Frontiers in Computing and Intelligent Systems
ISSN: 2832-6024 | Vol. 2, No. 3, 2022

Research and application of digital technology of film coating equipment

Luming Liu, Qingq Yang*, Zewei Zhu

The Institute of intelligent manufacturing, Wenzhou Polytechnic, Wenzhou 325035, China

* **Corresponding author**: Qingq Yang (Email: qqyang@wzpt.edu.cn)

Abstract: At present, most of the coating production still adopts relatively backward traditional methods, there are its equipment status, operation, production, repair and maintenance information of digital technology application less problems. In view of this problem, a data acquisition module and data processing system are developed to realize the data acquisition and real-time monitoring of the equipment temperature, vacuum degree, rotation speed, target material, film thickness and surface condition. The data acquisition module consists of a self-organized network system formed by the sensor nodes deployed in the detection area and installed on the device, combined with / wireless communication. Through the development of the system to achieve the digital and intelligent application of coating equipment.

Keywords: Internet of Things; Digital; PLC; Coating equipment.

1. Introduction

As an emerging technology, the Industrial Internet of Things (IIoT), can promote the development of industrial intelligence, improve production efficiency, and reduce manufacturing costs. Under the background of the information development characterized by digitalization, networking and intelligence, the intelligence degree of enterprises has been improved, which provides a large amount of data for the predictive maintenance and abnormal monitoring of the production and manufacturing process.

At present, the digital transformation of enterprises is mainly faced with a large number of equipment and systems existing inside the factory, but each system is independent of each other and has different standards, data sources are incomplete and not "clean", and there are serious "data island" problems between different systems. The data is characterized by multi-source, heterogeneous and incomplete data [1], How to deeply explore the value of data, and use it for process optimization, fault prevention and diagnosis, parameter optimization and other applications, has become a difficult problem for enterprises to overcome in safe production, efficient production and high-quality production.

In the industrial Internet of Things, the improvement and progress of safety production and production technology cannot be separated from data fusion, which is the process of realizing the collection, analysis and processing of massive Internet of Things data generated by industrial equipment and systems [2]. The data collected in the workshop may cause incomplete data due to improper operation, unstable network connection, sensor failure, frequent transmission and other reasons, thus adversely affecting the safety, reliability and accuracy of the whole system processing process. Using a modified random forest algorithm based on the decision pathway to compensate for the effects of incomplete data, Yuequn Zhang et al[3]. D Adhikari et al. use information fusion technology for interpolation, and use the ratio-based interpolation (RBI) algorithm to deal with high rates of missing data based on data fusion and data mining methods [4]. Lai X et al. used an autoencoder (AE) -based multi-task learning (MTL) model and dynamically optimized missing values to classify incomplete data sets with interdependencies among properties [5].

In view of the problem of missing industrial data, Han Li et al. identified and classified samples, established local interpolation models, and proposed a framework based on engineering field knowledge for modeling incomplete industrial data [6]. C Peng et al proposed a reliability model based on multi-source information fusion to study the reliability of CNC systems[7]. In order to improve the processing stability and product quality of the workpiece, B W ang et al. proposed a signal feature evaluation model and multi-feature identification system for vibration vibration detection to improve the accuracy of machine vibration detection [8]. The energy consumption prediction of the CNC machining process is modeled by the energy modeling framework based on incomplete data by Jian Pan et al [9].

For the system fault diagnosis and performance analysis, a fault tree analysis method is proposed by SLi et al. Eliminate uncertainty using expert opinion, combining field data based on Dempster-Shafer theory and rough set theory [10]. Guo C et al. proposed a new FDD method for process fault identification based on incomplete data interpolation techniques, with an improved stacked autoencoder in the incomplete data processing stage [11]. Jiang W et al., carried out a research on CNC machine tool health monitoring system based on artificial intelligence [12]. Dzaferagic M et al. discussed reliability issues in the Industrial Internet of Things (IIoT) by generating models to support fault diagnosis [13].

Compared with the traditional electroplating method, vacuum coating technology has great advantages in cost, environmental protection, product quality, decorative effect, energy consumption and other aspects, vacuum coating technology and film products are widely used in industry, especially in the field of electronic materials and components industry occupies an extremely important position [14~16]. The rapid development of surface and thin film science, microelectronics and nanotechnology makes the development of coating equipment and the research of monitoring method system become the focus of coating technology [17~19].

