Increasing the Accuracy of Color Measurement System to Reduce Waste of Non-Standard Color Problems in Kraft Paper Production.

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Article Info
Page Number: 6405-6415
Publication Issue:
Vol. 71 No. 4 (2022)

Article History
Article Received: 25 March 2022
Revised: 30 April 2022
Accepted: 15 June 2022

Abstract
This research is divided into two parts. Part 1 aims to study the design of standard calibration values based on comparative data collection. of internal auditors according to the International Commission on Illumination (CIE) standards and used for statistical analysis in order to use the analysis results to increase the measurement accuracy of the Color Sensor measuring instrument; A device to control factors that affect measurements, such as paper speed, light, heat or impurities. and set a standard for the measurement of the company by referring to the quality inspection department that limits the accuracy of the measurement range that does not exceed ± 0.5 for use in reducing the non-standard color waste in the kraft paper production process in the company

Keywords: Alternative Hypothesis (H1), Color Sensor, International Commission on Illumination (CIE), Null Hypothesis (H0), Spectrophotometer,

1. INTRODUCTION

The Thai kraft paper industry is continuously expanding its production capacity. In a case study, the paper factory uses the material as recycled paper to help reduce costs. Which can produce paper, which can be divided into 2 types [1], namely, plain paper (Liner) and corrugated (Medium), which the researcher has been interested in the paper, smooth (Liner), which from statistics showed that the occurrence of a lot of waste which is one of the many wastes That is a non-standard color waste. which can be caused by many reasons by collecting data and checking the initial problems found that in the production process will go through a variety of processes Since the import of pulp which the process used to calibrate the value of color Before reaching the internal quality inspector is The process of the indicators with the Color Sensor color measuring instrument based on the principle of simulating light [3]. by using artificial LED [2] lights to create light and hit the paper and the light hits the color reader which sets the angle of degrees according to the CIE [4] standard at 2 ° to reflect and transmit the signal to the program to be used as a measure of production when taking the measured value from the color measuring instrument to the calibration of the standard color measuring instrument.

2. OBJECTIVES

This document focuses on methods for reducing non-standard color waste in the kraft paper production process. by analyzing the root of the problem It focuses on the color measurement instrument used to measure color from the paper. and compared with standard measuring instruments QC Laboratory's Spectrophotometer [9]. to find ways to improve and optimize color measurement instruments. as well as to find ways to control factors that affect the measurement value of color measuring instruments to make the color measuring instrument more accurate when comparing the measurement value with the measuring instrument Spectrophotometer [11] with the following objectives :

1. Study the color sensor measurement principle and the factors affecting the color sensor measurements to create a control device for the factors affecting the color sensor.

2. To design value, calibration compensation is to be used to calibrate color sensors with an average difference of ± 0.5 or more than 95% accuracy (requirement from QC lab) when comparing measuring instruments Spectrophotometer.

3. To reduce the loss of non-standard color by less than 10% compared to the total waste in the kraft paper production process after improvement.

3. METHODS

The researchers studied the current problems in the kraft paper factory in a case study. The researcher will collect the measurement data of the color sensor (Figure 1.) instrument. There are 3 shades of all shades, namely blue (L), orange (a), and yellow (yellow), and the measured color values must be calibrated with a color measuring instrument. Spectrophotometer (Figure 2.) which is a standard QC Laboratory color measurement tool.

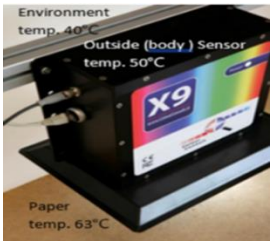

Figure 1. Color Sensor Measurement

Figure 2. Spectrophotometer Measurement

The researchers will analyze the problem with Fish-born Diagram.

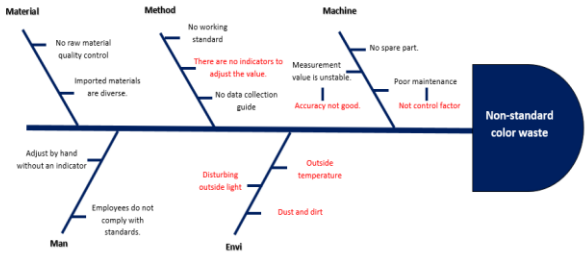

Figure 3. Fish-Born Diagram analysis

From finding the cause of the problem with the fish-bone diagram, it was found that the problem that resulted in the error in the measurement of the color sensor was caused by the Machine, which was an inaccurate and unstable measuring machine and Environment is a factor outside the control such as Temperature, interference light, dust and dirt.

therefore, invented a method to improve and solve the problem. divided into 2 methods

Method 1: Perform a manual test on factors affecting the color sensor measurements under three conditions:

1. Dirt and dust.
2. light interference.
3. The external combat temperature is more than 28 degrees Celsius.

It was found that all 3 factors affect the measurement value of the Color Sensor is shown in Table 1.

