

# **CORRUGATED BOARD & BOX MAKING**

Process, Raw Material Properties, Testing & Specification

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# CONTENT:

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- ✘ Brief Background
- ✘ Application
- ✘ Process of Board & Box Making
- ✘ Fundamentals of Bonding & Warp Control.
- ✘ Important Paper Properties
- ✘ Testing & Specifications

A presentation by:

*THE SOUTH INDIA PAPER MILLS LTD*  
*Printing & Packaging Division*



**SIPM PPD**



# THE USER INDUSTRY....

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- × Fast Moving Consumers Goods
  - + Processed Food & Beverages
  - + Non-Food (Pharmaceuticals, Home & Personal Care)
- × Consumer Durables
  - + White Goods
  - + Electronic Gadgets
- × Garments & Footwear
- × Fruits & Vegetables
- × Engineering Products
- × **E-Commerce**

# THE USER INDUSTRY...

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- The largest segment of Demand for Corrugated Boxes is the FMCG Sector. (60-65%)
- Demand for Corrugated Boxes in this segment is growing at 8-10% per year.
- Demand for Corrugated Boxes for E-Commerce is 'add-on' packaging and is growing exponentially

***The Raw Material to Produce  
Corrugated Box / Board is Liner  
Paper and Fluting Paper***

- Commonly referred to as  
“Container Board”***

# What is a Corrugated Board ?



Single face board

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Single wall board

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Double wall board

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Triple wall board

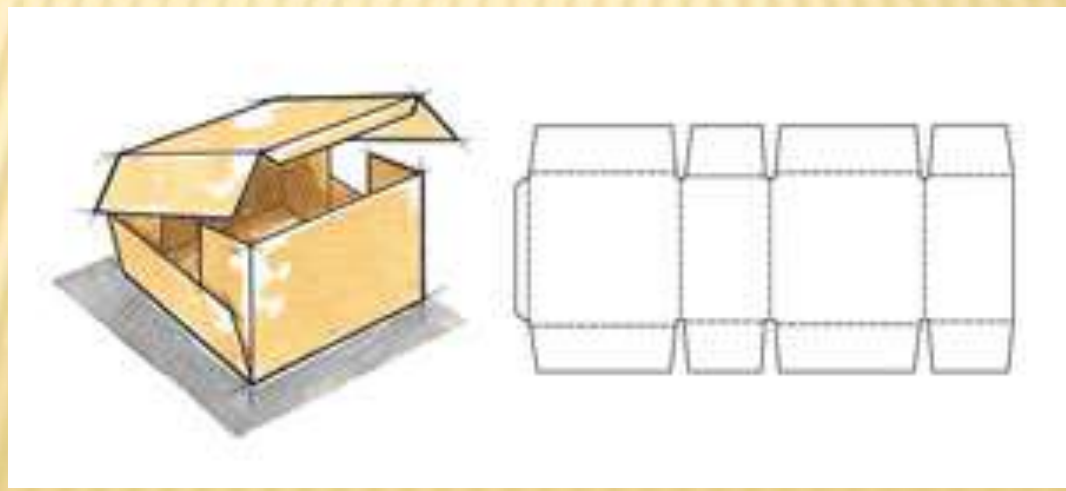
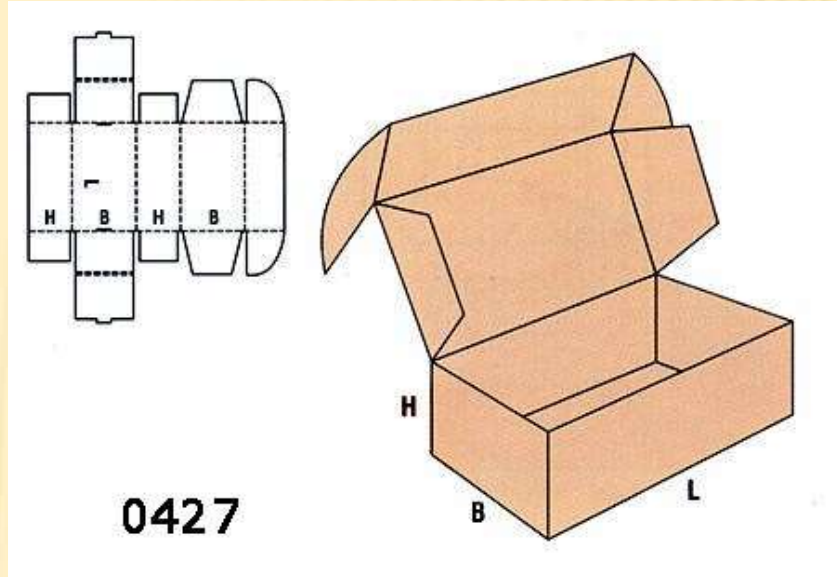
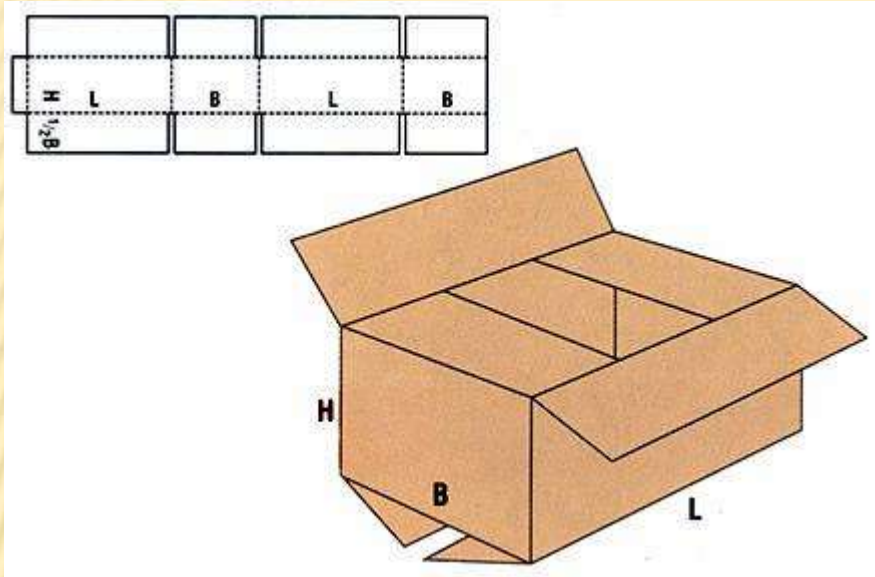
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***Corrugated Boards are Converted into Boxes or Die-cut Blanks based on the method of Packing, Storage & Delivery.....***



# Various Box Styles.....



# Corrugated Boxes & Application.....



# Corrugated Boxes & Application.....





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**⚠ DELIVERY CAUTION**

HANDLE WITH CARE

✓ 	✗ 
✓ 	✗ 
✓ 	✗ 
✓ 	✗ 

Warning : Person injury threat  
Two or more person are suggested  
to lift or move the cartons  
Use proper lifting procedure





# Corrugated Boxes & Application.....



*Promotes Brands*



# EXPECTATIONS FROM A “GOOD BOX” .....

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- ✘ Protects its Contents
  - + Against Damage
  - + Against Pilferage
  
- ✘ Promotes the Brand
  
- ✘ Allows Productive Packing
  - + Case Dispensing /Extraction \*\*
  - + Case Forming \*\*
  - + Auto Case Filling \*\*/ Manual Case Filling \*\*
  - + Case Closure (Sealing)
  - + Batch Identification (Ink Jet/Dot Matrix Printing)

# Components of Corrugated Board



Single face board

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Single wall board

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Double wall board

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Triple wall board

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# Corrugated Board making Process (*Wet-End*)

## Single Facer

- Production of Fluted Web
- Application of Adhesive to Flute Tips without “fluff out”
- Joining of Liner & Fluted paper & formation of “Green Bond”
- Transport of Single face web to the Bridge

## Automatic Bridge Control & Web Aligner

- Bridge Stock Control (to maintain a constant dwell time)
- Allow Green Bond Curing
- Maintain Web Tension & Alignment

## Glue Machine & Double Backer

- Pre-heating of Single Face Web & Liner paper for Bonding
- Application of Adhesive to Flute Tips of Single Face Web
- Joining of Single Face Web & Liner to create Bond
- Removal of Excessive Moisture from Corrugated Board



# Corrugated Board making Process (Dry-End)

Slitter Scorer

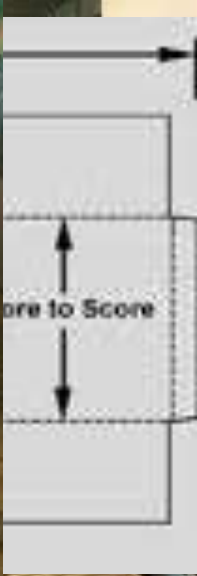
Slitting & Scoring of Continuous Corrugated Board



