© 2019 IJSRSET | Volume 6 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET196655

Optimization of Technical Parameters on the Color Variation in offset Printing Process

Tu Thanh Nam, Hoang Thi Kieu Nguyen*
Hanoi University of science and technology, Hanoi, Vietnam

ABSTRACT

In this study, the optimization of parameters of the printing process was carried out. The aim is to minimize the size of color variation in prints. A factorial design was used to evaluate the effects and interactions of three factors, that is, impression pressure, alcohol %, and press speed. The color variation is gauged by variation in ink transfer, which is governed by color difference (ΔE). The optimal conditions obtained from the desirable response are impression pressure of 0.15 mm, alcohol percentage of 12.2 % and press speed of 8500 sheets per hour. Under these conditions, about 0.62 of color difference is obtained.

Keywords: Offset Printing, Color Variation, Optimization, Experimental Design

I. INTRODUCTION

One of the foremost challenges faced by the printer is to control the shade variation in print both spatial and temporal for a given job. The color variation depends on many parameters of printing process such as impression pressure, ink and paper interactions, ink tack, press speed, fountain solution, environmental conditions,...To control these parameters many researches have been carried out. Rastko Milosevic et al [1] investigated the influence of different printing pressure levels between blanket and impression cylinders on sheet fed offset print quality. The print quality parameters considered for evaluation were tone value increase (TVI), gray balance, solid-tone optical ink density, relative print contrast, color gamut and color difference (ΔE). The investigated results were quite conflict for different evaluated parameters. For examples, the optical gray balance was achieved at normal printing pressure while low printing pressure exhibited good contrast and lower TVI and color difference parameters. The high printing pressure produced the highest color gamut volume and the highest solid tone optical ink density. Vikas Solanki et al [2] performed an experiment on effect of ink sequence on sheet fed offset print quality. The experiment was performed on art paper. Similar experiment was conducted by Lubdha Lade on effect of ink color sequence on color gamut. The results revealed minimum ΔE and maximum color gamut with KCMY. Sanjay Sharma et al. [3] focused to examine the effect of significant parameters such as ink tack, alcohol, and press speed on color variation.

The obtained researches indicated that the quality of printing process is dependent on the optimization of many influencing factors [3, 4].

In order to optimize the parameters of offset printing process, in this study the 2k experimental design [5, 6] was applied for evaluation of the individual contribution of selected variables to the color variation of prints. The investigated factors were impression pressure, alcohol percentage, and press speed.

II. METHODS AND MATERIAL

A. Materials and printing machine

- Coated paper 150 g/m2
- Nippon speed Ink
- Heidelberg speedmaster CD 102 printing press (2018)
- Fountain solution with addition of isopropyl alcohol, pH = 5.0

B. Printing process

The production runs were conducted on the coated paper (150 g/m2) for few days on a Heidelberg offset printing press. Variations of impression pressure, alcohol %, and press speed were investigated. The other technological parameters were set to a constant value.

In each experiment, 10 samples were random withdrawn from the printed sheets. The ΔE was calculated from these samples as an averaged value.

C. Color variation determination

The printed sheets were measured for L*a*b and ΔE values were computed as follows.

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2} \quad (1)$$

Where, L_1, a_1, b_1 and L_2, a_2, b_2 are color parameters of the OK sheet and the compared sheet, respectively

D. Experimental design and data analysis

In this work, a factorial design in which the influences of three experimental factors, e.g. impression pressure, alcohol %, and press speed, on the response, i.e. the color variation, was investigated. Two different levels were assigned to each factor. The factorial design is shown in Table 1. The levels of the factors are given by – (minus) for low level and + (plus) for high level. A zero-level is also included, a centre, in which all variables are set at their mid value.

A sign table, or design matrix, used to calculate the main effects and the interaction effects from the factorial design is constructed in Table 2.

