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Study of PG-Added Fountain Solution for Printing Offset Technique

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Abstract.
Although the printing technology, especially offset printing, has changed and grown quickly based on advanced invention and production capacity. However, the old offset machine printing such as one or two colour offset machines are still used massively in development countries. It is unpredictable when the old printing technology eliminated completely from the community, since it is affected by the economic level and extraordinary need of the public such as public election. The old machine which has been produced for more than 10 years usually has an issue related to the ink-water balance (iwb). The use of propylene glycol (PG) as single wetting agent improved iwb based on our previous study. Therefore, the effect of PG with fountain solution to the print quality is studied here. A series of fountain solution (FS) with additional content of 0 ppm, 13 ppm, 20 ppm, 40 ppm of PG was used to print an image on the art paper surface using sakurai offset machine. The optical parameters such as optical density (OD) and L*a*b were used to observe the effect of PG content in FS to the quality of printing. The OD on 0 ppm (reference), 13 ppm, 20 ppm and, 40 ppm of PG were 1.76 (reference), 1.83, 1.76, and 1.74, respectively. The optical density was identified as the maximum value at 1.83 on raster 100% of black colour for PG 13 ppm. At 13 ppm PG-added FS, the ΔE values of black (K) and Magenta (M) were 5.2 and 9.8, respectively, while ΔE values of cyan (C) and yellow (Y) were 1.7 and 1.8, respectively. It meant at PG 13 ppm, the K and M were stronger than the reference, while C and Y were equal. The same and lower OD compared to the reference showed unimproved color.

Keywords: offset printing, fountain solution, propylene glycol

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1. INTRODUCTION

The massive increases in global population and wealth since the beginning of the 19th century have been associated with equally massive increases in the need for life. [1] The natural source is getting limited to fulfill human needs. The exploration of new sources for human life is always in progress, including natural and energy resources. The consequence of natural resource use in correspondence with human activity is not only the limited resources but also the impact of environmental change, including climate change. Therefore, the natural and energy resources and the environment are the challenge issues for human life.[2-4] The rate of growth of global primary energy consumption has been remarkably stable since 1850 (2.4%/year ±0.08%) and shows no sign of slowing down. [5] The growth of energy consumption is triggered by the wide inventions of technology that support wealth, such as food storage, washing technology, transportation, medical science, and so on. All the inventions lead to further new material design and production, which have side effects including cost and waste. Based on this thinking, we can contribute to providing an invention to prolong the old technology as long as it is suitable for use.

Due to printing technology, the trend also changed from conventional technology to digital, from massive production to production on demand. Digital printing tends to boom, touching on the need for multiplied documents at every level. It seems cost-effective from a customer perspective with varied products.[6] However, digital printing, which will fill the market until the household level, offers massive production of electronic devices. Then we can predict that electronic waste has more difficulties in handling compared to a larger printing machine. Therefore, the more advanced technology in the printing industry, the more issues of technology waste handling arise, especially in relation to environmental challenges.

The use of high-performance printing machines such as a series of speed masters from Heidelberg is gradually eliminating the use of old machines such as Hamada and Ryobi. In large-population countries such as Indonesia or Southeast Asia, such as Vietnam, Thailand, and the Philippines, the old type of printing machine, as we mentioned before, still exists and competes with digital printing. The customers of old-type printing machines tend to be in a neat market related to the need for one or two color-printed products. The business players who run this machine are involved in micro and small enterprises (MSE). In fact, the MSE is more resistant to the economic crisis compared to big companies. MSE became the backbone of Indonesian economic crisis-solving in 1997 and during the COVID pandemic in 2019–2022. [7] In Indonesia, there are around 63.000 printing companies, and 80% of them are SME. They have to compete and keep their customers for life with minimal production tools, such as old-type machines.[8] The big printing companies in Indonesia are less than ten of those that specialize in price-setting printing products. Therefore, only around 15% are midsize companies that operate the old machine printing, which is more than 10 years old.[9]

Regarding the existence of printing SME, which operates the old printing machine to serve high demand for printing products such as envelope, brochures, and official sheet matter, we considered strengthening the role of SME by improving their product quality without the need for a new high-performance printing machine by evaluating the process conditions. It is well known that the old printing machines have issues with production capacity and accuracy. [10] However, most SME keep using this production tool because there is no choice related to financial ability. In addition, the maintenance of machines is limited by financial budgets. In the case of an offset printing machine, the water-ink balance is the key to getting an acceptable quality printout. Therefore, it can be a big issue for the operator to handle the old offset printing machine, which needs extra focus on maintenance activities, especially for the cases related to the fountain, inking, and printing unit. The fountain and inking units supply water and ink to the printing unit, respectively. On the surface of the printing plate in an offset printing system, water holds the area of the non-image while ink attaches the area of the image. The surface image is then transferred to the blanket and pasted to paper as a printout. The problem appears when water moves to the image area or ink goes to the non-image area and the water and ink mix, decreasing the print quality through emulsification.[11] The print-out quality is defined by observing density, brightness, and cleanliness compared to the standard or proof.[12]

The accuracy of a color printout is affected by the quality of the printing material, such as paper or ink, and the comfort between ink and paper. The ink-water balance on the printing plate also plays an important role. However, there is no guarantee that the image area is free from water. It depends on the printing plate quality as well—how strong the hydrophilic or hydrophobic surface of the printing plate is. [13] We have discussed this issue.[12] Therefore, for the old machine, we assumed the water content was higher on the image area as a hydrophilic surface than on the high-performance printing machine. The effort of this research is to tune the water content of the hydrophilic surface on the printing plate used in the machine so that the printout quality may equal that of a new advanced printing machine.

