SLITTING ROLL & WEB DEFECTS

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Shear, Crush/Score and Razor Slitting Evaluations
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Slitting & Trim
Winding
Web Handling
Extrusion
Laminating Coating
Paper Making
Calendaring

254 Defects Presented
Causes Identified
Solutions Offered

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
### Slitting and Trim Related Defects

<table>
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<tr>
<th>Defect</th>
<th>Slitter Causes</th>
<th>Trim Causes</th>
<th>Other Causes</th>
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<tbody>
<tr>
<td>Fuzzy Edge</td>
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<td>Turned Edge</td>
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<td>Roll Knots</td>
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18 Slitting Only Causes
57 Specific Slitting Causes
16 Specific Trim Causes
46 Other Causes
6 Slitting Only Causes
What They Say – If You Can Cut It With Scissors

You Can Shear Slit It

MATERIAL…MATERIAL…MATERIAL

Lots of Scissor Sizes Needed

Lots of Knife Sizes Needed
Shear Slitting Geometry

1. Cut Point
2. Shear Angle
3. Top & Bottom Knife Run-Out
4. Knife Overlap
5. Web Path; Tangential or Wrapped

Critical Dynamic Factors

1. Holder Operation, Integrity & Mounting
2. Side Load Force & Friction
4. Knife Over-Speed
5. Web Tension
6. Slit Web Separation
7. Static Electricity

Eighteen Interrelated Factors

All Can Have Negative Effects

Some More Significant
Some Work Together – Compounding Problems

Process Awareness

Important Knife Factors

1. Knife Materials
2. Knife Size & Shape
3. Knife Surface Finish/Coatings
4. Knife Sharpness
5. Knife Re-Sharpening
6. Knife Care
Shear Slitting Geometry – A Visual Preview

Cut Point

Overlap Geometry

Shear Angle Geometry

Knife Run Out
Comparing Scissor Cut and Shear Slit

Both Have One Angled Knife Contacting the Other

Scissors - 2nd Century Asia Minor

Straight Knives, Stationary Web and Moving Cut Point

Round Rotating Knives, Moving Web and Stationary Cut Point

Driven Bottom Knife Mini Pull Roll

Courtesy of Dienes USA
Shear Slitting Geometry

SMALL TOP / FRONT KNIFE

LARGER BOTTOM / BACK KNIFE

Advantages?

- Re-sharpening Required
- Easier Top Knife Changes
- Less Web to Top Knife Face Contact
- Larger Bottom Knife Web Support
Cut Point – Where Tangential Web Path Slitter System Design Starts

The Location Where the Web Meets the Contact Point of the Top and Bottom Knives

Key Importance: the Objective

Apex of Bottom Knife
Overlap and Offset
Web Support
Tension Control

“DEFECTS AS WE PROCEED”
Shear Angle  Cant Angle or Toe In

The Intentional Misalignment of the Top Knife to the Web Path Heading to the Wind Up

Top View  [looking down on knives]

Creates the Cut Point with Overlap
Shear Angle

Typical Angles

1/4° films, foils, adhesive webs and delicate materials

1/2° very typical most materials; paper products (material dependent)

3/4° nonwovens (stringer cutting)

1.0° Some Wovens (rare though sometimes recommended)

Knife Dulling;  Immediate, Surface Area & Load, Continual
Larger the Shear Angle the Quicker the Knife Wear
Shear Angle

Cut Point

Shear Angle

Bottom Knife

Straight Through & Follow The Bevel
Insufficient Shear Angle

You Can’t Slit …
But … You Can Fracture

Holder Wear and Looseness
Applied Side Load Force
Holder Clearance “Take Up”
Reduced Shear Angle = Open Nip, “Scrush” Cut
Very Rough Cut Edge

Dust Blizzard

 Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Shear Angle

Excessive Shear Angle

Steeper Shear Angle = More Web Disruption & Defects
Steeper Shear Angle = Faster the Knife Dulling

Courtesy of TAPPI – The Ultimate Roll and Web Defect Terminology Guide
Shear Angle Edge Effects

$1/4^\circ$ & $1/2^\circ$ Lab Tests

5 mil – $1/4^\circ$ - Tan. 0.030 O.L.
5 mil – $1/4^\circ$ - Tan. 0.060 O.L.
5 mil – $1/4^\circ$ - Tan. 0.120 O.L.
5 mil – $1/2^\circ$ - Tan. 0.030 O.L.
5 mil – $1/2^\circ$ - Tan. 0.060 O.L.
5 mil – $1/2^\circ$ - Tan. 0.120 O.L.
Shear Knife Axial and Radial Run-Out

Top and Bottom Knives

Motor Driven

Shaft Driven
Deviation from the average operational thickness and/or parallelism of the slitting tool during rotation.