Table 1. shows the results of the experiment to determine the factors affecting the colorimetric values using KA125 grade paper.

Color Effect Test					Effect on the measurement value		
Color	Normal	Dirty	Add Light	increase the temperature (°C) > 40 °C	Dirty	Add Light	increase the temperature (°C) > 40 °C
Blue)L)	62.52	62.19	62.44	63.19	decreased	decreased	increase
Orange)a)	17.68	17.54	17.21	16.09	decreased	decreased	decreased
Yellow)b)	42.18	40.99	41.53	40.95	decreased	decreased	decreased

Method 2: The researchers collected 63 samples of KA kraft paper from a color sensor and

a spectrophotometer in order to use the results for analysis. To find ways to improve.

The researchers have hypothesized will be used difference average as the offset value calibration for color sensors to increase accuracy when comparing spectrophotometers.

The tests are performed with Software flex sim to determine the results to reduce the chance of errors in actual measurements and take the values for analysis Statistical analysis was performed according to the paired t-test by analyzing the measurement accuracy of the Color Sensor before and after improvement with the same dataset with the following assumptions:

Hypothesis(H_0) = 0 is the accuracy of color sensor before and after improvement There was a significant difference.

Alternative hypothesis (H_1) ≠ 0 is that the accuracy before and after the color sensor improvement was not significantly different. at the significance level of 0.05

3.1. DATA COLLECTION

The exam will be divided into 2 parts as follows:

In method 1: collecting data and experimenting with factors affecting the measurement value of color. After the experiment, it was found that the factors affecting the measurement value of the color as shown in Table 1.

Researchers have developed a JIG Prototype to cover to control the factors that affect the measurement so that the color sensor can measure more accurately.

Figure 4. FIRST PROTOTYPE

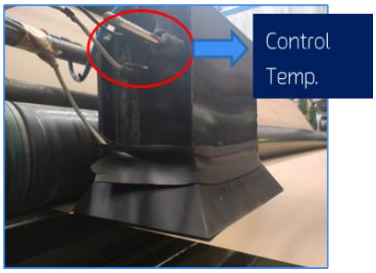

Figure 5. SECOND PROTOTYPE

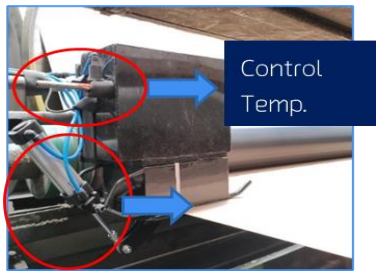

Figure 6. THIRD PROTOTYPE

After testing all 3 types of jig prototypes, the results are shown in Table 2.

Table 3. The table shows the results of the 3 types of color measurements with JIG designed.

Topic	Difference And Effect	Difference And Effect	Difference And Effect
	FIRST PROTOTYPE	SECOND PROTOTYPE	THIRD PROTOTYPE
Blue)L)	0.56	0.28	0.0015
Orange)a)	-0.25	-0.67	-0.03
Yellow)b)	1.02	1.87	0.05
Control Light	-	-	✓
Control Temperature < 40 °C	-	✓	✓
Dirty (Dust, Black pot, etc.,)	-	-	✓

Therefore, the researcher chooses the third Prototype that can control all factors that affect the color sensor measurements.

In Method 2: The researchers collected 63 samples of KA kraft paper from a color sensor and a spectrophotometer in order to use the results for analysis to find ways to improve.

As shown in Figure 3, shows the values of the colors L, a, and b using the color sensor measurement tool. and color measuring tools Spectrophotometer It can be seen that the measurement ranges of the two data sets are significantly different from each other.

