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Effect of Electrostatic Assist on Gravure Printability for Coated Paper

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Effect of Electrostatic Assist on Gravure Printability for Coated Paper

Introduction

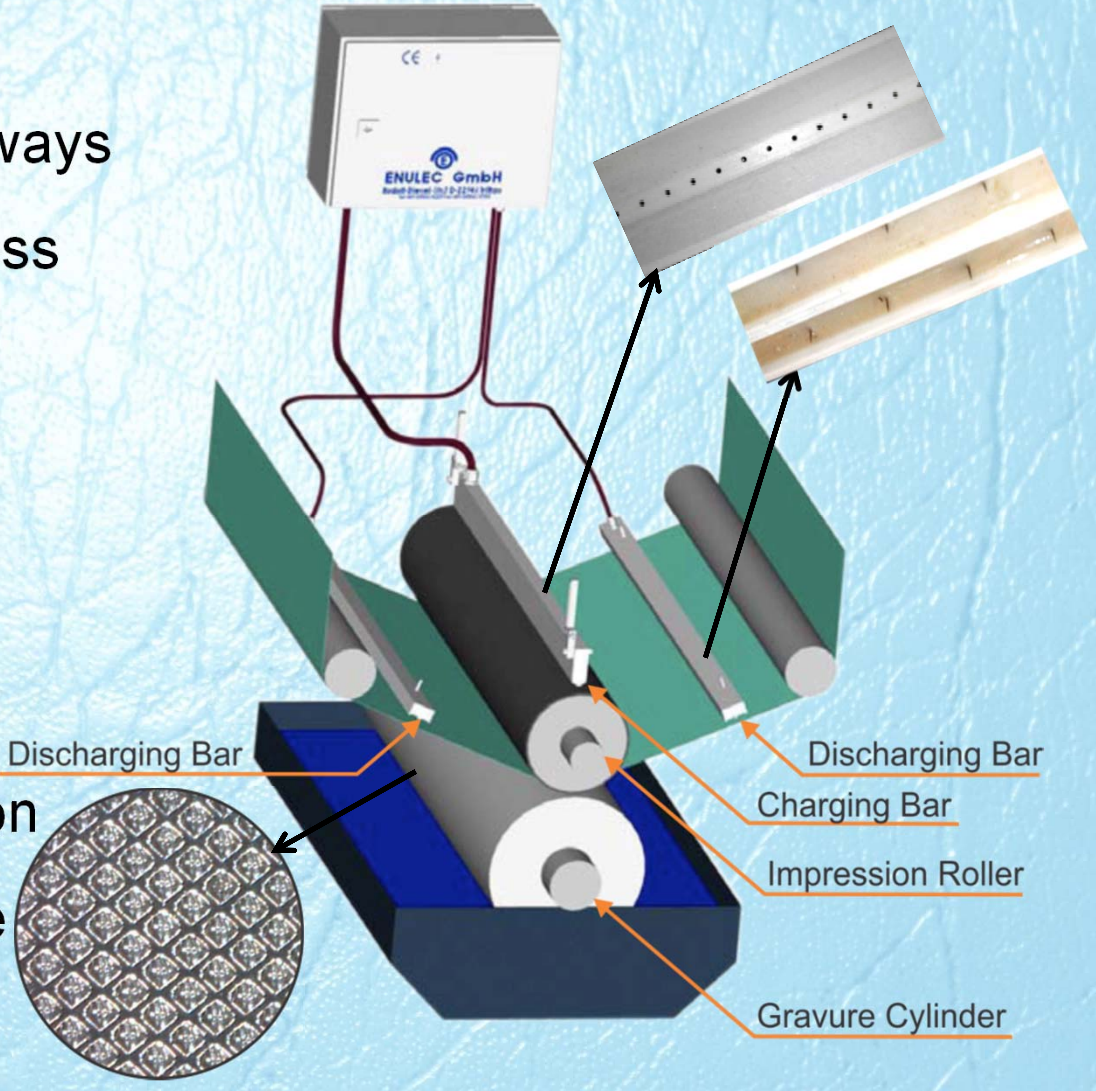
- Turnover of print industry in India: **INR 50,000 crores approx.**
- Annual Paper Consumption: **28 million tonnes approx.**
- Estimated Paper Consumption (2017): **37 million tonnes approx**
- Coated papers are widely used in labels, release liners, wraps, pouches, sachets etc.

Effect of Electrostatic Assist on Gravure Printability for Coated Paper

Introduction

- Gravure printing has always been widely used process for printing on flexible packaging papers.

- **Process Parameters:**
  Ink Viscosity, Pressure, Press Speed, Impression Hardness, Doctor Blade Line screen, ESA.



