Research on the Application of QR Code Technology in Quality Sampling Inspection of Packaging Paper for Roll-Type Boxes in Tobacco Materials

Lei Zhou*, Wei Wang, Hao Huang, Hui Yang, Yongzhong Xu, Fan Wu, Dawei Huang, Ning Ji, Hongchang Shang

Hongta tobacco (Group) Co., Ltd., Yuxi, Yunnan 653100 China

*Corresponding author's e-mail: 513653178@qq.com

Abstract. Currently, the conventional method of packaging paper for roll-type boxes in tobacco materials involves arrival-based sampling, where quality inspectors randomly select a number of units from the entire shipment to serve as inspection samples. This sampling method is significantly influenced by human factors, which can affect the representativeness of the samples. To enhance the quality control measures for packaging paper for roll-type boxes in tobacco materials, it is crucial to leverage new technologies to improve sample representativeness. This paper presents an analysis and discussion on this subject, offering valuable insights for the deployment of QR Code spot-checking in the tobacco industry.

Keywords: packaging paper for roll-type boxes; Spot-check; Quality control; QR Code

1 Introduction

1.1 Importance of the Project and Its Research Significance

Packaging paper for roll-type boxes is an important component of cigarette packaging materials. It is not merely a simple package but also a display window for the cigarette brand's image and value. Quality issues with packaging paper for roll-type boxes directly affect consumers' perception of the tobacco brand's characteristics and image. Therefore, quality control of packaging paper for roll-type boxes is the most crucial aspect of quality management in cigarette packaging materials.

The traditional method of spot-checking tobacco materials involves inspecting goods upon arrival. That is, once a batch of goods reaches the warehouse, quality inspection personnel randomly select a certain number of items from the entire batch as samples for testing. The representativeness of the sampled quality is greatly affected by human factors. This paper addresses the issue of human factors affecting the representativeness of spot-check samples for roll-type boxes. It conducts a comprehensive study on how to achieve quality control during the production process of roll-type boxes using

E. P. H. Lau et al. (eds.), *Proceedings of the 2024 3rd International Conference on Information Economy, Data Modelling and Cloud Computing (ICIDC 2024)*, Advances in Computer Science Research 114,
https://doi.org/10.2991/978-94-6463-504-1_13

spot-check samples. It was found that the QR codes on roll-type boxes have two main features: uniqueness and immutability. Moreover, from the process of code package application to code spraying, the entire sequence corresponds exactly with the production sequence of the roll-type boxes. Therefore, by uniformly sampling from the code package at fixed intervals, it is possible to evenly select samples from each production time period, and the quality of these samples can represent the quality of every phase throughout the full production cycle of the roll-type boxes.

This paper represents a bold innovation in existing sampling rules, bringing significant potential for improvement in quality control of roll-type boxes. By changing the sampling rules, the quality of the samples can reflect the overall quality of the entire batch of products. When quality issues occur, it enables precise traceability to the source of the problem; simply scanning the code can trace back to the production stage where the issue arose, and can also determine whether the products produced immediately before and after the problematic product have quality issues.

1.2 Research and Development Trends Domestically and Internationally

Major manufacturing enterprises in various sectors both domestically and internationally are continually exploring the expansion and application of QR code technology. Max E. Vizcarra Melgar et al. [1] studied high densitytwo-dimensional color code. RAHUL PATIL et al. [2] enhance the functionality of ATM machine using QR code technology. Xiaofeng Chao et al. [3-4] have explored the application value of QR codes in information management, discussing new management models in tobacco enterprises from both standards and practical perspectives. Yuchen Liu et al. [5] have conducted detailed studies on the production methods of traceability codes using QR codes in tobacco leaf quality traceability systems. Yankai Wang et al. [6-7] have established an engineering quality management framework that includes six modules such as equipment quality traceability management, based on QR code technology. It is evident that QR code technology is widely used and has significant potential for broader application. Inspired by the QR code positioning and recognition methods proposed by Ye Feng et al. [8-11], this article establishes a QR code-based sampling inspection model for the roll-type boxes and applies it to daily inspection work.

