# IMPROVEMENT AND APPLICATION OF IoT FOR QUALITY CONTROL PROCESS MANAGEMENT OF DYEING FABRIC AT PHONG PHU INTERNATIONAL JOINT STOCK COMPANY

# CẢI TIẾN VÀ ỨNG DỤNG IoT VÀO QUẢN LÝ QUY TRÌNH KIỂM TRA CHẤT LƯỢNG VẢI NHUỘM TẠI CÔNG TY CỔ PHẦN QUỐC TẾ PHONG PHÚ

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**Abstract -** Color quality is one of the important criteria in determining the output of a product in the textile industry. However, the color testing process in some current dyeing factories is still largely dependent on human factors. These traditional methods often lead to difficulties and complexity in the operation and management of production information. Through the cooperation and improvement of production process at Phong Phu International Joint Stock Company, Da Nang, the authors proposed a new process of color control quality control. Furthermore, this process will be integrated IoT into system management and product output data collection based on Blynk and ThingSpeak tools.

**Key words -** Quality Panagement; IoT; Blynk; ThingSpeak; Dyeing Process.

**Tóm tắt -** Chất lượng màu là một trong những tiêu chuẩn quan trọng trong việc quyết định đầu ra của sản phẩm trong ngành công nghiệp dệt may. Tuy nhiên, quy trình kiểm tra màu tại một số nhà máy nhuộm hiện nay vẫn phụ thuộc phần lớn vào nhân tố con người. Các phương pháp truyền thống này thường dẫn đến sự khó khăn, phức tạp trong quá trình vận hành và quản lý thông tin sản xuất. Thông qua sự hợp tác, cải tiến quy trình sản xuất tại Công ty Cổ phần Quốc tế Phong Phú, Đà Nẵng, nhóm tác giả đề xuất một quy trình kiểm soát chất lượng ánh màu mới. Hơn nữa, quy trình này sẽ được tích hợp IoT vào quản lý hệ thống và thu thập dữ liệu đầu ra sản phẩm dựa trên công cụ Blynk và ThingSpeak.

**Từ khóa -** Quản lý Chất lượng; IoT; Blynk; ThingSpeak; Quy trình Nhuộm.

## 1. Introduction

Textile industry is one of the sectors that account for a high proportion in the Vietnam's economy structure. The improvement of production efficiency is always invested and developed by enterprises to achieve higher productivity and profitability. In Da Nang, the textile industry has a long history of development, with big names such as Hoa Tho Textile and Garment Joint Stock Co., Huu Nghi Garment Joint Stock Co., Vietnam National Textile and Garment Group (Vinatex), ... [1]

In large textile factories, automation has been increasingly developed and applied in factories to reduce labor and increase efficiency. In addition, the system's data is also collected and organized for the purposes of continuous improvement of the business. However, in small and medium textile companies, automation is not fully implemented, and still depends much on human factors. This causes many effects on production efficiency and the consistency of product output quality. Realizing the above disadvantages, in the process of cooperating to work at a rich textile joint stock company, our group decided to improve the fabric color quality inspection process. This research aims to reduce time, reduce dependence on human factors and software application to collect and exploit data of production system [2, 3].

Phong Phu International Join Stock company is located at Lot M, Road No. 3, Hoa Khanh Industrial Park, Da Nang. This research focuses on production process at Wash B factory of the company. The role of this factory is in dyeing products which are manufactured by the company and semi-finished products from outside customers. The two main output products of the company are khaki pants and plastic goods.

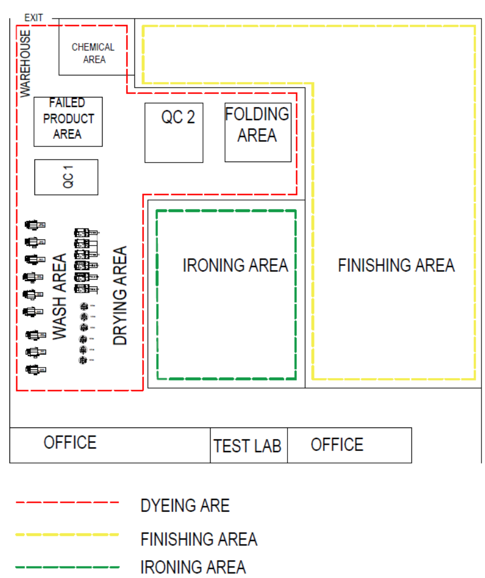


***Figure 1.*** *Wash B factory layout [4]*

As shown in Figure 1, the wash B factory consists of three main areas: dyeing area (includes chemical area, QC area, folding area and wash area), ironing area, finishing area. On this paper, dyeing area will be focused to improved the operation process of khaki pant products.

