Quality Specification of Fluting Media

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Presented at IPPTA Conference

Aurangabad – 18th Nov 2024

Understanding Quality Specification

- What are the specifications for fluting media?
- To understand that we must first understand-
  - Requirement of box users
  - Requirment of box makers.
- What are these requirements?
- Once we know the requirements, we can then understand the significance of each parameter.

Requirements of Box users

- The performance parameters required by box users are increasing day by day.
- Few decades ago, the only performance parameters defined by box users was Weight and Bursting strength.
- Over the time they have added Compression strength, Puncture resistance, Flat Crush, Bending stiffness, etc.
- Strength retention in high humidity conditions like storage and transportation in cold rooms or by refer containers.
- Let us have look at typical performance

Table 2. Corrugated cardboard, CB

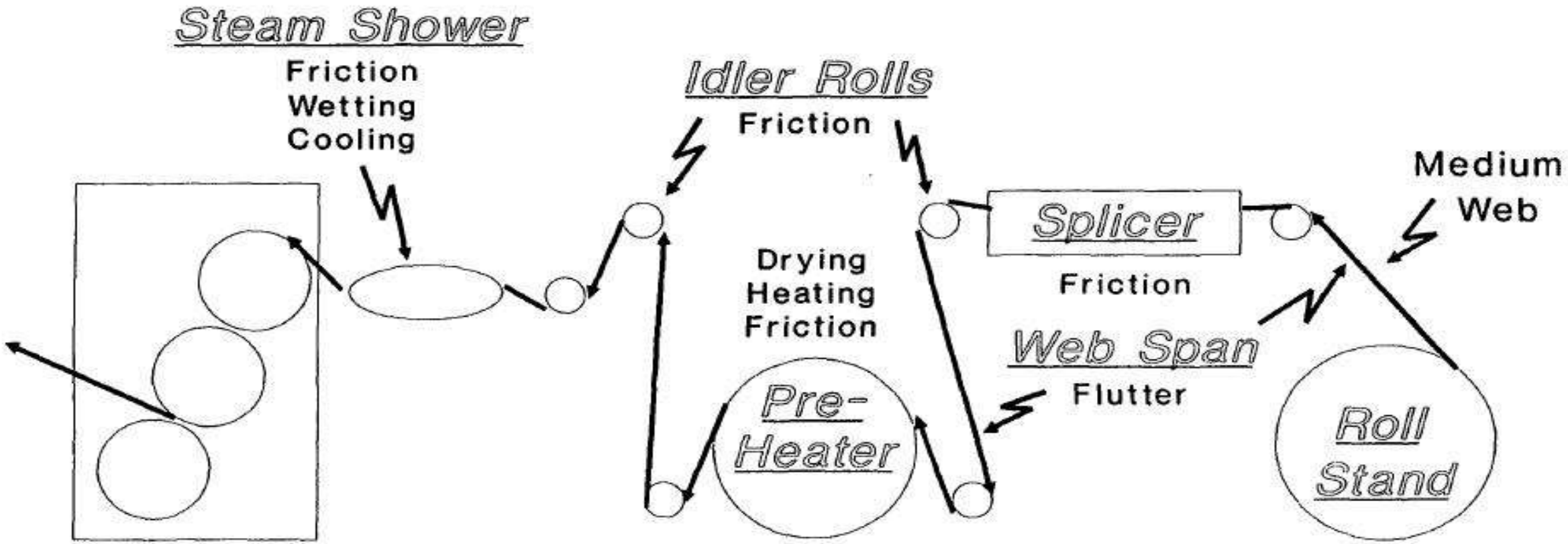
CODE	Bending stiffness[5] (Nm) ISO 5628 Min. average level[8]	Edgewise crush test (ECT) (kN/m) ISO 3037 Min. average level[8]	Bursting strength test (BST)[6] (kPa) ISO 2759 Min . average level[6]	Flat crush test (FCT) (kPa) ISO 3035 Min. average level[8]	Cobb 60 test, water absorptiveness[7] (g/m^2) ISO 535 Min. level	Cobb 60 test, water absorptiveness[7] (g/m^2) ISO 535 Max. level	FLUTE Type	Thickness (mm) ISO 3034 Between
CB 10	0.65	3.9	600	--	23	40	E	1.0-1.9
CB 20	0.84	4.5	850	--	23	40	E	1.0-1.9
CB 25	2.1	3.2	500	250	23	40	B	2.0-3.1
CB 30	2.5	3.9	600	280	23	40	B	2.0-3.1
CB 40	2.8	4.3	700	280	23	40	B	2.0-3.1
CB 50	3.1	5.0	850	340	23	40	B	2.0-3.1
CB 60	5.1	4.2	700	200	23	40	C/A[9]	3.2-3.9/4.0-4.8
CB 70	6.0	5.0	850	270	23	40	C/A[9]	3.2-3.9/4.0-4.8
CB 80	7.4	5.6	1100	270	23	40	C/A[9]	3.2-3.9/4.0-4.8
CB 90	8.4	6.5	1350	330	23	40	C/A[9]	3.2-3.9/4.0-4.8
CB 100	16	7.4	950	--	23	40	Double Wall	--
CB 110	20	8.8	1250	--	23	40	Double Wall	--
CB 120	29	11	1600	--	23	40	Double Wall	--
CB 150	26	12	1900	--	23	40	--	--
CB 230	50	16	2500	--	23	40	--	--
CB 260	75	20	4500	--	23	40	--	--