2 Main Research Topics

2.1 Feasibility of Using QR Codes on Roll-type boxes

Focusing on the QR codes on roll-type boxes, the study begins at the source by understanding the application methods for supplier QR code packages, the rules for coding QR codes on roll-type boxes, the transfer of QR code information, security issues, and more. It aims to identify the correlation between QR code coding rules and the roll-pack small box production process. The goal is to facilitate the exchange of information between roll-pack small box production and cigarette production, ensuring that the

information transmitted by the QR codes is timely, accurate, and flows smoothly, all while maintaining security.

2.2 Research on Improving Existing Sampling Methods

After roll-type boxes pass the incoming inspection, non-conforming products are often found again during the production material process, indicating that the spot-check samples do not strongly represent the quality of the entire production batch. Utilizing QR codes, a new sampling method has been developed.

By studying the correlation between QR code coding rules and the production process, and utilizing the inherent characteristics of the code package itself, new sampling rules have been formulated. These rules enable uniform sampling after the arrival of roll-pack small box products and cover all the imposition numbers of the roll-pack small box products. They also prevent suppliers from falsifying sampling samples, ultimately ensuring that the drawn samples accurately represent the quality level of the batch of roll-pack small box products.

2.3 Development of Quality Inspection Procedures for the Group and Suppliers

Supplier Level: Relying on the existing QR code management platform, a new QR code data management system is developed to interface with the group's logistics support system. This system must handle the upload, return, and receipt of code packages, recognize and apply sampling rules, and identify roll-pack trademarks with sampling codes during the reinspection phase. The operation of this system must not affect the functioning of the QR code platform.

Group Level: Through the group's logistics support system, the transfer of QR code information is achieved. A sampling program is embedded in the group's logistics support system, which can generate sampling codes automatically based on the code package data uploaded by suppliers and return them to the supplier’s QR code data management system. Quality inspectors can identify whether suppliers comply with sampling requirements by scanning QR codes at the time of delivery.

2.4 Feasibility of Direct Delivery Model for Roll-type boxes

Roll-type boxes have not adopted the direct delivery model primarily because of significant quality fluctuations within the same batch. Conventional sampling methods struggle to reflect the overall quality level of the entire batch, posing a high quality risk with the direct delivery model.

By utilizing QR code technology for sample spot-checking and quality control of roll-pack small box products, the feasibility of a direct delivery approach is explored. This can reduce quality risks, improve inventory capital turnover, and decrease storage space utilization, significantly enhancing cost reduction and efficiency.

3 Research on the Technical Route

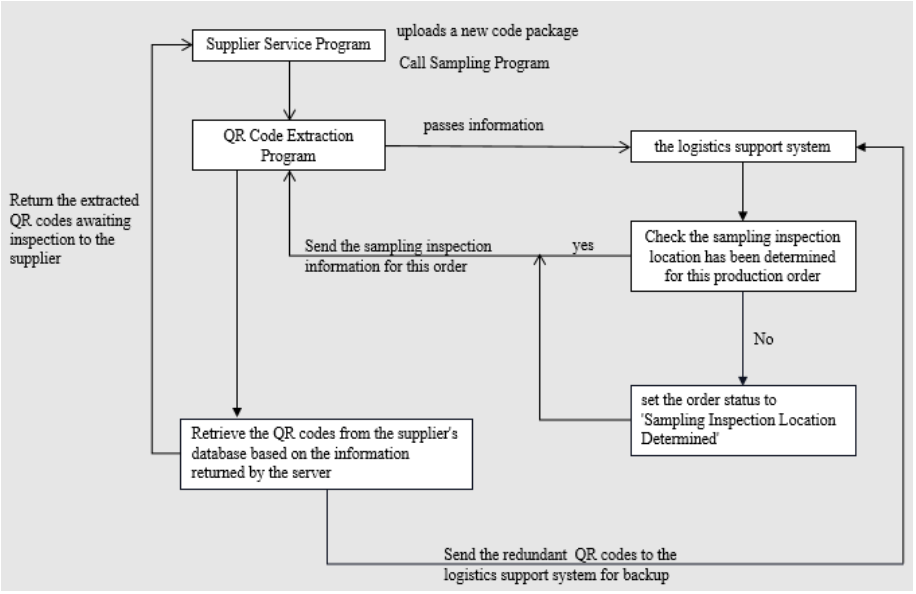

Fig. 1. Technical Implementation Diagram for the First Half of the Sampling Process

The first half of the sampling process is technically implemented as a detailed roadmap from uploading new code packages to extracting the QR codes to be inspected using QR code technology, as shown in Figure 1.

