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# Relationship of Solid Ink Density and Dot Gain in Digital Printing

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***Abstract*— Ours is the generation which is living in the age of science and technology. The latest scientific inventions have given rise to various technologies in every aspect of our life. Newer technologies have entered the field of printing also. Digital printing is one of these latest technologies which have further revolutionized entire modern printing industry in many ways. It also facilitates working on large variety of surfaces, besides these factors digital printing have grown widely and made a special impact in print market. The presented analysis system is used for study of print quality in Digital Printing.**

***Index Terms*— Digital Printing, Dot Gain, Solid ink density, Coated Paper and Uncoated Paper.**

## I. INTRODUCTION

Digital printing describes the process of transferring a document on a personal computer or other digital storage device to a printing substrate by means of a device that accepts text and graphic output. As with other digital processes, information is reduced to binary code, or "digitized," to facilitate its storage and reproduction. Digital printing has steadily replaced conventional printing techniques in many markets, especially at the consumer and business level; as a result of its substantially lower production costs.

**Dot Gain**

When halftone dots print larger on the press than they were originally on the printing plate or film, it results in loss of detail and lower contrast in the image. This effect is known as dot gain. It occurs on every job to a certain extent. Dot gain occurs in long press runs mainly due to excessive pressure. The following press variables have been found affecting dot gain: -

(i) Ink Properties
(ii) Paper Properties
(iii) Speed of the printing machine

The factors contributing to dot gain are both mechanical and physical.

**Solid Ink Density**

Solid ink density is the measurement of a solid printed patch on the paper, including the paper density. It generally relates to ink film thickness, however, a higher 'pigment load' ink will measure the same density at a 'thinner' ink film thickness, and this helps in controlling dot gain while meeting density requirements. As discussed above Dot gain is the measurement of the increase in tone value from original file to the printed sheet.

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## II. MATERIALS AND METHODS

Densitometer is used for measuring density of ink on the paper. Densitometer can be classified according to type of materials they are designed to measure i.e. opaque and transparent. Density of opaque materials is measured by reflected light with a device called reflection type densitometer. Density of transparent materials is measured by transmitted light with a device called transmission type densitometer. In order to measure the print quality i.e. solid ink density (SID) and dot gain (DG) on coated and uncoated paper in digital printing, densitometer (GRETAG MACBETH, D 19 C Series, and Made in Switzerland) Thomson Press was used.

**2.1 Data analysis**

The data was collected from Thomson Digital (Okhla – New Delhi) Press. So collected data was compiled in order to analyze and conclude. Two parameter i.e. solid ink density and dot gain were recorded for comparing the quality. By using the densitometer the statistical data was collected and analyzed the difference on two different modes of paper i.e. coated and uncoated, in digital printing. This statistical data is represented by using tables and figures between two parameters. I included the following points during my analysis:-

**2.1 (A) Dot gain effect on coated and uncoated paper in Digital Printing**

**2.1 (B) Solid ink density on coated and uncoated paper in Digital Printing**

These are illustrated as below:-

**2.1 (A) Comparison of Dot Gain (DG) on coated and uncoated paper in digital printing on 130 GSM**

The results of dot gain on coated and uncoated paper in digital printing are presented in figure (graphs) 1, 2, 3 and 4 are as follow: -

**(a) Dot gain of black color on coated and uncoated paper in digital printing on 130 GSM**

The mean values of Dot Gain in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs was found in the range of 6.00 to 19.00 on coated paper having 130 GSM. While the mean values of Dot Gain on the various jobs of printing was found in the range of 8.50 to 18.75 on uncoated paper.

| Black Color Dot Gain | | |
|---|---|---|
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 17.50 | 18.50 |
| Min. Value | 6.00 | 8.50 |

