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Effect of Gravure Process Variables on Print Defects in Shrink Film

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Effect of Gravure Process Variables on Print Defects in Shrink PVC Film

Introduction

- Today the brand owners are getting "package conscious".
- The global market for shrink sleeves is rising by 10% to 15% every year.
- PVC and PETG films holds the major share for this application.

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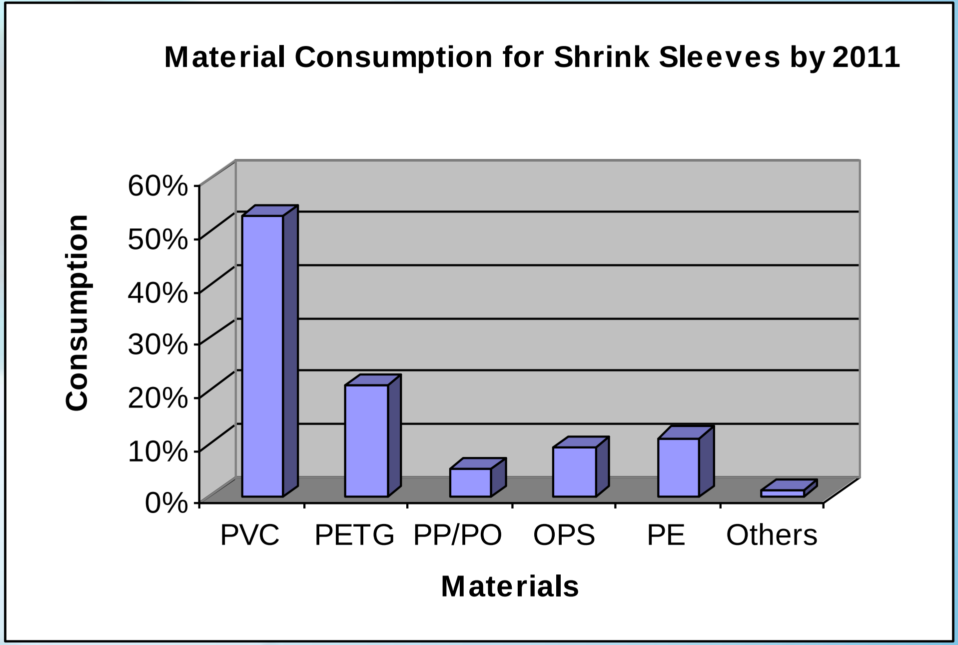
Introduction

- The global consumption of PVC shrink film in 2011 has increased by 59% since 2003.
- PETG ranks next after PVC in the shrink sleeve consumption.



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Introduction

- These films provide eye catching, 360º wrap around graphics that conforms to the product contours.

- It is essential to obtain superior quality printability on shrink films that can complement well with a package’s exterior.

- ***Printability*** is defined as an **optimal amalgamation of ink, substrate and process parameters**.

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Introduction

- **Printability Indicators on shrink films:**

1. Densitometry
2. Spectrophotometry and
3. Print defects such as voids, missing prints and dot skips.


Is there any Solution ???
Internal Quality Complaints
Customers Grievances
CTC Against Claim Value
Environmental Concerns

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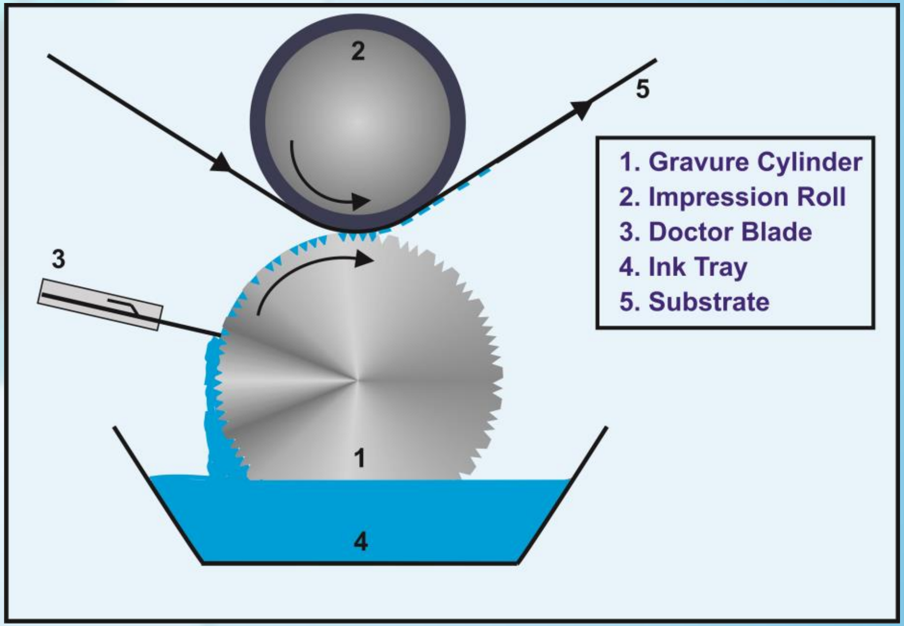
Gravure Process

