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Short Communication

Partially IOT Based Automated Quality Checking, Controlling and Data Analyzing Innovative System for Apparel Industry

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Abstract

Quality control in the garment and apparel industry is a crucial factor that helps to maintain reliability, quality and ensure that all garments meet a specific set of standards and specifications. But currently, quality checking, recording data and analyzing those data are being done manually. It usually takes a long period of time to address the root cause of the defects. In order to give a solution to this problem, Partially IOT based automated quality checking and data analyzing system was proposed and implemented for the production line. It can be used to mark the quality of each garment which passes through the quality section. The quality information was recorded in the database and current and hourly defect rates for production were automatically calculated. Then, using navel web applet, the end results were visualized with analyzed graphs. Hence, using proposed and constructed equipment, the defect rate of the production process per operator could be reduced by identifying the rate of decline in the quality of the product due to the error of the machine or the error of the operator. Then, by considering such error occurred cases, by taking timely remedy to the root cause of the error, it was possible to decrease the defect rate up to 51.03% and increase the production quantity by 6.4 %.

Keywords: *Appeal industry, data visualization, navel quality control technology, partial IOT based automation*

1. Introduction

Sri Lankan textile and apparel industry have gained a strong reputation worldwide for ethical manufacturing of high-quality apparels (Wijewardena, 2019). In the apparel industry, quality analysis and control of produced garments are a crucial factor that helps to maintain consistency, quality. Also, those procedures help to ensure that all the garments meet a specific set of standards and specifications (Export Development Board Sri Lanka, 2022,).

Rather than checking at after-production stage, inspection during production is crucial for ensuring that garments are produced to meet customer expectations and specifications. According to available literature, about 20% of defects occur during production (Kochar, 2024).

Mainly two factors effect on the rejection of a garment at quality inspection level. They are;

- Team member (Operator) Mistakes
- Machine malfunctioning

Currently, there is a system of manually recording the number of defects of each team member, but due to the change in the size of the input panel received by the team member, it is not possible to get an idea about team member's efficiency.

The best way to measure the efficiency of a team member is to calculate the defect rate. But, it is difficult to calculate defect rates in real-time using manual method. Therefore, it was taken a long time to address the root cause of the defects, most likely at the end of the day or the following day. Hence, the management could not be able to get quick decisions by analyzing real time data. Therefore, there was a huge waste of resources, time and money.

In order to address this problem, design and construction of an IoT based system for automatic quality checking and data analyzing system for apparel industry production line is discussed in this research study.

2. The proposed QC method and the related materials

2.1 Usual quality checking (QC) process in production line

The last part of the production line is quality checking. Garments that are rejected by the test of this process are known as rejects.

In order to explain the overall process, with reference to following Figure 1, Abbreviation TM is used for team member.

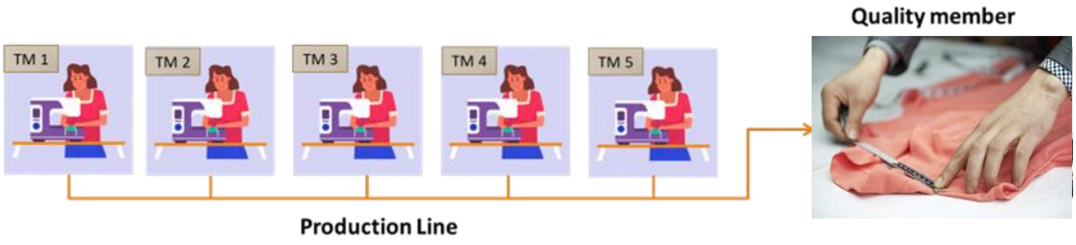

Figure 1: Usual Formal quality checking process in apparel production line

2.2 Case Study for implementing Smart Innovative QC Method

The world is moving towards smart Semi or Fully automated solutions with high reliability. Initially, the most error prone Collar linking operation was chosen for the proposed research study.