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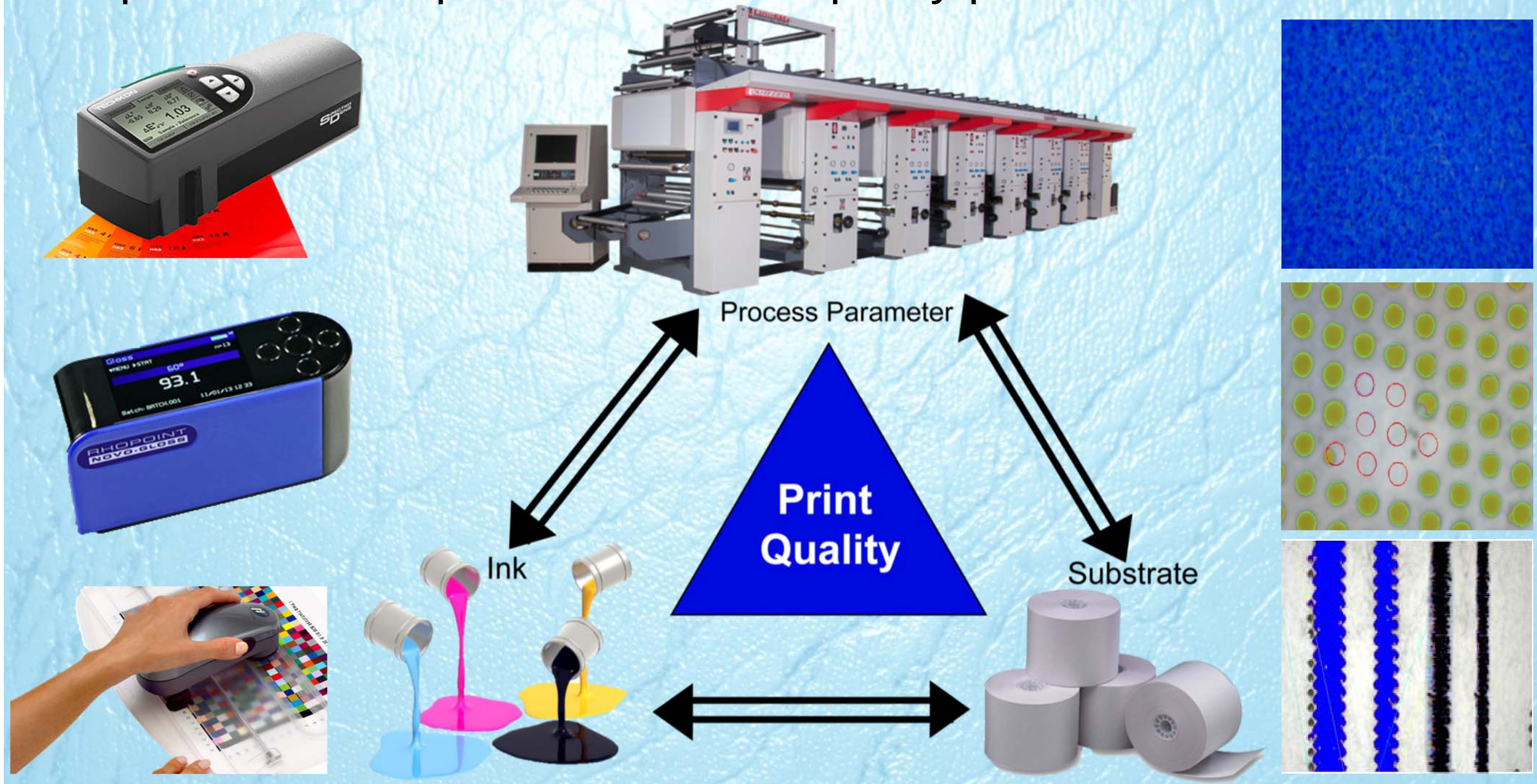
- **Printability:** Optimal amalgamation of ink, substrate and process parameters to produce the best quality print.



Wastage
Wastage
Wastage
Wastage
AIR
LAND
WATER
Methoxy Propenol
Ethyl Acetate
Isopropile Alcohol
Is there any solution ?????
Knorr
Sulze
Gelée de viande
ENO
All-in-One + Meaty
SEASONING GRANULES
DAS ORIGINAL

Effect of Electrostatic Assist on Gravure Printability for Coated Paper

Methodology

- Materials and Equipment
- Layout Design and Cylinder Preparation
- Baseline Identification
- Design of Experiments
- Analysis
- Identifying the significant factors and optimal settings
- Verification of optimal settings
- Development and Validation of Model

Effect of Electrostatic Assist on Gravure Printability for Coated Paper

Methodology: Materials and Equipment

- **Substrate:** 65 GSM C1S coated paper.
- **Ink:** Nitrocellulose (NC) resin based black process ink.
- **Solvent Combination**: EA + IPA + MP (55:30:15).
- **Gravure Press:**
  - Four color pilot gravure machine.
  - Maximum printing speed 2 m/s.
  - Top loading indirect ESA system.

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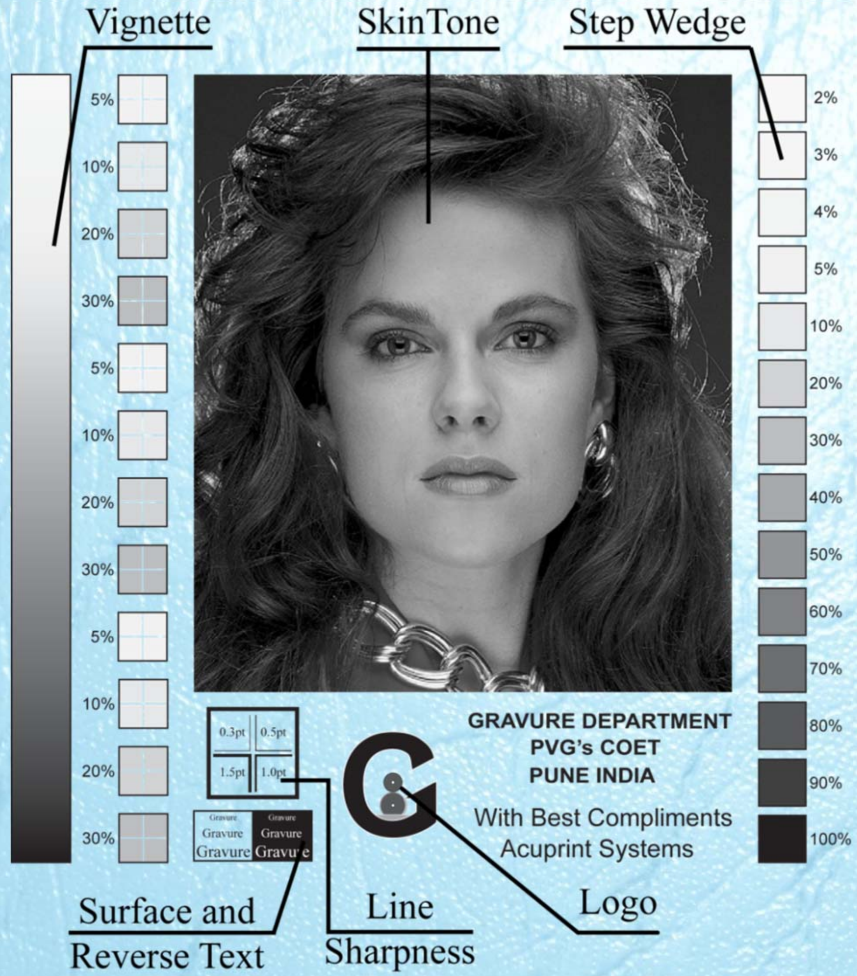
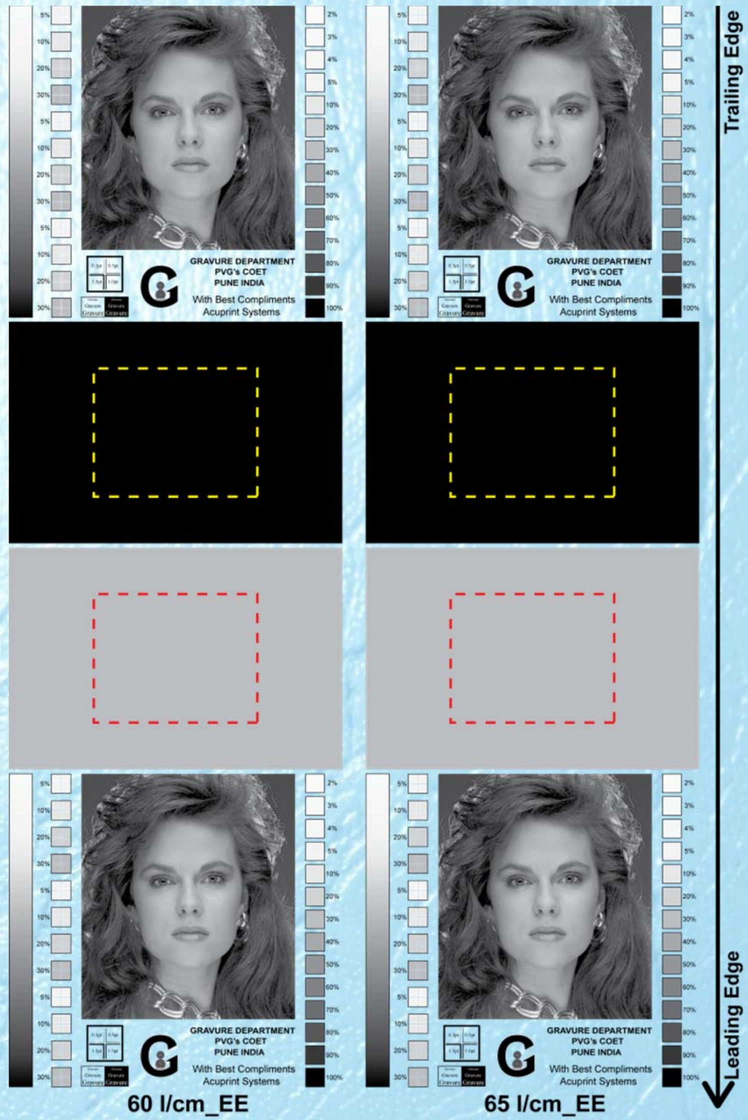
Methodology: Layout Design