TABLE I

FACTORIAL DESIGN

Exp. No	Variable			Response
	x_1	x_2	x_3	
1	-	-	-	y1
2	+	-	-	y2
3	-	+	-	y3
4	+	+	-	y4
5	-	-	+	y5
6	+	-	+	y6
7	-	+	+	y7
8	+	+	+	y8

TABLE III

MATRIX OF FACTORIAL DESIGN

Exp. No	X_0	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	$x_1x_2x_3$	Response
1	+1	-1	-1	-1	+1	+1	+1	-1	y1
2	+1	+1	-1	-1	-1	-1	+1	+1	y2
3	+1	-1	+1	-1	-1	+1	-1	+1	y3
4	+1	+1	+1	-1	+1	-1	-1	-1	y4
5	+1	-1	-1	+1	+1	-1	-1	+1	y5
6	+1	+1	-1	+1	-1	+1	-1	-1	y6
7	+1	-1	+1	+1	-1	-1	+1	-1	y7
8	+1	+1	+1	+1	+1	+1	+1	+1	y8

The experiments were evaluated in order to fit a regression model

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{123}x_1x_2x_3 \quad (2)$$

Where, y_j ($j = 1 \div N$, $N = 8$) is the response variable to be modeled; x_j ($i = 1 \div 3$)is the independent variable which influence y; b0, bi ($i = 1 \div 3$), b_{iu} ($i = 1 \div 3$, $u = 1 \div 3$) are model terms, that are estimated by

$$b_i = \frac{1}{N}\sum_{j=1}^{N} x_{ij}\, y_j \quad (3)$$

$$b_i = \frac{1}{N}\sum_{j=1}^{N} x_{ij}\, x_{uj} y_j \quad (4)$$

Analysis of variances (ANOVA) was used for graphical analyses of the data to obtain the interaction between the process variables and the responses. The quality of the fitted model was expressed with the coefficient of determination, R2, and its statistical significance was checked by the F-test. Model terms were selected or rejected based on the p value (probability) with 90% confidence level.

The regression model for real variables (z) describing the relationship between the investigated factors was determined from (1) by replacing variables x with z:

$$x_i = \frac{2(z_i^+ - z_i^0)}{\Delta z_i} \quad (5)$$

Where $\Delta z_i = z_i^+ - z_i^-$; z_i^+ , z_i^0 , z_i^- are values of the i[th] variable at high, low and mid level, respectively.
The optimum values of selected variables were obtained by using MATLAB 6.0. The interactive effects of the independent variables on the dependent ones were illustrated by three dimensional plots.

III. RESULTS AND DISCUSSION

Two different levels were assigned to each factor. These levels were experimentally determined to assure that the system has the ink transfer adapting to the requirement of offset printing technology (Color density is in the range from 1.4 to 1.7). The investigated results are reported in Table 3 – 5.

TABLE III

EFFECT OF IMPRESSION PRESSURE ON COLOR DENSITY

Pressure (mm)	Alcohol (%)	Speed (sph)	Density (D)
0.08	13	9500	1.2
0.09	13	9500	1.4
0.10	13	9500	1.5
0.11	13	9500	1.6
0.13	13	9500	1.6
0.15	13	9500	1.6

TABLE IV

EFFECT OF ALCOHOL % ON COLOR DENSITY

Pressure (mm)	Alcohol (%)	Speed (sph)	Density (D)
0.10	11.0	9500	-
0.10	12.0	9500	1.4
0.10	13.0	9500	1.5
0.10	14.0	9500	1.5
0.10	15.0	9500	-

- *Trouble in the printed sheet*

TABLE V

EFFECT OF PRESS SPEED ON COLOR DENSITY

Pressure (mm)	Alcohol (%)	Speed (sph)	Density (D)
0.10	13	7.000	1.2
0.10	13	8.000	1.4
0.10	13	9.000	1.5
0.10	13	9.500	1.5
0.10	13	11.000	1.4
0.10	13	12.000	1.3

Corresponding to the requirement, the experimental domains of three investigated factors were determined (see Table 6). Eight experiments in the factorial design and three experiments at the center point were simultaneously performed. All the experiment parameters are reported in Table 7 and the model matrix is given in Table 8.

