Evaluating the Change in Print Quality Due to Liner in Self Adhesive Labels

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Abstract: ***Self Adhesive Labels have the 4 layered sandwich structure of face paper, adhesive, silicone coating and release liner. The liners act as carriers for the labels throughout the processing stage and come out as clean waste in the label application stage. There is an attempt to replace the glassine paper liner labels with the filmic liner labels as they are lighter and recyclable and compact compared to glassine liners. The aim of the project is to evaluate the print performance of the polypropylene film liner labels in comparison to the glassine paper based labels. The design of experiments is done with relevant print quality parameters for the two label stocks. The responses of 2 materials at different levels of important printing factors are found. Study showed similar values with the two liners. The statistical analysis shows no significant change in dot gain by changing the liner hence equal print performance with two materials.***

Keywords: Self Adhesive Labels, glassine liner, Polypropylene liner, dot gain, print quality

1. Introduction

The self adhesive label forms an important part of packaging as the information carrier in most of the bottles and containers. It is popular among the different types of labels because of its ease of use and automation possible. It is fast growing in Indian label market. Comparatively the waste released into the eco system also is affected. The liner that comes out of the process as a clean waste can be reused or recycled for reducing the burden of land filling. The glassine liner can be recycled but the process is complicated and recycled material has limited use hence not practiced in industry. The Polypropylene (PP) film liner is easy to recycle and can be used to make other commodities like moulded chairs, furniture etc. Filmic liners are lighter in weight with equal strength and hence will be required in lesser quantity apart from being recyclable.

The PP liner is thinner and has a smooth surface. This can affect the print quality as the stock thickness may interfere with the impression pressure and hence the print reproduction. The smooth surface may give better and uniform print quality. So the study of two materials on press is subject of interest.

2. Label Printing

The label printing machines are narrow web flexography machines and come with inline finishing like varnishing, die cutting and sheeting or winding. The printing unit consists of ink tray, fountain roller, anillox roller, plate roller and impression roller[1].

- Fountain roller is covered with natural or synthetic rubber and rotates in the reservoir of ink. It picks up and delivers a heavy flow from fountain to the anillox. It is driven slower than anillox to wipe excess ink.
- Anillox is the ink metering roller and controls the flow of ink to the plate.
- The plate roller carries the image carrier plate which is mounted using sticky back tape. Impression roller is a plain steel roller that supports web during printing.

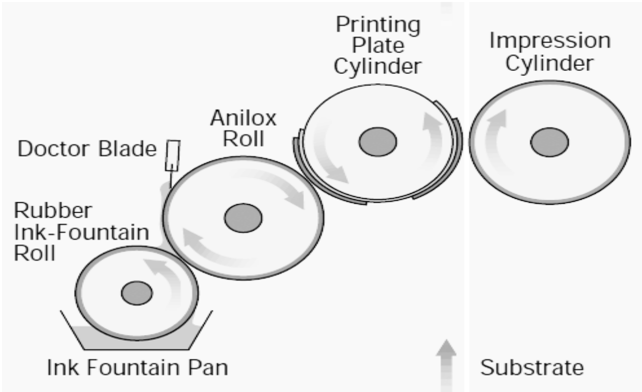

Figure 1: Schematic diagram of flexography

The plate roller has a smooth metallic surface onto which the sticky back tape is applied without air bubbles and then the rubber or photopolymer plate is stuck with proper alignment. Distortion factor is calculated using formula reduction%=K/D where K is given by plate manufacturer and D is the printing circumference.

Anillox roller the engraved inking roll is the heart of inking system. It is engraved by mechanical or laser engraving process. The cells may be of different shapes corresponding to different volumes, engraved at specific screen rulings ranging from 80 to 1200 lines per inch. For finer qualities the screen ruling of anillox should be 4-6 times more than the plate screen ruling[1].

After printing there is a die-cutting station where the die mounted on the rotary cylinder of required repeat length cuts through the face material without damaging the liner. The die is made of steel is mounted on the magnetic cylinder. The waste from non label area is stripped and wound onto matrix roll. The liner with the label is wound into a roll.

3. Literature Review

According to the technical paper by Laurel and Girard on measurement of printability in flexography, the important factors that affect print quality are ink, substrate, anillox roller specifications, plate characteristics, impression pressure and speed. In case of the chosen project the plate, anillox and ink are kept the same. Hence the effect of measurable factors screen ruling, speed and the material types are of concern. The quality quantification is done by the factors like mottling, edge sharpness and cleanliness of solid area[2]. Orloff, Challas and Rudman have worked on effect of ink and impression pressure on print quality[3].