Bottom Knife Axial Run-Out Causes:
- Excessive Knife I.D. Clearance
- Set Screw Cocking
- Defective Air Shaft
- Debris When Mounting
- Poor Re-Sharpening, Loss of Perpendicularity
Bottom Knife Axial Run-Out Affect & Defects

Depending On Holder Response Time …
High Frequency Cyclic Loading – Knife Chatter
High Frequency Force/Friction Fluctuations
Cut Point Displacement or Loss
Reduced Knife Life/Sharpness
Faster Holder Wear
Resulting in …
**Bottom Knife Radial Run-Out**

**Definition:**
Deviation from the average operational radius of the slitting tool.

**Bottom Knife Radial Run-Out Causes:**
- Excessive Knife I.D. Clearances
- Debris When Mounting
- Poor Resharpening
- Defective Air Shaft
- Deflecting Shaft, Whip Vibration
- Non Concentric Bore I.D. and O.D.
Bottom Knife Radial Run-Out Defects

Changing Overlap Depth *
Cyclic Travel Chord w/Longer Web to Knife Rubbing *
Cyclic Top Knife Width w/Increased Web Deformation *
Cyclic Cut Point Changes w/Web Sawing *
Cyclic Side Loading w/Shorter Knife & Holder Life
Top Knife Rotating Speed Variances *

* To Be Discussed
**Top Knife Axial & Radial Run-Out**

**TOP KNIFE AXIAL RUN-OUT**

Top Knife Causes:
- Debris When Mounting
- Poor Manufacturing or Re-sharpening

**TOP KNIFE RADIAL RUN-OUT**

Top Knife Causes:
- Excessive Knife I.D. to Holder Hub Clearance
- Non Symmetric Diameters
- Manufacturing or Poor Re-sharpening
- Holder Looseness
Shear Knife Axial and Radial Run-Out Design

Axial
Recommended
TIR 0.002” to 4,000 fpm
TIR 0.001” to 8,000 fpm
TIR 0.0005” to 10,000 fpm

Radial
Recommended
TIR 0.004” to 4,000 fpm
TIR 0.002” to 8,000 fpm
TIR 0.001” to 10,000 fpm

Taking a Look at Manufacturing Specifications
Radial Run-Out Control

Shaft Driven Bottom Knife Concerns

Bore I.D. to Shaft O.D. Clearance

Knife Locking Method

Shaft Deflection and Rotation

Debris

Motor Driven Bottom Knife Concerns

Bore I.D. to Motor Hub Clearance

Debris at Assembly

Unbalanced Bottom Knife – Motor Bearings

Recommended Radial Run-Out

- TIR 0.004” to 4,000 fpm
- TIR 0.002” to 8,000 fpm
- TIR 0.001” to 10,000 fpm

Photo Courtesy of Maxcess International/Tidland & Dienes USA
Knife Contact with Web: Knives #1, #2 & #4 at Maximum T.I.R. and Knife #3 with Minimum T.I.R.

Knife Contact with Web: Knife #3 at Maximum T.I.R. and Knives #1, #2 & #4 Minimum T.I.R.
#3 Bottom Knife Radial Run-Out Web Flux

- **Max R.O. Excessive Contact**
- **180° Min R.O. Zero Contact**
- **Web Sawing**
- **Cyclic Vertical Rub**
- **Web Pushed Up Knife Face**

**Entrance Roll**

**Exit Roll**

**Bottom Knife #3**

**#2 & #4 Bottom Knife Web Support**
Top Knife Overlap

Key Factors
Top Knife Bottom Below Bottom Knife Top
Overlap Required to Establish Cut Point
Needs to Be Stable

Challenges
Radial Run Out
Machine Vibration
Material Pressure
Possible Shaft Deflection
Setting the Proper Amount *
**Insufficient Overlap**

**FIVE MAIN CAUSES:**

1. Operator Misjudgment
2. Slow Loss of Air Pressure
3. Machine Vibration
4. Shaft Run-Out and/or Whip
5. Excessive Radial Run-Out

Leading to…

**TOP KNIFE JUMP**

Knife destruction, safety concerns

*Lost Carbide Insert*

Not Often Repeated

*Leads to Excessive Overlap*

**ANOTHER CONCERN:**

Material Thickness change; film to sheet
Excessive Knife Overlap

MOST COMMON AND WORST ERROR MADE

SIX MAJOR SLITTING PROBLEMS

1. Web Travel Chord Increase
2. Cut Point Change
3. Knife Width Increase
4. Side Load and Knife Friction Increases
5. Top Knife Edge Cut Radial Rubbing
6. Top Knife Slowing
Excessive Knife Overlap

WEB TRAVEL CHORD

CUT POINT

Top Knife
Bevel Side

Top Knife
Flat Side

Winder
Pull
Tension

WEB TRAVEL CHORD

Brake
Hold
Back

DAV CAD
NTS
Problem 1: Web Travel Chord Increase

Shear Angle Creates Web Misalignment
Web to Knife Contact Aggravating Tension Levels

0.030” – 0.040” Depth Recommended
At 0.060” Depth, Chord Length Increases by 41%
At 0.125” Depth, Chord Length Increases by 102%
Excessive Knife Overlap

Problem 1: Web Travel Chord Increase

Travel Chord Exceptions
Wide Rim Knives
Reduced Web Disruption

W = 0.250” - 0.393”