TABLE VI

INVESTIGATED FACTORS: LEVELS AND CONDITIONS

Factor	Experimental domain		
	Level (-)	*Level (0)*	*Level (+)*
z_1:Impression pressure (mm)	0.09	0.12	0.15
z_2: Alcohol (%)	12	13	14
z_3: Press speed (sph)	8000	9500	11000

TABLE VII

EXPERIMENT PARAMETERS

Exp No	Pressure (mm)	Alcohol (%)	Speed (sph)	ΔE
1	0.09	12	8.000	5.5
2	0.15	12	8.000	4.1
3	0.09	14	8.000	9.8
4	0.15	14	8.000	7.5
5	0.09	12	12.000	7.1
6	0.15	12	12.000	5.5
7	0.09	14	12.000	5.2
8	0.15	14	12.000	5.7
9	0.12	13	9.500	2.8
10	0.12	13	9.500	2.2
11	0.12	13	9.500	2.4

TABLE VIII

EXPERIMENT PARAMETERS

Exp No	Pressure (mm)	Alcohol (%)	Speed (sph)	ΔE
1	0.09	12	8.000	5.5
2	0.15	12	8.000	4.1
3	0.09	14	8.000	9.8
4	0.15	14	8.000	7.5
5	0.09	12	12.000	7.1
6	0.15	12	12.000	5.5
7	0.09	14	12.000	5.2
8	0.15	14	12.000	5.7
9	0.12	13	9.500	2.8
10	0.12	13	9.500	2.2
11	0.12	13	9.500	2.4

Coefficient values and statistical parameters obtained for the model are given in Table 9. For assessing the statistical significance of the result, a t-test (t-Student) was carried to the 95% confidence level.

As the results shown in Table 9, with the confidence value > 95%, the coefficients, except b_{12}, are significant and the obtained equation is as follows.

$$y = 6.31 - 0.61 + 0.76x_2 - 0.43x_3 + 0.33x_1x_3 - 1.17x_2x_3 + 0.38x_1x_2x_3 \quad (6)$$

This model was then analyzed by F- statistical test for analysis of variance (ANOVA) to assess the “goodness of fit”. The analysis results are presented in Table 10.

The value of F-statistic (the ratio of mean square due to regression to mean square to real error) of 105 is much larger than $F_{0.05,8,7}$ (3.73) so the model is significant at the chosen probability level and it is correct [6]. In addition, the lack of fit error was used to test whether the model can fit the data well. The ratio between lack of fit (SS_{lof}) and pure experimental error (SS_{pe}) is much smaller the critical $F_{0.05,1,2}$ (18.51). This result confirms that the model adequately fits the data. The R^2 of 0.99 also indicates that only 1% of the total variation could not be explained by the empirical model [6]. Clearly, at that significance level, it is acceptable to use the obtained model that does not include the rejected terms.

TABLE IX

COEFFICIENT VALUES AND STATISTICAL PARAMETERS OBTAINED FOR THE MODEL

Coefficient	Coefficient value	Standard deviation	p-value
b_0	6.31	0.29	< 0.05
b_1	-0.61	0.29	< 0.05
b_2	0.76	0.29	< 0.05
b_3	-0.43	0.29	< 0.05
b_{12}	0.15	0.29	< 0.05
b_{13}	0.33	0.29	< 0.05
b_{23}	-1.17	0.29	< 0.05
b_{123}	0.38	0.29	< 0.05

Replacing the x variables by the z factors, the model for real variables is obtained:

$$y = -233.65 + 970.49z_1 + 17.75z_2 + 0.024z_3 \\ -79.80z_1z_2 - 0.103z_1z_3 - 0.02z_2z_3 + 0.08z_1z_2z_3 \quad (7)$$

The function above is now describing how the experimental variables and their interactions influence the color variation. The model shows that the interaction of pressure and alcohol percentage has a significant effect on the color variation on the printed sheets. An increase of alcohol with one scaled unit (e.g. from 12 to 13%) results in an increase of the delta E by about 17. Therefore, to remain the stability of color the pressure has to be enhanced 2 units.

TABLE IX

STATISTICAL PARAMETERS OBTAINED FROM THE ANOVA TEST PERFORMED FOR THE MODEL

Source of variation	Sum of square (SS)	Degree of freedom (ddl)	Average square	Fisher number	Signifi-cation	R^2
Regression	22.1	8	2.76	105	3.73	0.99
Residues	0.18	7	0.03			
Lack of fit	0.02	1	0.02	0.25	18.51	
Pure error	0.17	2	0.08			

The conclusion is clearly shown in Fig.1. A curvature in the surface of these factors indicates that they are interdependent. The response surface also implies that the optimal conditions were exactly located inside the design boundary (Fig.2).