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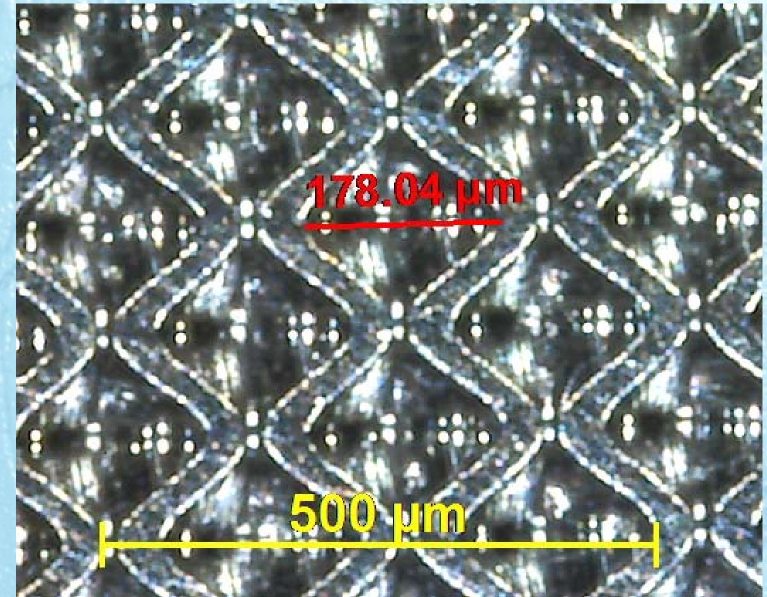
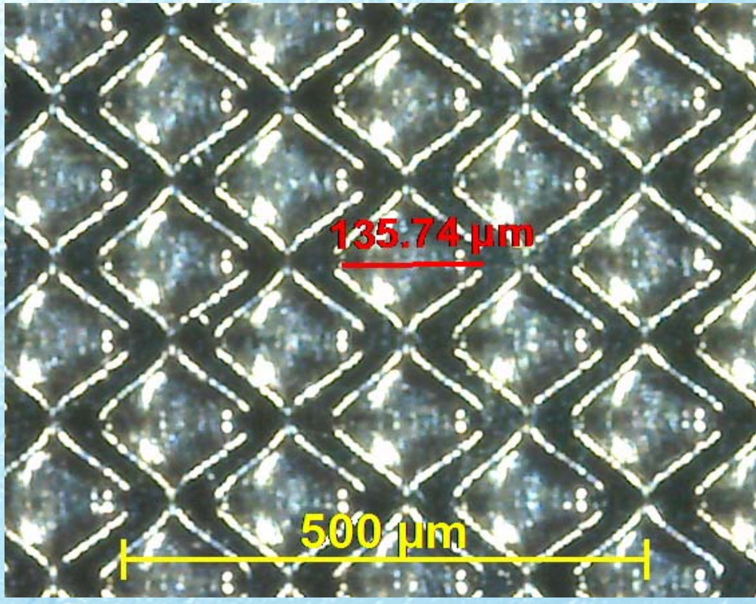
Methodology: Cylinder Preparation

- The cylinder was electronically engraved with **60 lpcm** and **65 lpcm** at **30°** cell and **130° stylus angle.**

- Cell opening for 60 lpcm and 65 lpcm are 178.04 µm and 135.74 µm.





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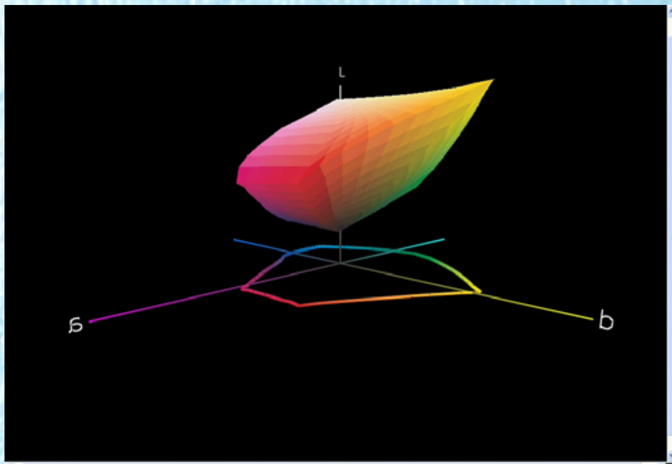
Methodology: Baseline Identification

- **Production Runs:** 65 lpcm, 19 sec, 1.667 m/s, 3.5 kg/cm^2 with **ESA OFF** for few days on a pilot gravure press.