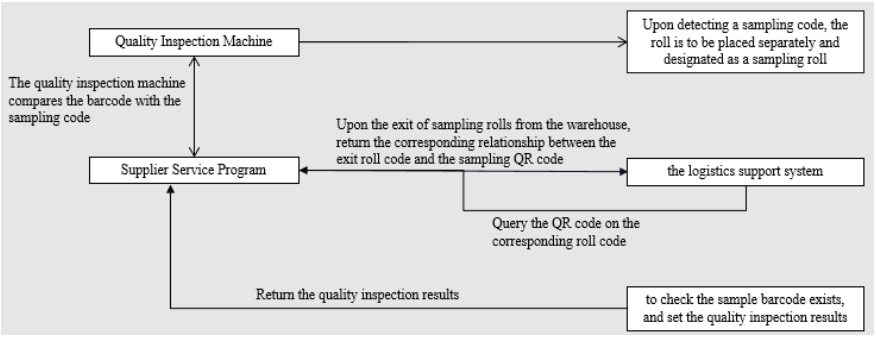

Fig. 2. Technical Implementation Diagram for the Second Half of the Sampling Process

The second half of the sampling process is technically implemented as a detailed roadmap from the supplier's inspection machine recognizing the inspection code to the delivery of the sampled products, as shown in Figure 2.

4 Key Aspects of Implementing the Technical Route

4.1 Designing New Sampling Rules

By studying the correlation between the QR code spray coding rules and the production process of roll-type boxes, it has been discovered that the spray coding order corresponds directly with the production order. Utilizing this feature, new sampling rules are designed to ensure uniform horizontal and vertical sampling distribution, prevent suppliers of roll-type boxes from falsifying samples, and ultimately ensure that the samples drawn accurately represent the quality level of that batch of roll-pack small box products. This addresses the problem of controlling roll-pack quality in small boxes within the tobacco industry.

Through data analysis and optimization, established the new sampling rules, as follows:

(1) The supplier applies for the code package data on the QR code platform, create Production Work Order and transmits it to the logistics auxiliary system;

(2) According to the recorded work order, the system checks the production quantity of the reel small box corresponding to the work order;

(3) According to the production quantity and quality inspection requirements, calculate the required sampling quantity of the current work order, the number of sampling QR code = the required sampling quantity *1.2;

Where: 1.2 for sampling redundancy, to avoid the sampling code in the production process scrap;

(4) Sampling QR code basic interval = production quantity /(sampling two-dimensional code quantity +1);

(5) The first sampling QR code is randomly generated in the first 1-5000 to ensure that the sample at the beginning of production can be obtained;

(6) Subsequent QR code serial number = previous QR code serial number + basic interval of sampling QR code + patch count. When the randomly sampled products do not cover all the plate numbers, to ensure that the samples cover all plate numbers, a plate count needs to be added to the sampling serial number. The plate count will cycle between -6 and 6. This is done to avoid the situation where, when the interval between QR codes is a multiple of 6, the remainder of all sampling serial numbers divided by 6 remains unchanged.

4.2 The established sampling model

The number of QR codes to be sampled is randomly selected from the code pack. The first sampling QR code is randomly determined from the first 5,000 QR codes, and the positions of the remaining QR codes are determined according to the following method:

$$\mathbf{n(x) = n(1) + \frac{N}{m}(x - 1) + \Delta d} \tag{1}$$

Where:

(1)N: Total number of produced QR codes;

(2)m: Number of QR codes to be selected (m);

(3)n(1): The first sampling QR code (randomly generated from the first 1 to 5,000 codes);

(4)x: Position of the x-th QR code ($x \geq 2$);

(5)d: The plate offset. Since there are a maximum of 6 printing plates, the remainder of $d = x/6$ is taken ($d = 0, ..., 5$).