## 2. Current dyeing process analysis

The dyeing process is shown in Figure 2. The warehouse department will receive the input materials (not yet dyed khaki pants) and collect the data (number of items, color, ...) to compare with the output quantity. After completing the import, these khaki pants will be transferred to QC department to finish the input quality checking, which is includes: Pre-wash measuring, color code seperating, cleanliness checking. Then, the wash statistic staff will bring the checked materials to wash area for dyeing step. The worker will put the pants into the machine which is pre-installed with input parameters such as temperature, wash time, rotation speed. In this area, there will be four steps. Firstly, dyeing medium is prepared with chemicals and dyes (Yeing step). Next, the chemicals is added to keep the color of the khaki pants (Enzyme step). Then, the worker will add an adjusting dye to balance the color as required (Tint tint step). Final step is soften fabric after dyeing (Softed-lake step). After finish the process at wash area, the semi-products are squeezed and dried at drying area.

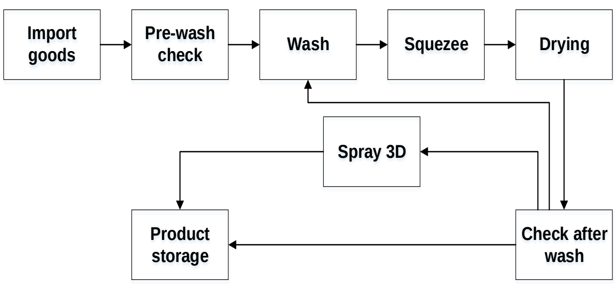


***Figure 2.*** *Dyeing Khaki pants process*

For the next, the dyed khaki pants will be moved to the QC area to check out the output quality. The QC process has two steps: QC1 and QC2. At the QC1, each product batch will be randomly selected 3-4 products representative for each size to mesure required parameters. The measurements in here focuses on elasticity of fabric after dyeing process. QC2 process includes SB color and other errors testing as shown in Figure 3. Each pair of pants will be turned over, and the QC will check for basic errors of the pants as shown in Figure 4. Then, they continue to check for errors including: Smear (1); Tearing error (2); Stripe error (3); Ruffled error (4), Dirty error (5). Finally, the color uniformity will be compare with standard catalog for testing by their eyes.

***Figure 3.*** *SB color range*

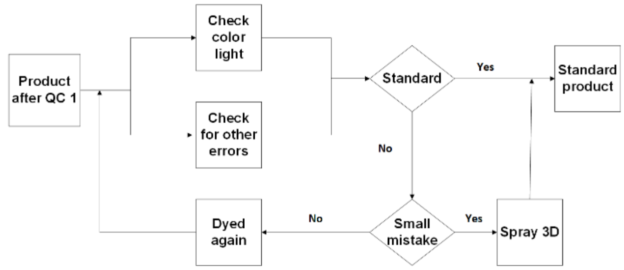


***Figure 4.*** *Quaity control process (QC2)*

All inspections are done manually by eyes. The error checking section is performed almost simultaneously and alternately. The average time to check each pants is 54-60 seconds, in which the time to consider color quality takes a quarter of the time.

***Table 1.*** *Timing of inspection and folding process*

| No. | Tasks | Average time |
|---|---|---|
| 1 | Flip pants | 4s |
| 2 | Check for other errors | 22s |
| 3 | Check for SB color light | 28-30s |
| 4 | Folding | 5s |

***Table 2.*** *Error statistics for a month [5]*

| 1st standard product | 1st defective product |
|---|---|
| 105492 | 13843 |

***Table 3****. Error rates*

| No. | Type of error | Error rate/ Defective product |
|---|---|---|
| 1 | Smear error | 14/13 843 |
| 2 | Tearing error | 1/13 843 |
| 3 | Stripe error | 2/13 843 |
| 4 | Ruffed error | 0/13 834 |
| 5 | Dirty error | 108/13 834 |
| 6 | Outside SB Error | 13718/13 843 |

The company's September 2019 product statistics is shown in Table 2, 13843 defective products were recycled, only 1898 second waste products accounted for 13.71%.

