

Research on the Intensive Material Management System of Biomass Power Plant

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Abstract. In view of the universal problem which the material management is loose, and lack of standardization and interactive real-time in the biomass power plant, a system based on the method of intensive management is proposed in this paper to control the whole process of power plant material. By analysing the whole process of power plant material management and applying the Internet of Things, the method can simplify the management process. By making use of the resources to maximize and data mining, material utilization, circulation rate and quality control management can be improved. The system has been applied in Gaotang power plant, which raised the level of materials management and economic effectiveness greatly. It has an important significance for safe, cost-effective and highly efficient operation of the plant.

1. Introduction

With eco-environmental issues such as global energy crisis and climate warming becoming increasingly severe, biomass, as a green and clean renewable energy, has received extensive attention. Hence, biomass power generation technologies have been rapidly developed and utilized. Biomass power plants are capital and technology intensive. Raw materials and equipment occupy comparatively larger proportion in power production and operating costs. Therefore, biomass power plants have put forward stricter requirements on the continuity, stability, timeliness and reliability of material management [1].

Traditional material management has problems of scattered resources, improper purchase and supply, process control and scientific overall planning shortage, etc. In addition, inventory management model of manual bookkeeping and artificial form filling has disadvantages of inconvenient updating, searching and maintaining; low input accuracy; bad dynamic real-time statistics; low work efficiency; impossible restraint on man-made violations, etc. [1-2]. Current material information platform can solve the above problems to a certain degree. However, it is lack of material life cycle of effective management and quality control, and ignores the excavation, analysis, utilization of material management data and in result it can't properly deal with the problems of dispersed fuel and long supply distance in biomass power plants. Also, transaction information about materials and management planning interactive timeliness are not adequate, which don't have refined and intensive managing means and cause high materials circulation costs and low productivity.

This essay developed an intensive material management of biomass power plant against these shortages. The system, which combines intensive management, internet of things technologies,



distributed potential of internet web technology, workflow management, automatic data identification, realizes intelligent classified reserves of materials, purchase in-out storage procedure integration control, materials' whole life cycle tracking, and qualified supplier management. It also strengthens correlation analysis between materials' purchase-consumption data and power plants' production-maintenance activities, hence provides new ways to strengthen power material management, enhance power plants' management and operation level, and optimize resource distribution.

2. Systematic key technologies and framework design

2.1. Key Technologies

Internet of things (IOT) is a sort of network technology extended and expanded on the basis of internet technology. It can realize "Internet of Everything", conduct information exchange and communication. The objects the IOT would connect and serve are terminal equipment and various sorts of "materials". A typical framework of IOT is divided into 3 layers including sensing layer, network layer and application layer from bottom to top [3]. By using sensor technology, it delivers object information through sensing layer to network layer where information is processed and transferred according to a set communication protocol. Finally, application layer processes object information for abundant utilization provision. It can combine IOT with information needs of power plants material management, realize remote monitoring, auto-alarm, control, diagnosis, maintenance, data excavation, decision analysis, hence achieve global management and service toward equipment [4-5]. IOT can well meet the requests of continuity, stability, timeliness, reliability of material management. In this essay, automatic identification and wireless transmission technologies are mainly involved.

(1) Automatic identification technologies

Sensing layer is the foundation of IOT framework whose core is automatic identification technology. Such technologies realize information data's automatic identification and transmission which mainly include radio frequency identification (RFID), biometric recognition, magnetic recognition, etc.

(2) Wireless transmission technologies

Such technologies are a sort of data transmission means using wireless technologies. They have a broad utilization prospect in the IOT age because of their flexible networking, low integrated costs, stable performance, easy maintenance, little limits from region, mobile communication supporting, etc. By far, wireless transmission technologies mainly are: public wireless transmission including GPRS, 2G, 3G, 4G; special wireless transmission including MDS data radio, blue tooth, Wi-Fi, ZigBee, etc.

2.2. Systematic Framework Design

Accurate and proper requirement analysis is the foundation and key of systematic framework design. Existing material management departments are relatively independent with their lack of information synchronization and sharing, complex approval process. This would influence normal power production and operation maintenance. At the same time, existing material management system now only has traditionally normal storage management related functions. It can't reasonably utilize material transaction to proceed data mining, analyse association relationship between material data and power plant production and maintenance.