Requirements of Box users

- Edge Crush test (ECT) to Compression strength (CS)
- Flat Crush test (FCT)
- Bending stiffness
- Bursting strength (BS)
- Cobb
- Weight

Requirement of Box makers

- Performance parameters
- Runnability.
- Strength Retention.
- Understanding the requirements will help us to understand the significance of various performance parameters.

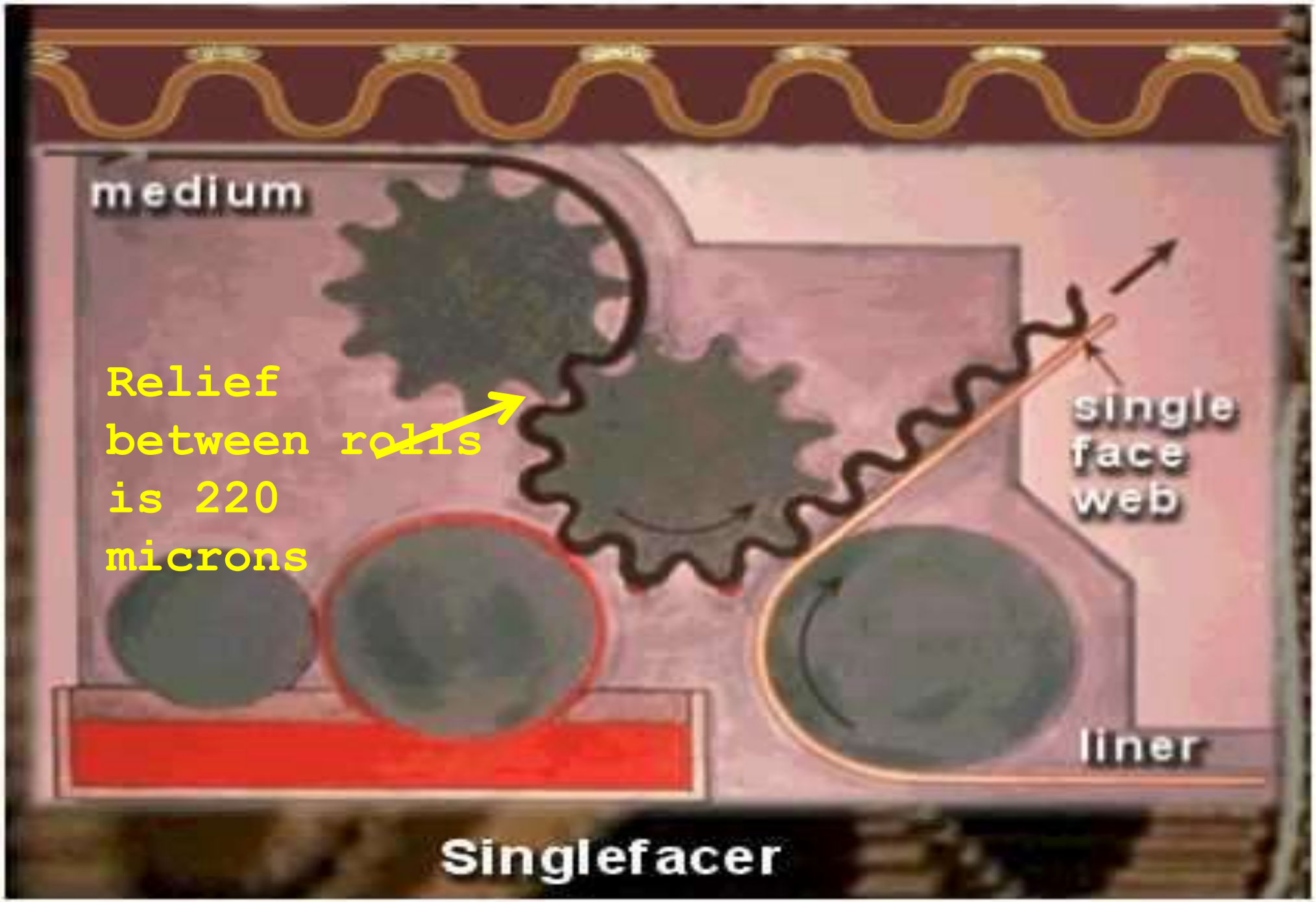

Steam Shower
Friction
Wetting
Cooling
Idler Rolls
Friction
Medium
Web
Splicer
Friction
Drying
Heating
Friction
Web Span
Flutter
Pre-
Heater
Roll
Stand
Single-Facer
Drying
Heating
Labyrinth Friction
Labyrinth Flexing
Labyrinth Compression
Top Corrugator Roll teeth
Medium Material
Caliper
MD Tensile
MD Stretch
Elastic Moduli
Coef. Of Friction
Brake Setting
Roll Diameter
Out-Of-Round Roll
Uneven Roll Hardness

Medium

- Fluting medium has not been considered as important part of corrugated board for a long time; however, the newer requirements of box users is forcing us to have look at it.
- Important or not, the fluting medium is what makes the corrugated board perform.
- The corrugated board is a sandwich structure in which the medium is the “meat of that structure”
- The medium must maintain the separation of the liners to form the sandwich.

Medium

- It must do this after:-
  - Being burned on the pre-heater drums.
  - Punished with steam shower.
  - Pulled, bent, and squashed in the corrugating rolls.
  - Doused with a watery starch mixture.
  - Flat crushed compressed in the hot plate section.
  - And, finally in the finishing section of box making.


medium
Relief
between rolls
is 220
microns
single
face
web
liner
Singlefacer

Stresses and Strains in Single-facer