4.3 Development of the Supplier-Side Sampling System

In order to adapt and change the sampling logic according to business needs, and to access some code package information, a program needs to be developed and deployed on the supplier side. Since this program must connect to the supplier's database, it requires cross-platform capabilities, supports multiple databases, and has a unified database interface for easy integration. Java was ultimately chosen as the development platform for the supplier-side sampling program. The Java ecosystem features a JDBC unified database interface that is easy to integrate, and the packaged jar files are cross-platform capable. Additionally, an interface definition file will be provided to facilitate the integration of the sampling program by suppliers. The sampling program communicates with the supplier's code package database through the JDBC database interface and a predefined view structure, and communicates with the logistics support system via http, as shown in Figure 3.

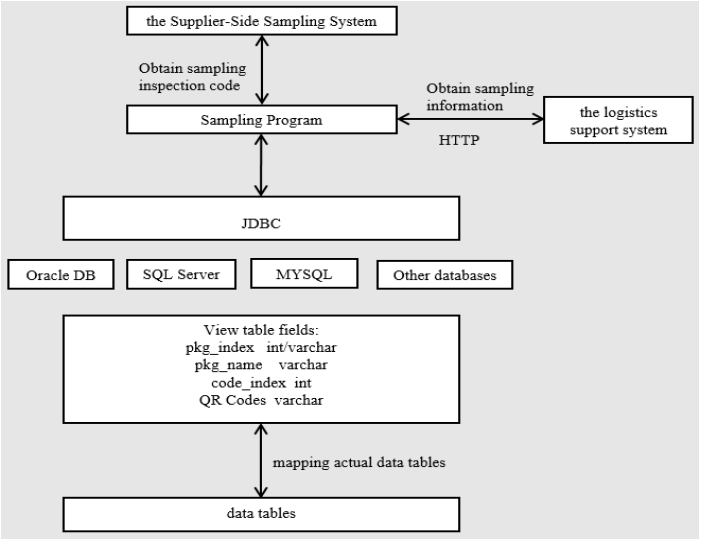

Fig. 3. Sampling Program Structure Diagram

4.4 Development of the Group-Side Sampling Program

To obtain supplier work order information and specify the operating rules for the sampling program, a set of data interfaces needs to be developed on the Group-Side.

According to business needs, the following contents were designed for this set of data interfaces:

- Create Production Work Order;
- Cancel Production Work Order;
- Inform of Sample QR Code;
- Inform of Quality Inspection Results;
- Supplier Inspection Outbound;
- Modify Production Order Number;
- Get Server Request;
- Send the Last 10 Bytes of All roll-type boxes QR Codes on a Packet;
- Attach Purchase Order (Requisition);
- Internal Implementation of Sampling Program Interfaces.

The 'Get Server Request' is used when systems on the Group side need to retrieve data from the supplier side. The normal sequence of interface calls in the business flow is shown in Figure 4.

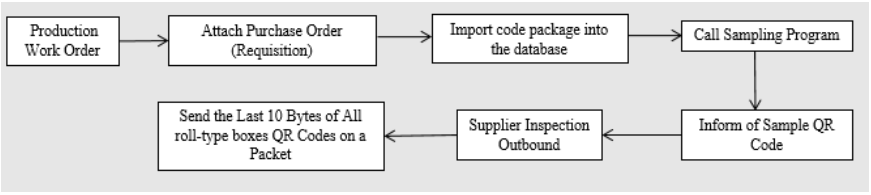

Fig. 4. Interface Call Sequence Diagram

The 'Get Server Request' is implemented through two calls, allowing the logistics support system to query data from the supplier side, as shown in Figure 5.