3.1 Effect of substrate on density and dot gain

In his technical article Mr. Dimitris Ploumidis in Gravure Exchange has discussed effect of substrate on density and dot gain[5]. Density, or reflective density to be more accurate, is a measure of the percentage of reflected light. In printing processes, this usually means the percentage of light that is reflected from the substrate and the ink.

$$\textbf{Density} = \log_{10} 1/\text{Reflectance factor}$$

The dot area is, percentage coverage of ink on the substrate. In reality ink spreads (or gains) and covers a larger area. This additional percentage is defined as dot gain or Tonal Value Increase (TVI). Dot area (A), is given by density of the tint (Dt), and solid density (Ds)—in the Murray-Davies Equation.

$$A = (1-10^{-Dt}) / (1-10^{-Ds})$$

Usually, during production, the 50 percent or 40 percent dot areas are measured since the gathered value provides an overall insight for the whole reproduction scale. The substrate has a major effect on the amount of dot gain. The table below is useful in illustrating the relationships. The same amount of magenta ink laid down on a coated and an uncoated substrate gave following results as per the authors[6].

Table 2: The effect of substrate on dot gain

Magenta	Dsolid	D80%	D40%	DG80%	DG40%
Coated	1.42	0.86	0.33	9.60%	15.40%
Uncoated	1.04	0.82	0.39	13.40%	25.20%

3.2 Influence of surface characteristics on dot gain

In a technical paper published in advanced material Research by Zhen Cai Qu and Guang Xue Chen the influence of surface characteristics to dot gain is studied, and the law of dot gain with paper surface characteristics is discussed. The results showed that dot gain is different in different papers, dot gain is also different with different colors in the same paper, and it is serious in cyan but light in yellow [6].

4. Methodology

Design of experimentation is very essential to statistically prove the results through mathematical models. With mathematical models trend line can be extrapolated to estimate the results for some new combination of data. Based on literature review it was found that change in substrate finish can affect dot gain during printing. To find statistical evidence apart from substrate two other factors speed and screen ruling were also taken up in designing of the trials. So the trials are carried with the same set of parameters at different machine speeds and screen rulings for the two label stocks. Full factorial experimentation led to conducting eighteen trials[7].

Table 1: Design of experiments

Factors	*Levels*	*Values*
Speed	3	40,50,60 (metre/minute)
Screen Ruling	3	133,150,175 lines per inch(lpi)
Substrate liner	2	Glassine, PP

6 color narrow web flexographic printing machine was used to print the test chart using UV curable inks. Digital photopolymer plates 1.14mm thick are used for printing. Kodak Thermoflex narrow platesetter is used for exposing the plate and thermal developer used for plate processing. Distortion compensation given was 6.06% and round dot shape was used. Angles used for platemaking are 7.5^0, 52.5^0, 22.5^0, 82.5^0 respectively for yellow, Magenta, Cyan , Black. Anillox rollers used were of 1000 lines per inch screen ruling for all the colors with cell volume of 4 billion cubic micron per m^2. Laser engraved anillox rollers are used with an angle of 60^o. UV lights with an emission of 160W/cm are used to cure the inks. Label stocks used have a structure of white coated gloss paper, rubber hotmelt adhesive and the liner is glassine in one and clear polypropylene in another. X-Rite's Spectro Eye was used for measuring density and dot gain.

Flexographic Image Reproduction Specification and Tolerances has given the standard print density for process colors for different substrates[8]. It is important to maintain the same density throughout printing to get a standard platform for comparison. The print densities are maintained by choosing right kind of ink and with proper usage of anillox rollers. Total Area Coverage is maintained within the specifications by using proper settings in the plate making process. An tolerance of 0.1 is considered for densities while printing[4].

Table 3. FIRST values of flexographic ink densities

Machine Type	*Substrate*	*C*	*M*	*Y*	*K*
Narrow Web	Paper	1.35	1.25	1	1.5
	Film	1.25	1.2	1	1.4

5. Results

The printing trials were conducted till stable results were seen and when the print density values were as per FIRST specifications 100 samples were collected for each of the trials. Dot gain values were measured for 30 sheets for each of the trials. Average of the readings is taken and the graphs and tables are used to visually analyze the trends.

- Text sharpness was found to be reproduced similarly at all trials at a fine quality up to 3 point size and readable but with less sharpness at 2 point size. The visibility was clear with cyan, magenta and black but less for yellow below 3 point size both direct and reverse text.
- Lines were sharp up to 0.1 point size in both direct and reverse in all trials.
- Bar codes were detected 100 % for all the combinations.
- Images were visually inspected and no significant difference was evident.

Dot gain values for dot areas starting from 10 to 90 are tabulated in the intervals of 10%. It can be seen from the data that there is direct relation between screen ruling and dot gain. At each of the speeds 40m/min, 50m/min and 60m/min the values of dot gain increase as the lpi is changed from 133 to150 to 175 for glassine liner label. Similar trend is seen with polypropylene liner based labels. So it can be interpreted that the screen ruling has an effect on dot gain in self adhesive labels irrespective of speed and liner material in the given situation.