Table.1. Black Color Dot Gain

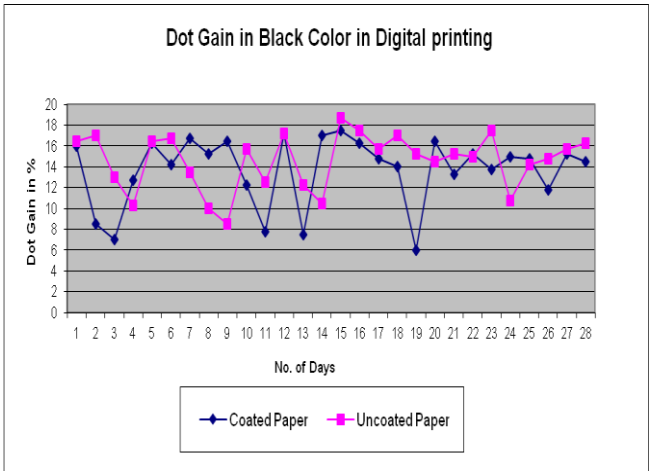


**Fig.1. Dot gain of black color on coated and uncoated paper in digital printing on 130 GSM**

**(b) Dot gain of cyan color on coated and uncoated paper in digital printing on 130 GSM**

The average values of observations of Dot Gain (DG) of cyan color on coated paper are presented in figure no. 2. The mean values of Dot Gain at Thomson press-HP 5500 was found in the range of 5.00 to 16.00 in digital printing on 130 GSM coated paper. In contrast, the mean values of Dot Gain was found in the range of 3.00 to 15.50 in case of 130 GSM uncoated paper. The point to be noted is that the range of dot gain for cyan color is less as compared to that of the black color.

| Cyan Color Dot Gain | | |
|---|---|---|
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 15.50 | 15.50 |
| Min. Value | 5.00 | 3.00 |

Table.2. Cyan Color Dot Gain

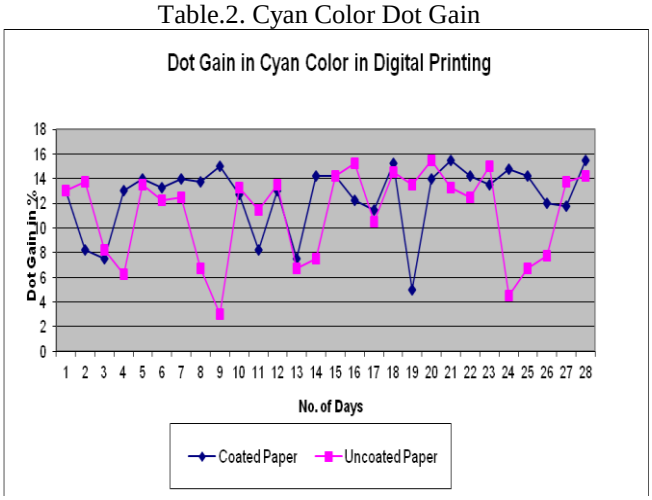


**Fig.2. Dot gain of cyan color on coated and uncoated paper in digital printing on 130 GSM**

**(c) Dot gain of magenta color on coated and uncoated paper in digital printing on 130 GSM**

During observations of Dot Gain (DG) of magenta color on coated paper, the mean values of DG in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs was found in the range of 2.75 to 17.75 on coated paper having range of 130 GSM. While the mean values of DG in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs was found in the range of 4.25 to 17.25 on uncoated paper.

| Magenta Color Dot Gain | | |
|---|---|---|
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 17.75 | 17.25 |
| Min. Value | 2.75 | 4.25 |

Table.3. Magenta Color Dot Gain

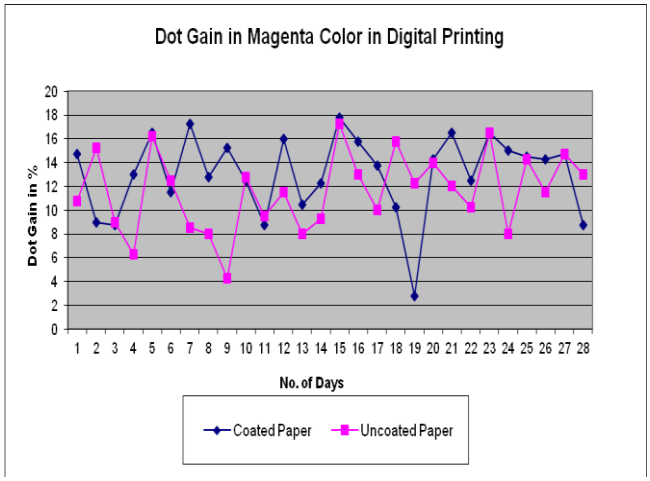


**Fig.3. Dot gain of magenta color on coated and uncoated paper in digital printing on 130 GSM**

**(d) Dot gain of yellow color on coated and uncoated paper in digital printing on 130 GSM**

While observations of Dot Gain of yellow color in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs, the mean values of Dot Gain was found in the range of 3.50 to 16.75 on coated paper having range of 130 GSM. While the mean values of Dot Gain was found in the range of 2.75 to 16.25 on uncoated paper having range of 130 GSM.