- **Sample Size:** 20 printed sheets for mottle and missing dots.
- **Baseline for Mottle and Missing Dots:** 2.31 and 109.
- **Target:** To minimize from the baseline.

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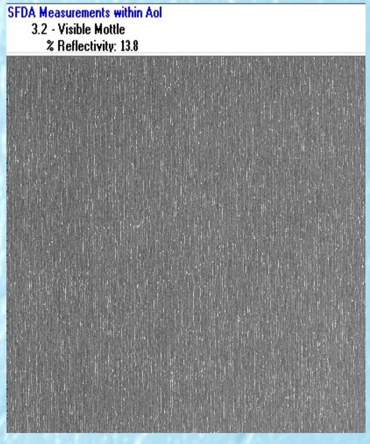
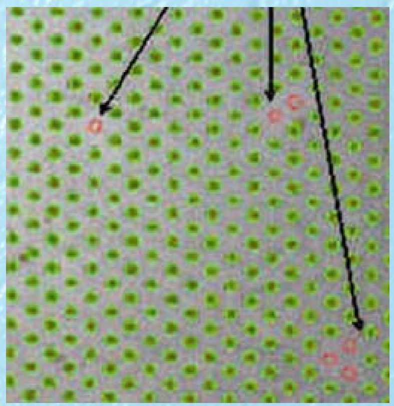
Methodology: Measurement

- Samples were scanned at 600 ppi by Verity IA Print Target v3 s/w.
- AOI of 70 x 55 mm analyzed through SFDA algorithm to calculate mottle.
- 30% patch on step wedge captured by DPM microscope at 50 X and processed in Fibro software to calculate the no. of missing dots.





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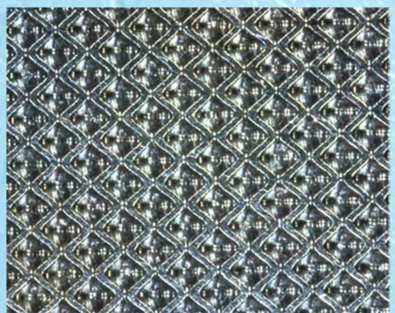
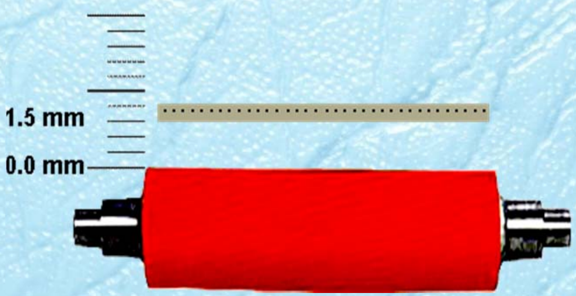
Methodology: Experimental Design

- **5 factors, 108 runs** and **2 replicates** thus, totaling to **216 runs.**

S. No.	Factors	Unit	Levels		
			Low	Mid	High
1	Line Screen	l/cm	60	-	65
2	Ink Viscosity	s	17	19	21
3	Press Speed	m/s	1.333	-	2
4	ESA Voltage	kV	8	10	12
5	ESA Air Gap	mm	1.5	3	5



60 LPCM



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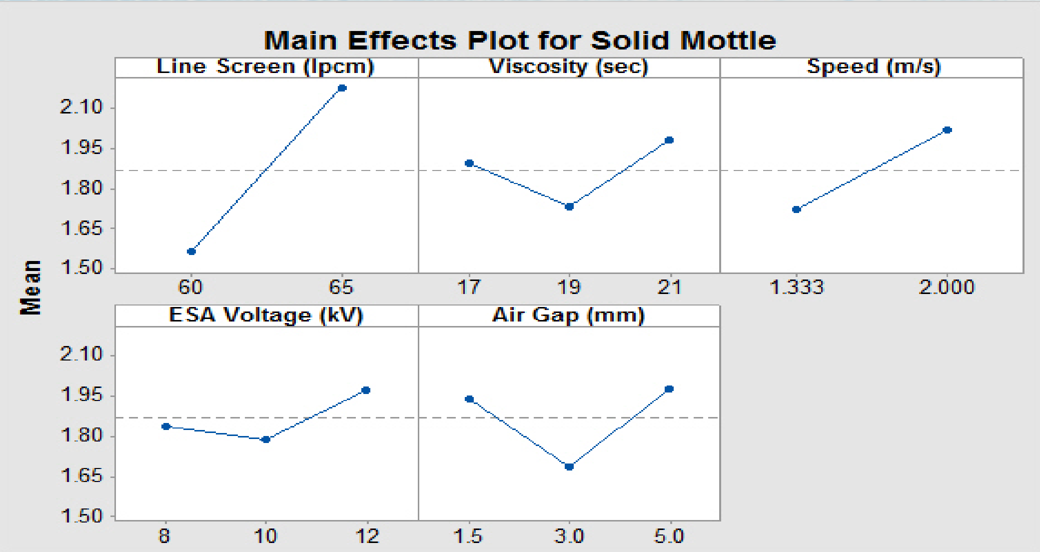
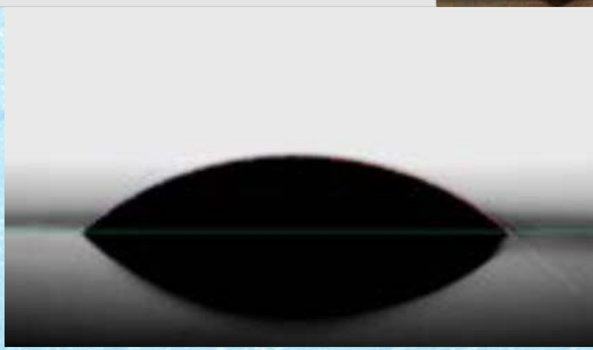
Methodology: Analysis_Mottle

- All factors show significance in minimizing solid mottle.