NC Cut - Off



Auto Down Stacker



Auto Order Change

Wet - End Order Change

Dry - End Order Change



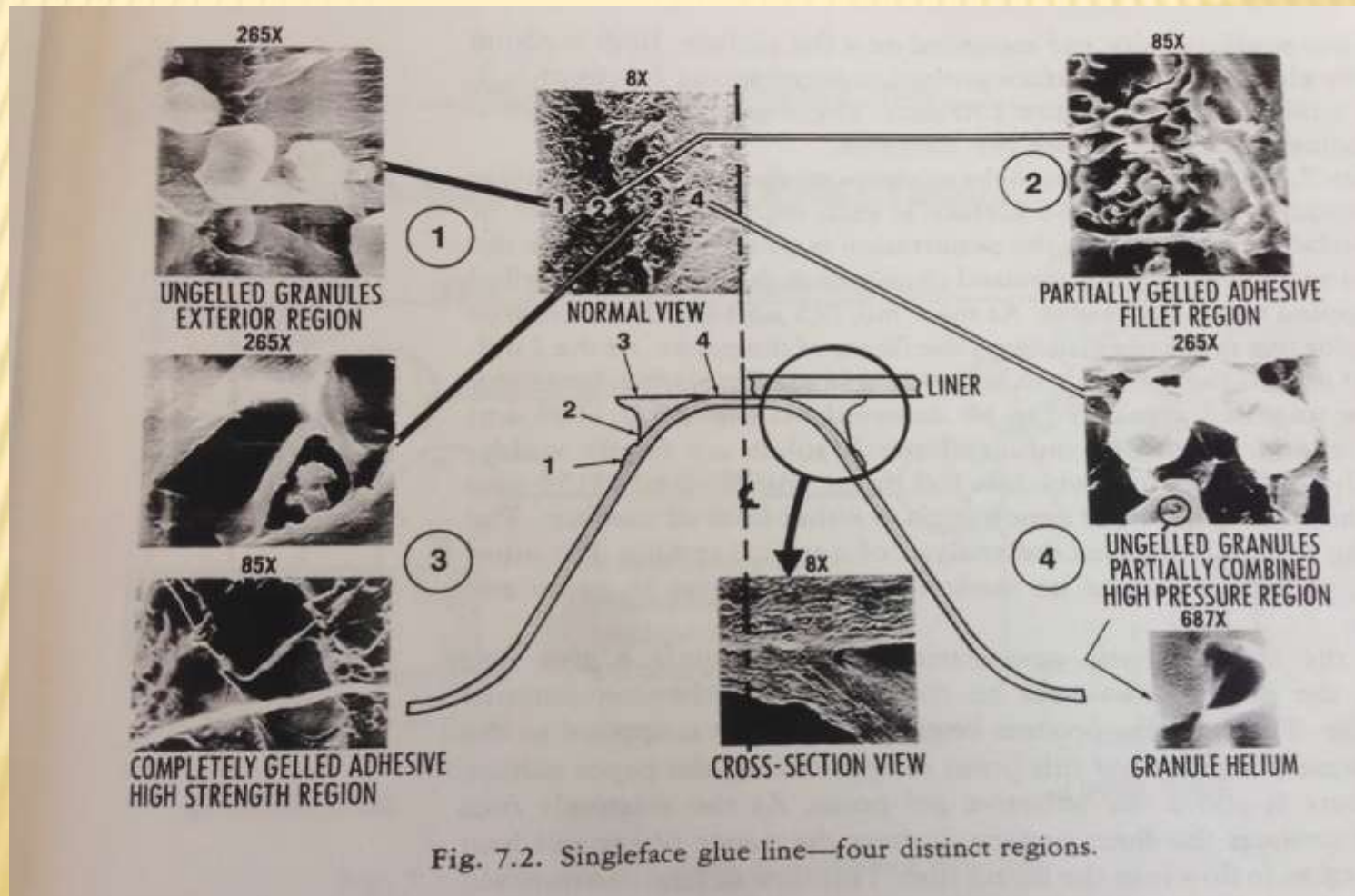
# **CRITICAL PROCESSES IN BOARD MAKING & IMPORTANT PAPER PROPERTIES**

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- ***Bonding on the Corrugator***
- ***Board Warp Control***

# THE BONDING MECHANISM.....

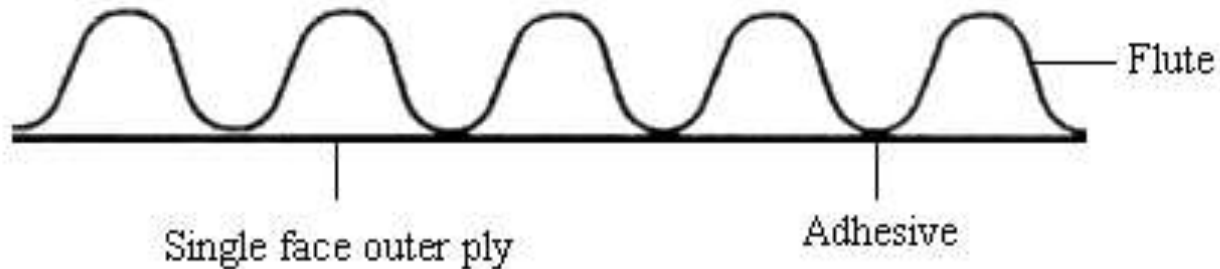
- *By in-situ Gelatinization of Suspended Starch Granules to create a Bridge between the Bonding Substrates (Flute & Liner Papers)*



# BONDING AT THE CORRUGATOR.....

## ✘ The Single Face Bond

- Joins the Corrugated Medium to a Liner to create Single Face Sheet. ( “Two Ply Sheet” )

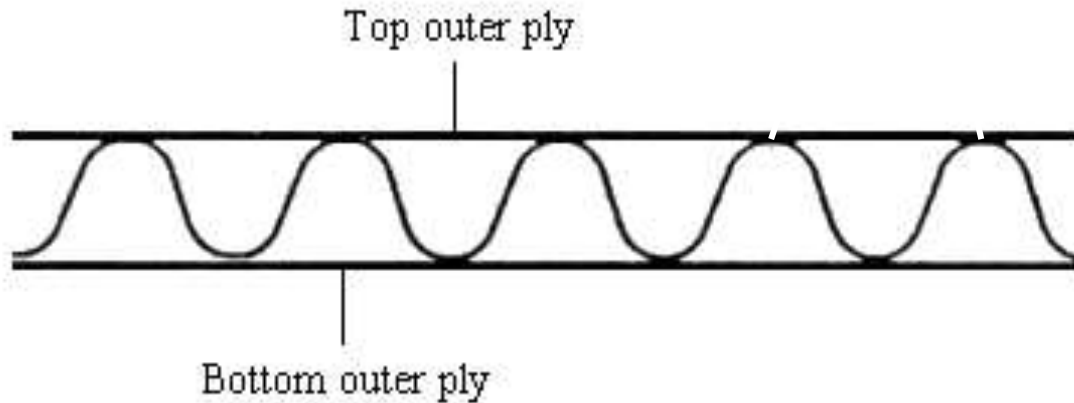


3. Bond strengthening by dewatering of gelled adhesive film created in step 2.

# BONDING AT THE CORRUGATOR.....

## ✘ The Double Face Bond

- Joining the flute tips of Single Face Web to Liner paper to create a Combined Corrugated Board.





# BONDING AT THE CORRUGATOR.....

## The Role of Starch in creating Adhesive Bonds on the Corrugator

- Starch granules do not impart adhesion between two substrates unless they are gelatinized.
- Gelatinization is the swelling & bursting of granular Starch to form a tacky Adhesive.
- Gelatinization requires water to penetrate the Starch granules with adequate heat (Heat of Gelatinization).

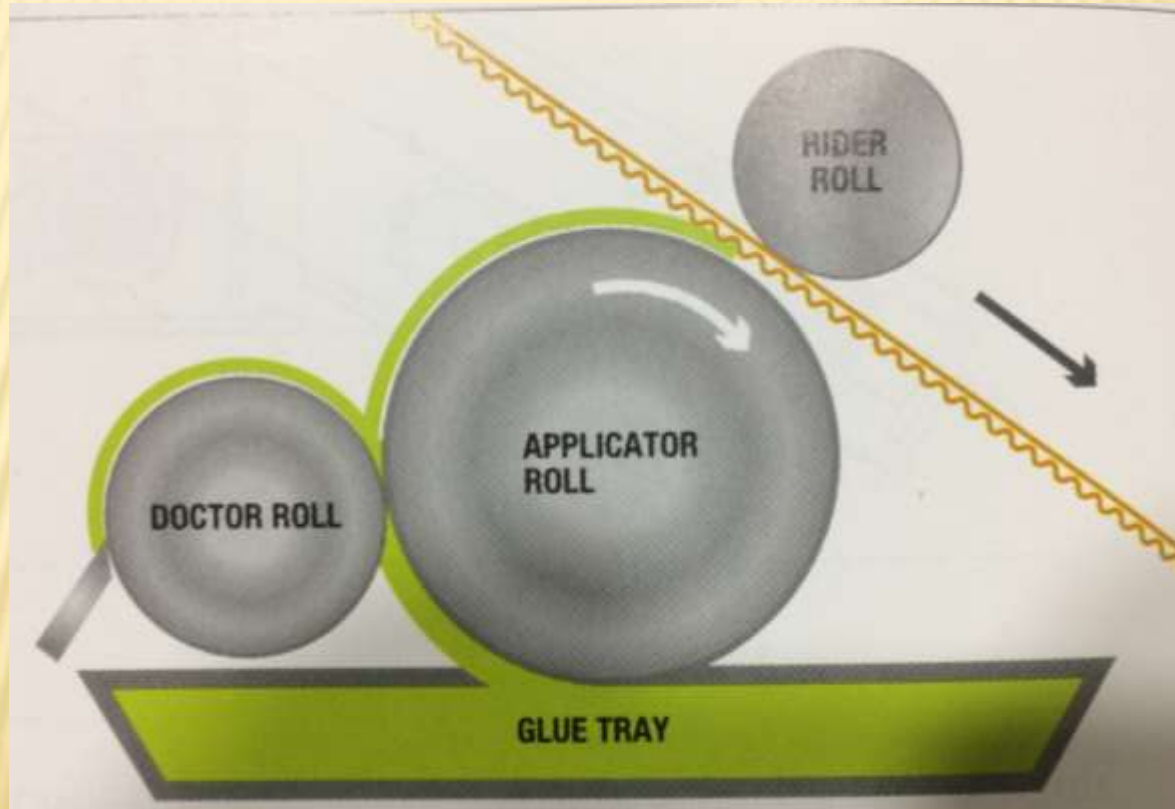
# BONDING AT THE CORRUGATOR.....