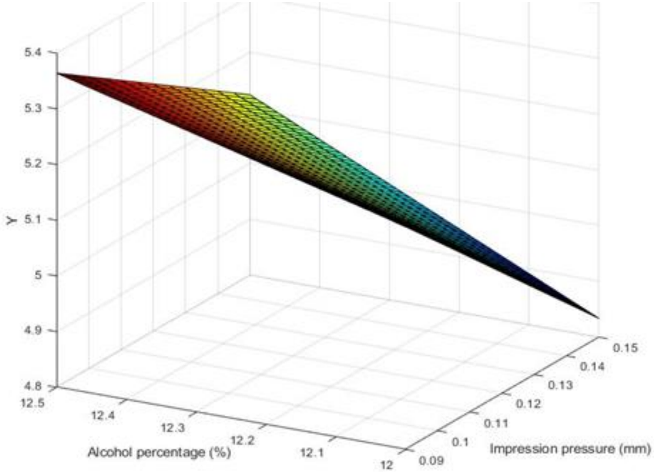

Figure 1: Surface graph of response y (color variation) showing the effect of pressure and alcohol % (at speed of 10000 sph)

From (6), by using MATLAB software, the optimal conditions are calculated as follows. z1 = 0.15 mm; z2= 12.2 %; z3 = 8200 sph. Under these conditions the minimized value of color variation is 0.62 (ΔE). A similar result was also observed by [3], in which the optimized setting was 8000 press speed, 2 ink tack value, and 6% alcohol.

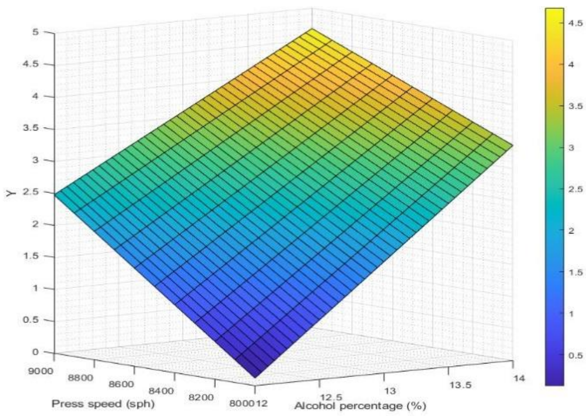

Figure 2: Surface graph of response y (color variation) showing the effect of alcohol and press speed (at pressure of 0.15 mm)

IV.CONCLUSION

The results showed that the three factors considered in this study play an important role in the printing process. The optimal conditions obtained for impression pressure, alcohol percentage, and press speed are 0.15 mm, 12.2% and 8200 sph, respectively. Under these conditions, about 0.62 ΔE of color variation is obtained. This value means that the deviation of color cannot be observed.

V. REFERENCES

[1] Milošević, R., Kašiković, N., Novaković, D., &Stančić, M. .2014. Journal of Chemical Technology & Metallurgy, 2014,49(4), ISSN:1314-7471

[2] Solanki, V., Pandey, A., & Kundu, A. Effect of Ink Sequence In Sheet-fed Offset Print Quality

[3] Sanjay Sharma. 2016. International Journal of Innovative Research in Science, Engineering and Technology, 2016, 5(5) ISSN:2347-6710

[4] Ho My Thanh, Tran Van Thang, Hoang Thi Kieu Nguyen. 2016. International Journal of Engineering Research & Technology, 2016, 5(12), ISSN: 0974 –3154

[5] T. Lundstedt, E. Seifert, L. Abramo. 1998. Chemometrics and Intelligent Laboratory Systems, 1998, 42

[6] I. Fendri1, L. Khannous, A. Timoumi. 2013. African Journal of Biotechnology, 2013, 12(30), ISSN:1684-5315

Cite this article as :

Tu Thanh Nam, Hoang Thi Kieu Nguyen, "Optimization of Technical Parameters on the Color Variation in offset Printing Process ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 6, pp. 229-234, November-December 2019. Available at doi : https://doi.org/10.32628/IJSRSET196655
Journal URL : http://ijsrset.com/IJSRSET196655