Linking Machine used to quickly and easily connect together the seams of knitted garments such as sleeves, body, collars, and bands. Collar linking is a very stern task prone to errors and defects which should be done with proper training and attention. Hence, its defect rate is also very high. Therefore, there is a strong need to reduce the defect rate for this particular operation. According to the previous research study carried out on the company, with data and statistical analysis, approximately 10% of resources were wasted at collar linking stage without profit due to such Team member (Operator) mistakes and due to machine malfunctioning.

2.3 Smart System Design and the functionality Analysis for the selected Malfunction

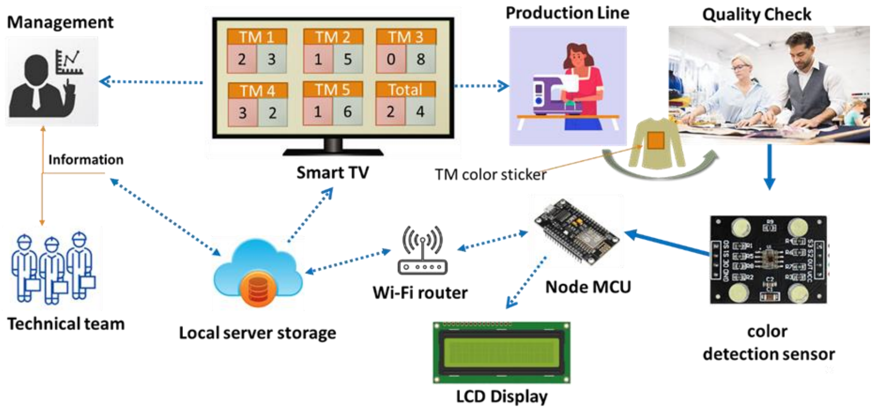

Figure 2: System design data flow diagram for the proposed navel QC technology

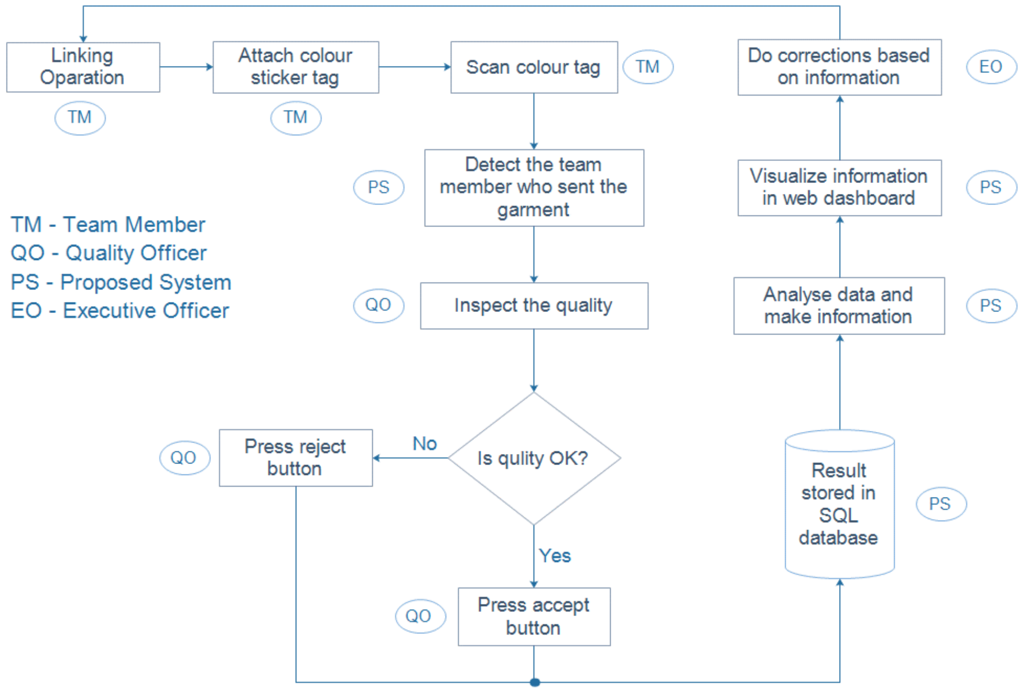

Figure 3: The proposed QC System functioning flow chart

The overall process illustrated in figure 2 and figure 3 which can be given in the following steps

1. After linking and sawing, a colored sticker tag which is unique to identify the operator of the team with a unique color for each team member was pasted on the garment. (Team members were selected with inherent color sticker tags on the garment, so that the color is identical to each operator of the machine).