2. METHODOLOGY/ MATERIALS

In this research, a Sakurai printing machine was used, produced by Sakurai in 1975. During the process of printing, the normal wetting agent usually used in production was 4% of the fountain solution concentration with 8% of IPA. We bought a fountain solution from the market. The pH of the solution in the printing process was kept at 4.5 to 5.5, while conductivity must be lower than 1500 μS. We used art paper for printed material, which was commonly used by MSE printing in Indonesia. The specification of art paper is 98.87 gsm, 89.39% brightness, 97.50% opacity, 47.50 g/cm^2 (cobb test), and 6.81 cm of oil absorption. To produce the printed samples, we prepared a normal wetting solution as standard. The printout with standard wetting agent was then compared to the printout that used a series of standard wetting agents with propylene glycol-added 13 ppm, 20 ppm, and 40 ppm. We printed out 500 sheets for each different wetting solution to ensure the stability of printing production. We observed all the printouts from the density and L*a*b for each color, such as cyan, magenta, yellow, and black, using Techon.

3. RESULT AND DISCUSSIONS

In our previous work [12], the use of propylene glycol lead to improve the density and brightness of printout. However, we did not consider the existence of fountain solution commonly used in printing production. The main components of fountain solution are isopropyl alcohol (IPA) and Arabic gum (AG).[14] [15] The IPA decrease surface tension of solution which lead to better surface wetting which means only a tiny layer of water existed on the plate surface. A tiny layer water is easy to evaporate which make surface dried and ink might cross to non-image area. The AG is needed to prohibit the fast drying on the non-image area surface since the water can be hold. Therefore, we kept the acidity wetting agent at the range 4.5 to 5.5 where GA solved on the solution well, because the higher acidity the GA tent to deposit on the base of water tank, while the lower, the GA might be floated. For the wetting agent, we used deionised water with 26 μS. When the fountain mixed with the deionised water to get 4% fountain of wetting agent, the conductivity was measured at 268 μS. After printing process, the conductivity reached to

980 μS. The standard of conductivity of wetting agent below 1500 μS is the best practice of offset printing process in Indonesia.

As seen at Figure 1, for the optical density of printout, we checked the black color produced solution with propylene glycol (PG) 0 ppm, 13 ppm, 20 ppm, and 40 ppm added in the fountain solution. The black (K) is the stronger color compared to cyan, magenta and the weaker is yellow. The CMY are still able to reflect the light while the black (K) adsorbs the light coming completely. In addition, K can hinder the CMY. Therefore, we measured the optical density with 100% of tone value. The data measurement can be seen as follow:

Table 1: The PG-added wetting solution versus optical density of printout.

PG (ppm)	0	13	20	40
OD	1.76	1.84	1.76	1.74

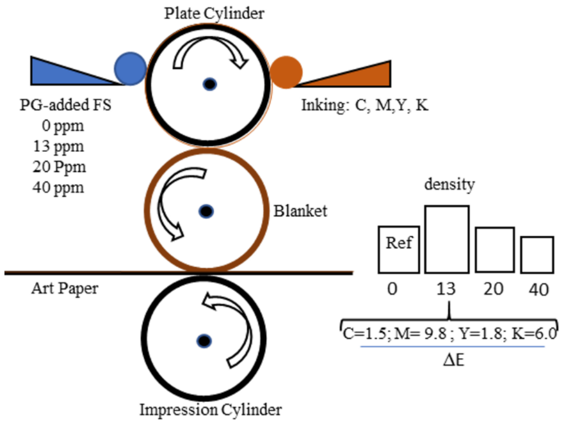

Figure 1: Schematic data taking procedure and observation.

Based on the table 1, the 13 ppm PG added to the wetting agent (fountain solution) increased the density from 1.76 to 1.84. However, the higher of PG content the density tent to decrease. The PG strengthened the role of IPA added in fountain solution through thinning the water layer on the plate surface. In this case, the 13 ppm PG added was able to remove the trace water on the image area part of the printing plate and the image area accepted the ink perfectly. However, the more PG added, the presence of water on the non-image area lead to be less and the trace of PG took place of image area. To observe the effect of PG presence, we took data of L*a*b as follow.

