Intelligent Cable Joint Quality Management System Based on RFID Technology

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Abstract. Intelligent workshop production is based on the stable implementation of the enterprise production plan, the use of the Internet of Things technology to achieve the visual management and services of the enterprise, improve the control of the production process of the enterprise, reduce the manual intervention of the production staff of the enterprise, to build a user-friendly production workshop with real-time information and visual production process. This paper mainly studies the intelligent cable joint quality management system based on RFID technology. This paper designs a data acquisition and monitoring scheme for RFID in the workshop site and material warehouse. Taking the RFID reading process in the workshop site as an example, the communication process between the bottom layer and the upper computer is described in detail to provide data support for the control and control of the industrial site. This paper studies the tag conflict prevention algorithm in the RFID system when the materials are out of storage. The algorithm divides the tag conflict into several independent and small-scale optimal sub-structures according to the number of conflict slots.

Keywords: RFID Technology, Intelligent Production, Cable Joint, Production Quality Management

1. Introduction

With the rapid development of national economy, the quality requirements of cable manufacturing companies are increasing day by day, and the management requirements of cable joint manufacturing companies are stricter. The quality stability of cable joint manufacturing company is one of the important conditions to ensure the economic development of cable joint manufacturing company. Cable manufacturing company quality management application software technology relative lag, has done a lot of work to qa personnel difficulty, so missed scheduling and wrong operation and cause widespread quality abnormal phenomenon occurs frequently, seriously affected the normal production of cable manufacturing company and people's living standards, and impact on the development of...
national economy. With the development of cable manufacturing companies and the strengthening of
the construction of intelligent quality management system, it is imperative to establish a set of quality
management system that can reduce the working pressure of the company staff in cable joint
manufacturing and significantly improve the work efficiency. Scientific management must rely on
real-time and accurate production data. RFID technology can obtain relevant information of target
objects through electronic tags and complete real-time collection of production data without manual
intervention, so as to provide rapid and accurate data information for production management of
manufacturing enterprises in the context of the Internet of Things, so as to improve management
efficiency. Compared with other automatic recognition technologies, such as face recognition,
fingerprint recognition, bar code recognition, etc., RFID has basically integrated all their advantages,
featuring non-contact, high precision, low cost, permanent storage, little external influence, etc., and
has become the core technology in the era of the Internet of Things [1].

In recent years, radio frequency identification (RFID) technology is more popular, it originated in
the Second World War, and the era has developed to today, all countries in the world are concerned
about RFID technology, and also in the exploration of the technology and the integration and
development of all walks of life. Oliveira's presentation aims to improve the visibility of internal
logistics through the use of RFID by electronics companies in the automotive industry. The first step in
the project was to identify traceability issues for the company's raw materials and to design an
RFID-based solution to address these issues. In addition, major challenges related to the
implementation of the solution were identified and discussed. The current internal logistics process is
described and major traceability issues are identified [2]. Thompson's need for automatic identification
and location and the monitoring of the status of logistics objects as a source of data for secure supply
chain documentation and control is increasing. By using such technologies, the intelligent logistics
area can be used for logistics and production processes [3].

This paper designs a set of quality control and management system for the whole production
process of cable coupler based on RFID technology according to the current situation of cable coupler
production management. The system uses RFID radio frequency technology to obtain the production
information from the cable joint production workshop, and the production information is transmitted
to the monitoring management system through RFID middleware. The management personnel can
obtain the production situation in real time, realize the visualization of production line, shorten the
production cycle and improve the production quality.

2. Application of RFID Cable Joint Quality Management

2.1. RFID System tag Conflict prevention Algorithm
(1) Overview of RFID Technology
RFID is a kind of automatic identification technology, the identification process does not need the line
of sight contact, is not affected by environmental factors, at the same time has the advantages of low
cost and low power consumption, so it stands out in the competition with other identification systems,
become one of the most valuable technologies. RFID uses electronic tags to mark target objects.
Electronic tags contain electronic chips and antennas, which are used to store data, and antennas are
used to obtain rf energy [4]. RFID reader is responsible for receiving and processing data, and realizes
automatic identification and information sharing of items through network transmission. Because of its
many advantages, RFID is widely used in transportation, medical care, industry, logistics and other
fields [5]. At present, cable joint manufacturers mainly apply RFID technology to real-time collection
of production data, quality traceability and production automation.