2. The stitched garment was sent for quality inspection along with the tag.

3. ESP 8266 Node Micro Controller Unit (MCU) was used to detect the team member who sent the garment by detecting the color of the tag using the designed and constructed color sensing module (Khan et al., 2019).

4. After inspection, the quality checking officer can decide and record whether the product can be accepted or need to be rejected by simply pressing the accept button or reject button.

5. LCD display was used to indicate the team member's ID number alongside whether it is accepted or rejected.

6. ESP 8266 Node MCU was updated according to the rejected or accepted garment count of relevant team member, then the result that was stored in local server SQL database.

7. Smart TV or Desktop computer could be used to view rejected or accepted garment counts and defect rates via web interface.

8. Then, the stored data can be further analyzed for making final decisions.

2.4 Hardware Implementation

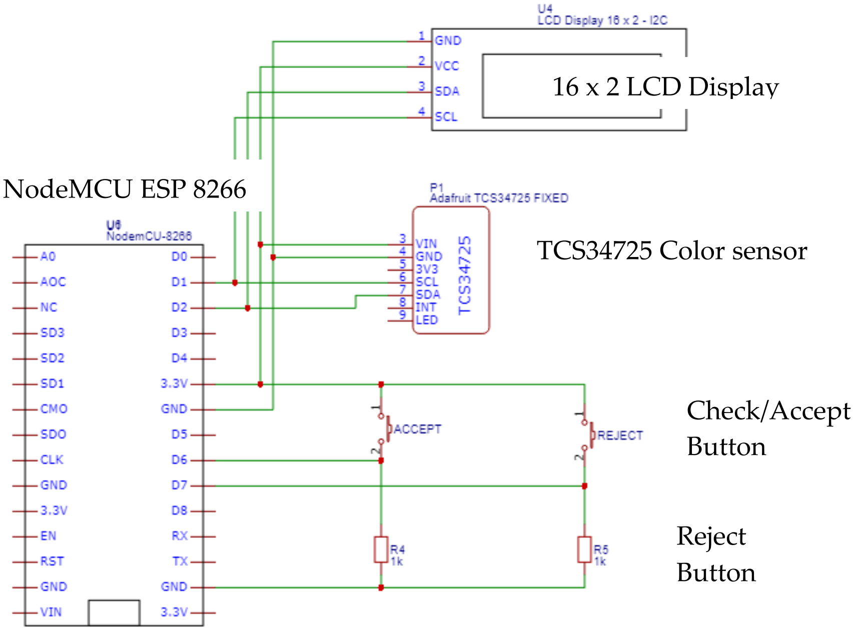

Figure 4: The Hardware implementation for the innovative QC technology

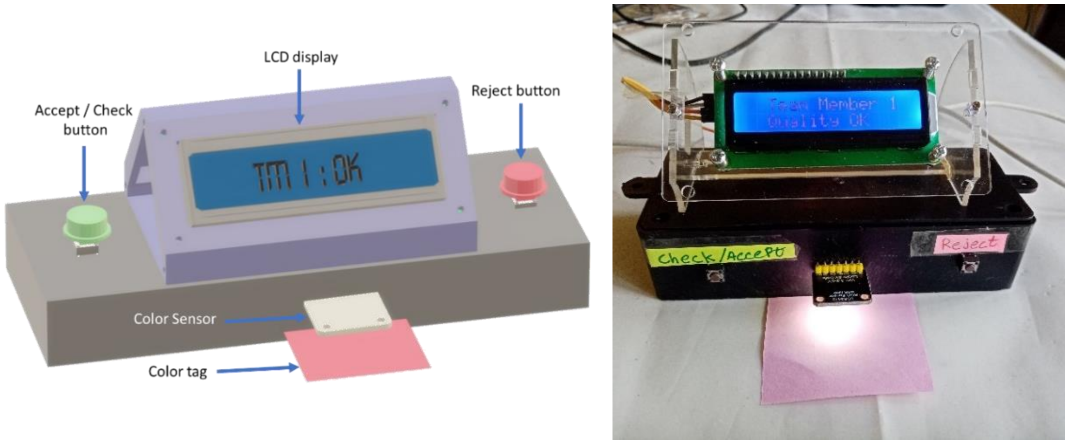

Figure 5: The prototype system developed for the QC implementation

The overall design of the proposed innovative system hardware is illustrated in above figure 5. The color sensor in the proposed system is used to detect the color of the tag after pressing check button. Then, the MCU (Micro Controller Unit) recognized the team member number relevant to the color. After that, the team member ID number was displayed on the LCD screen. As