17 s



19 s

21 s

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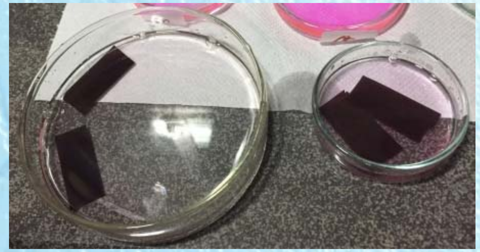
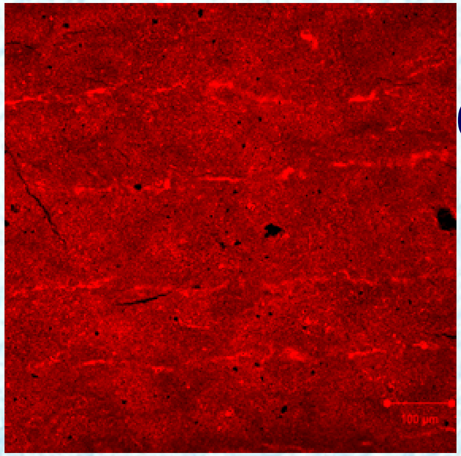
Methodology: Analysis_Mottle

(a)



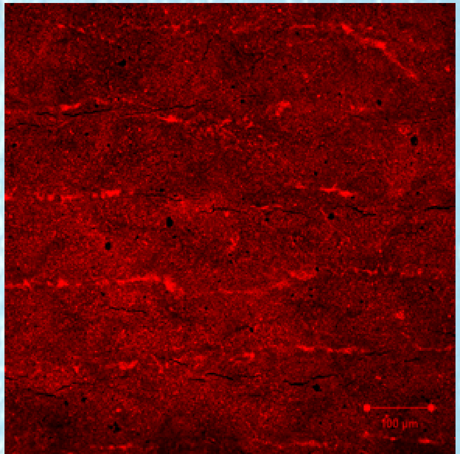
(b)

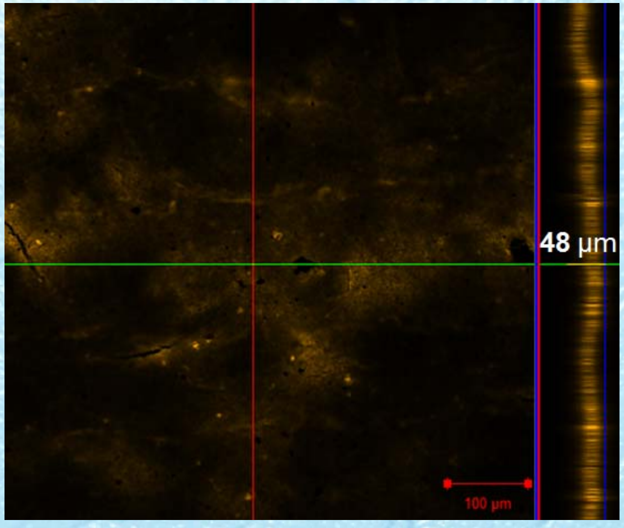
(c)

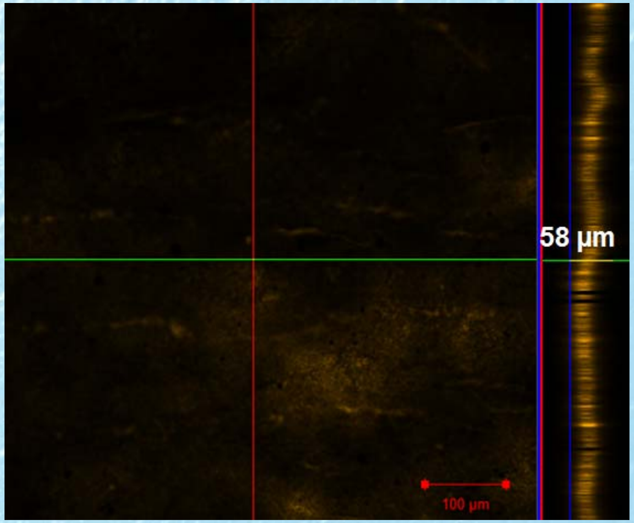


60 lpcm

65 lpcm







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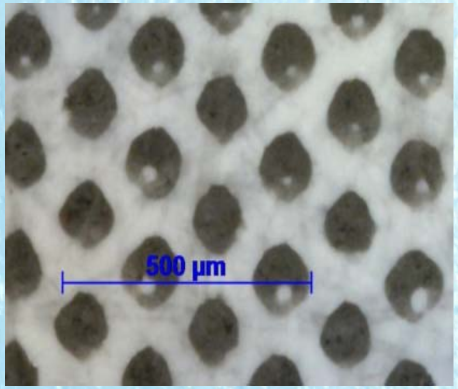
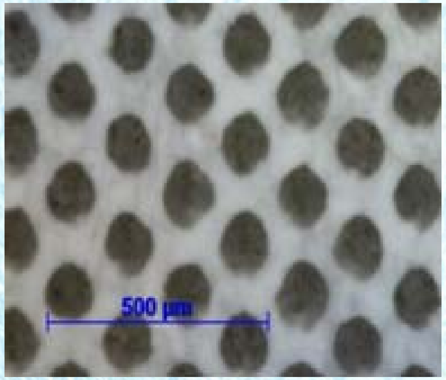
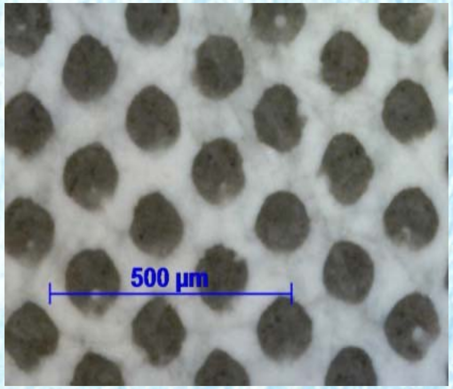
Methodology: Analysis_Mottle