| Yellow Color Dot Gain | | |
|---|---|---|
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 16.75 | 16.25 |
| Min. Value | 3.50 | 2.75 |

Table.4. Yellow Color Dot Gain

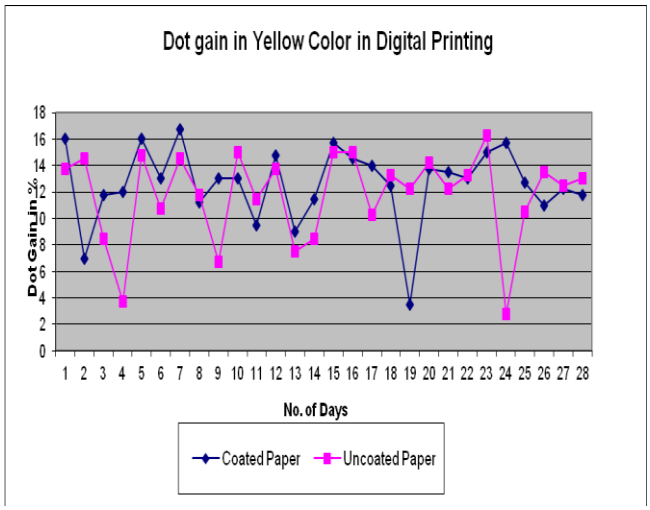


**Fig.4.Dot gain of yellow color on coated and uncoated paper in digital printing on 130 GSM**

**2.1 (B) Comparison of Solid Ink Density on coated and uncoated paper in digital printing**

The results of Solid Ink Density (SID) on coated and uncoated paper in digital printing are presented in table and figure (graphs) 5, 6, 7 and 8 are as follow : -

**(a) Solid Ink Density (SID) of black color on coated and uncoated paper of 130 GSM in digital printing**

The results (average values) of observations of Solid Ink Density (SID) of black color on coated paper of 130 GSM are presented in figure 5.

The mean values of SID in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs was found in the range of 1.74 to 1.94 on coated paper of 130 GSM range. The mean value of SID was found in the range of 1.51 to 1.61 on uncoated paper having 130 GSM. From the above mentioned SID values of black color on coated and uncoated paper; the range of average values of SID were higher in case of coated paper as compared to uncoated paper; because of its more smoothness property.

| Black Color Solid Ink Density | | |
|---|---|---|
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.94 | 1.61 |
| Min. Value | 1.74 | 1.52 |

Table.5. Black Color Solid Ink Density

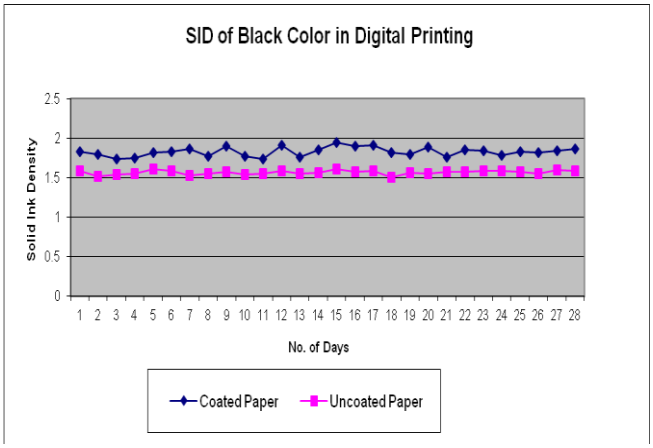


**Fig.5. Solid Ink Density (SID) of black color on coated and uncoated paper of 130 GSM in digital printing**

**(b) Solid Ink Density (SID) of cyan color on coated and uncoated paper in digital printing on 130 GSM**

The average values of observations of Solid Ink Density (SID) of cyan color on coated paper are presented in figure 6. The mean values of SID at Thomson press-HP 5500 was found in the range of 1.33 to 1.52 in digital printing. In contrast, the average values of observations of SID of cyan color on uncoated paper; as presented in figure 6; the mean values of SID was found in the range of 1.17 to 1.28 on uncoated paper of 130 GSM.

| Cyan Color Solid Ink Density | | |
|---|---|---|
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.52 | 1.28 |
| Min. Value | 1.33 | 1.16 |