High performance coating technology requires real-time monitoring of equipment temperature, vacuum, speed, target,

film thickness, surface conditions, and feedback control. At present, most of the coating production still adopts relatively backward traditional methods, equipment information, operation data, production information, maintenance information, maintenance information and other information of the digital technology application is less, its information, digital and intelligent level is relatively backward. Therefore, by applying the Internet of Things technology to every link of coating production, this paper realizes the digital and intelligent production of coating technology.

2. Research contents

In view of the relatively backward informatization, digitalization and intelligence level of coating process equipment, this project focuses on the problems related to the digital application of Internet of Things technology in coating (coating) production, and puts forward the construction and implementation plan of the operation and maintenance management and monitoring system of coating (coating) equipment. Through the Internet of Things technology, the production and manufacturing system for coating (coating) equipment is developed to realize the man-machine thing connection, connect the equipment with the production process in real time, save and analyze the production process data, and the abnormal state of the production equipment can be found and treated in time, and achieve the improvement of production efficiency and safety.

The scheme focuses on the study of data acquisition, network communication and data processing and other technical problems of coating (coating) equipment, through the comprehensive application of these technologies, and finally realize the digitalization, information and intelligence of coating production.

2.1. Data collector module

The data information in the Internet of Things system comes from the terminal equipment, which can sense the surrounding environment through various sensors. And it is more accurate and wider than human perception. Sensor technology as one of the key technologies in the Internet of Things system, how to build a suitable sensor network to collect the information of the coating (coating) equipment will be the focus of the research.

Common data acquisition technologies include PLC communication port data acquisition and standard electrical signal acquisition. In addition, the equipment display screen signal analysis can also conduct data acquisition. Combined with the above three data acquisition schemes, a suitable data acquisition module is developed to collect the process data of the coating (coating) production equipment.

In coating (coating) equipment, with signal, data technology to produce equipment data acquisition, the operation of energy and raw materials consumption, into the library for real-time monitoring, strictly control the quality of products, improve the automation of production process, improve production efficiency and promote product quality, promote the improvement of automation level and core competitiveness. The combination of intelligent sensing Internet of Things technology and coating (coating) technology can also greatly improve the safety factor of coating (coating) production and reduce operation accidents.

The data collector includes the following functions.

(1) Data collection: use all kinds of sensors to collect the operating status of coating equipment, air valve switch status, operation time, voltage, current, power, temperature, pressure, vacuum degree, target quantity, the distance between the target and the arc needle (specific parameters shall be provided by the manufacturer).

(2) Edge calculation: summarize, encapsulate, integrate, calculate and store the information of the equipment. Energy consumption, running time, output and other data of the equipment.

(3) Intelligent diagnosis: through intelligent comparative analysis of historical data and early warning parameters, diagnosis of equipment operation status and health quality analysis and early warning.

2.2. Network communication module

Transmission network is the data transmission channel of the Internet of Things. Through the wired and wireless data links, the data detected by the sensor network is uploaded to the service platform, and the data from the management platform can be received. The transmission network is the intermediate carrier of the Internet of Things data and the Internet data exchange, and is the terminal access part of the Internet.

In the production process of coating (coating) equipment, the adoption of network transmission technology is related to the accuracy, integrity, reliability and real-time of the data. Therefore, how to develop a network transmission module to ensure the stability, reliability and security of data transmission under the environment of strong industrial production interference is one of the research priorities of this project. The module needs to support 232,458 or usb interface to network communication, and the network needs to support Ethernet, wifi, 4 / 5G, lora, or NB-IOT networks.

2.3. Development of the operation and maintenance management and monitoring platform for coating equipment

The operation and maintenance management monitoring platform mainly include interface software, database software, monitoring platform software, statistical analysis software and mobile terminal APP.

(1) Interface software: connect the device data acquisition and monitoring module and the mobile phone terminal app to obtain the uploaded data. The data is also stored in the database.

(2) Database software: fixed parameters, operating parameters, threshold parameters, fault maintenance data of cloud storage equipment, etc. At the same time, it also has the database disaster recovery and backup function.