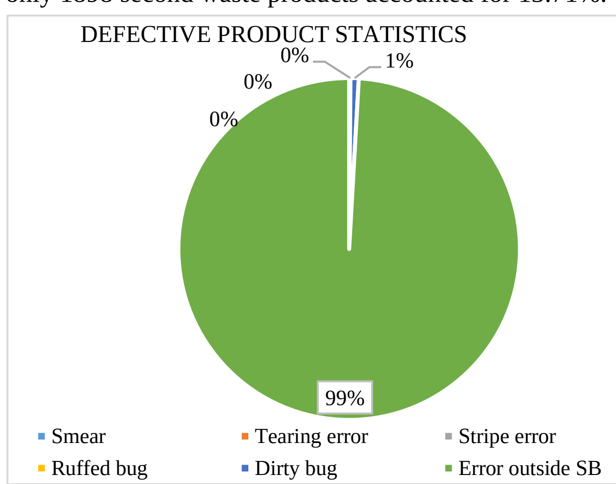


***Figure 5.*** *Error rates*

Data is collected and shown in Table 3, it can be concluded that the fault of the dyed product is mainly focused on the defect in the SB color error (more than

**99%**, as plotted in Figure 5). It was mentioned above that the SB color test takes more than a quarter of the time on average. So it was rated as one of the most important errors.

For SB color testing, the dyed khaki pant products is compared to the standard catalog by eye. Here, the catalog is built from the suggestion of customers as shown in Figure 6. Firstly, a batch of the khaki pants is dyed and passed the physical and color testing. Then, this demo batch is sent to the customers to get the feedbacks. The SB color standard catalog is suggested later.

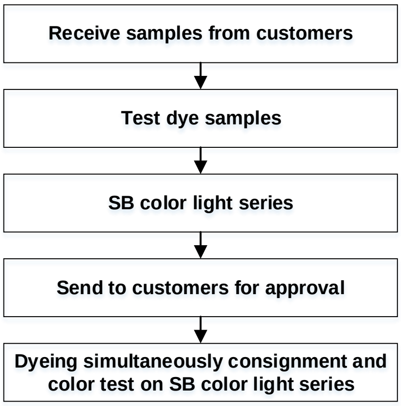


***Figure 6.*** *The process of building and applying SB color light*

During the post-dyeing inspection, it is necessary to comply with the following requirements:

- Test light intensity is between 1200-1300 lux;
- QC team needs to be trained;
- There must be a standard sample catalog at the inspection area;
- Finished goods inspection report must be signed by QC for lately responsibility;
- Passed products must be classified and clearly identified.

Finally, warehouse department will receive the finished products. All information at each stage of the process will be updated on the shipment's itinerary.

After analysis the QC process, our team recognized the SB color testing phase has many visual factors: eye ability, light, etc., leading to the inspection of many deviations. Secondly, SB color testing time takes more than 50% of QC process time. The process largely depends on human factors. Moreover, there are external factors that lead to erroneous results such as: light intensity, eye status of workers, fatigue by long time working. From the above shortcoming of the current process, especially the quality control stage, this article will cover changing the color testing process and the application of software for data management.

## 3. Research method

### *3.1. Structure diagram of the model*

The system as shown in Figure 7 includes

- App (for worker);
- Improved conveyor (the system of conveyor belt transporting pants after wash, on the conveyor belt there is a color sensor to check the color of the pants and count the product passed number);
- Router (Data will be sent to server via wifi);
- Server (Use Blynk server);
- Manager (Application for the manager);
- ThingSpeak (An open source for data storage and data export);
- Desktop (A place to display the visualization of data managers).