- The growth and success of gravure are attributed to the simplicity of the process with fewer variables to control.

- **Key Variables:** Viscosity, Speed, Pressure, Hardness, Doctor blade, Cell geometry.



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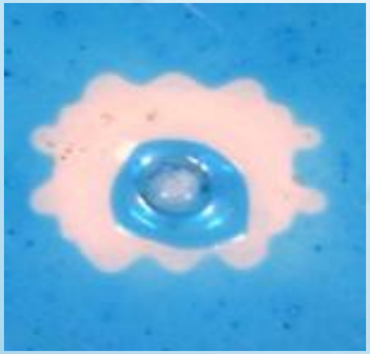
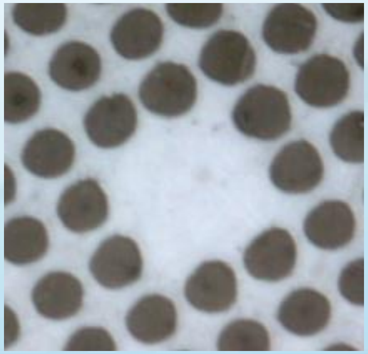
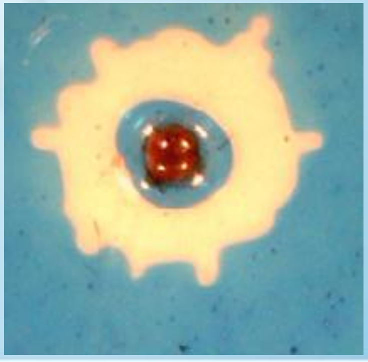
Introduction

- Printing on shrink film is a major challenge for a printer.
- The surface imperfections in these films cannot be totally eliminated during their manufacturing.
- The areas around the anomalies are starved of ink, leading to print defects like voids and dot skips.







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Introduction

- This results in internal complaints and rejections, customer grievances, cost to company against claim value and environmental concerns.
- Efforts to prevent such defective prints from being shipped to the customer involve multiple inspection and added costs.
- Reduces the product margin.
- Hence, it is of utmost importance to study the various plausible factors that can affect print voids.

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Methodology

- Selection of Gravure Process Variables
- Layout Design and Cylinder Preparation
- Baseline Identification
- Design of Experiments
- Analysis
- Identifying the significant factors and optimal settings
- Verification and checking for consistency