(3) Monitoring platform software: that is, the central large-screen kanban displays the geographical distribution, operating parameters, time data, output data, quality data, etc. of all equipment in real time.

(4) Statistical analysis software: mainly the platform software for management and operation. Through big data technology, all the uploaded data of the equipment are analyzed and displayed by authority and modules, including operation time analysis, production data analysis, production quality analysis, energy consumption efficacy analysis, health quality analysis, fault maintenance statistics and operation statistics, etc.

3. System scheme

3.1. Project implementation plan

(1) Process data acquisition technology of coating equipment. The calculation data is collected by the method of reading the communication interface of the PLC controller, the equipment status and energy consumption parameters are analyzed by the method of collecting the equipment circuit signals, and the process flow parameters are collected by the method of developing the sensing device.

(2) Transmission and communication mode of coating process data. The communication mode of wired network is adopted in the working condition of the new workshop, and the wireless network communication mode is adopted in the working condition of technical transformation in the existing workshop. Long-wave communication is used in the working conditions of electromagnetic interference and communication blocking obstacles, and short-wave communication is used in the case of large amount of communication data.

(3) Development of the coating process data analysis software. Collect the key process node parameters according to the coating process flow, predict the production abnormality and equipment abnormality according to the process node parameters, and analyze the product quality.

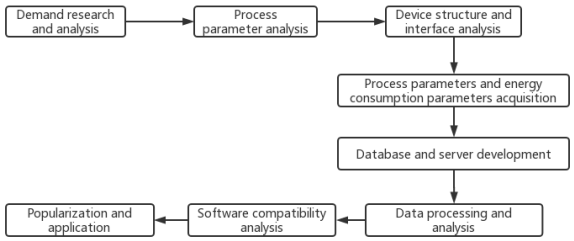


Figure 1. Technical route of digital technology development of coating equipment

3.2. Technical route

Technical route is shown in figure 1, including coating (coating) equipment digital operational requirements research analysis, analysis of process parameters, equipment electrical structure and interface analysis, processing parameters and equipment status energy parameter acquisition, data transmission, database and server development, data processing analysis, software compatible design, popularization and application, etc. Data processing and analysis include analysis of product performance, output, production schedule, equipment status, monitoring of production process and equipment abnormalities; software compatibility design refers to the interface design of the software layer, ERP, MES and other industrial software; promotion and application is the monitoring application of data collection, transmission, processing and other related technologies to other electromechanical component processing equipment and processes.

4. System design

The system is mainly composed of data collector, process operator, database and data Kanban. The data collector is responsible for collecting the process parameters of the coating equipment, including voltage, current, power, power consumption, temperature and vacuum; The process operation station is operated by man to record the start time of the experiment and the start and end time of each process. The collected equipment data is transmitted to the database through 4G, Ethernet, WIFI and other communication methods, and is monitored through the data Kanban, as shown in Figure 2.

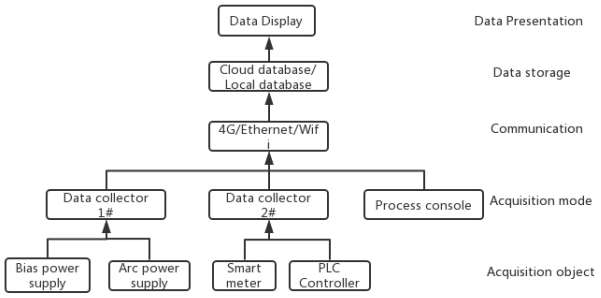
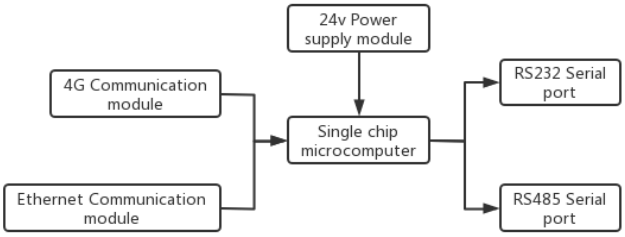


Figure 2. Overall system design

4.1. Hardware design

The data acquisition device adopts the control module with STM 32 SU as the core and 4G module, Ethernet module, RS 232 module and RS 485 module as the main communication modules to realize the production process data acquisition of the coating equipment, as shown in Figure 3.



