit temperature and provide reliable basis for field workers to accurately control the change of pit parameters.

c) It is helpful to improve operation efficiency and reduce operation cost.

d) Through the centralized management and control of the whole parameters and the whole process of the pit, the intelligent operation and management function of the whole workshop can be realized.

6. Conclusion

Building a suitable IoT monitoring system and using WSN technology to monitor the temperature, humidity, PH value, dissolved oxygen concentration, CO2 concentration, alcohol concentration, temperature outside the pit and other important fermentation parameters in different fermentation periods, and periodically upload these data to the workshop monitoring platform through WSN wireless communication. On the one hand, the monitoring platform continuously records the process data in production, analyzes the changes of temperature, humidity, pH value, dissolved oxygen concentration, CO2 concentration, alcohol concentration, temperature outside the pit and other parameters, and reflects them to the field operators in the form of reports or mobile app to provide accurate data guidance for their field operation. On the other hand, it can share the data and analysis results through the Internet to the superior supervision platform. The superior supervision platform makes overall statistical analysis to reveal the relationship between the parameter change of liquor solid fermentation and the yield and quality, which provides a scientific basis for the timely and reasonable adjustment of liquor making process in different seasons and provides important basic data for the establishment of big data platform for distilleries.

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References

[1] Z.W. Zhang, J.N. Wang: Crane Design Manual (China Railway Press, China 1998), p.683-685.

[2] K Ashton: That internet of things thing, RFiD Journal, Vol. 22(2009), p.97-114.

[3] L Atzori, A Iera, G Morabito: The internet of things: A survey, COMPUTER NETWORKS, Vol.54(2010)No.15 , p.2787-2805.

[4] Y. S Yoon, H Zo, M Choi, et al: Exploring the dynamic knowledge structure of studies on the Internet of things: Keyword analysis, ETRI JOURNAL, Vol. 40 (2018) No.6, p.745-758.

[5] XB Yan, RG Qiu: Intelligent monitoring system of wildlife conservation area based on internet of things, REVISTA CIENTIFICA-FACULTAD DE CIENCIAS VETERINARIAS, Vol. 28(2018) No.6, p.453-460.

[6] J Yang, F Wei: Design and research of ship's intelligent monitoring system in wireless network environment, JOURNAL OF COASTAL RESEARCH, Vol. 83(2018), p.495-498.

[7] Shun Yang, Shimin Liu: Process monitoring system of beer fermentation based on ZigBee-WSN, Computer Engineering and Design, Vol. 34(2013) No.12, p.4410-4414.

[8] I Exposito, I Cuinas, JA Gay-Fernandez: Efficient traceability solutions in the wine production by RFID and WSN, 2013 7TH EUROPEAN CONFERENCE ON ANTENNAS AND PROPAGATION (EUCAP), (2013), p.3539-3542.