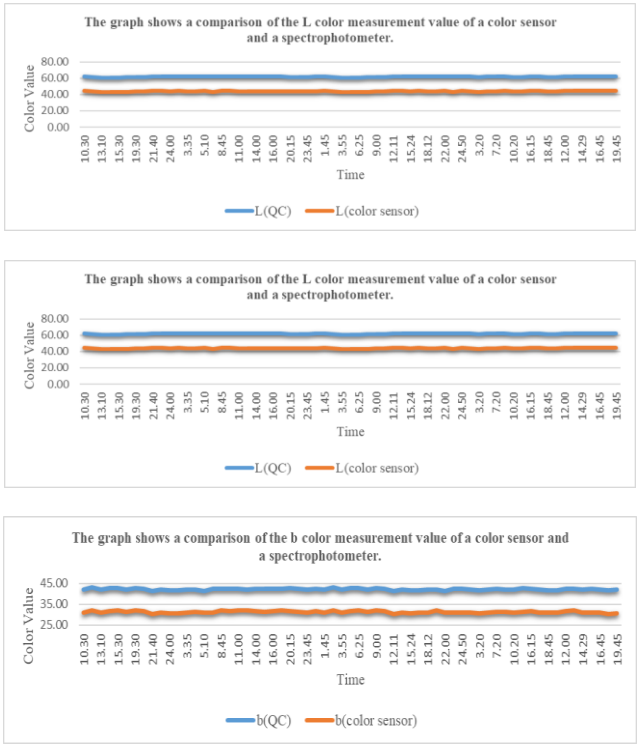

Figure 7. Data comparison of the L, a, b color measurement value of the color sensor and a spectrophotometer.

Analyze sample data from 63 color sensor measured values.

It was found that the measurement accuracy of the color sensor L was 71.24%, a was 65.56%, and b was 74.29% compared to a spectrophotometer. and having a mean difference of more than 0.5 As shown in Table 3, which resulted in the staff adjusting the color values cannot be adjusted correctly. Show in Table 3.

Table 3. shows the results of the analysis of the measurement data set of both types of measuring instruments

	Mean Difference	Accuracy
Color	(Average)	%
Blue (L)	17.77	71.24 %
Orange (a)	-6.04	65.56 %
Yellow (b)	10.98	74.29 %

The researchers have hypothesized will be used difference average as the offset value calibration for color sensors to increase accuracy when comparing spectrophotometers.

The tests are performed with Software flex sim to determine the results to reduce the chance of errors in actual measurements as shown in Figure 4.

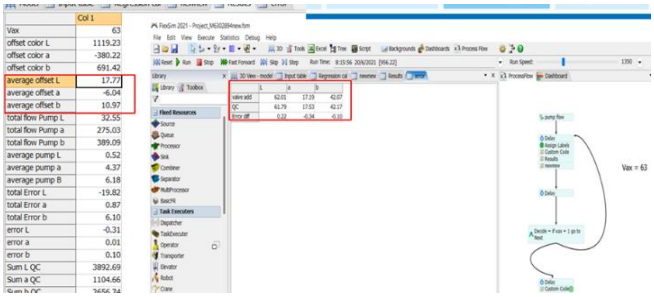

Figure 8. Image of mock test results for decision-making with Flex sim program.

After taking the mean difference as the offset calibration value for the color sensor to compare with the spectrophotometer.

It was found that the color sensor was accurate in color shades. L has an accuracy of 99.56%, a has an accuracy of 98.18% and b has an accuracy of 99.38%

Statistical analysis was performed according to the paired t-test by analyzing the measurement accuracy of the Color Sensor before and after improvement with the same dataset with the following assumptions:

Hypothesis(H_0) = 0 is the accuracy of color sensor before and after improvement There was a significant difference.

Alternative hypothesis (H_1) $\neq$ 0 is that the accuracy before and after the color sensor improvement was not significantly different.

at the significance level of 0.05

From the experiment, it was found that the P-Value in all three datasets was less than 0.05, thus accepting the hypothesis and rejecting the alternative hypothesis, concluding that the color measurement value of the color sensor and spectrophotometer There are significant differences. shown in Table 4.

Table 4: The table shows the analysis of the results of flex sim program

	Value of statistic	Accuracy	Mean Difference
Color	P-VALUE	%	Average
Blue)L)	0.11	99.68	-0.3144

Orange)a)	0.258	99.86	0.0140
Yellow)b)	0.313	99.90	0.0968

And display the result as a graph to be able to see the difference as shown in figure 8.