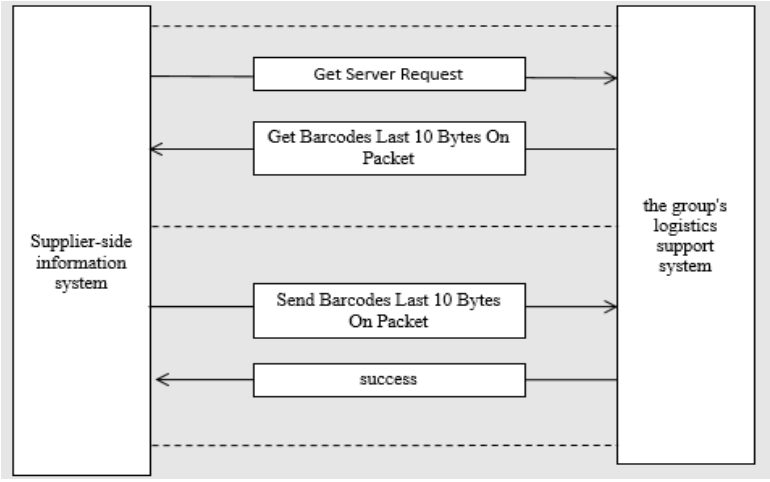

Fig. 5. Interface Call Diagram

The supplier-side system regularly calls 'Get Server Request'. When the group's logistics support system needs to query data, it returns the required data content. Upon receiving this response, the supplier-side then proactively sends the data to the group's logistics support system. This method avoids the need for the supplier-side to provide an interface accessible from the external network and also prevents the need to maintain multiple supplier server addresses in the group's logistics support system.

5 System-Generated QR Code (Example)

The Group's Logistics Assistance System utilizes sampling models and rules to generate QR codes for quality inspections, ensuring that samples with less stable product quality during the start and end of production shifts are consistently selected, significantly enhancing the representativeness of the samples. As shown in the table1:

Table 1. System-Generated QR Code Diagram

Serial number	Total QR code production	The number of QR codes to be selected	Location of the first QR code (random)	The location of the middle QR code	The middle QR code plate offset	The final location of the QR code	The final QR code plate offset
1	150000	5	500	60503	3	120505	5
2	150000	5	1000	61003	3	121005	5
3	150000	5	2000	62003	3	122005	5
4	250000	10	500	100505	5	225505	4
5	250000	10	1000	101005	5	226005	4
6	250000	10	2000	102005	5	227005	4
7	500000	20	500	225504	4	475502	2
8	500000	20	1000	226004	4	476002	2
9	500000	20	2000	227004	4	477002	2

6 System Security and Efficiency

Interface data is transmitted in JSON format through HTTPS POST requests, and all interfaces are protected by access key authentication to ensure the security of the interfaces. The access key needs to be obtained from the business system and can be changed at any time, with the old access key becoming invalid after the change. Suppliers can transition from development testing to formal use by updating the access key to avoid key disclosure. Each supplier has their own access key, and the system can associate the access key with the information of the interface caller's supplier after obtaining it. Transmission through HTTPS also avoids the risk of data being intercepted or tampered with during transmission.

After the supplier calls for inspection and outbound shipment, the logistics business auxiliary system will request the last 10 digits of the QR code on the supplier's inspection reel label from the supplier's system. The last 16 digits of the QR code are random

codes, but the logistics auxiliary system only retrieves the last 10 digits from the supplier's system for comparison. This only requires transmitting 62.5% of the full data volume, which can avoid the risk of data leakage caused by transmitting a large number of QR codes, reduce the performance consumption of QR code verification, lower the transmission data volume, and still meet the needs of verifying QR codes.

7 System Quality Evaluation

This test was carried out for a total of 2 round, and no serious defects occurred during the test of the production management module.