Table 2: 0 ppm PG-added FS (as reference)

Color	Cyan	Magenta	Yellow	black
L*	44,21	41.79	82.58	15.91
a*	-27.44	76.72	-3.12	1.34
b*	-56.19	13.30	104.6	5.23

The information in Table 2 was optical data taken from the normal wetting solution used in printing process. The content of wetting solution is IPA, GA, buffer and other sold in the public market with plastic container packaging. This product is commonly used in local printing production. We used the data on the Table 2 as a reference to calculate the difference color.

Table 3-5 are to showing the chromatic color of printout when the printing process used wetting solution added with 13 ppm, 20 ppm and 40 ppm of PG. The color then compared to table 2 to explore the effect of PG-added in the wetting solution.

Table 3: 13 ppm PG-added FS.

Color	Cyan	Magenta	Yellow	black
L*	43.53	49,15	81.73	18.08
a*	-26.89	72.10	-1.91	1.38
b*	-57.33	-5.18	103.60	10

Table 4: 20 ppm PG-added FS (reference).

Color	Cyan	Magenta	Yellow	black
L*	45.08	45.50	82.90	16.68
a*	-28.72	74.48	-3.06	-0.07
b*	-56.39	1.96	104.41	9.16

Table 5: 40 ppm PG-added FS (reference).

Color	Cyan	Magenta	Yellow	black
L*	41.98	42.3	81.65	21.78
a*	-19.64	74.34	-2.56	-2.37
b*	-53.90	11.6	97.54	3.69

The difference color between printout using normal wetting solution and PG-added wetting solution was calculated using L*a*b* coordinate with formula below,

$$\Delta E = \sqrt{\left(L^{*} - L_{n}\right)^{2} + (a^{*} - a_{n})^{2} + (b^{*} - b_{n})^{2}}$$

Where L*, a* and b* are the measured data of lightness with scale from 0 to 100, the color range from greener to redder, and from bluer to yellower, respectively. Greener and bluer were symbolized with negative sign, while redder and yellower were positive sign. For example, the more negative of a*, the greener, and the more positive of a*, the redder. ΔE is deviation of chromatic color compared to the reference (standard). L_n, a_n, b_n are L*, a* and b* taken with wetting solution PG-added 13 ppm, 20 ppm and 40 ppm.

As seen at the table 6, the added PG 13 ppm to 20 ppm, the M and K were changed because the ΔE more than 5 (due to iso 14642-2, 2017), while The C and Y remained the same as reference. However, when the added PG was 40 ppm, all colors were totally different from reference. This data was inline to OD as seen in table 1, where the density changed at added PG 13 ppm. However, the more PG added, density turned to the same as reference which meant the color quality decreased because PG trace presented on the image area substituting the water trace.

From table 1 and table 6, the different color lead to different quality of color between reference and color from PG added process. The different color, especially M and K, at PG added 13 ppm offered the better quality color compared to reference because at that point, the OD was also better than reference. Vice versa, the different color at PG added 20 and 40 ppm showed unimproved color quality, even the color got worse since at that point the OD decreased.

Table 6: Difference color in using of normal versus Pg-added wetting solution.

PG-added	color	ΔE
13 ppm	Cyan (C)	1.4
	Magenta (M)	9.8
	Yellow (Y)	1.8
	Black (K)	5.2
20 ppm	C	1.6
	M	10.6
	Y	0.4
	K	6.0
40 ppm	C	8.4
	M	6.7
	Y	7.1
	K	7.1

ISO 12647-2:2017 perspective. Since we used the coating paper, the size of dot shall be 20 to 30 micron. Assessing the print quality, the color of print substrat need to be examined as one of the factors to calculate the deviation of print color measured compared to the proof. In addition the L*, a* and b* of printout must be considered to evaluate the color difference, especially for C, M and Y since the integration of them give the grey instead of K. Gloss the substrate must be 10 to 80. However, we considered that the material and the process were best practice applied in the public where traditionally the print quality examined based on experience of the operators, due to the characteristic of micro and small enterprises. Therefore, the main points of the research goal were observing the increase quality with the standardized material and process printing based on micro and small printing enterprises capability. The term of standardised was keeping the consistent condition between reference and process-innovated printouts.

4. CONCLUSION AND RECOMMENDATION

Refer to our work before [12], the role of PG was to hold the trace water molecules on the image area of the printing plate increasing quality of printout. Although the presence of IPA in commercial wetting solution was not able to remove trace water molecules on the image area, it synergised with PG added to limit the water volume attached on the plate surface, lead to minimize use of PG. However, if the content of PG in the wetting solution became excessive, the role of trace water molecules on the image area replaced by PG which decreased the quality of printed out color.

Since IPA-PG synergism in the wetting solution, the concentration of PG became critical point to boost the quality of printed out color. In this work, printout quality at 40 ppm of PG showed decrease while 13 ppm indicated the better quality than reference. However, the optimal concentration of PG, in synergism with commercial IPA, need to be explored more.

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