- Corrugating process imposes sufficiently large stresses and strains on the medium while forming and moulding medium to the shape of flute under conditions of Elevated –
  - Temperature,
  - Pressure, and
  - Moisture.

Stresses and Strains in Single-facer

- The stress and strain in medium during formation of flute consists of two parts:
  - The tensile stress and strain acquired during transportation of the medium from parent roll to the point where the flute is formed.
  - The stress and strain of forming resulting from severe local deformation of the medium as it attains the fluted

Tension in the medium

- The tension in the medium is largely dependent on the:
  - Force required to unwind the paper roll
  - Overcome friction between the medium and the pre-heater drum.
  - Overcome the friction at the reel brake.

Bending and shear strains

- Analysis of bending and shear strains show that:
  - Failure due to bending strains manifest itself as rupture of the surface fibres. (type 1)
  - Shear strain failure would result in delamination at or near the centre of the medium. (type 2)

Type 1 failure

Type 1 failure

Type 2 failure

Elements of fliting medium

- Strength required to form strong arches & columns.
- Good formability.
- Ability to bond to linerboard at higher speed.
- Elements of the medium that must be controlled
  - Heat and Moisture.

Heat and Moisture

- Fluting occurs due to hygro-strain variation, which is caused by the moisture variation created during fast convection (through air) drying.
  - This is the reason for proper moisture and bulk in fluting media
- High drying temperature promotes inelastic (irreversible) deformation in paper due which flutes are preserved.
  - Requirment of heat.