The defects in the whole test process of 1 round have been repaired by personnel in the test process, which has been completed and the overall quality assessment of the version is good. As shown in the table 2:

Table 2. Version defect statistics

Test module	Number of fatal defects	Number of serious defects	General defect number	Number of minor defects
port	0	0	0	0
Sampling procedure	0	0	0	0
Random check code verification function	0	0	0	0

8 Conclusions

This project conducted research on the QR codes on roll-type boxes, innovatively proposing a mode of QR code sampling for roll-type boxes. It developed a sampling program to facilitate the transmission of QR codes, relying on the program and existing information platforms to carry out QR code sampling. This ensures that the sampled products better represent the quality level of the batch, Finding problems is easier to trace back, leading to a certain improvement in the control of the quality of tobacco materials at the source. After the sample is qualified, the roll-type boxes is directly sent to the production site, and the benefits are shown in the table 3:

Table 3. Realized benefit

Number	Economic and technical index	Realized benefit
1	Saving on handling charges	¥39172.31
2	Savings on Warehouse Storage Costs	¥331379.94
3	Improvement in Inventory Turnover Rate	49.74%

References

1. Vizcarra Melgar,Max E.,Farias,MyleneC.Q. High densitytwo-dimensional color code[J].Multimedia tools and applications.2019,78(2).1949-1970.DOI:10.1007/s11042-018-6299-4 .
2. RAHUL PATIL, SAGAR SALUNKE, RAJESH LOMTE, et al. Efficient Cash Withdrawal from ATM Machine Using QRcode Technology[C]. //2019 5th International Conference on Computing, Communication, Control and Automation: 5th International Conference on Computing, Communication, Control and Automation (ICCUBEA), 19-21 Sept. 2019, Pune, India.:Institute of Electrical and Electronics Engineers, 2019:1-3.
3. Xiao Fengchao Discussion on the Application of QR Code in the Lifecycle Management of Information Equipment in Tobacco Companies [J]. Science and Information, 2020(27): 29.
4. Wu Gaofeng The Application of QR Code Technology in the Manufacturing and Distribution Process of Tobacco [D]. Zhejiang A&F University, 2013. DOI: 10.7666/d.Y2365395.
5. Liu Yuchen Design of Tobacco Leaf Quality Tracing System Based on QR Code Technology [J]. Automation Technology and Application, 2021, 40(10): 146-148. DOI: 10.3969/j.issn.1003-7241.2021.10.034.
6. Wang Yankai, Fan Xiang, Ma Baoliang, et al Research on the Framework of Construction Project Quality Management Based on QR Code and Portal Technology [J]. Construction Economy, 2023, 44(1): 99-104. DOI: 10.14181/j.cnki.1002-851x.202301099.
7. CHEN ZHAO. Agricultural Product Traceability System Based on QR Code[C]. //2019 2nd International Conference on Mechanical Engineering, Industrial Materials and Industrial Electronics (MEIMIE 2019). 2019:330-333.
8. Ye Feng, Lin Haoqing. Batch Location and Recognition Algorithm of QR Codes under Complex Background [J]. Journal of Zhejiang University of Technology, 2019,51(4):355-361. (in Chinese) DOI:10.3969/j.issn.1006-4303.2023.04.001.
9. Wang Hua, ZHAO Weifu, Zhang Shuang, et al. Multi-target QR code location recognition method with constrained clustering algorithm [J]. Computer Applications & Software,2023,40(5):243-247,271. (in Chinese) DOI:10.3969/j.issn.1000-386x.2023.05.036.
10. NOUREDINE HUSSAIN, CHRISTOPHER FINELLI. KP-YOLO: A Modification of YOLO Algorithm for the Keypoint-Based Detection of QR Codes[C]. //Artificial neural networks in pattern recognition: 9th IAPR TC3 workshop on artificial neural networks in pattern recognition (ANNPR), September 2–4, 2020, Winterthur, Switzerland.:Springer Nature Switzerland AG, 2020:211-222.
11. MAHSSA ABDOLAHI, HAO JIANG, BOZENA KAMINSKA. Robust data retrieval from high-security structural colour QR codes via histogram equalization and decorrelation stretching[C]. //2019 IEEE 10th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference: 10th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), 10-12 Oct. 2019, New York City, NY, USA.:Institute of Electrical and Electronics Engineers, 2019:340-346.