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Excessive Knife Overlap

Problem 2: Cut Point Change

Increased Depth Moves the Cut Point
Web Contacts Top Knife Early
Sawing Effect Creates Edge Cracking or Excessive Dust

.8 mil Aluminum Foil with Increasing Overlap

0.030” 0.060” 0.120”

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Excessive Knife Overlap

Problem 3: Knife Width Increase

- D.B. 0.030”
- D.B. 0.060”
- D.B. 0.125”

Changes may not seem large but consider…

- 148% more web displacement
- 102% longer web/knife contact … and …

Web Speed  Web Tension  Material Fragility
Excessive Knife Overlap

Problem 4: Drive Friction Increase

Separate Rotation Axis
Bottom Knife Driven
Top Knife Freewheeling*
Two Sharp Metal Edges
Side to Side Single Point Contact
Bottom Knife is Top Knife Rotating Force
Inherent Rotational Slippage

Note: Driven Top Knives
Excessive Knife Overlap

Problem 4: Drive Friction Increase

Increasing Knife Overlap Changes the Bottom Knife Drive Angle

0.040” Overlap
Increased Drive Angle Increases Knife Friction
Maximum Friction
Reverse Rotation
Excessive Knife Overlap

Problem 6: Top Knife Slowing

Theoretical Minimum Top Knife Speed at Web Speed
General Over-speed Rule of Thumb + 3% to 5%

Concerns:
Web Density, Web Splices, Globs

Too Slow;
Web Bunching
Web Tearing and Web Breaks
Slitting Defects

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Two Common Web Path Travel Directions

Vertical

Horizontal
**Two Web Path Options**

**Tangential and Wrapped**

**Main Differences**

*Web to Top Knife Contact*

*Bottom Knife Web Support*

Required Wrap Amount Varies with Web Material Flexibility

**Rule of Thumb:** The thinner, more flexible the web, the higher the wrap angle possible
Two Web Path Options

Wrapped

Mini-Tension Zone
More Web Support & Stability
Less Web to Knife Contact
Low PLI & Stretchy Webs

MKB’s or Spacers
Bottom Knife Over-Speed
Excessive Web Tension Scratching
Longer Set Up Time
Cost

Photo Courtesy of Maxcess International/Tidland
Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Web Speed Variance – Inside the Slitting Zone

**Crush Cutting**

Intentionally Driving Anvil Roll Faster than Web Speed

**Crush Anvil Roll Overspeed**

Optional to Reduce Fibrous Stringers

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Bottom Knife Under-Speed Defects

Web Bunching
Web Tearing and Web Breaks - Australia
Serrated Edge
Fuzzy Edge
Cracked Edge
Turned Roll Edge
**Bottom Knife Over-Speed Defects**

Too Fast;

*Excessive Slitting Dust*

*Fuzzy Roll Edge*

*Bottom Knife Scratching*

*Reduced Knife Life*

Courtesy of TAPPI – Ultimate Roll and Web Defect Terminology
Separating and Aligning Slit Widths

Prior to Slitting

Single Web Tension Profile

Want Taut Flat Web

Free of Wrinkles or Fold Over’s

Causing Roll Slivers or Slitter Flutter

Pre-Slit Spreader Roll

Roll Fold Over

Caution

Spreader Roll and Excessive Lateral Stresses

Courtesy of Converting Accessory Corporation
Slitting, Separating and Aligning Slit Widths

Single Shaft Winding

NICE!!
Aligned to Cores

NOT NICE!!!!

Surface Winder

Roll Face Damage

The Old Drop Test

Courtesy of Catbridge Machinery

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Web Tension Control - Winding

Critical to Good Winding and Slitting  Not Too Loose or Too Tight

Winding Tension; wind-up, pull rolls, brakes, load cells, dancer

TOO TIGHT  Winding Defects
Web Tension Control - Winding

Critical to Good Winding and Slitting Not Too Loose or Too Tight

TOO LOOSE Winding Defects

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Web Tension Control - Slitting

Slitting Tension Zone – *Isolate Slitting Section from Unwind*;
  in-feed & exit rolls, flat, taut web; no web bounce, no shifting

Gauge Bands;
  uneven tension across the web, tight & floppy sections

Wind Effects;
  motor blowers, web lift & slitting dust
Web Tension Control - Slitting

Unwind Web Cut Point Disturbances
Web Blocking: Adhesive – Static Electricity
Idler Roll Bearing Drag
Web Misalignment

Needs
In-feed & Exit Close As Possible
In-feed, Exit & Bottom Knife Rolls Same Diameter

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Web Tension Control – Slitting Issues

Web Too Loose:
Dust in Roll
Irregular Slit Widths (scalloped edge)
Cambered Edge
Cracked Edge from Trim Removal

Too Tight:
Slitter Edge Curl
Potential Web Breaks

Courtesy of TAPPI – The Ultimate Roll and Web Defect Troubleshooting Guide
Special Thanks to

Duane Smith
Product Manager
Specialty Winding
of
Egan-Davis Standard

and

TAPPI PRESS
Norcross, GA
770-446-1400