the result of proposed automation, the QC officer only has to mark the accepted quality garment's tags by pressing the accept button .Also, the rejected were marked by pressing the reject button (shown in figure 4). Finally, these data were sent to the local server SQL database by the MCU.

In the proposed prototype system, I2C serial communication protocol was used to communicate between microcontroller, TCS34725 Color sensor and LCD display using common data bus (Figure 5). The I2C protocol involves using two lines to send and receive data: a serial clock pin (SCL) that the NodeMCU Controller board pulses at a regular interval, and a serial data pin (SDA) over which data is sent between the two devices. Because, the I2C protocol allows each enabled device to have its own unique address, both microcontroller and peripheral devices (Color sensor and LCD display) could be used to take turns of communicating over a single line, hence it is possible for microcontroller to communicate with many devices while using just two pins of microcontroller (Zambetti et al., 2024).

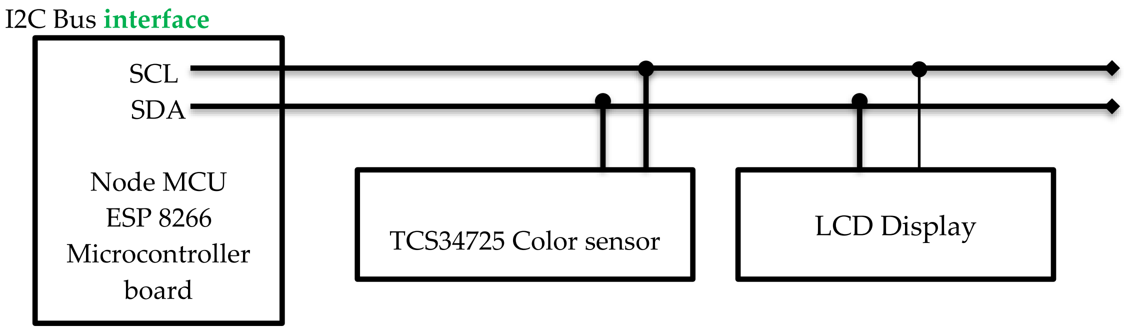

Figure 6: The I2C communication established in proposed prototype system

2.6 Software Implementation

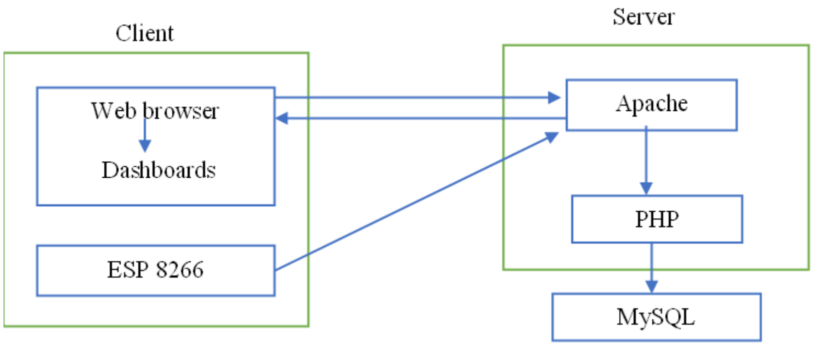

Figure 7: The proposed system software and network architecture

2.6.1 Client Side

Dashboards of the systems can be viewed through the web browsers in client side. Also ESP 8266 MCU was acted as the client and it was used to send data to the server. Clint side web-based dashboards were implemented using HTML and CSS.