## *The Role of Starch in creating Adhesive Bonds on the Corrugator*

- Moisture for gelatinization is available in the suspension of granular Starch in the Water.
- Heat is supplied for gelatinization primarily by heating the Substrates being Bonded together (Liners & Fluting papers)

# ADHESIVE DELIVERY TO THE BONDING POINT

- × Granular, Un-geletinized Starch granules suspended in water do not form a 'good' film of adhesive
- × A 'Carrier' Component is required to create a film



Creating Adhesive Film on Transfer Rollers in Single Facer & Glue Machine

# GLUE PREPARATION

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## ✦ Preparing the Adhesive by Stein-Hall Process

### Two Component Adhesive

- Carrier Component :- Partially Gelatinised Starch Granules (about 25% of Adhesive Quantity)- these help to form a film by 'carrying' un-gelled granules.
- Non Gelatinised Starch Granules (about 75% of Adhesive Quantity)
- Required Gel-Point & Viscosity is achieved by Controlled addition of Caustic & Borax



# BONDING AT THE CORRUGATOR.....

## Role of Heat on the Corrugator

- To Create Adhesive Bonds between the different Paper Components of the Board using an adhesive comprising of a suspension of Starch granules in Water.
- To Remove the Excess Moisture induced into the Board Structure by the Adhesive.

# BONDING AT THE CORRUGATOR.....

## The Role of Heat in creating Adhesive Bonds on the Corrugator

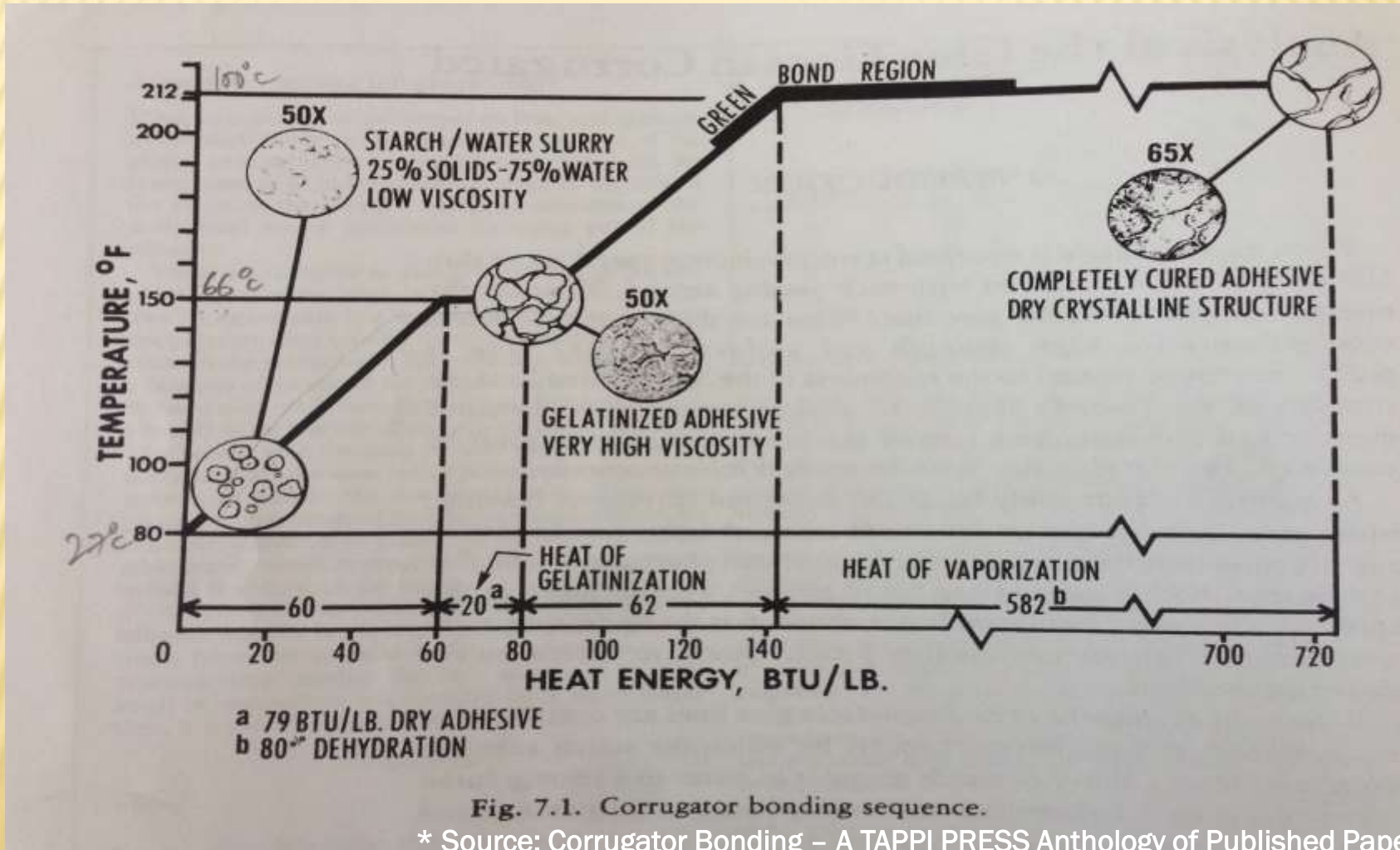


Fig. 7.1. Corrugator bonding sequence.

\* Source: Corrugator Bonding – A TAPPI PRESS Anthology of Published Papers

# BONDING AT THE CORRUGATOR.....

- *Adequate Heat & Pressure is Critical for the Single face Green Bond.*
- *Adequate Heat is required for the Double face bond & for removing excess moisture induced by Adhesives in the combined board.*



# HOW IS THE HEAT REQUIRED FOR BONDING IMPARTED TO THE POINT OF ADHESION ?





# HEAT CARRIAGE & DISSIPATION

*Paper has two major components*

- *Fiber – Low Specific Heat (0.33kcal / kg / °C)*
- *Water – High Specific Heat (1.0kcal / kg / °C)*

# HEAT CARRIAGE & DISSIPATION

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- *When paper is heated by 1 °C the moisture component carries 3 times the amount of Heat than the Fiber component.*
- *Paper with higher moisture content carries more heat than dryer paper at the same temperature.*

# HEAT CARRIAGE & DISSIPATION

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- *The heat required to raise the adhesive temperature to the Gel-point & beyond is imparted by Pre-heaters & Pre-conditioners to the Fluting / Liner.*

# IMPORTANT PAPER PROPERTIES FOR GOOD BONDING.....

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- *Higher Moisture Papers Bond better & are less prone to cracking during scoring due to their inherent flexibility*
- *At Low Moisture content papers have to be heated more to carry adequate heat for bonding This tends to increase their Brittleness.*



# BONDING AT THE CORRUGATOR.....

Paper Properties must facilitate Anchoring of Adhesive Bridge to both Substrates:

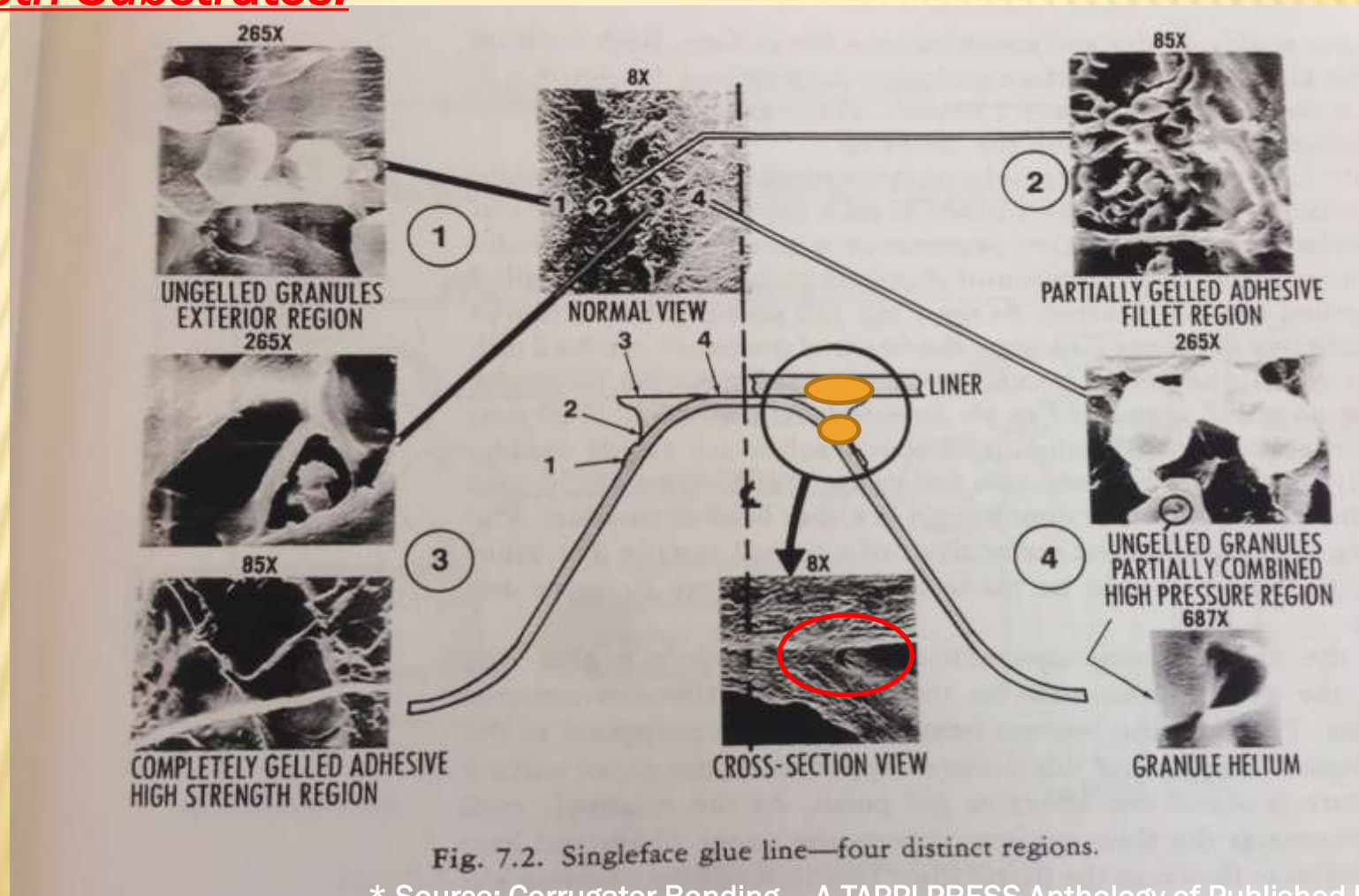


Fig. 7.2. Singleface glue line—four distinct regions.

\* Source: Corrugator Bonding – A TAPPI PRESS Anthology of Published Papers

# IMPORTANT PAPER PROPERTIES FOR BONDING:

- ✘ Moisture – Critical for carrying adequate heat to the bond site
- ✘ Cobb – Should be appropriate for Speed of Operation.
- ✘ Porosity – Too much or too little are both bad. The adhesive has to form a proper “Bridge” between substrates and “Anchor” in each one.

# BOARD WARP CONTROL AT CORRUGATOR.....

## *Criticality of Warp*

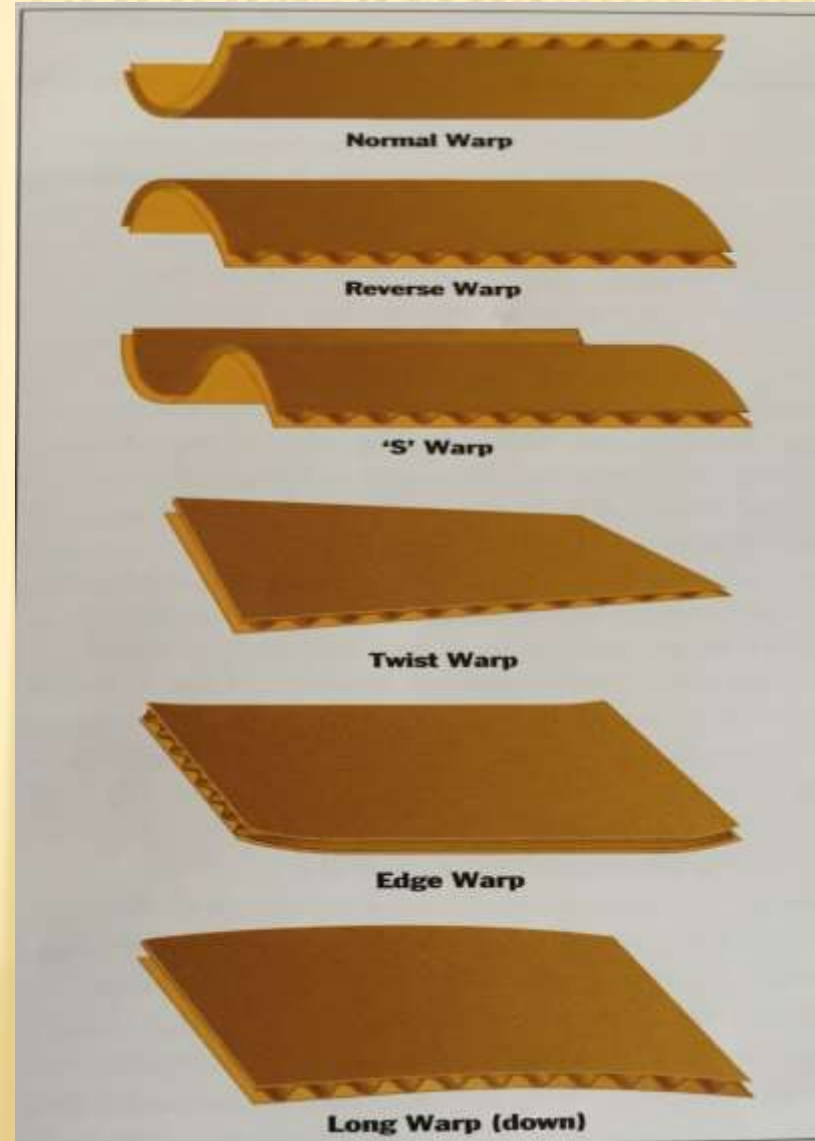
- Reduction in Structural Strength of Board / Box
- Inaccurate Box Dimensions as due to Mis-registration of Slots
- Shifting of Print Matter
- Productivity Loss at Converting Machines



# BOARD WARP CONTROL AT CORRUGATOR.....

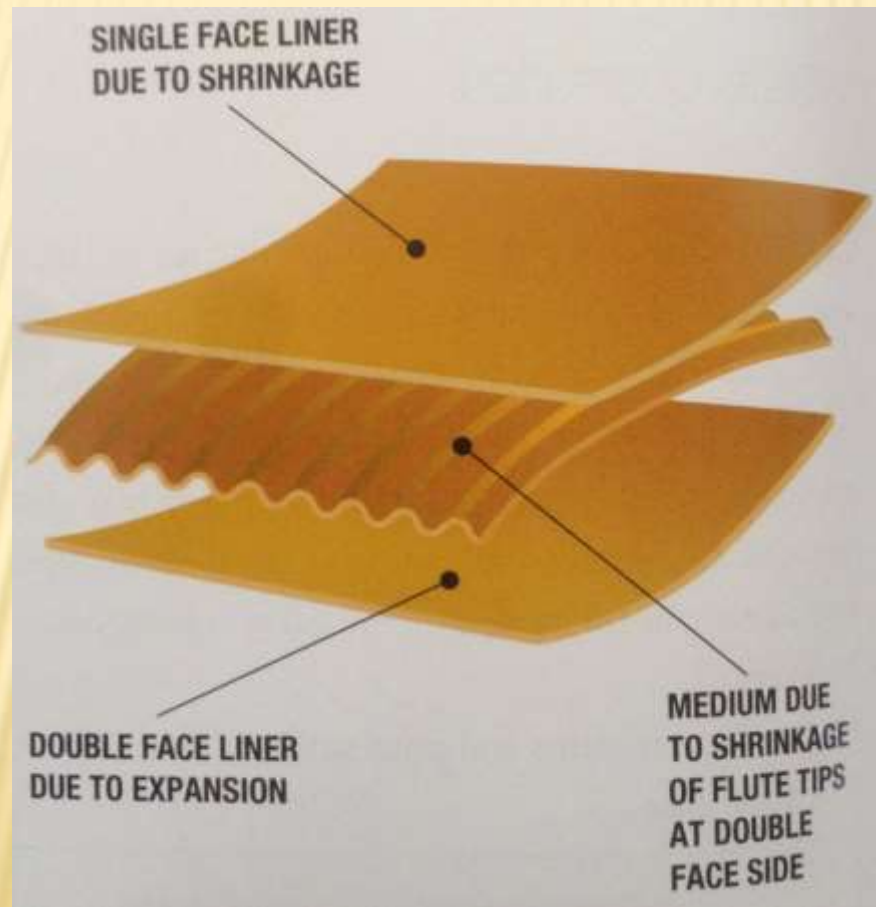
## Common Types of Warp

- Upward Warp
- Downward Warp
- S-Warp
- Machine Direction Warp, etc.