(2) Tag Conflict Prevention Algorithm
ALOHA algorithm is the simplest time division multiple access method, which is used to solve the
problem of multi-point access in wireless communication network. Later, it was applied to RFID
anti-collision scheme and was the earliest anti-collision algorithm used in RFID system [6]. In
ALOHA algorithm, within the scope of the reader to identify the label as long as it receives the reader
to send command, began to send their own data information to the reader, the transfer of information in multiple tags appear signal conflict, reader will send information issued orders to stop the labels, etc, have not been identification tag will randomly select a later time. In the process, label send their information in the form of probability, therefore, the collision based on ALOHA algorithm is a probabilistic algorithm, on the basis of ALOHA algorithm, derived the time slot, frame time slot ALOHA algorithm ALOHA algorithm, dynamic frame time slot ALOHA algorithm and other algorithms, with the deepening of the research, the collision algorithm based on ALOHA system is also constantly improve and perfect.

In the ALOHA algorithm, at the beginning of each frame, the reader broadcasts the length of the data frame to the tag, specifies the number of slots in the next frame, and activates all tags in the identified area. The random number generator generates a random number between 0 and frame length. After receiving the frame length, each label independently selects a random number as the time slot serial number of the data signal to send, and then the label stores the obtained random number in the register. In each slot of the next frame, the reader gets a new slot by sending the start command. If the label slot serial number is zero, the data signal will be sent to the reader. If the label serial number is not zero, the time slot serial number will be subtracted by 1, and no response will be given to the reader. For the label, if to transmit data to the reader did not occur in the process of collision, the label in after sending the data itself change state, no longer response to a reader in the subsequent process orders, if a collision occurs, the collision label wait for the arrival of the next frame, in the next frame to select a time slot to send data signals. The reader keeps repeating the above steps. If no label response is received in a certain frame, it means that the reader has received all label information [7-8].

At present, ALOHA is the most commonly used anti-collision algorithm in RFID system. Assuming that the frame length set by the reader is \( F \) and there are \( N \) labels to be recognized in the recognition area of the reader, then the probability that only one label sends a data signal in a time slot is:

\[
p(r) = C_N^r (\frac{1}{F})^r (1 - \frac{1}{F})^{N-r}
\]  

The process of tag recognition can be regarded as a Markov process, in which the tag to be recognized in the next frame is uniquely determined by the result of the current recognition:

\[
p(0) = (1 - \frac{1}{F})^N
\]

\[
p(1) = \frac{N}{F} (1 - \frac{1}{F})^{N-1}
\]

\[
p(c) = 1 - (1 - \frac{1}{F})^N - \frac{N}{F} (1 - \frac{1}{F})^{N-1}
\]

RFID system defines throughput rate as: tag identification rate within a certain period of time, that is, in the dynamic identification process, only the ratio of the number of time slots corresponding to a tag to the total number of time slots.

2.2. RFID Quality Management System Architecture

The three-tier architecture consists of presentation layer, business logic layer and data access layer. Among them, the presentation layer adopts ASP.NET MVC framework; As the middle layer, the business logic layer realizes the system business logic. The data access layer interacts with the database using Entity Framework ORM technology. The quality control management system for the whole production process of cable joint adopts the three-layer architecture design method.

1) Presentation Layer

The presentation layer of the quality control management system in the whole production process of cable connector uses ASP.NET MVC technology for page logic processing. The Controller in ASP.NET MVC plays a connecting role and is responsible for responding to users' requests to
ASP.NET MVC system, and each request is mapped to a special Controller [9]. The View encapsulates
the rendering logic, renders the user interface for the response, and displays the data information. The
Model acts as the lowest level application component responsible for the business logic.

The presentation layer is realized by the view and controller. The static files such as HTML and
CSS are adopted to realize the page design and layout. JQuery and AJAX are adopted as the basic
framework of JavaScript.

(2) Business Logic Layer
The system business logic layer acts as the intermediate layer and is responsible for receiving the
presentation layer input in the framework. In addition, it is responsible for interacting with the bottom
layer to execute the business, sending the results to the top layer. The business logic layer processes
the data according to user requirements, carries out relevant operations through the bottom layer, and
returns the final results to the presentation layer controller, which conducts the system business logic
processing.

(3) Data Access Layer
Entity Framework is adopted in the system. Entity Framework can access the database according to
ADO.NET mode, or it can correspond the relational data table relationship with the object-oriented
Entity class relationship one to one, and access the database through mapping with the database.
Entity Framework incorporates LINQ technology. For simple application systems, LINQ To SQL
maps one-to-one To data Entity classes according To tables in the database and their relationships,
which is a good way To complete data mapping and access. For complex enterprise applications,
LINQ To Entities supports a more flexible data mapping mechanism To better define and implement
business logic.

(4) Database
Database is a collection of persistent data of the system. As an important tool for the system to
store and retrieve data, it is an essential part for any system [10]. The specific design idea of the
database is as follows: the conceptual model of the database is established according to the
requirement analysis and functional design of the system.