Table 4: Dot gain values for glassine liner label

Speed	*40 m/min*			*50m/min*			*60m/min*		
Dot Area %	133 Lpi	150 Lpi	175 Lpi	133 Lpi	150 Lpi	175 Lpi	133 Lpi	150 Lpi	175 Lpi
90	7	9	9	7	9	9	7	9	9
80	15	17	18	14	16	18	14	16	17
70	20	24	25	18	23	25	18	23	25
60	23	29	30	21	27	30	20	26	30
50	25	33	34	22	31	34	22	31	33
40	27	35	38	26	32	34	24	33	34
30	28	36	36	26	33	34	24	33	34
20	27	34	35	25	30	31	24	30	30
10	25	30	30	20	24	24	21	24	24

Table 5. Dot gain values for polypropylene liner label

	40 m/min			50m/min			60m/min		
Dot %	133 Lpi	150 Lpi	175 Lpi	133 Lpi	150 Lpi	175 Lpi	133 Lpi	150 Lpi	175 Lpi
90	5	7	8	6	9	9	7	9	9
80	12	14	16	13	15	17	13	16	17
70	15	19	22	18	23	24	18	24	25
60	17	22	26	20	27	29	20	27	30
50	19	26	28	23	32	33	22	31	33
40	20	27	28	25	33	34	24	33	34
30	21	25	26	25	33	34	24	33	33
20	16	21	21	24	30	31	23	29	29
10	15	18	18	20	24	24	19	23	22

For analysis the dot gain at 50% dot area is chosen as it can represent other dot areas. It can be seen from the response table that the dot gain is less with PP liner material at low speed of 40m/min. But at other speeds the values are similar. Hence there is not effect of liner material seen on dot gain. Using analysis of variance and plot of single factors as well as interactions the significance of different factors chosen in the experiment on the response values are studied. Based on probability values the model stands significant or not[8]. The trials were done for all process colors but cyan is taken for representation since in cyan color differences will be more visible.

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Predictor Coef SE Coef T P
Constant -7.064 7.908 -0.89 0.387
Speed 0.05833 0.08635 0.68 0.510
Substrat -2.000 1.410 -1.42 0.178
Screen R 0.23313 0.04087 5.70 0.000
S = 2.991 R-Sq = 71.4% R-Sq(adj)=65.3%
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The P values indicate significant effect of Screen Ruling on dot gain. It does not show any significant relation between other parameters and the responses. It is also seen from the tables given above that the dot gain increases as the screen ruling increases.

Table 6: Response values for the trials

Trial No.	*Machine Speed m/min*	*Screen Ruling lpi*	*Liner Material PP/GL*	*Dot gain at 50% C*
1	40	133	GL	25
2	40	133	PP	19
3	40	150	GL	33
4	40	150	PP	26
5	40	175	GL	34
6	40	175	PP	28
7	50	133	GL	22
8	50	133	PP	23
9	50	150	GL	31
10	50	150	PP	32
11	50	175	GL	34
12	50	175	PP	33
13	60	133	GL	22
14	60	133	PP	22
15	60	150	GL	31
16	60	150	PP	31
17	60	175	GL	33
18	60	175	PP	33

Acknowledgment (Heading 5)

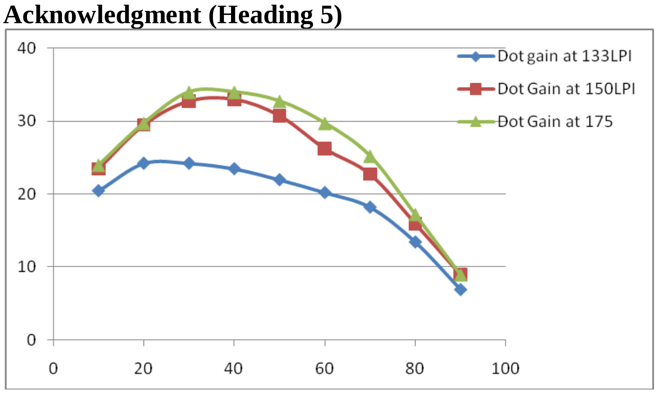

Figure 2: Graph of dot gain vs screen ruling in one of the trials

6. Conclusion

The print trials on 2 label stocks at different speeds show no difference in quality of the line matter including text, line and bar codes. To study half tone quality images were printed for visual analysis which showed no difference. The percentage dot gain is not significantly affected by speed and the material. The average percentage dot gain is slightly different in two substrates. But statistics doesn't show any significant interaction. Also this difference was not found in other colors. The percentage dot gain is found to be significantly affected by the screen ruling as there was a raise in the dot gain with the screen ruling irrespective of the other 2 factors. There were no significant interactive effects of the factors on the chosen responses. Hence it can be concluded that for the given set up there was no difference in print quality by changing the liner from glassine to polypropylene for self adhesive labels.

7. Acknowledgement

I am thankful to Prof. R. G. Kaduskar, PVG's COET, Pune for his timely guidance, constant support and encouragement. I would also like to thank Mr. Shailesh Nema, UPM Raflatac, Mr. Amar Chajed and Webtech labels for their support.

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