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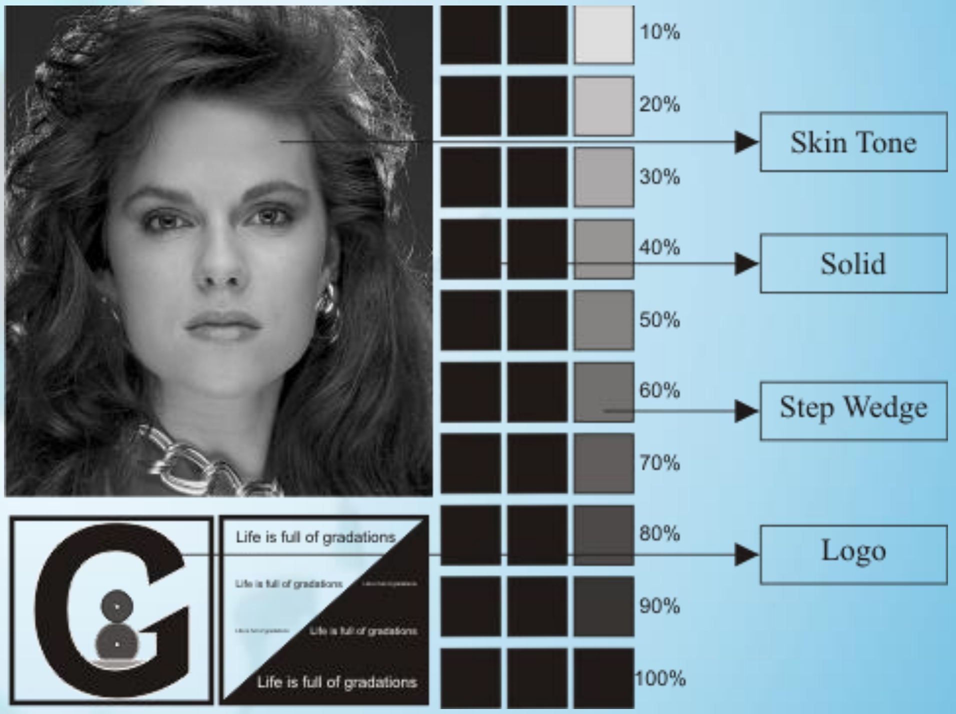
Methodology

Layout Design

- A monotone layout comprising of a skin tone, solid patches, step wedge, logo and surface/reverse text.



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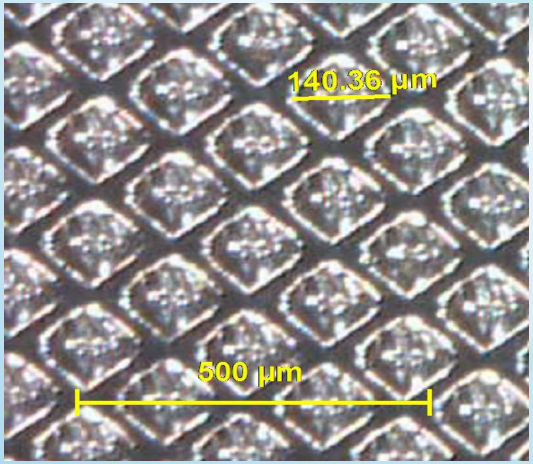
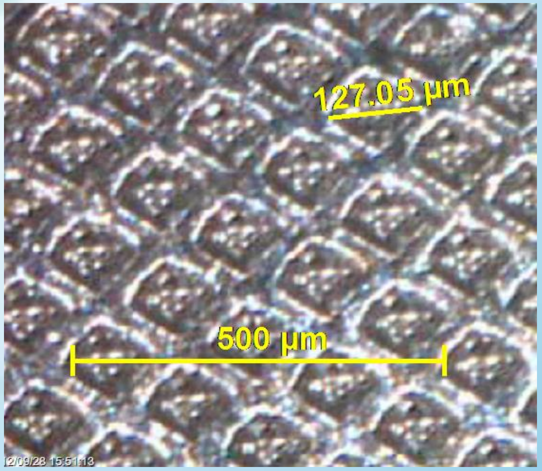
Methodology

- Electronic Engraving with 175 and 200 LPI at 45^0 cell angle.
- **Cell Depth:** 42 µm and 36 µm with an opening of 140 µm and 127 µm.





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Methodology

Baseline Identification

- The production runs were conducted on the PVC film (40µ) for five days on a pilot gravure press.
- **Parameters:** 175 LPI Line screen, 19 sec viscosity, 100 m/min speed, 70 shore A hardness and 3.5 kg/cm^2 pressure.