3. Function and Performance Test of RFID Quality Management System

3.1. System Test
System test is the key link of program quality assurance, it is to develop the software program to carry
on the complete test, in order to verify the correctness and effectiveness of the system. System testing
requires developers and users to complete together, through representative, purposeful operation of the
program, the discovery of existing problems and timely resolution.

3.2. System Test Environment
As the terminal running the system, the PC client requires the following hardware requirements:
Windows10 operating system, 8G memory, 500G hard disk capacity;
Install Microsoft.NET Framework 4.5;
PC has the function of connecting to the network, and can normally access the server-side database;
In order to ensure the normal import and export of related reports and templates, relevant office
software should be installed.
For PCS with scheduled release tasks, LED sending cards need to be installed; For PCS with photo
or scan tasks, the corresponding driver needs to be installed.

3.3. Functional Test
Functional test is mainly responsible for the comprehensive application and testing of all the functions
of the system, including sampling scheme, sampling process, dynamic modification rules,
maintenance of inspection plan, entry of inspection results, inspection characteristics and other
functions, which are displayed by means of test case table.

3.4. Performance Test
In performance test, testers mainly conduct unit test, integration test, system test and special system test, which mainly includes system reliability, ease of use, performance, maintainability and portability.

4. RFID Quality Management System Test Results

4.1. Function Module Test Results

| Serial number | Module                | Testing capabilities       | Results |
|---------------|-----------------------|---------------------------|---------|
| 1.1           | User modules          | Registered                | Pass    |
| 1.2           |                       | Login                     | Pass    |
| 2.1           | Design module         | Data modification          | Pass    |
| 2.2           |                       | Design module modification| Pass    |
| 3.1           | Manufacturing module  | Schedule quality modification| Pass   |
| 3.2           |                       | Modification of production task| Pass |
| 3.3           |                       | Data query                | Pass    |

As shown in Table 1, the system was functionally tested in this paper. In the user module, the user login needs to verify the correctness of the account and password; Has the function of remembering the password and deleting the account; After logging in successfully, the version number of the system will be checked. If there is the latest version, it will be prompted to update. After entering the main interface, you can only operate your own content according to the permissions. Manufacturing function module includes wiP management, production task management, RID release, quality inspection inquiry, rework notice, scrap notice and schedule quality analysis, etc. as you can see, the test of all through the system function module, can normal use

4.2. System Performance Test Results

(1) Functional Response

|               | Sampling maintenance | Sampling process | Inspection plan | Inspection characteristics |
|---------------|----------------------|------------------|-----------------|----------------------------|
| Establish     | 2.43                 | 2.35             | 2.51            | 2.50                       |
| Modify        | 2.39                 | 2.38             | 2.49            | 2.49                       |
| Show          | 2.34                 | 2.26             | 2.47            | 2.48                       |
Figure 1. Partial functional response

As shown in Table 2 and Figure 1, in the system test, configuration backup and storage of each network device and log will be carried out as planned, and data such as server location, IP address, port information and network configuration will be recorded, saved and replaced to ensure smooth operation of the quality management system. According to the importance of specific business data, the system can make a perfect backup plan for its database, and strictly follow the plan, make full and incremental backup of the database regularly. In response test, take procurement plan, sampling process, inspection plan and inspection characteristics as examples to test the response of functions such as establishment, modification and display. After testing the response, we know that the operation of these functions can be controlled within 2.6s.

(2) CPU Usage

Figure 2. CPU utilization rate of the system in different time periods

As shown in Figure 2, the application occupancy of the quality management system in different time periods was tested. It can be seen that the system occupancy rate was relatively high in the four time periods from 10-12 points to 14-16 points, and the overall occupancy rate of the system was around 50%. Among the three system modules, the system occupancy rate of the design module and
the manufacturing module is relatively high, and the system occupancy rate of the design module and the manufacturing module is 20% in the two time periods of 10-12 and 14-16. The overall occupancy rate of the system does not exceed 50%, and it can run smoothly on a PC.

5. Conclusions
In this paper, based on the background of manufacturing industry, combined with the electrical joint manufacturing process of cable joint manufacturing company, designed a set of RFID-based cable joint production process quality control management system. This paper designs the overall function module and sub-module of the system. The system is divided into three functional modules: design, user and manufacture. The quality control management system combines information technology with refined production management to realize the real-time monitoring of the production and manufacturing process of enterprises, save engineering time, reduce resource consumption and shorten project cycle, which is of great significance to the digital information construction of enterprises. This paper designs the overall function module and sub-module of the system. The system is divided into three functional modules: design, user and manufacture.

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