Table.6. Cyan Color Solid Ink Density

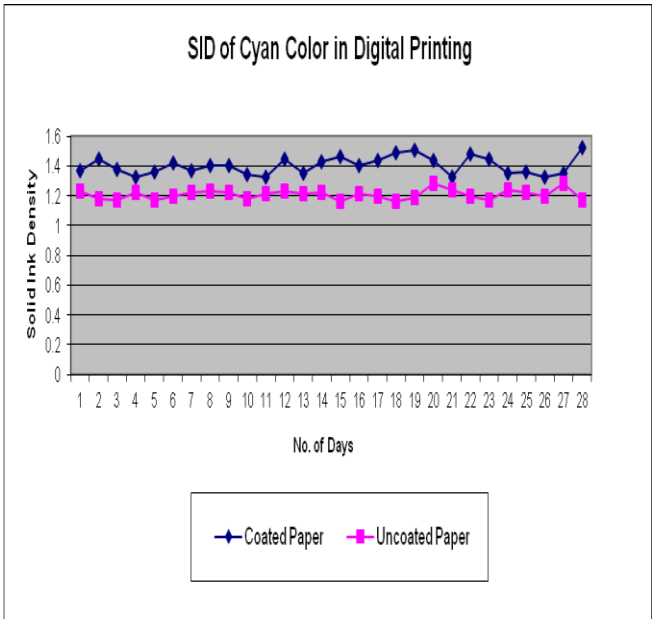


**Fig.6. Solid Ink Density of cyan color on coated and uncoated paper in digital printing on 130 GSM**

**(c) Solid Ink Density (SID) of magenta color on coated and uncoated paper in digital printing on 130 GSM**

The mean values of SID in digital printing on Thomson press-HP 5500 digital printing machine was found in the range of 1.36 to 1.45 on coated paper of 130 GSM.The average values of observations of Solid Ink Density (SID) of magenta color on uncoated paper for the various jobs was found in the range of 1.17 to 1.27 on uncoated paper having 130 GSM range. The results of observations of Solid Ink Density (SID) of magenta color on coated paper are presented in table 7 and figure 7.

| Magenta Color Solid Ink Density | | |
|---|---|---|
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.47 | 1.27 |
| Min. Value | 1.38 | 1.17 |

Table.7. Magenta Color Solid Ink Density

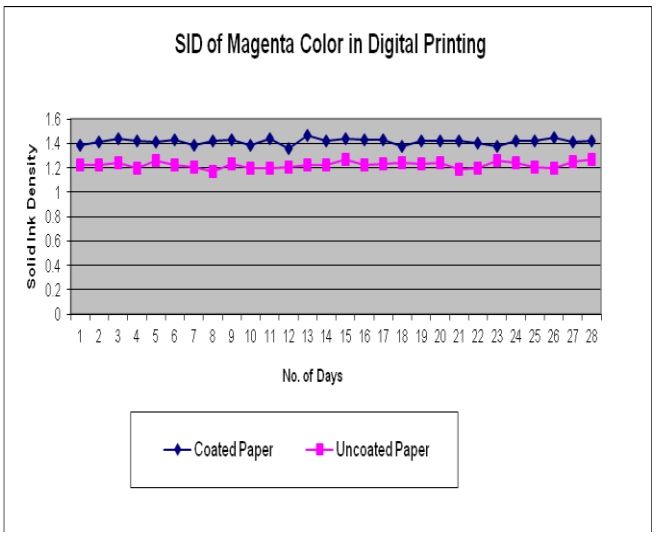


**Fig.7.Solid Ink Density of magenta color on coated and uncoated paper in digital printing on 130 GSM**

**(d) Solid Ink Density (SID) of yellow color on coated and uncoated paper in digital printing on 130 GSM**

The mean values of SID in digital printing on Thomson press-HP 5500 digital printing machine used for printing the various jobs was found in the range of 1.29 to 1.52 on coated paper of 130 GSM. While the mean values of SID in digital printing for printing the various jobs was found in the range of 1.21 to 1.35 on uncoated paper of 130 GSM. The results (average values) of observations of Solid Ink Density (SID) of yellow color on coated paper are presented in table 8 and figure 8.

| Yellow Color Solid Ink Density | | |
|---|---|---|
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.52 | 1.35 |
| Min. Value | 1.29 | 1.21 |