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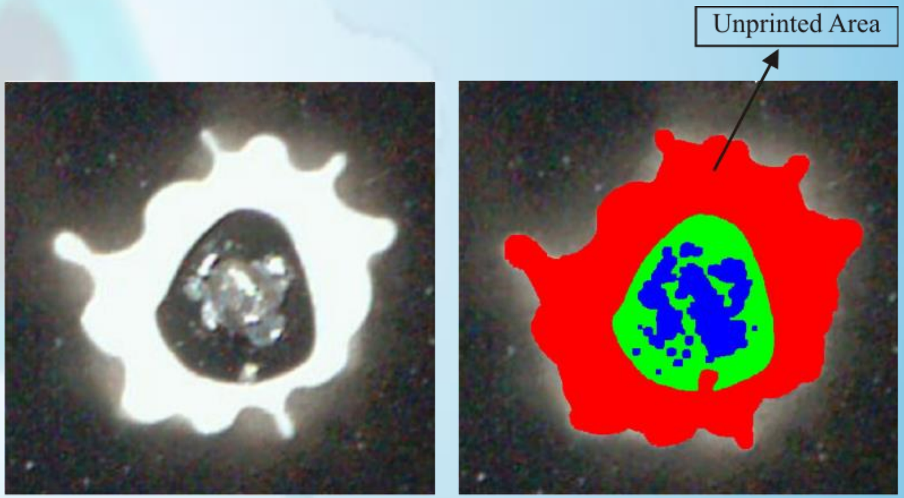
Methodology

Baseline Identification



- The print voids were captured using DIGITUS microscope.
- Magnification: 200X.
- Processing: Dexel Imaging 2.4.4
- **Sample Size:** 25 sheets (250 mm x 460 mm).

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Methodology: Baseline Identification

Production Runs	Mean Void Area/Sheet (mm^2)	Std. Dev.
P1	0.1897	0.0845
P2	0.3078	0.0606
P3	0.2684	0.0612
P4	0.269	0.0652
P5	0.1005	0.0318
Baseline	**0.2271**	**0.0607**

Target: 50% of the Baseline i.e. 0.1135 mm^2

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Methodology: Screening Experiment

- A general full factorial design with 54 runs and 2 replicates.

S. No.	Variables	Unit	Levels		
			Low	Mid	High
1	Line Screen	LPI	175	-	200
2	Viscosity	sec.	17	19	21
3	Speed	m/min.	80	100	120
4	Hardness	Shore A	60	70	80

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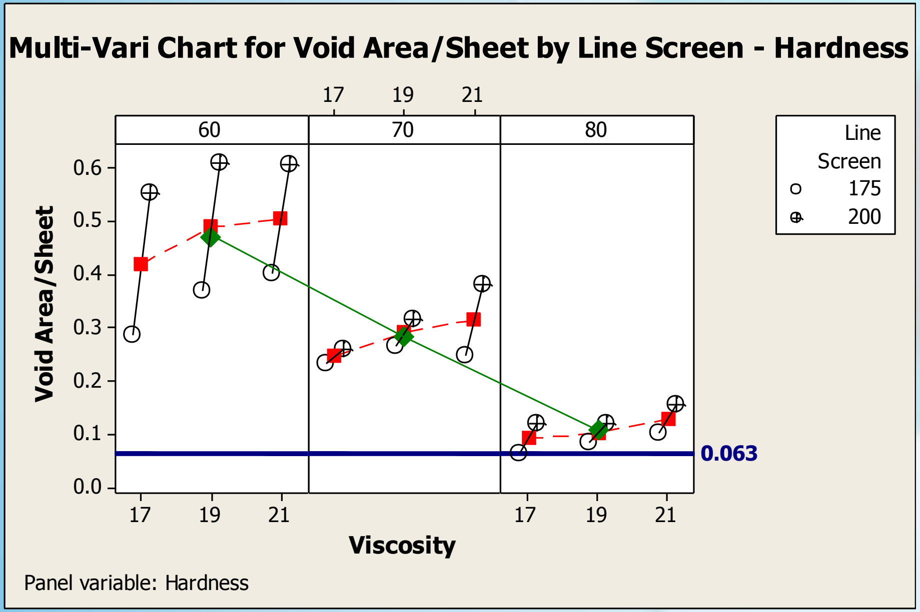
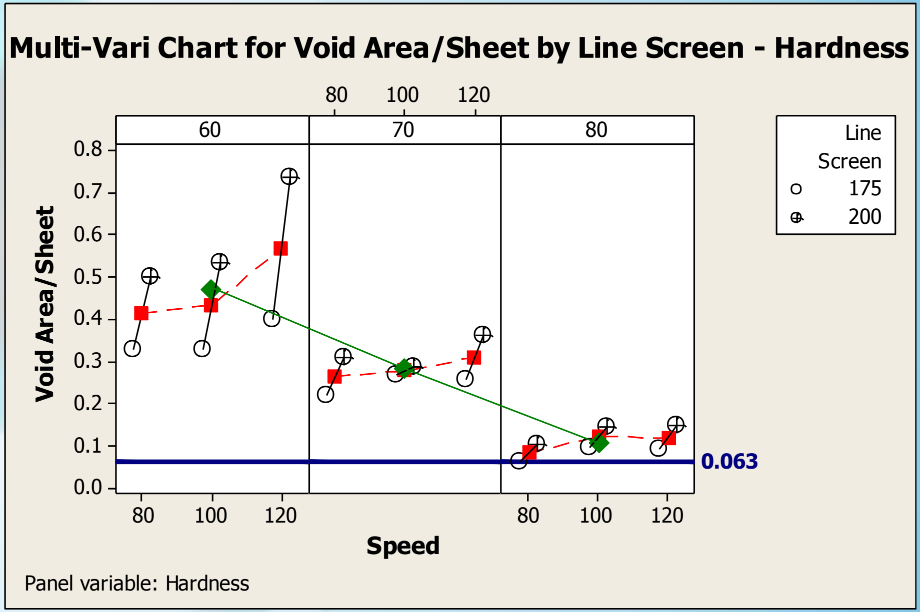
Methodology: Analysis