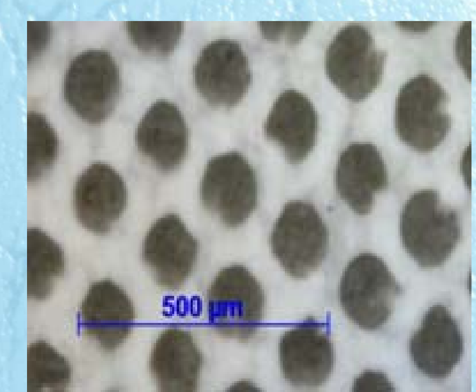
8 kV



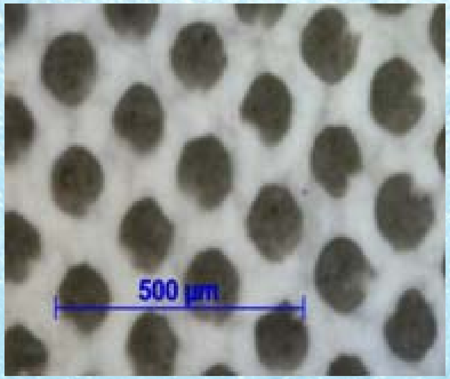
10 kV



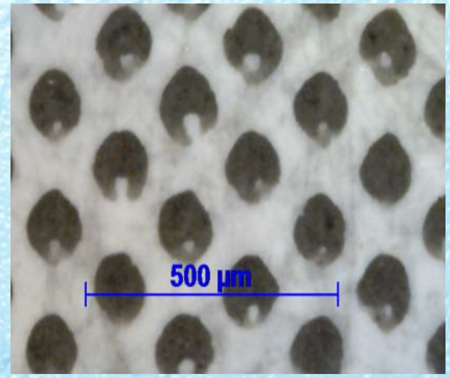
12 kV



1.5 mm



3 mm



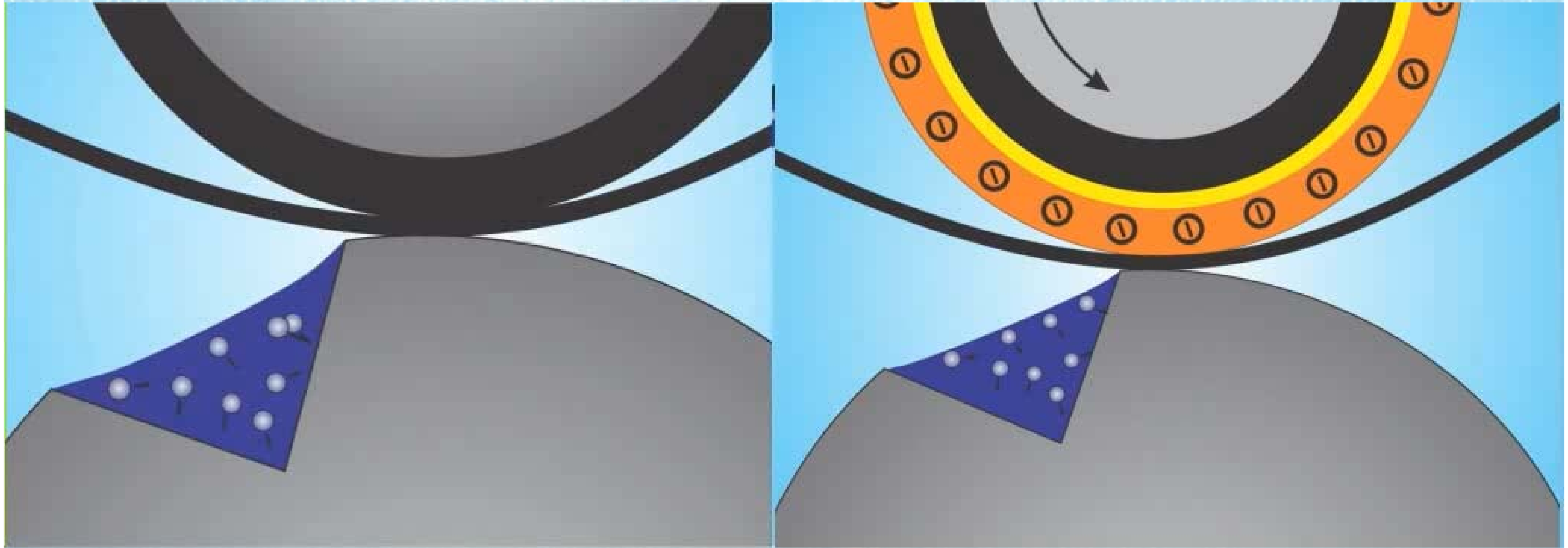
5 mm

Air Gap (mm)	Voltage (kV)	Current (mA)
1.5	8	0.9
	10	1.3
	12	1.6
3	8	0.8
	10	1.1
	12	1.5
5	8	0.5
	10	0.8
	12	1.2

Effect of Electrostatic Assist on Gravure Printability for Coated Paper

ESA OFF

ESA ON



Effect of Electrostatic Assist on Gravure Printability for Coated Paper

Methodology: Analysis_Mottle

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	14	33.2938	2.3781	103.05	0.000
Line Screen (l/cm)	1	20.6709	20.6709	895.71	0.000
Viscosity (sec)	1	0.2542	0.2542	11.01	0.001
Speed (m/s)	1	4.6699	4.6699	202.36	0.000
ESA Voltage (kV)	1	0.6629	0.6629	28.72	0.000
Air Gap (mm)	1	0.2893	0.2893	12.54	0.000
Viscosity (sec) * Viscosity (sec)	1	1.7417	1.7417	75.47	0.000
ESA Voltage (kV) * ESA Voltage (kV)	1	0.6218	0.6218	26.95	0.000
Air Gap (mm) * Air Gap (mm)	1	3.5017	3.5017	151.73	0.000
Line Screen (l/cm) * Viscosity (sec)	1	0.1757	0.1757	7.61	0.006
Line Screen (l/cm) * Speed (m/s)	1	0.2788	0.2788	12.08	0.001
Viscosity (sec) * Speed (m/s)	1	0.1363	0.1363	5.91	0.016
Viscosity (sec) * ESA Voltage (kV)	1	0.1197	0.1197	5.19	0.024
Viscosity (sec) * Air Gap (mm)	1	0.1216	0.1216	5.27	0.023
ESA Voltage (kV) * Air Gap (mm)	1	0.3319	0.3319	14.38	0.000
Error	201	4.6386			
Lack of Fit	93	2.4006	0.0258	1.25	0.135
Pure Error	108	2.238	0.0207		
Total	215	37.9325			