1) Demand Analysis

Combining actual work contents of material management in power plants, we determined functional requirements of the system. The main objects are to design and realize a set of comprehensive information management system which integrates material information management, production-maintenance material planning management and qualified supplier management together. The system mainly serves the following requirements [6-7]:

(1) realizes intelligent sorted storing, storage management, supplier management, automatically identify storage information, and dynamically update inventory information.

(2) Provides abundant statistic query, automatically export and print statistical report to realize lifecycle asset tracking.

(3) Has office automation to realize integrally tracking and managing material management procedure including purchase, listing, inventory making, etc.

(4) Has the limit alarm function which can data-based analyse and automatically associate production and operation activities with material consumption to assist purchase plan making and decision support.

2) Framework Design and Topology Structure

This essay optimized the material management procedure in power plants of which the system frame diagram is as shown in Figure 1.

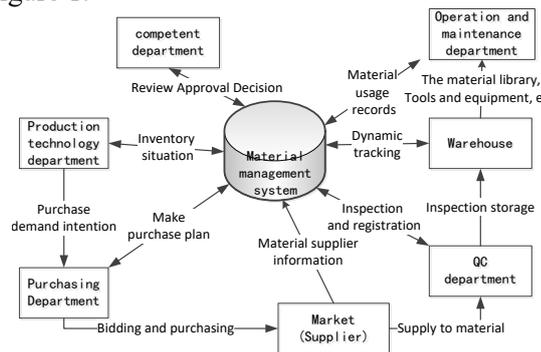


Figure 1. The material management procedure in power plants

The target is to provide intellectualization and informatization level to provide convenient and efficient means for power material management [8]. Thus, this system adopts open network model which mainly consists of workstation clients (Browser), smart mobile terminal (Client) and material management Web system server (Server). Its primary hardware topological structure has been shown in Figure 2.

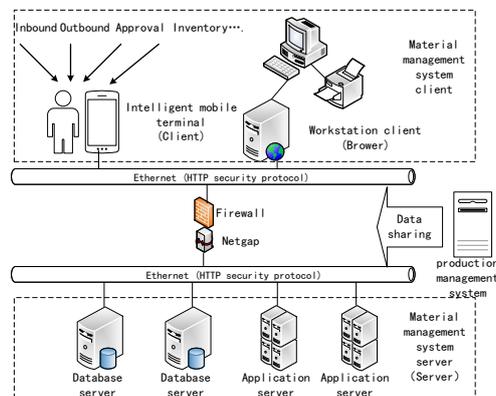


Figure 2. The topology map of the hardware system

On the aspect of development system, it adopts the BMS structure which combines explorer, mobile terminal and server together and integrates B/S - M/S hybrid architecture as development system.

The server side is in charge of data storage management and utilization after data integration which includes database server and application server. The both servers adopt hot standby method to ensure their reliability. The workstation client provides friendly interface for power plant staff. The mobile terminal installs corresponding client app for smart phones to provide convenient operation.

3. Design and realization for functional module of the system

3.1. Functional Module Structure of The System

This system mainly meets the material management requirements, serves for decision making leadership, production and technology, purchase, quality supervision, warehouse, and operation-maintenance department. This chapter will design the whole functional module for the whole system after analysing its function flow model, as is shown in Figure 3.

The system's design has brought in the IOT. The whole functional module is divided into sensing layer, network layer and application layer from bottom to top [4]. The sensing layer applies barcode recognition technology. It employs intelligent mobile terminals to scan materials' barcodes, through which achieves information synchronization, storage management, inventory making, progress tracing, and material tracking functions. The network layer provides data communication network to achieve network convergence and information transmission. The system uses the power plant's local area network, blue tooth, Wi-Fi, GPRS to establish communication network service.