Reduction in void area with increase in hardness at lower line screen.

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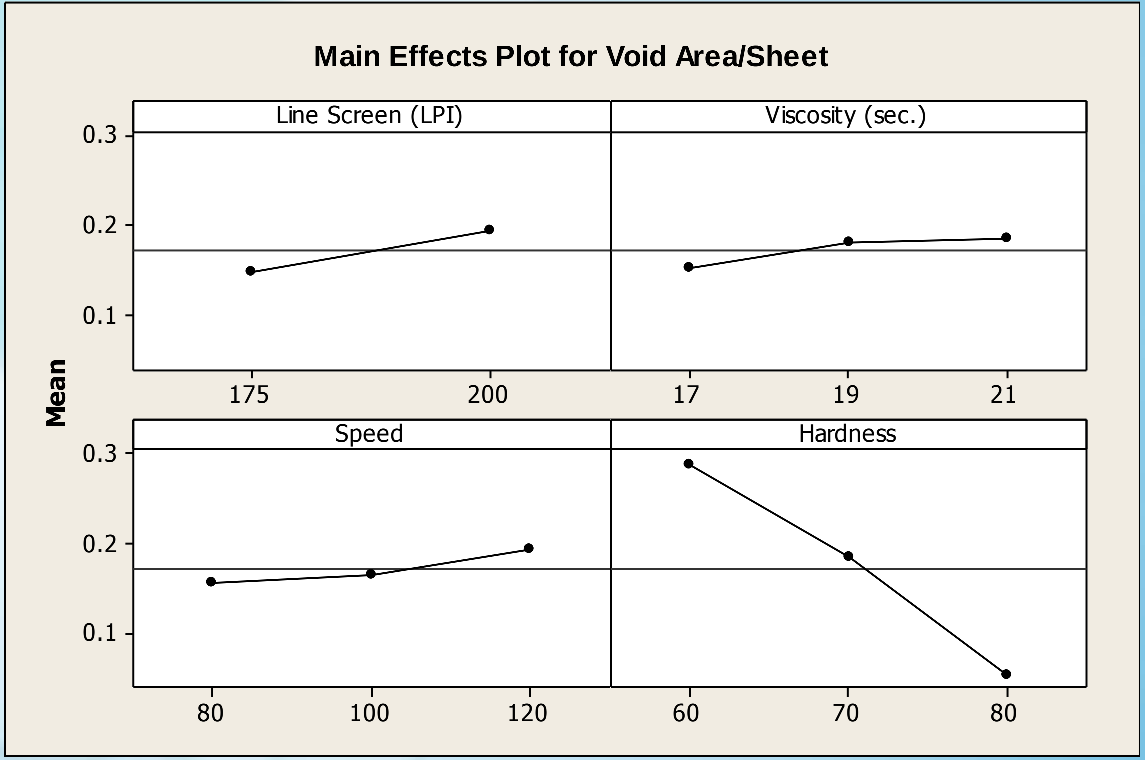
Methodology

Analysis

- **Significant factors:** Hardness and Line screen.
- **Important factors:** Viscosity and Speed.