Key Characteristics of Fluting Medium

1	Water absorption	6	Stretch (MD)
2	Porosity	7	Formation
3	Moisture content	8	Compression resistance (RCT, SCT)
4	Flat crush (CMT)	9	Calliper (Bulk)
5	Tensile strength (MD)	10	Compression in Z plane

Water absorption

- Water absorption is the rate at which water is absorbed by the medium.
- Water drop test described in TAPPI – T 819 is recommended test method. There are other methods also.
- Absorptivity influences the ability of medium to accept water from –
  - Steam showers
  - Starch Adhesive. (20% solids + 80% water typical ratio)

Water absorption

- High absorptivity causes poor bonding due to excess absorption of water from adhesive by medium before the gel temp is reached.
- Low absorptivity causes poor bonding due to lack of penetration of the adhesive into medium.
- Low absorptivity also inhibit penetration by steam showers causing problems with flute formation.

Porosity

- Although porosity is a measure of air resistance, its influence on medium is like water absorption.
- Very Low porosity of medium affects the runnability on corrugator.
- Very Low porosity makes it difficult for moisture vapor to penetrate, inhibiting the softening of medium, which is necessary for good flute formation.

Porosity

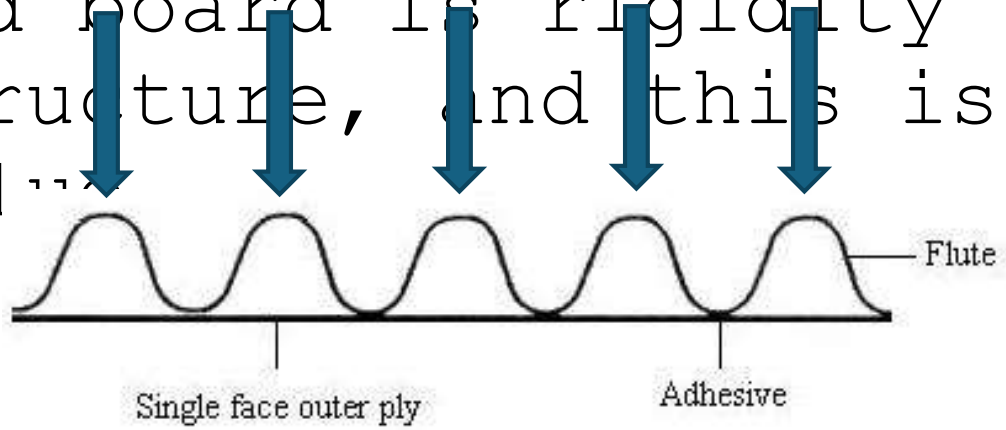
- Very high porosity indicates an open sheet that can allow too rapid penetration of water from adhesive resulting in poor bonding.
- This will result in high adhesive consumption as the operator try to compensate for this problem. In turn leading to other issues like warp.
- Single facers hold the medium using vacuum created by fingerless system.

Moisture content

- The moisture content of medium directly affects its ability to achieve good flute formation.
- Dry medium does not allow penetration readily leading to poor bonding in single facer.
- Dry medium exhibits tendency to form high-low flutes as well as fractured flutes.

Flat crush of medium

- Flat crush of medium referred to as CMT value (Concora Medium Test) measures the resistance to the crushing of laboratory fluted strip of medium.
- Test method used is TAPPI – T 809
- The most important characteristics of corrugated board is rigidity of the fluted structure, and this is influenced by CMT val...



Flat crush of medium

- CMT value provides a lab procedure to predict the flat crush resistance of the corrugated board.
- Very low CMT values results in loss of caliper of the board during converting operations leading to loss of stacking strength of box.
- Very high CMT values causes flute formation problems and score line cracking problems.

Tensile Strength

- Tensile strength is the strength of paper under tension.
- TAPPI – T 494 is the test method for determining the tensile strength.
- Tensile strength affects the ability of medium to withstand
  - The stress of flute formation
  - Resist tearing and breaking from acceleration in single facer.

Tensile Strength

- Very low MD tensile strength leads to web breaks.
- Low MD tensile strength leads to high-low flute formation and fractured flutes.

Stretch

- Stretch is the maximum tensile strain developed in a test specimen before rupture.
- TAPPI – T 494 test method used for tensile strength is used for stretch.
- Stretch influences the flute formation characteristics of medium.
- High stretch values decrease high-low flutes and help in higher running speeds

Formation

- Formation is the measure of the uniformity of fiber distribution.
- Poor formation contribute to the development of high-low flutes and fractured flutes.
- Better formation helps in achieving higher bond speeds at single facer.