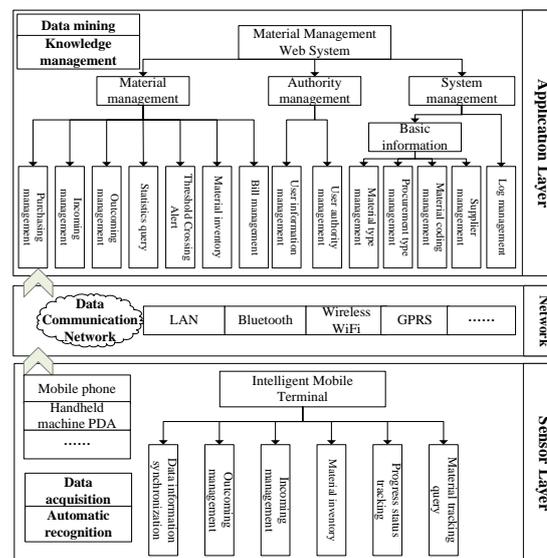


Figure 3. The whole system after analysing its function flow model

The application layer is material Web control system which mainly includes material, right and system management modules. The material control module can achieve purchase management, storage management, statistics and query, limit alarm and bill management; the right control module can achieve user information and right management of which the multi-level authorization can effectively ensure the system's safety and reliability; the system control module mainly maintains basic information (suppliers, material classification, material encoding, purchase types, etc.) and system logs.

3.2. Functional Design

This part conducts the following design combining the power plant material control procedure according to requirements analysis and frame design [9]:

(1) The sensing layer which takes data synchronization as its basic support traces materials to achieve functions of which storage management, approval state reversing, material tracking query are the core functions. Each power material has a unique barcode label and workers select function menu through intellectual mobile terminals. With scanning the labels, the material information is automatically identified and thus, storage and inventory making tasks are completed. The mobile terminals run independently and distributively. They have full recording functions including multi-media such as photographing, recording, texting and mobile locating which are convenient for workers to dynamically trace material state. Mobile terminals have cooperative office function which can enable its users to log in terminal software to accomplish plan application, procedure approval, email notification, etc. Timely information synchronization brings accurate data resources to data excavation

and analysis in the application layer. This can guarantee the accuracy and consistency of material storage information and realize material life cycle tracking management.

(2) The network layer uses wireless mesh network (WMN) and field bus network to operate final access. It uses wide area network (WAN) such as GPRS/CDMA network and IP network, etc., to achieve backbone connection. Such combined transmission method accomplishes the integration of cable network, wireless network, network protocol and thus can make effective seamless connection.

(3) Application layer material management Web system is the core function which serves the clients. It uses centralized collecting data synchronized from mobile terminals and processes data after analysis.

Purchase control module achieves purchase plan making, intellectual decision making and work flow management using the technology of timely dynamic reaction on material storage data. Through this module, workers can propose purchase requests, purchase departments can make purchase plan, and competent authorities can make examination and decisions. The system automatically relates information such as storage state, suppliers, prices together to assist plan decision making. Storage control provides material storage control function for work stations. As a supplement and support for the terminal storage management, workers can log in the Web system to make storage operation. The statistic and query module can provide multi-dimension data analysis, multi-choice customized queries and diversified chart shows. The limit alarm function can make alarms when material storage is lower than the set limit. It can remind its users through sounds, emails, and popups on the system platform.

The right control and system management module are the foundation for the system to achieve core functions. They provide multi-layer right managing and system administrators can assign rights to the users. The basic information control module can realize material classification and coding management.

3.3. Technical Realization of The System

(1) Sensing Layer: The sensing layer intellectual mobile terminal App adopts Java language based on the Android 4.0 platform to develop in Android Studio. The mobile terminal uses lightweight SQLite database. The core barcode identification technology of the terminal accomplishes scanning, capturing, decoding using integrated barcode scanning function of Android platform from local cameras invoked through system interfaces. As for the details, one can add corresponding interface jar pack into project programs to achieve such function.

(2) Network Layer: This layer adopts multi-network integration construction plan including wireless LAN, field bus cable network, and GPRS/CDMA network. The server side accesses network through field bus cable network and provides communication for mobile terminals through gateways and routes created wireless Wi-Fi LAN. Within the plant area, Wi-Fi signal covered area can enable real time transmission through wireless LAN; GPRS communication method is adopted outside such area to achieve data exchange between distributed terminals and integrated collection servers to ensure reliability and synchronization of data.

(3) Application Layer: Such layer's Web system has a developing platform based on Microsoft NET Framework 4.0. The system adopts ASP.NET based on NET platform as its developing technology, C# as its programming language. On the client side, it uses JavaScript as its scripting language. The database chooses Embarcadero Technologies Company's ER/Studio as its modelling tool. The database management system is SQL Server2008. Its development tool is IDE: Visual Studio 2013 of NET.