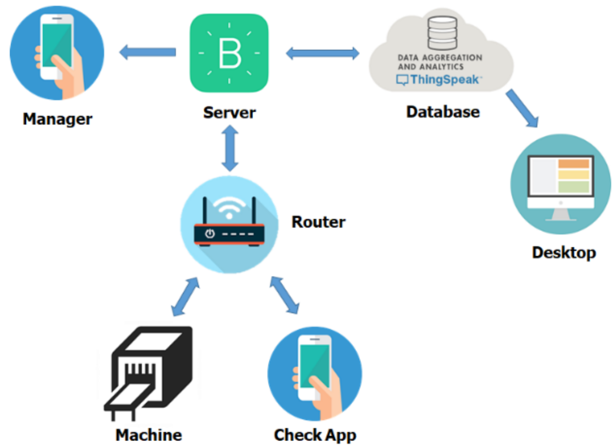


***Figure 7.*** *Overview diagram of research model*

### *3.2. Blynk tool*

Blynk is the platform designed for the Internet of Things [6]. It can control hardware devices remotely; Display sensor data and save data during the operation procedure. There are three main components in the platform, as follow:

- Blynk App - allows creating theme by dragging and dropping different widgets that have been designed by providers;
- Blynk Server - responsible for central data processing between phone, tablet and hardware;
- Library Blynk - support for almost all popular hardware platforms - enables communication with the server and processing all incoming and outgoing commands.

With Features, characteristics as

- Provide APIs & user interfaces for all supported devices and hardware;
- Connect to the server using: Wifi, Bluetooth and BLE, Ethernet, USB (Serial) and GSM;
- The utilities on the supplier's interface are easy to use;
- Drag and drop interface directly without writing code;
- Easily integrate and add new functionality using the virtual connection ports built into the blynk app;
- Track historical data;
- Communication from device to device using Widgets;
- Send emails, tweets, realtime notifications, etc.

With the Blynk's structure diagram as shown in Figure 8, the tool will be used both for the manager's application and for the worker to check for errors.

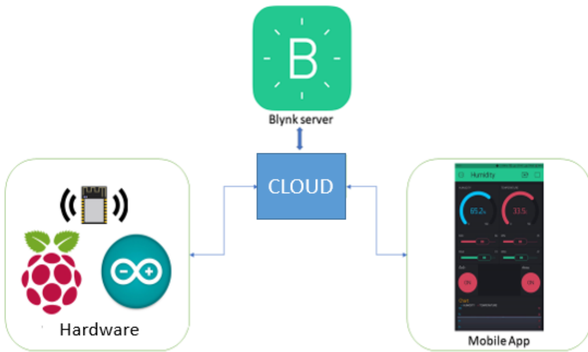


***Figure 8.*** *Blynk's structure diagram*

### *3.3. ThingSpeak*

ThingSpeak is an IoT analytics platform service that allows to aggregate, visualize, and analyze live data streams in the cloud [7]. The data can be sent to ThingSpeak from connected devices, create instant visualization of live data, and send alerts. ThingSpeak was originally launched by ioBridge in 2010 as a service to support IoT applications. ThingSpeak has integrated support from MATLAB digital computing software from MathWorks, allowing ThingSpeak users to analyze and visualize data uploaded with Matlab without having to purchase a Matlab license from Mathworks.

### *3.4. The machine sorts fabrics by color*

Arduino is an open source platform. It is used to build electronic applications that interact with each other or with a more favorable environment [8]. Arduino is like a small computer so that users can program and execute electronic projects without having to have specialized tools to load code. The Arduino interacts with the world through electronic sensors, lights, and motors as shown in Figure 9.

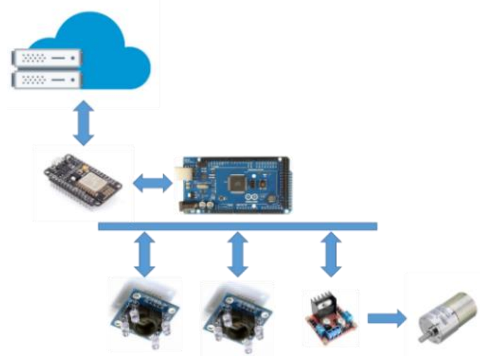

***Figure 9.*** *Diagram of the blocks*

Arduino includes hardware consists of an open source circuit board (often called a microcontroller). It is programmable. Another part is integrated development support software IDE (Integrated Development Environment) which is used to compile, compile code and load the program for the board.