2.6.2 Server Side

XAMPP local host service was used to host all the dashboards. Also XAMPP server facilitated to run PHP files through Apache server including MYSQL databases. Server-side programming was done by using PHP and Java Script. The analysis graphs were plotted using Google Graphs applet.

2.7 Defect rate for the focused QC process

Defect rate is a measurement of how many number of units are defective, out of a specific total number of units (Montgomery & Runger, 2018). In this study, defect rate was used as a measurement to determine product quality for production line. Defect rate was calculated using the following equation number 1.

$$defect\ rate\ = \frac{No.of\ defects}{No.of\ output\ tested} \times\ 100\ \%\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ [1]$$

3. Results and Discussion

3.1 Collected data from the system

Following data were obtained using the proposed and implemented main dashboard

- Total accept and reject count
- Defect rates for each operator
- Mean defect rate and production

Figure 8: The GUI of Main dashboard of the proposed navel system

Hourly defect rates were calculated and displayed for each team member in Hourly defect rate dashboard. Then team member's defect rates were compared using the chart. The fluctuation in defect rates of each team member was shown in the graph.

Hourly Defect Rates (%)

Hour	TM 1	TM 2	TM 3	TM 4	TM 5	TM 6
1	3.8	0	4	7.7	3.7	0
2	0	0	3.7	10	0	3.5
3	3.4	0	0	7.1	0	0
4	3.3	0	3.3	3.4	0	0
5	0	0	3.3	0	3.3	0
6	0	0	0	0	3.3	0

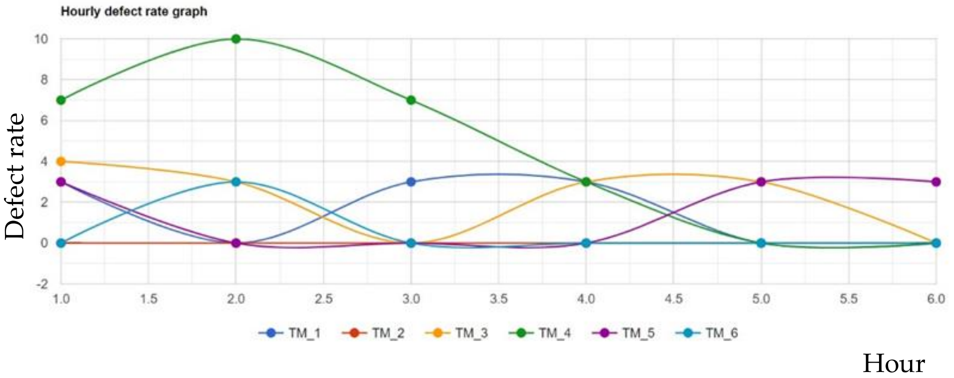

Figure 9: The calculated hourly defect rate and corresponding graph for each team member

Hourly productions were calculated and displayed for each team member in Hourly production dashboard. Each team member's production was compared using the chart (Sihombing et al., 2019). The fluctuation in production of each team member was shown using the following graph (Figure 10).

Hourly Production

Hour	TM 1	TM 2	TM 3	TM 4	TM 5	TM 6
1	25	27	24	24	26	25
2	26	27	26	27	26	27
3	28	30	28	26	27	29
4	29	30	29	28	30	29
5	30	30	29	30	29	30
6	30	30	30	30	29	30