Table.8. Yellow Color Solid Ink Density

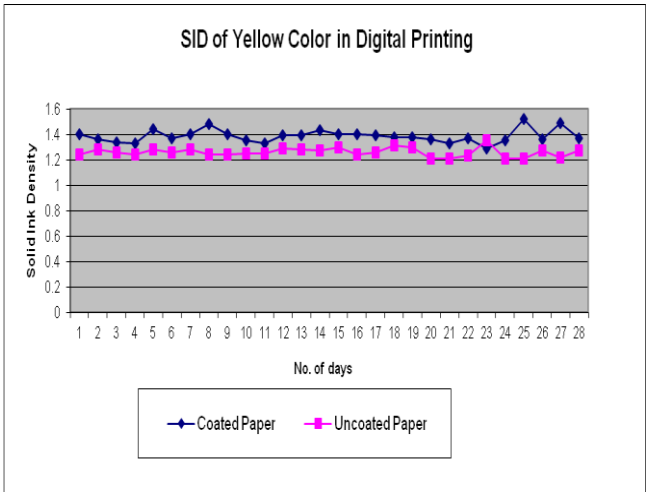


**Fig.8.Solid Ink Density (SID) of yellow color on coated and uncoated paper in digital printing on 130 GSM**

## III. Results and Discussion

The data was collected and analyzed. It was found that the mean values of solid ink density and dot gain were observed in accordance with standard range of the print quality and printing technology in terms digital printing process. We also observed repeated values of Dot Gain and S.I.D. again and again during the present investigations. The overall result made from the observation is that there is always consistency with digital printing either it is solid ink density or dot gain. While observing these two printing quality parameters on two different types of substrates i.e. coated paper and uncoated type, I found that digital printing has slight variations on these two substrates. Summary of the analyzed data of Dot Gain and Solid Ink Density is delineated in table 9 and 10 respectively as below:-

| Black Color Dot Gain | | |
|---|---|---|
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 17.50 | 18.50 |
| Min. Value | 6.00 | 8.50 |
| Cyan Color Dot Gain | | |
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 15.50 | 15.50 |
| Min. Value | 5.00 | 3.00 |
| Magenta Color Dot Gain | | |
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 17.75 | 17.25 |
| Min. Value | 2.75 | 4.25 |
| Yellow Color Dot Gain | | |
| Dot Gain % | Coated Paper | Uncoated Paper |
| Max. Value | 16.75 | 16.25 |
| Min. Value | 3.50 | 2.75 |

Table.9. Summary of Dot Gain on coated and Uncoated Paper

| Black Color Solid Ink Density | | |
|---|---|---|
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.94 | 1.61 |
| Min. Value | 1.74 | 1.52 |
| Cyan Color Solid Ink Density | | |
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.52 | 1.28 |
| Min. Value | 1.33 | 1.16 |
| Magenta Color Solid Ink Density | | |
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.47 | 1.27 |
| Min. Value | 1.38 | 1.17 |
| Yellow Color Solid Ink Density | | |
| SID | Coated Paper | Uncoated Paper |
| Max. Value | 1.52 | 1.35 |
| Min. Value | 1.29 | 1.21 |

Table.10. Summary of Solid Ink Density on coated and Uncoated Paper

As graphs indicates that there is only minute differences of ink densities on coated and uncoated substrates. But print quality of coated paper is comparatively better than uncoated paper because higher is ink density deposited with approximate percentage of dot gain in both the cases. It means digital printing spills a desirable control on print ink density on the coated substrate. In digital printing process, dot gain occurred but only ignorable but also desirable i.e. up to a certain extent which can be ignored. It means digital printing results in good quality production because higher dot gain causes image loss that result into reduction of print quality. However; dot gain also varies in a consistent order while printing the jobs but controllable. It means digital printing results in good quality production in case of coated paper because higher dot gain results into reduction of print quality.

## IV. Conclusion

Digital printing is the method of printing using the digital techniques in which the printing is done without any intermediate step i.e. eliminating numerous steps involved in other printing processes like chemical processing, film and plate making. Digital printing is mainly based on computer controls and operated with the help of computers with the aid of many types of soft wares which provides different types of suitable formats for the printing machine. Now-a-days most digital presses apply ink in single pass. The above research indicates that there is consistency during printing on coated paper and uncoated paper. The

conclusion derived from the above research work indicates that, for the both coated paper and uncoated paper as the solid ink density increases so the dots gain also increase. Hence there is one-to-one relationship between the dot gain and solid ink density in digital printing irrespective of the coated or uncoated paper. It was concluded as Solid Ink Density increases Dot Gain also increases and vice-versa.

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