### *3.5. Wifi connection module – NodeMCU*

NodeMCU as shown in Figure 10, is developed based on the ESP8266EX WiFi Chip inside. The ESP-12E easy to connect WiFi module also integrates CP2102 IC, which makes it easy to communicate with the computer via Micro USB to manipulate the board. And there are buttons and LEDs available to facilitate the learning and research process. With a compact size, flexible board easily connects with peripheral devices to create projects

***Figure 10.*** *Wifi Module- NodeMCU*

Technical specifications includes

- Chip: ESP8266EX;
- WiFi: 2.4 GHz supports 802.11 b/g/n;
- Operating voltage: 3.3V;
- Input voltage: 5V through USB port;
- Number of I/O pins: 11 (all I / O pins have Interrupt/PWM/I2C/One-wire, except pin D0) ;
- Number of Analog Input pins: 1 (maximum input voltage 3.3V) ;
- Flash memory: 4MB;
- Communication: Micro USB Cable;
- Security support: WPA/WPA2;
- Integrated TCP/IP protocol;
- Programming on the following languages: C/C++, Micropython, NodeMCU – Lua.

### *3.6. Color sensor TCS3200*

Application for color grading, induction and sunlight calibration, reading strip testing, color matching test. Technical specifications is as follow

- Supply voltage (2.7V to 5.5V);
- Convert from light intensity to frequency with high resolution;
- Programmatically select different color filters and output frequency pattern;
- Low power consumption. Communicate directly with microcontroller.

TCS3200 color sensor module with the ability to recognize 3 RGB primary colors and 4 white LEDs. The TCS3200 can detect and measure almost all visible colors. Applications include strip reading testing, color grading, ambient light sensor and calibration, and color matching ... the TCS3200 has optical detectors and has 2 color filters including: Filter is red, blue, or green, or without (clear) filter. The filters of each color are evenly distributed throughout the arrays to eliminate placement deviations between the color points. Inside is an oscillator that produces a square wave output whose frequency is proportional to the intensity of the selected color.

Work chart of the worker: Each conveyor system will include two main workers at the head and the end of the system. The conveyor belt worker is responsible for checking for minor errors and entering error data. The worker at the end of the conveyor belt will fold the products.

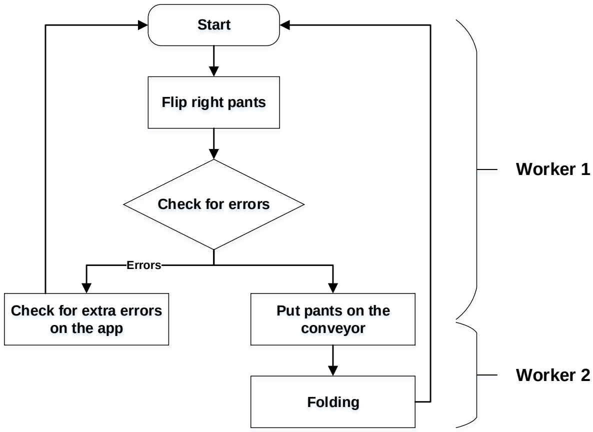


***Figure 11.*** *Worker's working model*

Job description of workers according to the diagram in Figure 11.

## 4. Research results

### *4.1. Results of model check app*

The mockup model is built up to simulate the operation of the propose system as shown in Figure 12. The interface as shown in Figure 13, will be displayed as a buton for the worker to enter the sub error data. Data will be uploaded to a general server and displayed on the manager app and data on thingspeak.