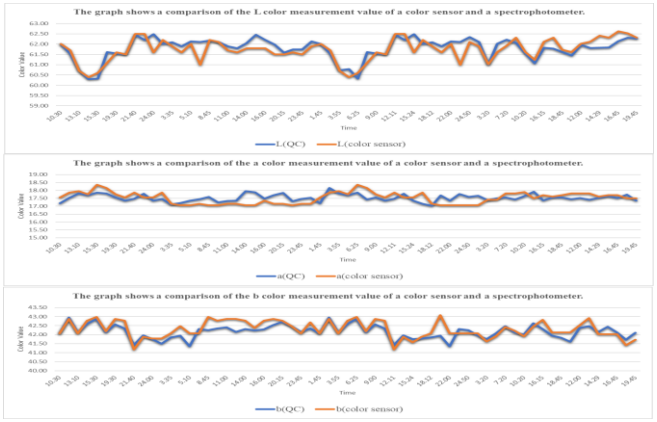

Figure 9. The graph shows the result after using the mean difference to increase the accuracy of the Color Sensor with the Flex Sim simulator.

3.2. RESULTS

By taking JIG THIRD PROTOTYPE from Method 1 and taking the Offset value from the mean difference from Method 2.

Let's test it together. They were measured while the machine was running by measuring 60 samples of KA grade kraft paper and comparing them with a spectrophotometer as shown in Figure 10,11 and collecting the results.

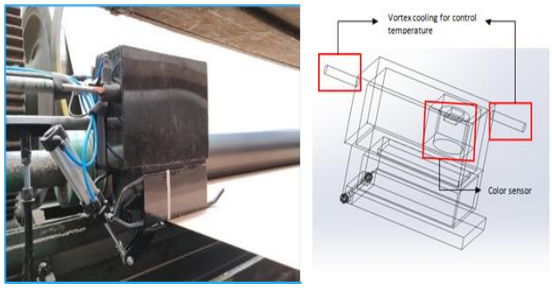

Figure 10. The picture shows JIG THIRD PROTOTYPE

Figure 11. Taking offset value in software.

It was found that in the color shade L has an accuracy of 99.76%, a has an accuracy of 99.39% and b has an accuracy of 99.20% with an average difference of not more than 0.5 according to the QC lab's requirements shown in the table 5.

Table 5: Graph showing the measurement result of the Color Sensor in KA after using Jig model 3 together with the offset value.

Color	Spectrophotometer	Color sensor	Accuracy	Difference	P-VALUE
	(avg)	(avg)	(%)	(avg)	
Blue (L)	61.98	62	99.76%	-0.02	0
Orange (a)	17.8	17.84	99.39%	-0.04	0
Yellow (b)	42.12	42.18	99.20%	0.06	0

4. CONCLUSION

In this study, the researcher divided the test into 2 methods which can be summarized as follows:

Method 1: The researcher designed an experiment to determine the factors affecting the measurement value of the color sensor measuring device. And designed devices to control the factors that affect the measured values. It was found that from the experiment, JIG THRID PROTOTYPE was able to control the factors affecting the color measurement value of the measuring instrument.

Method 2: The researcher hypothesized to analyze the color difference measured by the color sensor and the Spectrophotometer. Then the mean difference of the two measuring instruments is obtained. and the researchers hypothesized that If the mean difference is designed as a standard calibration for a color sensor measurement instrument. The resulting value will be more accurate and precise. and after experimenting and bringing the values to simulate the results, it was found that The mean difference can be used to increase the accuracy of the color

sensor measurement instrument. with a tolerance of not more than ±0.5 by statistical analysis by Paired T-Test to analyze the color values obtained from both measurement instruments for comparison before and after improvement.

when the two methods are used together It was found that after the improvement from actual testing By measuring the color of the Color Sensor, it was found that the accuracy was increased by more than 95% and the mean difference was less than 0.5 for all 3 shades shown in table 6.

Table 6: Graph showing Accuracy values after improvement using methods 1 and 2.

Accuracy values after improvement using methods 1 and 2.		Result
Accuracy by actual use	Difference	increased and more than 95%
L = 99.76 %	L = -0.02	
a = 99.39 %	a = -0.01	
b = 99.20 %	b = 0.01	

Comparisons were made before improvement from January to April. and after improvement from may to June found that in kraft paper liner There is less than 10% of non-standard color waste. shown in Figure 10.

Figure 12. Waste of non-standard color types decreased after improvement.

4.1 Proposed Improvements

from research results, The researcher predicts that if this research is used to collect results in other paper grades such as KAU, KJ, KX, etc., it will be able to increase the accuracy of the Color Sensor color measuring instrument to be more accurate compared to standard measuring instruments Spectrophotometer and organized as a measurement standard for the case study factory

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