Compression resistance

- Compression resistance correlates with the vertical stacking strength potential of the corrugated boxes.
- There are two commonly used methods for measuring compression resistance of liners and Fluting medium.
  - RCT (Ring crush test)
  - SCT or STFI (Short span compression test)

Compression resistance

- TAPPI – T 818 test method measures the RCT of liner
- TAPPI – T 826 test method measures the SCT of liner.
- Failure to meet specified minimum RCT or SCT values on medium will result in boxes that will not meet stacking strength expectations.

Calliper (Bulk) and Z direction compression

- Higher bulk in medium helps faster formation of flutes as mentioned in earlier slide.
- At same time it is detrimental to have very high bulk or high GSM for medium.
- Corrugating rolls are designed to operate most effectively with medium having caliper below 220 microns. (Relief between rolls). Caliper of 140 GSM medium is around 220 microns.

Calliper (Bulk) and Z direction compression

- Whitsitt and Sprague (1986) investigated and presented the factors affecting the retention of compressive strength during fluting, i.e. the impact of the fluting process.
- Their results indicate that 15-20% of the ECT potential of corrugated board is lost during the fluting process.
- The reductions in strength are caused by the high bending and tension stresses induced in the medium paper during fluting. During this process, the medium is exposed to high

Calliper (Bulk) and Z direction compression

- If GSM is high, these stresses are too high, visible fractures of the medium will occur.
- High bulk at lower GSM with better Z direction compressibility will result less losses during flute formation as well as better flute preservation.

Medium Runnability

The Properties that have been related to medium runnability are:-

MD Tensile	MD Modulus of elasticity
MD Stretch	ZD modulus of elasticity
Caliper	Compressibility and Abrasiveness
Co-efficient of friction	Porosity

Medium Runnability

- Medium should have a "**Good Runnability**".
- Runnability is defined as the ability to run corrugator at maximum permissible speed without affecting flute quality.

Medium Runnability

- The term runnability encompasses two major performance criteria:
  - Flute formation.
  - Bonding.
- The flute formation criteria includes:
  - Fractured flutes
  - High / Low flutes.
  - Leaning flutes

Medium performance

- Both these defects are influenced by the:-
  - **Medium Physical properties.**
  - Corrugating process settings.
  - Mechanical condition of the corrugating equipment.
- Up to 10% loss in compression strength due increase percentage of high /low flutes and 30% drop in flat crush due to fractured and leaning flutes.

High / Low Flutes

- The term high / low flutes refers to the variation in the height of the fluted medium component of the single face web.
- The high / low flute defect is important because of its adverse effect on the combined board strength properties and package performance.
- For example, there will be loss of compression strength up to 10% due to decrease in ECT as the percentage of high / low flutes increases.

Factors affecting High/low flute defects

Variables	Change needed to reduce high / low flutes
Basis weight	Decrease
Calliper	Decrease
Co-eff of friction against heated steel	Decrease
Formation	**Uniform**
MD Stretch	**Increase**

Fractured Flutes

- The term “Fractured flutes” refers to the physical separation of the corrugating medium fiber network during the flute forming process in the single facer.
- There will be a drop in ECT as well as flat crush due to fractured flutes.

Factors affecting the flute fracture defect

Variables	Change needed to reduce flute fracture
Moisture content	Increase
MD tensile	Increase
MD stretch	Increase
Calliper	Decrease
Co-eff of friction	Decrease
Formation	Uniform
Porosity	Decrease

Medium properties affecting medium strength retention after fluting

Variables	Change needed to improve the strength retention after fluting
Tensile strength	Increase
MD tensile stretch	Increase
Density	Increase
Calliper	Decrease

Typical parameters for Media

GSM	110	120	140	160	175	200
Moisture %	8 - 10	8 - 10	8 - 10	8 - 10	8 - 10	8 - 10
Cobb 30 (30 sec)	40 - 50	40 - 50	40 - 50	40 - 50	40 - 50	40 - 50
SCT MD kN/m	2.00	2.20	2.60	3.00	3.40	3.80
CMT 30 MD Newtons	230	250	300	340	360	380
RCT CD kN/m	0.70	0.80	1.25	1.60	1.80	2.00
Tensile Strength MD kN/m	8.00	8.00	9.00	10.00	10.50	11.00
Calliper mm	0.16	0.18	0.22	0.26	0.28	0.32

Thank you – Have a nice day

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