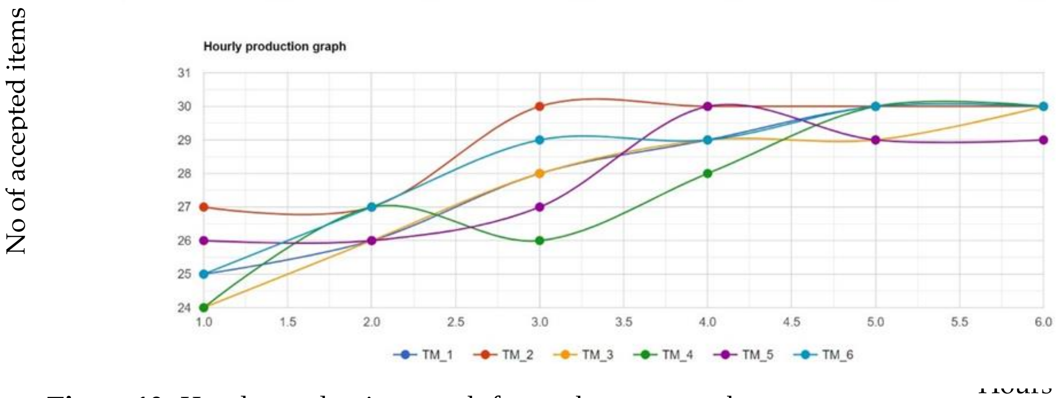

Figure 10: Hourly production graph for each team member

3.2 The Quality Degradation Test Results

Following graph shows that hourly defect rates for the first four (4) hours of the day. A significant increase in the defect rate of the team member 4 was observed during the first hour. It was also automatically indicated in red color on the main dashboard.

But considering the variation in quantity of accepted items produced, no significant variation was shown during the first hour for team member number 4. Quality degradation could quickly be identified by focusing on the defect rate rather than the number of accepted items displayed on the dashboard.

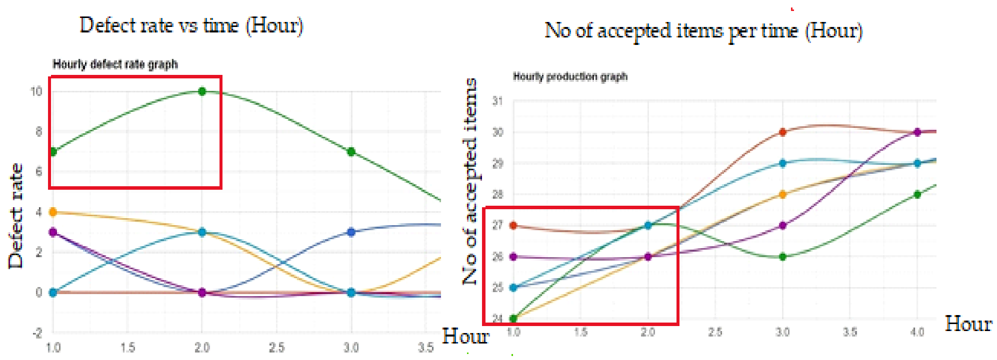

Figure 10: The Variation analysis for defect rate and production for the team member 4

3.3 Results obtained using the Innovative method for reducing quality degradation

After identifying the quality degradation, the reason for it was investigated. In this case study, it was caused by a very minor technical fault in the machine. After fixing that fault, the defect rate returned to normal.

Following graph shows that the team member number 4's defect rate after identifying and solving the problem of quality degradation. This was mainly done by using the quality checking system (QCS) against projected defect rate without identifying quality degradation (without QCS).

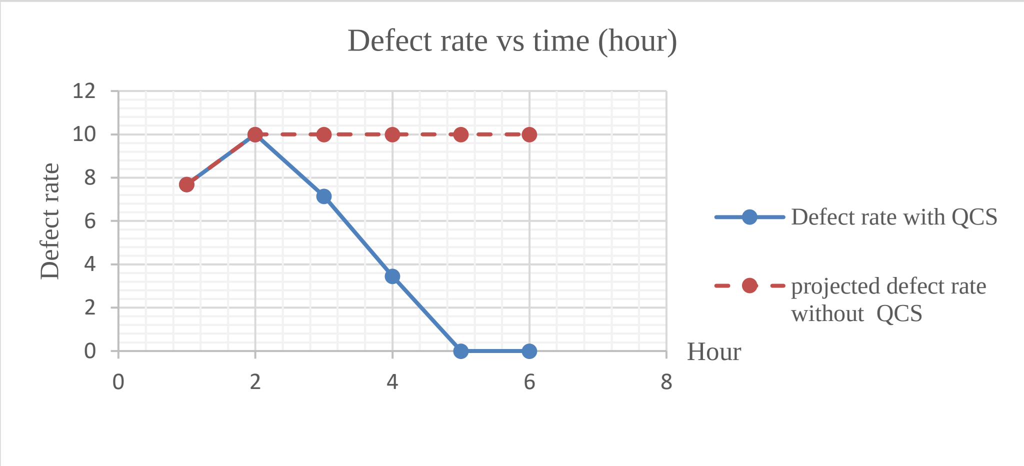

Figure 11: The 4's defect rate with QCS against projected defect rate without QCS