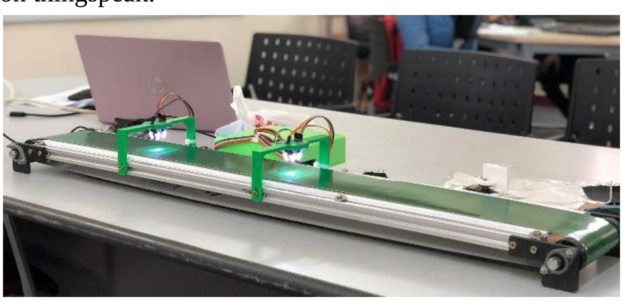

***Figure 12.*** *Simulation model*

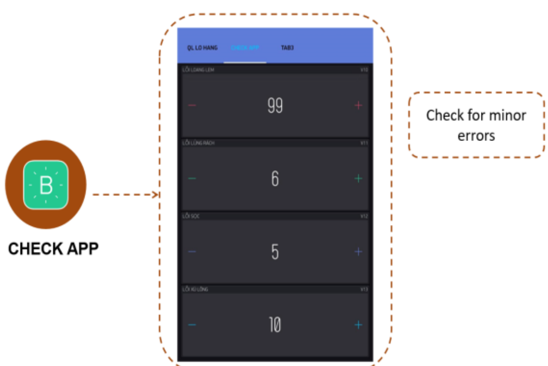


***Figure 13.*** *Interface of check app*

### *4.2. Model results of SB color light test*

With the algorithm as shown in Figure 14, the system is started. First to check data from the server. If a color reset command is received (ie receive a new SB color code board), the system will receive a sample color learning order and at the same time reset the count value for the system when passing a new shipment.

If there is no order from the server, continue to check the product's color scheme. If the product meets the SB standard sheen, the system counts 1 passed product and pushes the product to the folding area. Conversely, if the product is defective in SB color, it will automatically count the defective product data by 1 unit and the lever will push the product to the recycling area. The loop kept going on.

System functions:

- Check SB color;
- Counts for pass and error products.

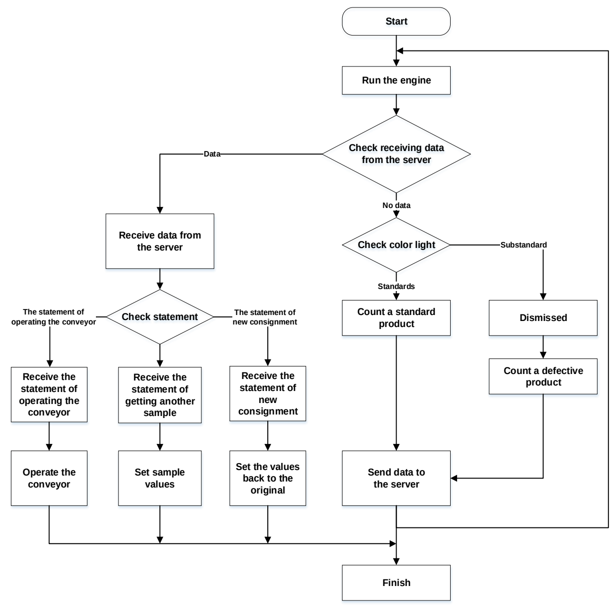


***Figure 14.*** *Algorithm diagram*

### *4.3. Displayed results on the manager app*


***Figure 15.*** *Interface on the manager app*

The data on the serve will be displayed on the manager app as shown in Figure 15. It Includes data from the check app and data from the color light test system. App also helps the manager to control and reset the new color palette for new shipments simultaneously. Also displays other values such as the lighting of the dyed area.

### *4.4. Results show up on Thingspeak*

Error row data will be displayed as a daily value update chart. Besides, the system allows us to download data to the desktop as shown in Figure 16.


***Figure 16.*** *Data on Thingspeak*

### *4.5. Processing time*

If when the system is applied, the color check stage is automated so the worker time depends only on the input and output time. In which the input time, which is the time to turn the pants (average 4s) and check for errors (average 21s), the total input time is 25s. The time for the final stage, i.e. the folding phase is 4-5 seconds. The travel time on the conveyor belt can be customized. Since these 3 phases take place in parallel, it is possible to maximize the process time of 25 seconds.

## 5. Development orientation and conclusion

With the proposed model of improvement and the application of IoT in the dyeing fabric quality inspection process at Phong Phu International Joint Stock Company, after the research process, the results shown that:

- The color test model will help automate the quality control process and avoid errors caused by visual factors: eye capabilities, lighting, environment, ...
- Conveyor speed can be adjusted to save working time.
- Using the app on the phone will be convenient for the manager no matter where you are.
- Shipments data will be integrated and stored synchronously, convenient for management and can be gradually replaced for itineraries.
- The management model on the app for the manager and the check app model can be customized the features to suit the requirements.
- The process time depends on the input time, so the direction of improvement to shorten the time for the input phase.

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