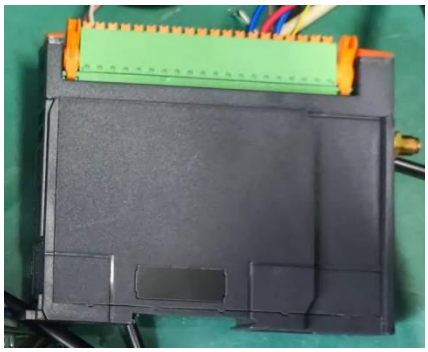


Figure 3. Hardware system and data collector

4.2. Software design

The data Kanban displays the collected power supply data, energy consumption data, production data and process console operation records through the kanban and alarms the abnormal data to realize the real-time monitoring of the production process data of the coating equipment, as shown in Figure 4. At the same time, the start and end time of each process node can be recorded through the process operation table, so as to realize the considerable and controllable time of each process, as shown in Figure 5.

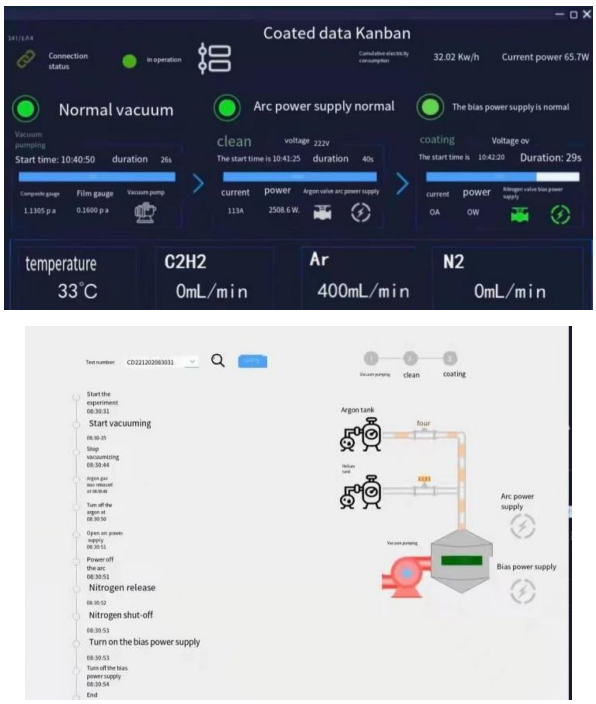


Figure 4. Data Display

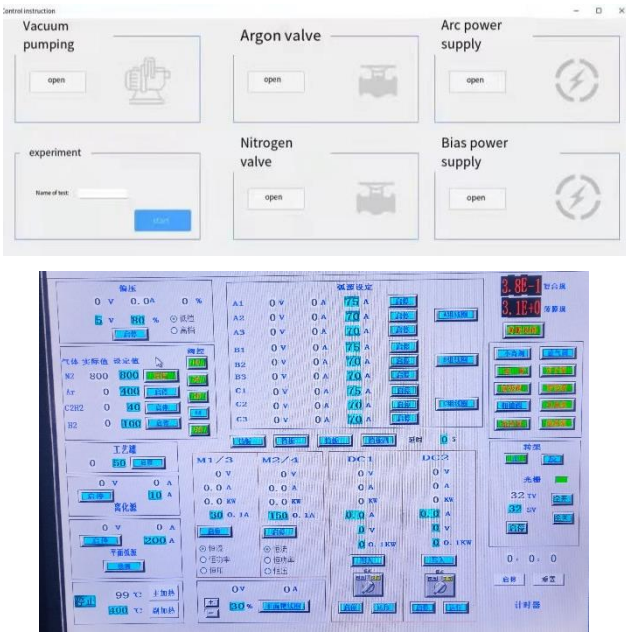


Figure 5. Process operation

5. Conclusion

In this paper, a data acquisition module serving the information collection of coating (coating) production equipment is developed for sensing and processing the status of the production equipment and product process, so as to realize the remote monitoring and management of the production process. And develop a data processing system based on front-end data acquisition module. The data processing system is used to organize and process the data and parameters of the production process collected by the front-end acquisition module, analyze the current production equipment and product process, and realize the monitoring and management of the production process. The research work in this paper can provide the engineering application basis for the digital transformation of factories.