Effect of Electrostatic Assist on Gravure Printability for Coated Paper

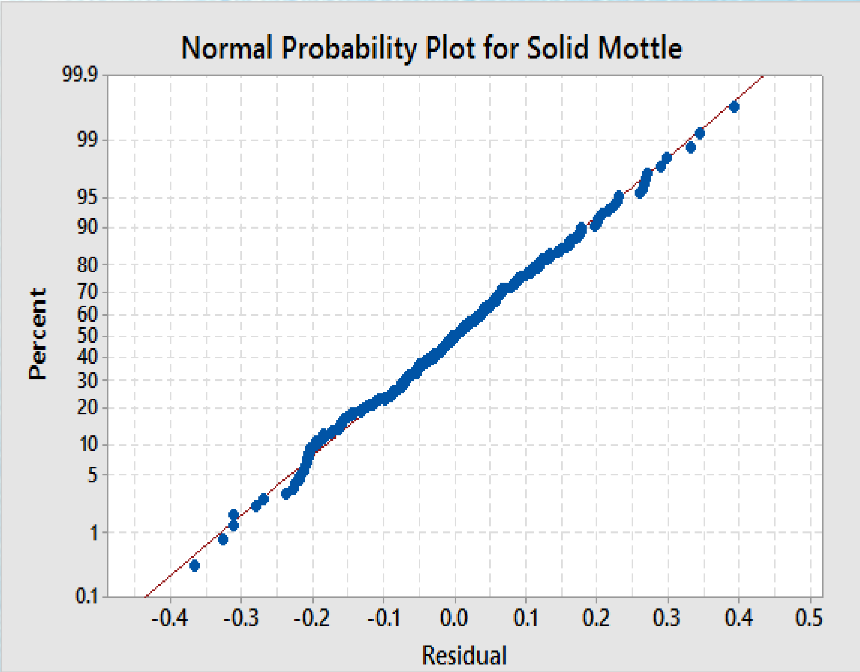
Methodology: Analysis_Mottle

Summary of Model

S = 0.144881 R-Sq = 91.54 % R-Sq(adj) = 91.08 % R-Sq(pred) = 90.47%

Regression Model

Solid Mottle = 0.22 + 0.3283 Line Screen - 1.308 Viscosity + 2.258 Speed - 0.420 ESA Voltage - 0.573 Air Gap + 0.048 Viscosity * Viscosity + 0.035 ESA Voltage * ESA Voltage + 0.090 Air Gap * Air Gap - 0.007 Line Screen * Viscosity - 0.043 Line Screen * Speed + 0.046 Viscosity * Speed - 0.009 Viscosity * ESA Voltage - 0.010 Viscosity * Air Gap + 0.017 ESA Voltage * Air Gap



Residuals are normally distributed.

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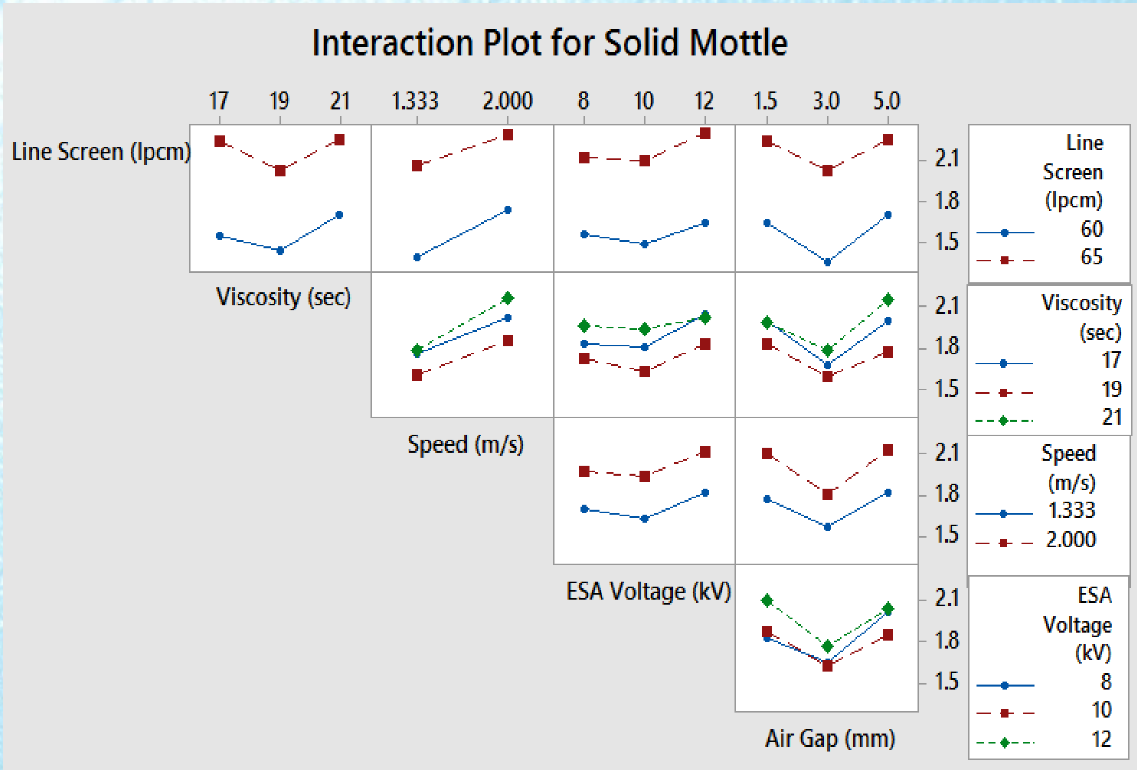
Methodology: Analysis_Mottle

- **Interactions:**

  Viscosity with Speed,

  Voltage and Air Gap,

  Voltage with Air Gap.



- **Best Settings:**

  60 lpcm line screen,

  19 sec ink viscosity,

  1.333 m/s speed,

  10 kV ESA voltage

  and 3 mm air gap.

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Methodology: Verification

- The best settings (60 lpcm, 19 sec, 1.333 m/s, 10 kV and 3 mm) was confirmed by conducting a press run.

Trails	Solid Mottle	Std. Dev.
Production Run	2.31	0.5725
Verification Run	1.05	0.1410
Consistency Run	1.07	0.1640

- A significant improvement is evident from production run to verification and consistency run in solid mottle.