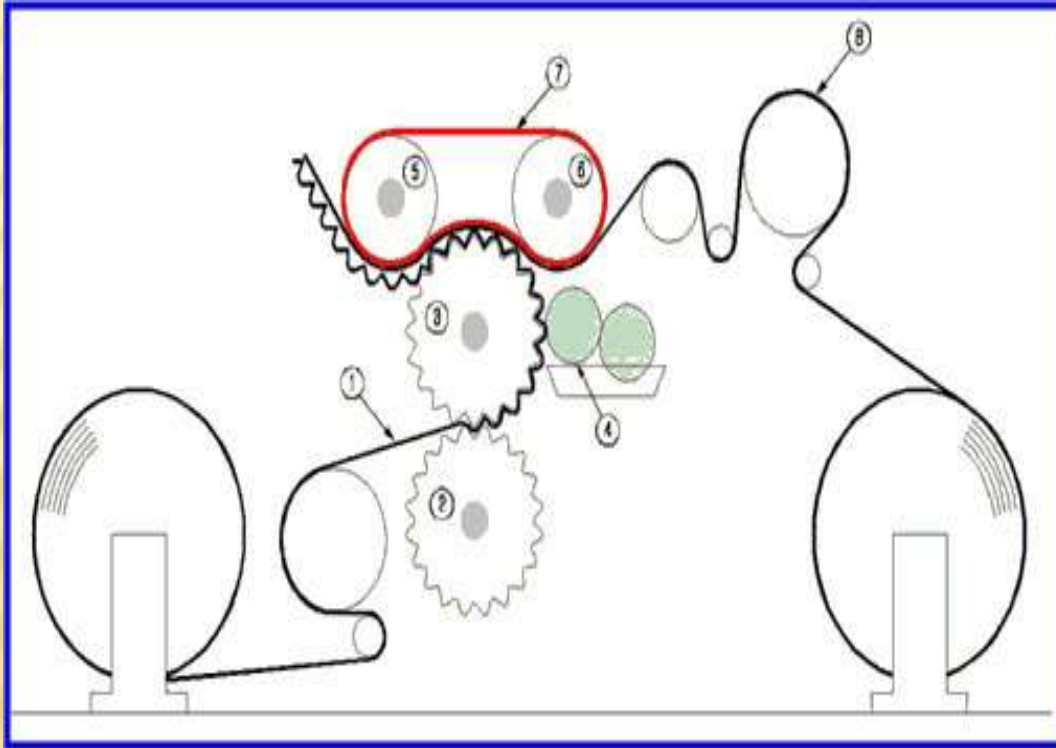


# BOARD WARP CONTROL AT CORRUGATOR.....

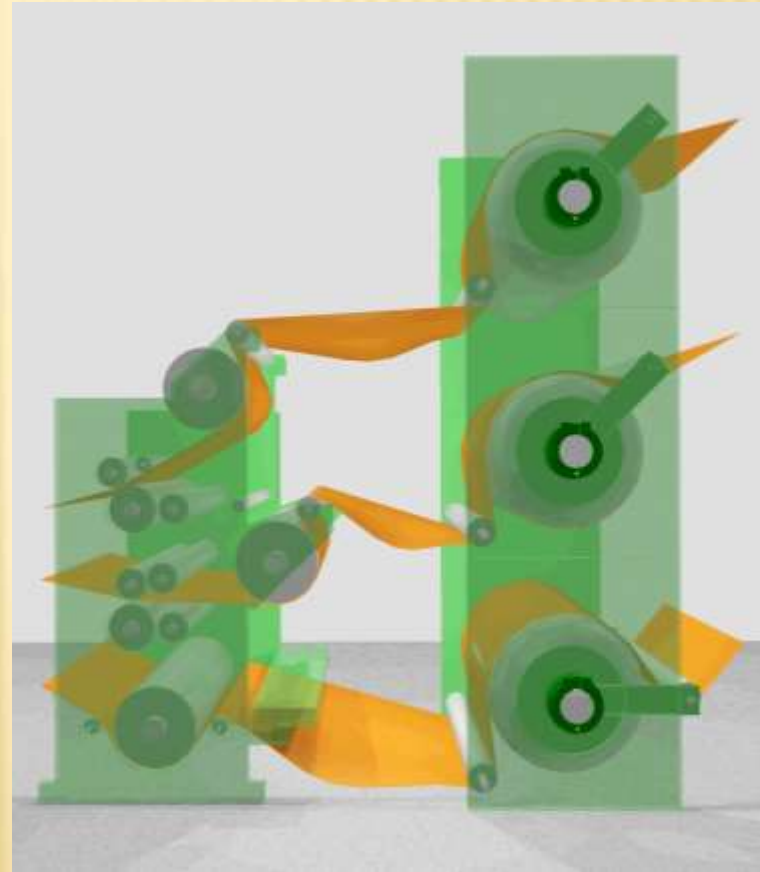
## Reason of Board Warpage



## Single Facer



## Double Facer





# BOARD WARP CONTROL AT CORRUGATOR.....

## *Control Mechanism of Warp (Manual Mode)*

- Increase or Decrease the Paper Wrapping of Pre-heaters at SF Liner or DF Liner
- Check the Glue Application & Control if Abnormal at SF or at Glue Machine
- Adjust DF Liner Paper Tension or 2 Ply Web Tension to Control Machine Direction Warp or Long Warp
- There is no Operational Solution to “S Warp” & “Twist Warp” as it occurs due to Profile Moisture Variation.

# BOARD WARP CONTROL AT CORRUGATOR.....

## Control Mechanism of Warp (Auto Mode)



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# *The Corrugating Machine...*