Acknowledgment

The This work was supported by the project of Wenzhou Science and Technology Bureau under Grant G2020012.

References

[1] Huang, Q, Li, T, Yang, X, .(2019).Dynamical Information Fusion of Multisource Incomplete Hybrid Information Systems Based on Conditional Entropy.IEEE 14th International Conference on Intelligent Systems and Knowledge Engineering (ISKE), 2019.

[2] Toward Secure Data Fusion in Industrial IoT Using Transfer Learning[J].IEEE Transactions on Industrial Informatics, 2021. DOI 10.1109/TII.2020.3038780.

[3] Zhang Y, Luo L, Ji X, et al.Improved Random Forest Algorithm Based on Decision Paths for Fault Diagnosis of Chemical Process with Incomplete Data[J].Sensors, 2021, 21.

[4] Adhikari D, Jiang W, Zhan J.Imputation using information fusion technique for sensor generated incomplete data with high missing gap[J].Microprocessors and Microsystems, 2021:103636.

[5] Lai X, Wu X, Zhang L.Autoencoder-based multi-task learning for imputation and classification of incomplete data[J].Applied Soft Computing, 2020, 98:106838.

[6] Li H, Liu Z, Zhu P.An Engineering Domain Knowledge-Based Framework for Modelling Highly Incomplete Industrial Data[J].International Journal of Data Warehousing and Mining (IJDWM), 2021, 17.

[7] Peng C, Cai Y, Liu G, et al.Developing a Reliability Model of CNC System under Limited Sample Data Based on Multisource Information Fusion[J].Mathematical Problems in Engineering, 2020.

[8] Wang B , Liu S , Gu D .Intelligent chatter detection for CNC machine based on RFE multi-feature selection strategy [J].Measurement Science and Technology, 2021, 32(9):095904 (20pp).

[9] Pan J, Li C, Tang Y, et al. Energy Consumption Prediction of a CNC Machining Process With Incomplete Data[J]. Journal of Automation (English version), 2022,8 (5): 987-1000.

[10] Li S, Yang Z, Tian H, et al. Failure Analysis for Hydraulic System of Heavy-Duty Machine Tool with Incomplete Failure Data[J].Appl.Sci.2021, 11(3), 1249.

[11] Guo C, Hu W, Yang F, et al. Deep learning technique for process fault detection and diagnosis in the presence of incomplete data[J]. Chinese Journal of Chemical Engineering: English edition, 2020.

[12] Jiang W. Research on Error Monitoring Model of CNC Machine Tool Based on Artificial Intelligence[J].Journal of Physics Conference Series, 2020, 1574:012125.

[13] Dzaferagic M, Marchetti N, Macaluso I.Fault detection and classification in Industrial IoT in case of missing sensor data.2021. DOI:10.36227/techrxiv.14540061.

[14] Khan S, Lorenzelli L, Dahiya R.Flexible MISFET devices from transfer printed Si microwires and spray coating[J].IEEE Journal of the Electron Devices Society, 2019, 4(4):189-196.

[15] Tian, Lihui, Feng, et al.Microstructure, Microhardness, and Wear Resistance of AlCoCrFeNiTi/Ni60 Coating by Plasma Spraying[J].Coatings, 2018.

[16] Xu X , Yi D , Wang Z , et al.Greatly Enhanced Anticorrosion of Cu by Commensurate Graphene Coating[J].Advanced Materials, 2018, 30(6):1702944.

[17] Luo Songsong. Design and analysis of leak detection system of vacuum coating equipment [J]. China Glass, 2017 (42): 7-10.

[18] Dai Mingjiang, Lin Kaisheng, Tian Junrui, et al. Complete set of equipment, process and application of ion source composite vacuum coating [J]. China, 2015,000 (010): 46-47.

[19] Wang Yubo, Li Yulong, Wang Wenqin, et al. The ent stress monitoring of chemical coating process based on fiber grating sensing [J]. Journal of Photonics, 2016,45 (008): 70-74.