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Methodology: Analysis

Term	Coef	SE Coef	T	P
Constant	-5.47998	0.941773	-5.8188	0.000
Line Screen	0.03085	0.00466	**6.62016**	**0.000**
Viscosity	0.01345	0.00405	3.32125	0.001
Speed	0.00996	0.003586	2.77671	0.007
Hardness	0.06359	0.013257	**4.79661**	**0.000**
Line Screen*Hardness	-0.00037	0.000066	-5.67426	0.000
Speed * Hardness	-0.00012	0.000051	-2.32006	0.022

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Methodology: Analysis

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	6	2.8393	2.8393	0.4732	103.235	0.000000
Line Screen	1	0.3478	0.2009	0.2008	**43.827**	**0.000000**
Viscosity	1	0.0299	0.05056	0.0505	11.031	0.001264
Speed	1	0.0694	0.0353	0.0353	7.71	0.006591
Hardness	1	2.2174	0.1055	0.1054	**23.007**	**0.000006**
Line Screen*Hardness	1	0.15	0.1476	0.1475	**32.197**	**0.000000**
Speed*Hardness	1	0.0246	0.0246	0.0246	5.383	0.022434
Error	97	0.4446	0.4446	0.0045		
Lack of Fit	47	0.2563	0.2563	0.0054	1.447	0.099977
Pure Error	50	0.1884	0.1884	0.0037		
Total	103	3.2839				

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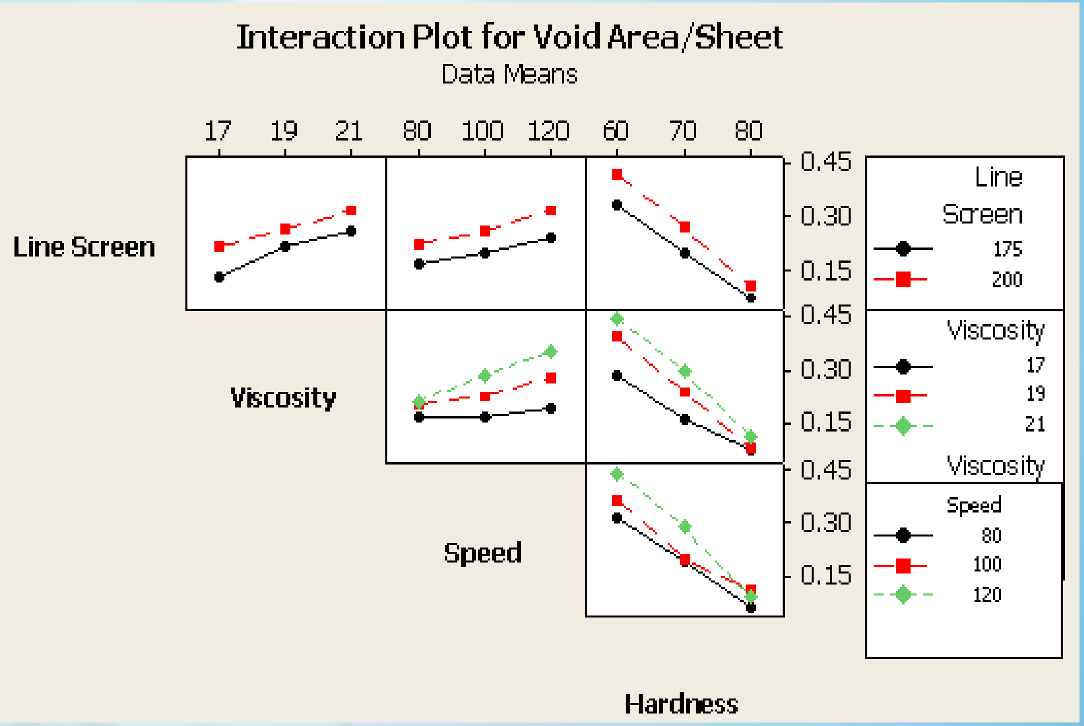
Methodology

Analysis

- **Interactions:** Hardness with Speed and Line screen.
- **Best Settings:** 175 LPI, 17 sec, 80 m/min and 80 shore A.