# Corrugated Box making Process

Board Feeding

Regular Slotted Cartons

Die-Cut Boxes & Wrap Around Blanks

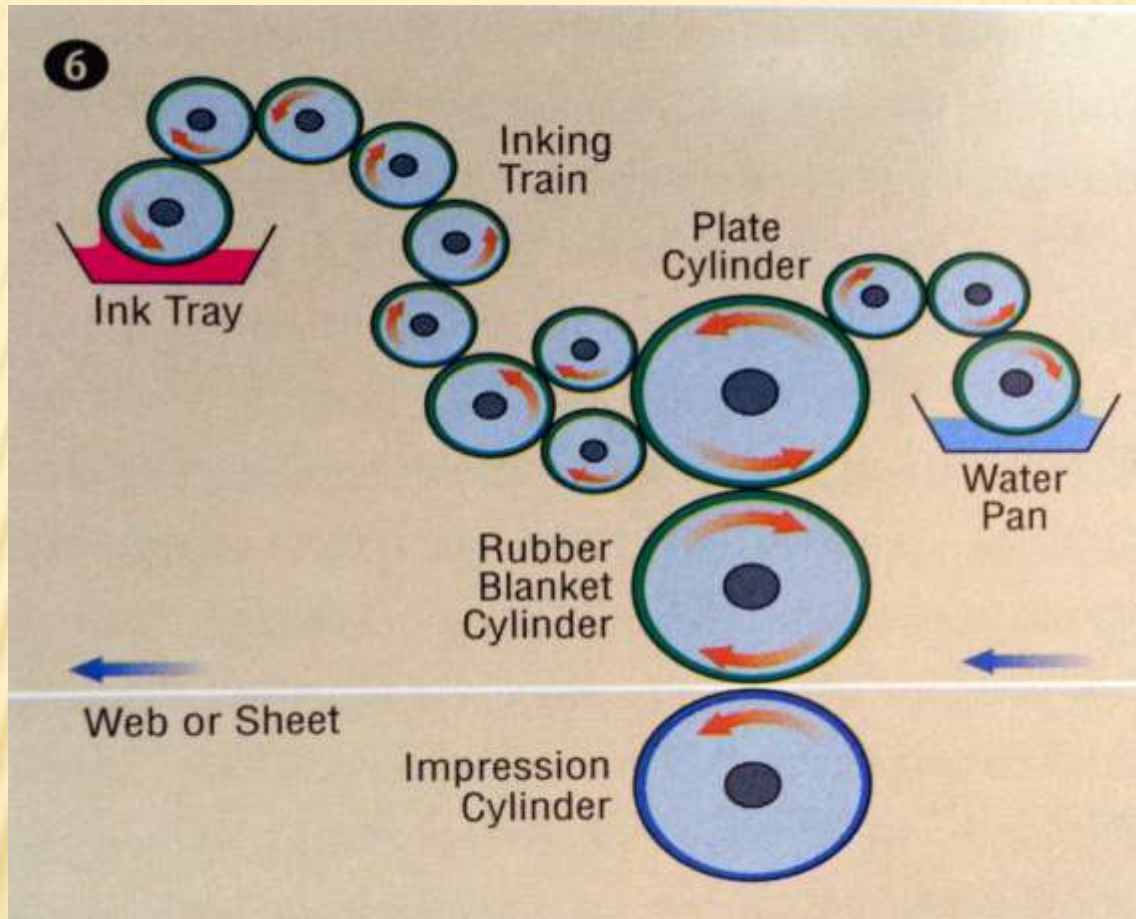




# ***DIFFERENT PRINTING TECHNOLOGIES***

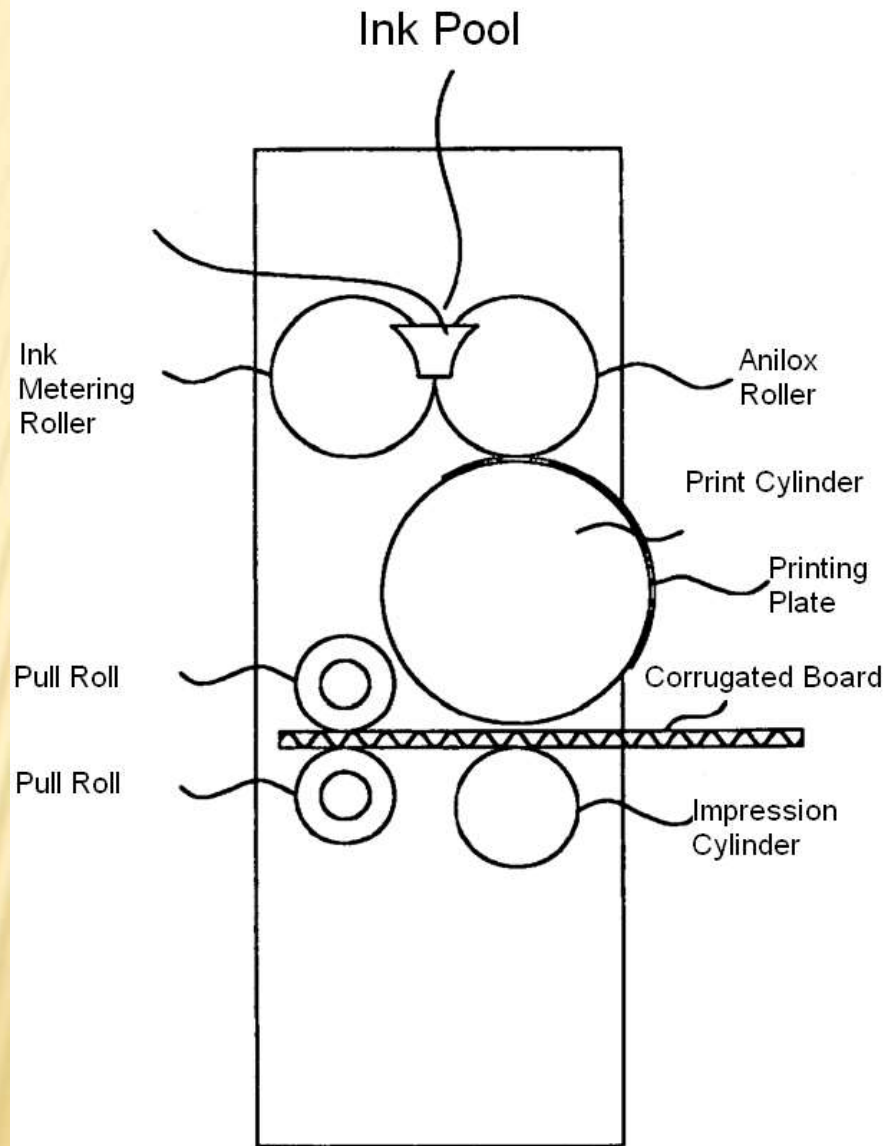
- ✘ All high speed printing is impression based Printing
  - + Offset Printing
  - + Flexographic Printing

# OFFSET PRINTING TECHNOLOGY



Schematic representation of Offset Printing Press

# FLEXOGRAPHIC PRINTING TECHNOLOGY



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# ***The Flexo Folder Gluer...***



*DEVELOPMENTS IN CORRUGATED  
CASE MAKING RAW MATERIAL TO  
ACHIEVE NEW PARAMETERS FOR  
MEASURING BOX STRENGTH*

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## Testing of Corrugated Board & Boxes

*Currently Bursting Strength is the most popular measure for the strength of a corrugated paper box in India.*

*Is Bursting Strength the best/most appropriate measure of the strength of a Corrugated Box ?*

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# *BS – ORIGIN & RELEVANCE*

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- ✘ *Originated as a test for virgin Kraft paper used for bag and sack applications- relevant measure was rupture- appropriate for the application*
- ✘ *Could be successfully extended to corrugating raw materials as long as paper manufacturing technology and raw materials were homogenous – Softwood pulp, Single ply, light pressing etc.*

## *BS – ORIGIN & RELEVANCE (CONTD.)*

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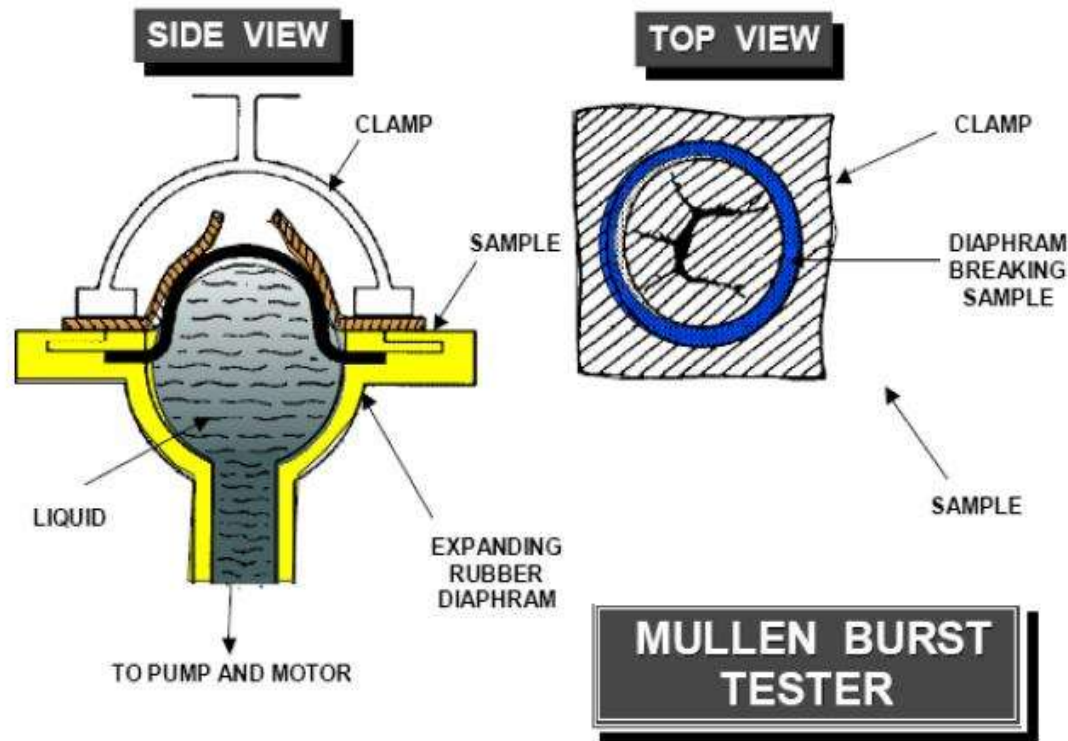
- ◉ *Major Factors contributing to the gradual obsolescence of the BS as a measure:*
  - *Research information on the nature of box failure and contributing factors*
  - *New raw materials for paper making – waste paper and other non-conventional materials*
  - *Evolution of paper making technology- particularly Forming and Wet Pressing*
  - *Evolution of High Density/High Performance Liners*



*The Mechanism of Bursting;  
What does it measure?*

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# Mullen Burst Tester determines the force required to break through the paperboard sheet



*Measures inter fiber bonding strength through failure under tensile forces*

*The Box handling Environment is harsh !*



*Any solutions for this ?*





*How does a box actually fail in protecting the goods being stored /transported ?*