4. Application of the system

4.1. Real-time Monitoring

The intensive material management system proposed by this essay has been put in practical use in the Gaotang Biomass Power Plant of Shandong State Grid Electric Power Research Institute. System menu includes selections like material query, state alarm, statistical analysis, purchase management,

storage management, inventory making and bill management, etc. These selections achieve whole-procedure monitoring on material flow within the whole power plant. By clicking corresponding function area, one can enter relative partial monitoring information database which includes storage statistics of primary facilities, statistics of supply from suppliers, recent storage operation records, recent material purchase information, state alarms, to-do tasks, etc. About the former two items of the above selections, one can find intuitive histograms and line charts in corresponding columns. Also, the both function areas have real-time updating and saving functions. The other four function areas are shown by lists within corresponding columns. This system can monitor material system's operation state in real time, elevate efficiency of unified management toward field device. Such functions can avoid complex work of workers to record and elevate automatic monitoring and alarm level.

4.2. Data Analysis

By adequately use data excavation technology, the system censuses and analyses data collected from its sub-systems, perfects the issue of insufficiency of interaction timeliness between material transaction information and management plan, saves material circulation costs, enhances production benefits and decreases power consumption rate of power plants. It is predicted that two years after such transformation, the power plant will save power consumption at about 2% per year and its energy consumption will also be gradually reduced.

4.3. Energy Conservation Prospect

The Gaotang Biomass Power Plant takes electricity and heat as its main sales. Its generators' unit capacity is 1×30MW which had been put into operation as the original biomass generation units on January, 2007. The power plant's state of operation over the years is shown in Table 1.

Table 1. Gaotang biomass power plant operating conditions in the past three years.

year	Generating capacity (10000 kWh)	Grid connected power(10000 kWh)	Fuel consumption (10000 tons)
2013	21239.664	18731.26	30.3837
2014	22641.12	20044.448	34.5451
2015	23244.768	20721.624	37.31

According to the power plant's annual power generation report of 2015, its annual electricity production is 232.44768 million kilowatt hours with plant power consumption rate of 10.85%. That is, the plant's electricity consumption is 25.2314 million kilowatt hours. On ensuring the same electricity supply, it can be predicted that 0.5 million kilowatt hours can be saved every year and reduce biomass 681.34 tons. According to an average unit price of 289 RMBs/ton of biomass purchased by the power plant, 196,900 RMBs would be saved every year.

5. Conclusion

This essay proposed an IOT technology and BMS structure based material management system toward the currently existing issues of power plant material management. The system perfected the material management procedure of power plants and had been put into practical use in power plants where proved to run well. It also adopted portable intellectual mobile terminals to construct a platform for network information sharing and mobile cooperative office. Timeliness and accuracy of material management had been enhanced. Materials' life cycle tracking and quality control had been realized.

References

- [1] Liu Zhaoqian, Jiang Yong. Analysis on Storage Management System Perfection of Power Plants [J]. Mechanical and Electrical Information, 2014, 33:156-157.
- [2] Xie Siqin. On the study of plant material and equipment management [J]. Technological Development of Enterprise, 2015, 04:101-102.

- [3] Hu Yongli, Sun Yanfeng, Yin Baocai. Information Sensing and Interaction Technology in Internet of Things. *Chinese Journal of Computers*, 2012, 35(6):1147-1163.
- [4] Rao Wei, Ding Jianyong, Li Rui. Application of Internet of Things Technology in Smart Grid. *Central China Electric Power*, 2011, 24(2):1-5.
- [5] Zhao Zhijun, Shen Qiang, Tang Hui, etc. Theory and Key Technologies of Architecture and Intelligent Information Processing for Internet of Things. *Computer Science*, 2011, 38(8):1-8.
- [6] Wang Dekuan, Zhang Yi, Liu Xiaobo, etc. The Overall Idea of Smart Hydropower Plant Automated System. *Hydropower Plant Automation*, 2011, 35(01):4-8.
- [7] Hu Shaoying, Li Yonghong, Xie Kai, etc. A Study on Reservoir Dispatching Automation System Based on Smart Hydropower Plant. *Hydropower Automation and Dam Monitoring*, 2012, 36(01).
- [8] Han Bing. Design and Implementation of EAM System of Datang International Tangshan Power Plant. Beijing University of Posts and Telecommunications, 2001.
- [9] Zhou Bin. The Design and Implementation of Assets Management for Weifang Power Plants [D]. Shandong University, 2010.