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Methodology: Verification and Consistency

- The best settings (175 LPI line screen, 17 sec viscosity, 80 m/min speed and 80 shore A hardness) was confirmed by conducting a press run.
- It was checked for its consistency by re-running for 5 days.

Trials	Line Screen (LPI)	Viscosity (sec)	Speed (m/min)	Hardness (shore A)	Void Area/ Sheet (mm^2)	Std Dev. Void Area
Verification	175	17	80	80	0.07921	0.0417
Consistency	175	17	80	80	0.07622	0.0569

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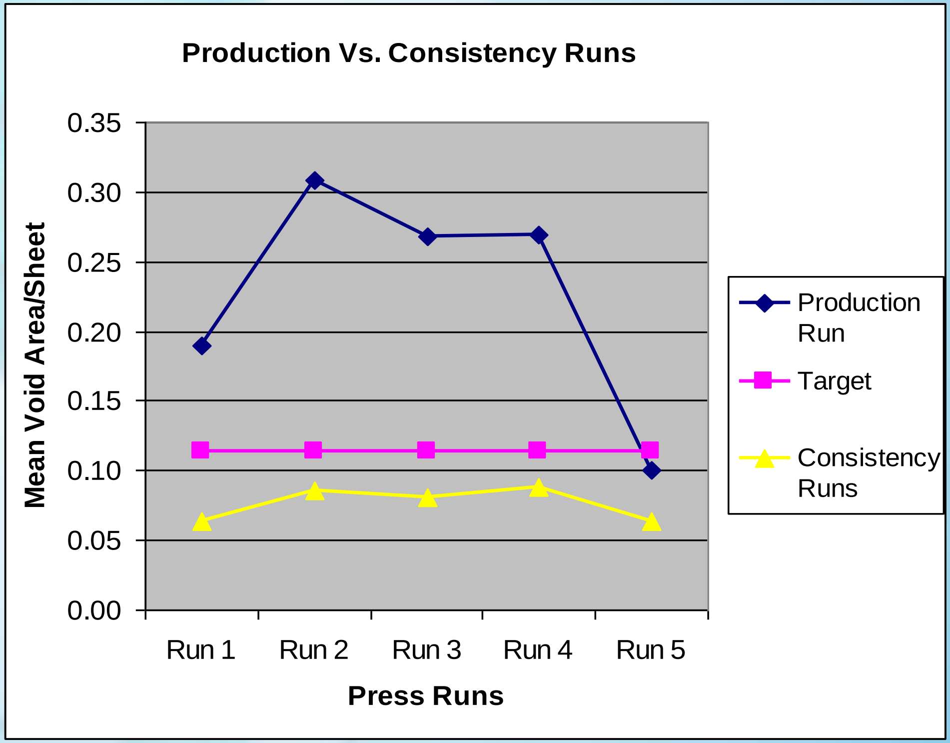
Methodology: Production Run and Consistency Run

The void area/sheet for all the consistency runs were well below the set target of 0.1135 mm^2.



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Methodology: Production Run and Verification Run

Trials	Void Area/Sheet (mm^2)	Std. Dev.
Production Run	0.2271	0.0607
Verification Run	0.07921	0.0417

- Significant improvement from Production to Verification Run.
- The void area is minimized to 65.12%.
- The set target 0.1135 mm^2 was achieved for viscosities ranging between 17 to 19 sec, speed ranging between 80 to 120 m/min at 175 LPI line screen and 80 shore A hardness.

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Conclusion

- Gravure printing being widely used for shrink applications, it becomes very necessary for the printer to minimize print voids so as to reduce losses and wastage to a greater extent.

- Optimization of the process parameters itself has a solution to these issues.

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Conclusion

- Identifying the correct set of parameters can prove to be beneficial for the industry.
- The analysis revealed line screen and hardness as the most influential factor in minimizing the void area.
- The optimal parameters (175 LPI, 17 sec, 80 m/min and 80 shore A) were identified that minimized the void area/sheet to **65.12%** which is well above the set target.

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Conclusion

- In today's competitive environment, companies of all scales are feeling the pressure to streamline their business in order to save money and simultaneously meet the growing demand for environmental responsibility and accountability.
- Hence, if these changes are successfully implemented on a large scale, they could accomplish in meeting both environmental and cost saving goals for a company.

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Thank You