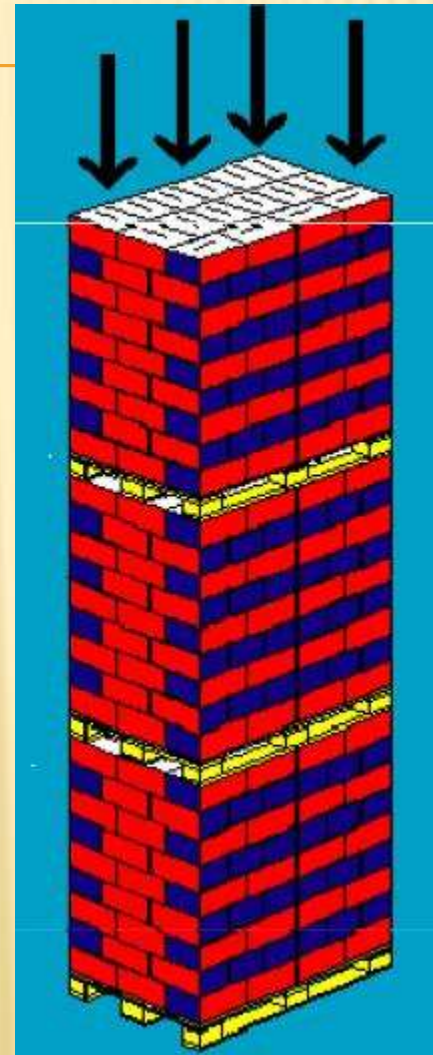




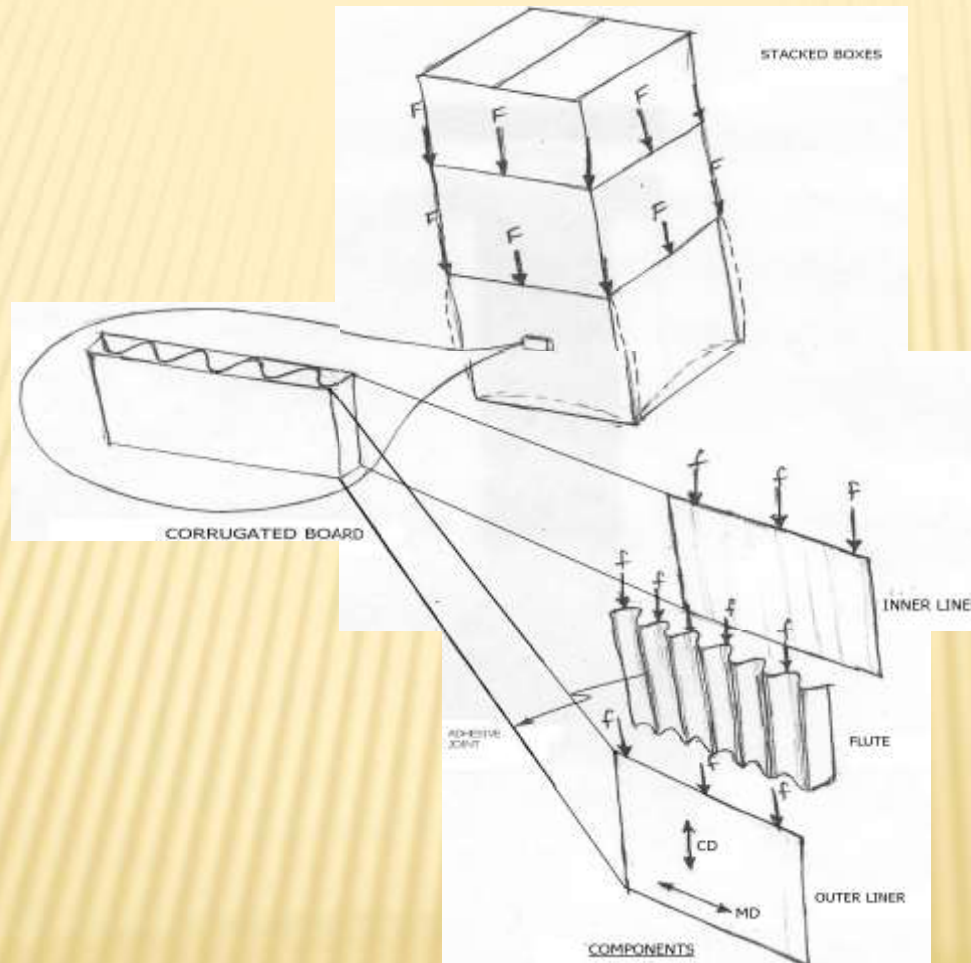
*What should an appropriate  
measure look like?*

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*The ability of the box to withstand top-down loading ( Stacking strength ) is critical.*



*What is the role of individual components of the board in imparting stacking strength ?*



# ***BCT/ECT – A RATIONAL MEASURE OF BOX QUALITY***

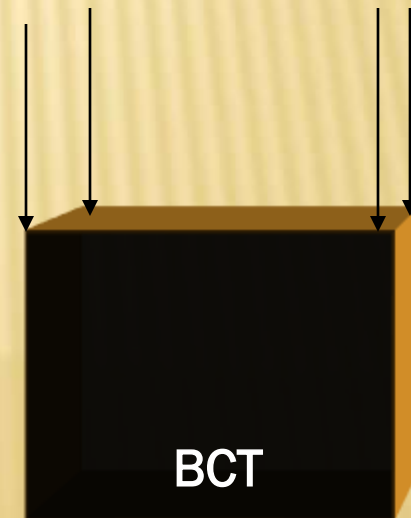
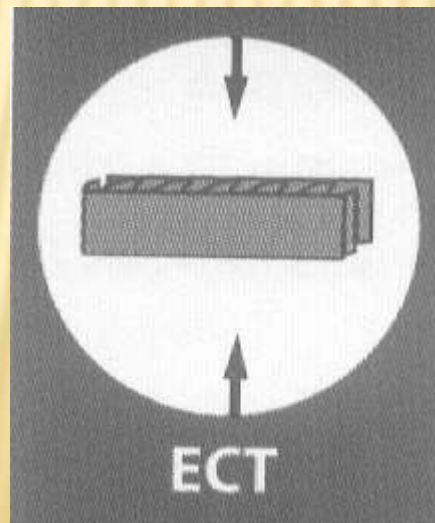
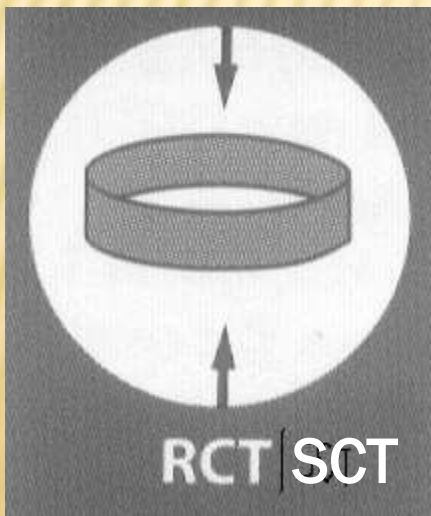
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- ✘ *This test measures an important box parameter that is relevant to the success of the box as a protective container in transit and storage.*
- ✘ *A ECT specification can be set to dovetail with tests for the raw material and the corrugated board*



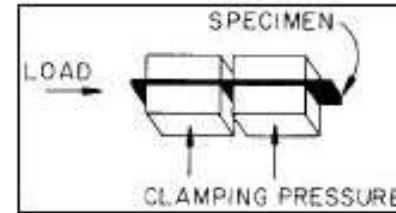
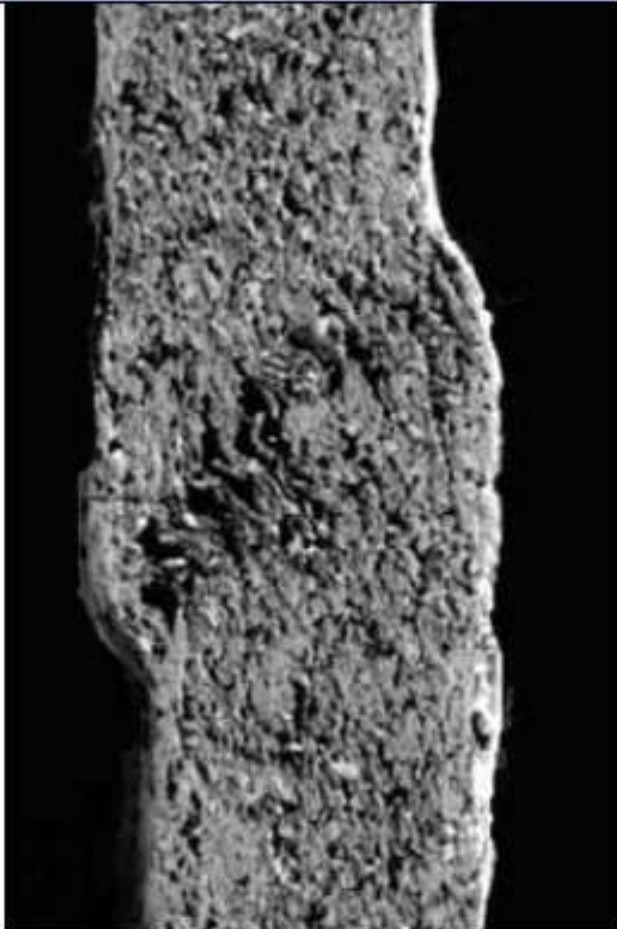
# *RCT/SCT, ECT & BCT*

- ✘ *RCT/SCT – Tests the Raw Material*
- ✘ *ECT – Tests the efficiency of Board Making*
- ✘ *BCT – Tests the efficiency of Box Making*



# SHORT SPAN COMPRESSION (STFI) TEST MORE APPROPRIATE FOR LIGHT WEIGHT LINERS AND FLUTING

**Compressive failure**



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***BCT or BS ?***

***What's appropriate ?***

***Others have walked this path before...***

- 
- ✘ CEPI European Containerboard Standard – specifies SCT Index **OR** Mullen **Equivalent**
  - ✘ Uniform Freight Classification Standard USA – Alternate Rule 41 – Specifies **Alternate** ECT Specification for Mullen + Combined Substance of Liners.