- The best settings revealed minimization of solid mottle by **55%** on 65 GSM C1S paper.

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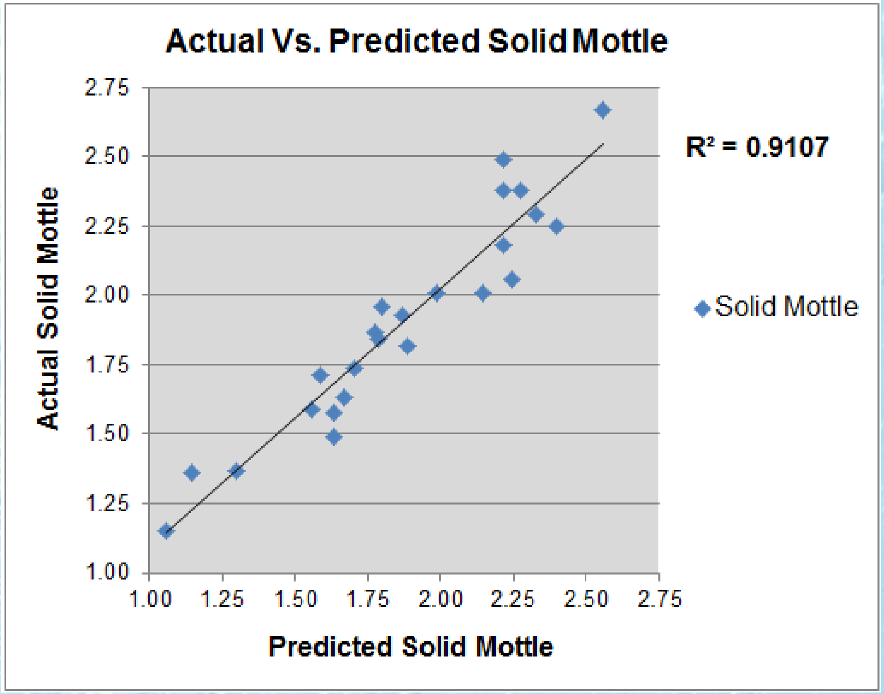
Methodology: Validation of Model

The model developed was validated by comparing the mottle calculated from experimental data and mottle predicted from the regression equation.

A correlation coefficient of **0.9107** for mottle prediction justifies the prediction ability of the model.



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Methodology: Analysis_Missing Dots

Test and Confidence Interval (CI) for one Proportion

Test of p = 0.05 vs p < 0.05

Sample	X	N	Sample p	95% Upper Bound	Exact P-Value
1	1	216	0.0046	0.0218	0.000

- The p-value (0.000) depicts that no missing dots were encountered from 216 runs at predetermined 95% confidence interval (CI).
- As the p-value < 0.05, hence the null hypothesis (p = 0.05) is rejected.

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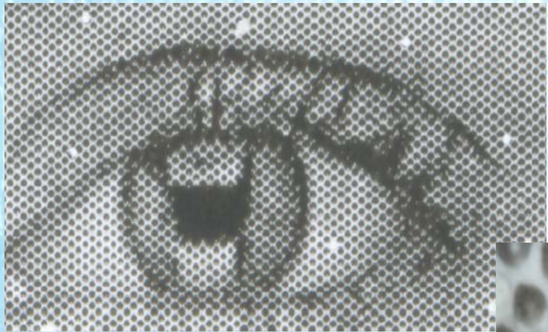
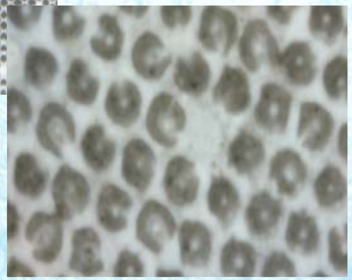
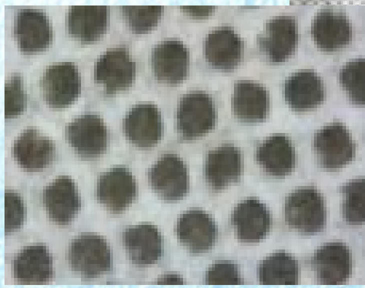
Methodology: Verification



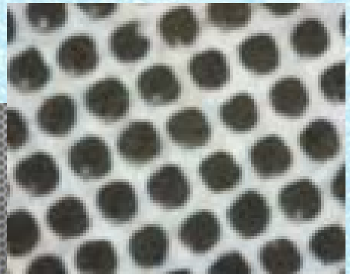
Production Run
ESA OFF



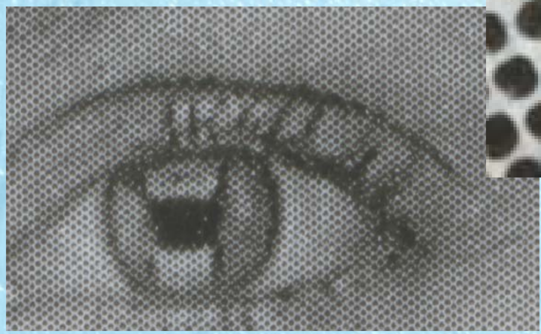


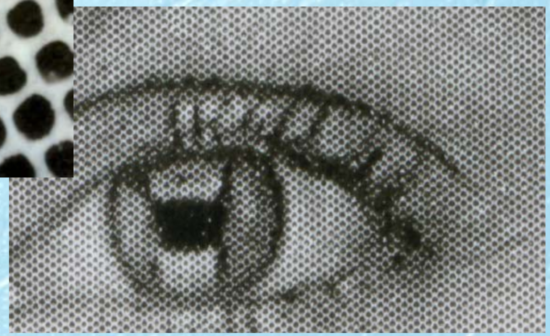
17 sec ESA ON

19 sec ESA ON



21 sec ESA ON





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Conclusion

- Optimization of the gravure process parameters itself has a solution to reduction in losses and wastage to a greater extent.
- The outcome of the study shall help the printers to understand the key process parameters and monitoring of optimal settings minimizing the print defects.
- Minimization of defects helps in controlling wastage and enhancing productivity and profitability of an organization.
- Preventing internal and external rejections shall help to reduce environmental damage to a larger extent.

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Acknowledgements

OMNOVA SOLUTIONS

ROSINI

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ENULEC ELECTROSTATIC

ACUPRINT SYSTEMS

SAKATA INX
Vissual Communication Technology

Thank You