Let us consider team member 4,
Assume,
D1 = Mean defect rate after the identified quality gradation (with QCS)
D2 = Mean defect rate without identified quality gradation (without QCS)

By considering the data stored in database during the first 6 hours
D1 = 4.71
D2 = 9.62
Estimated percentage reduction in defect rate due to the

$$\text{use of QCS} = \frac{D2 - D1}{D1} \times 100\ \%$$

$$= 51.03\ \%$$

3.4 The Observation for the Increase of the production

An increase in the production was observed along with the decrease in defect rate of the team member No.4, which is illustrated in the following table 1.

Table 1: Team member No. 4 production with QCS and projected production without QCS

Hour	Total Production (Accept + Reject)	Defect rate with QCS (%)	Production with QCS	Projected defect rate without QCS (%)	Estimated production without QCS
1	26	7.692	24	7.692	23
2	30	10	27	10	27
3	28	7.143	26	10	25
4	29	3.448	28	10	26
5	30	0	30	10	27
6	30	0	30	10	27
Mean	29	4.71	27.5	9.62	26

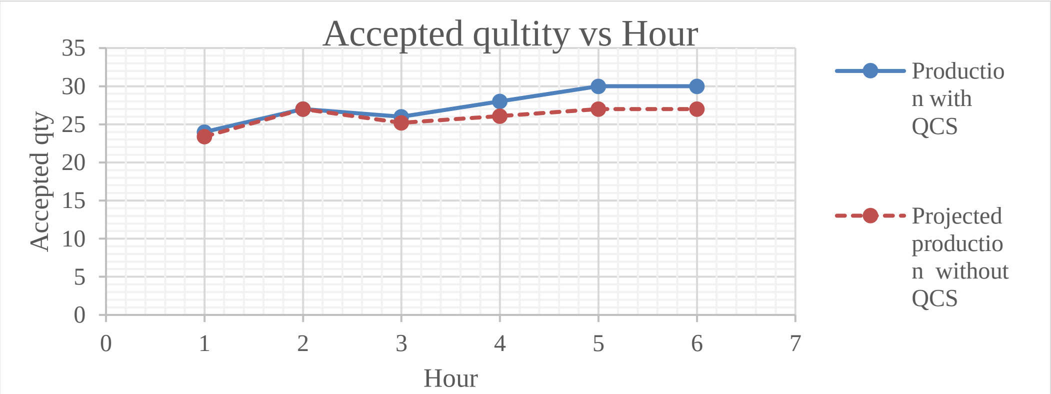

Figure 12. Member 4 production: with QCS against estimated production without QCS

In this research study, we have done following calculations in order to evaluate the increase in production compared to the quality degradation.
Considering team member No.4,
Assume,
P1 = Production rate after identifying quality gradation
P2 = Estimated production without identified quality degradation.

Estimated percentage increment in production due to

the use of QCS= $\frac{P1 - P2}{P2} \times 100\ \%$

$= 6.4\ \%$

4. Discussion and Conclusion

The above analysis based on the discussed case study shows that, it is convenient and more efficient to take the quality degradation decisions based on defect rate rather than number of accepted productions. Hence, the method could be used to detect quality degradation quickly rather than inspection of production rate by only using only human labor. To increase the quantity of production, the speed of the team member as well as the reduction of the defect rate were mainly affected. An increase in the production rate of the team members over the initial situation were observed as they continued to engage in the same operational task. Therefore, the increase in production speed can be achieved effectively by reducing the defect rate.

According to the trials done, it is observed that the defect rate of the concerned member was reduced by about 50% and the production rate was increased approximately by 6%. Moreover, by such real-time solving, the defect related root course of the defect can be reviewed with the quality degradation indications. It was concluded that the partial IoT based automated quality checking and data analyzing system proposed and designed in this research study can be efficiently used for apparel industry to enhance the quality control process effectively as well as more reliably with partial human quality control involvement.

5. Acknowledgement

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