# ***HIGH PERFORMANCE LINERS & FLUTING***

- ✘ *Developed to meet the high strength - low weight requirements for cost effective Box designs.*
- ✘ *New High RCT, low Substance (GSM) grade.*
- ✘ *Acceptance criteria – Ring Crush Test (RCT)*
  - *Short Span Compression Test (SCT)*
  - *Concora Medium Test (CMT)*

# *HIGH PERFORMANCE LINER ( HPL) & HIGH PERFORMANCE FLUTING*

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## *DEVELOPMENT:*

- ✘ Superior Fibre .*
- ✘ Improved formation with appropriate fibre orientation.*
- ✘ High intensity Web Pressing.*
- ✘ Use of strength enhancing polymers.*

# *THE ADVANTAGE OF USING THE NEW GRADES*

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- ✘ An Example to put performance in perspective



Consider a box that has a BS specification of 18 kg/cm<sup>2</sup>

	L	W	H
Box Dimension (mm)	600	400	300
Perimeter	2000		

Consider the following 2 options that meet the BS specification

	Top Liner	Fluting	Bottom Liner
Option 1:	250 gsm(28 BF)	150 gsm (20 BF)	250 gsm(28BF)
Option 2:	400 gsm(40 BF)	120 gsm (16 BF)	120 gsm (16 BF)

Also consider a 3<sup>rd</sup> option that does not meet the BS specification

	Top Liner	Fluting	Bottom Liner
Option 3:	220 gsm HPL -2.6kN/m	150 gsm HPF-1.7kN/m	220 gsm HPL-2.6kN/m

## *The Comparison...*

	<b>GSM</b>	<b>BCT</b>	<b>BS</b>	<b>BCT</b>	<b>Cost</b>
Option 1:	<b>803</b>	<b>372 kgf</b>	149%	85%	118%
Option 2:	<b>682</b>	<b>348 kgf</b>	153%	79%	108%
Option 3:	<b>658</b>	<b>438 kgf</b>	100%	100%	100%

*Option 3 which does not meet the BS criterion has the highest Compression Strength and the lowest Cost.*

# *Desired Paper Quality & Other Functional Properties*

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- High Compressive Strength with Lower Basis Weight
- Odour Free
- Crack Free
- Breakage & Tear Free

# A FEW FACTS OF CORRUGATING INDUSTRY...



# THE INDUSTRY....

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- The Corrugated Box Industry converts about 5.5 million MT of Paper into about 8 to 8.5 billion square meters of Corrugated Boxes every year.

# THE INDUSTRY....

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- The Corrugated Box Industry is highly fragmented and currently comprises of about 13,000\* mainly Small Scale Enterprises scattered across the country.
- \* Guesstimates vary between 12,000 and 14,000 active units.

# THE INDUSTRY....

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- The Corrugated Box Making Industry has been changing rapidly in terms of Scale and Technology after its “De-reservation” in 2007
- Prior to 2007, the caps on investments in the industry ensured that the industry comprised of small, low productivity, poor quality capacities

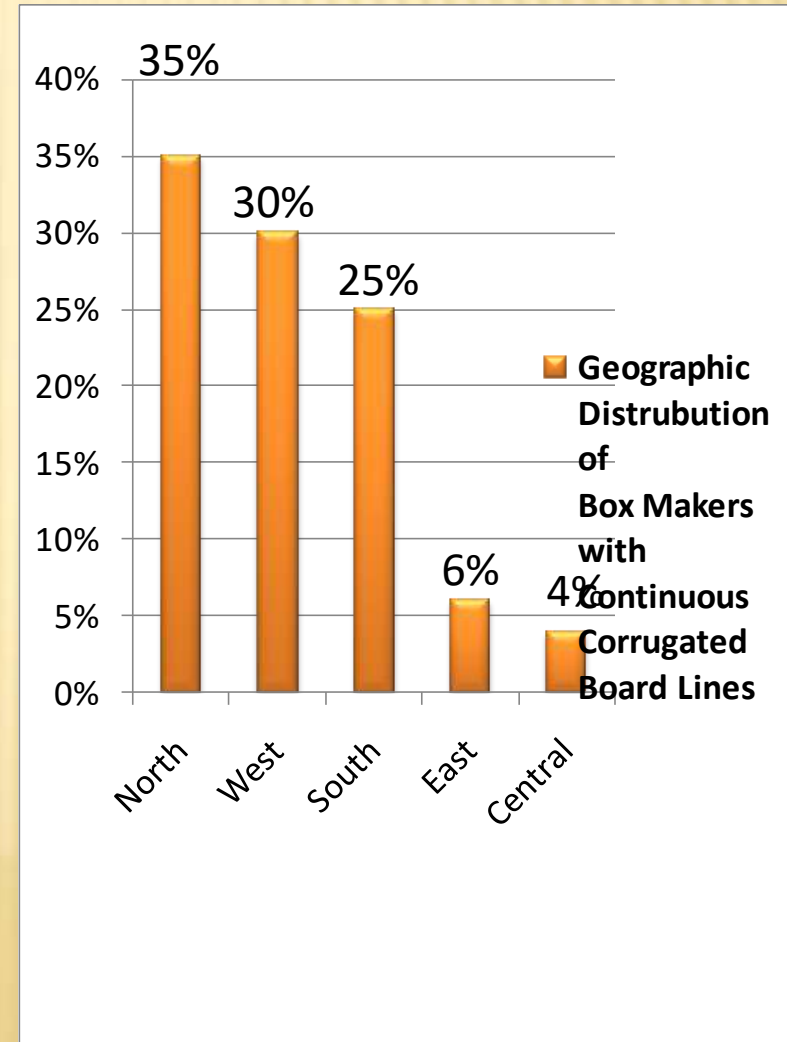
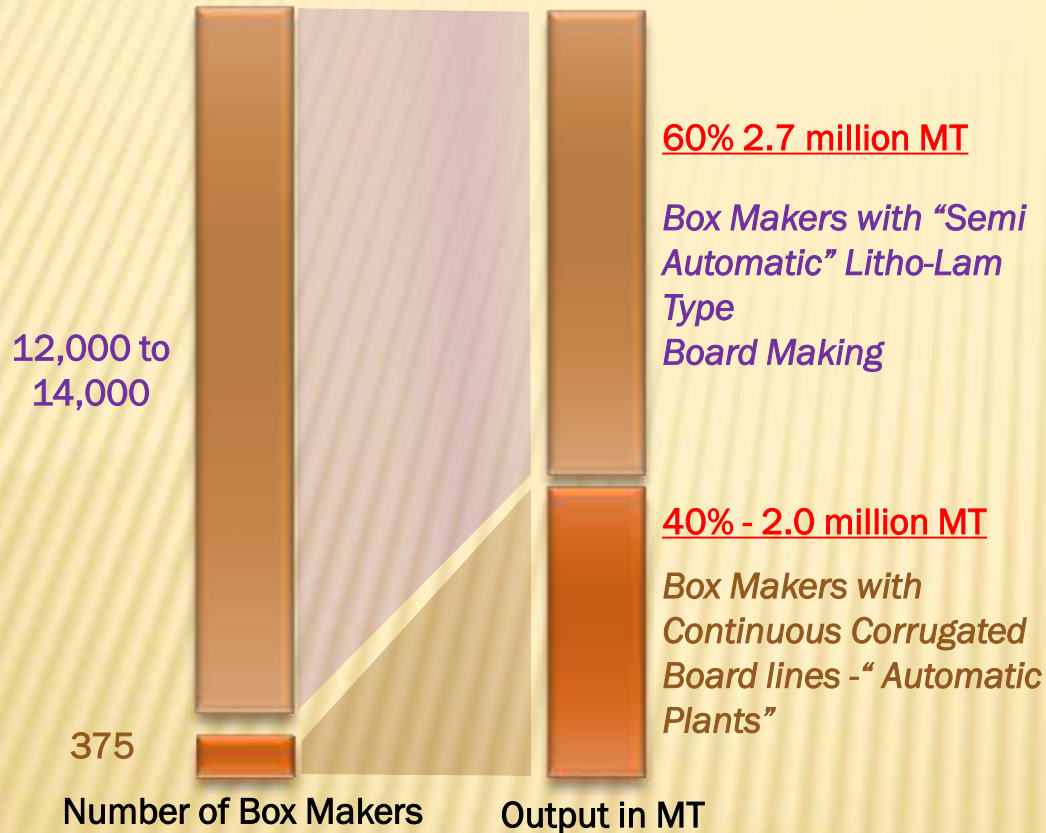
# THE INDUSTRY....

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- ✘ Prior to 2007, the Industry was completely dominated by “Semi-Auto” \*\* (Litho Lam) Board making facilities
- ✘ There has been rapid increase in number of “Automatic Plants” (Continuous Board making)
- ✘ Within the set of “Auto Plants” the degree of automation of control varies considerably & there is even a larger variation in the sophistication of converting equipment (Corrugated Boards to Boxes)



# SIZE OF INDUSTRY SEGMENTS BY NUMBERS, OUTPUT & LOCATION



# TRENDS IN THE USER INDUSTRY...

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- New Geographic locations based on changes in Taxation Policies & Logistical Advantage.
- Higher Capacity, more Productive, Automated, Brand-Owned manufacturing facilities coming up.
- Frequent Product/SKU changes on Manufacturing Lines.
- Shorter Lead Times.

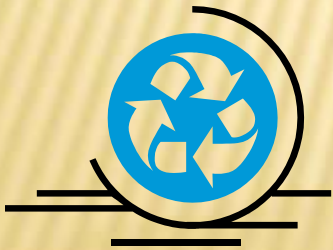
# TRENDS IN THE USER INDUSTRY...

- ✘ Shift in Board construction from Double wall (5 ply) to Single Wall (3 ply) for most FMCG products.
  - + 3 ply Construction is Cost Effective and adequate for most FMCG cases.
  - + Case Sealing using Hot-melt Gluing systems tends to increase the overall rigidity of 3 ply (single wall) boxes & contributes to better in-transit performance

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*Thank you*

*for a patient hearing*



*Recycle –Its good for all of us.*