High Speed Shear Slitting: Facing the Issues.
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As line speeds increase, controlling shear slitting set up variables becomes critical. Blade overlap or depth of cut, side load force, cant angle, blade profile, blade run-out and bottom knife overspeed relative to line speed, are some of the factors which will be discussed. These variables have an impact on the quality of the slit edge, blade life and the ability to produce quality coated products at higher speeds. For this presentation, the variables have been grouped into four types of dynamics: 1) hardware dynamics, 2) nip dynamics, 3) web path dynamics and, 4) material response in the shear slitting nip.

Increasing Web Speed will Influence:

1) Hardware Dynamics:
   -- Runout of slitter components becomes a significant factor in blade wear.
   -- Vibration and harmonics of slitter section will change, usually with increased severity.
   -- Critical speed dynamics on rotating slitter mandrels will limit maximum speed and reduce blade life.

2) Nip Dynamics
   -- Cant (shear) angle requirements are rarely changed as speed is increased.
   -- Blade separation forces may increase when slitting thick, dense materials.
   -- Nip speed on wrap configured machines may be undersped, depending on slitter type.
   -- Slitter speed -vs- machine speed mismatch may occur, depending on machine design.

3) Web Path Dynamics
   -- Web path choice (wrap -vs- tangent) is an important factor with some materials.
   -- Web flutter becomes more significant with thinner materials.
   -- “Symmetrical” slitter setup may be needed to prevent “steering” of thick, rigid materials.

4) Material Response in the Shear Slitting Nip
   -- Web characteristics in the nip (notch sensitivity, elongation, etc.) may respond differently at different speeds.

1): HARDWARE DYNAMICS:

Runout Becomes Significant
   • Blade runout is often overlooked as an issue. At low speeds, (up to 500 fpm), an eccentricity of 0.010” may be tolerable, but at 1500 fpm it’s significant, and at 3500 fpm it’s catastrophic. Blade wear, vibration, and potential for blade “jumping” will increase dramatically.

The Vibration Issue
   • As speed increases, overall machine vibration (including the slitting section) increases, and will create a corresponding decrease in blade life.
   • Slitter blade run-out and slitter mandrels that are too small in diameter are prime causes of vibration at the slitting section.
   • Unwind and rewind roll uniformity has a strong influence on machine vibration which may transmitted to the slitting section.

Critical Speed Dynamics
   • Mandrel mounted slitters (upper and/or lower slitters) are subject to critical speed harmonics. Mandrel mounted upper slitters are especially troublesome, due to relatively small mandrel diameters. Center supports may be needed.
   • Critical speed harmonics force operators to set the slitters deeper, reducing slit quality, and increasing blade wear.

2): NIP DYNAMICS
The Cant (Shear) Angle

- Once the appropriate angle is determined for a given product, an increase in speed rarely requires a change in the angle, but some exceptions may include...
- Fibrous or high elongation products may need more angle as speeds increase.
- Low elongation materials (metals, polyester, etc.) rarely need more than 0.5° cant angle at any speed.

Blade Separation Forces.

- Most flexible packaging materials do not need more than about 2 pounds of side load force at typical slitter speeds. If higher forces are being applied, other problems may be present.
- Stiff, high density web materials may need high side load forces to prevent blade separation. As speeds increase, even higher side load forces may be needed.

Slitter Speed Mismatch

- Electronically controlled slitter section drive systems must be profiled so as to keep the slitters oversped throughout the acceleration/deceleration curve of the machine. Any speed mismatch will influence slit quality.
- Mechanically driven systems are relatively immune to the problem, since the slitter section is usually coupled with the web drive system and will follow the web speed throughout the accelerate/decelerate cycle.

Nip Speed in Wrap Slitters.

- The nip speed should match the web speed for optimum quality, however...
- Traction driven upper slitters will have an undersped nip in wrap configured machines; slit quality will be very dependent on razor-sharp blade edges under such conditions.
- Actively driven upper slitters could be precisely synchronized with the web, and will guarantee that the nip speed matches the web speed. Driven upper slitters on twin arbor systems are the only practical alternative.

3): WEB PATH DYNAMICS

Flutter.

- Flutter at the slitting nip compromises slit quality.
- The tangent slitter table should be kept as short as possible, with significant entry and exit wraps. Any flutter at the slitting nip will compromise slit quality.
- Long slitter tables need higher web tension to suppress flutter.
- Air turbulence, tension pulses, static electricity, and other disturbances are more troublesome on long slitter tables.
- Wrap slitting is relatively immune to flutter at the slitting nip.

Symmetrical Setup May Be Needed

- Stiff, rigid materials will be deflected laterally by the wedging action of an upper blade. This condition will be more troublesome when a large number of upper slitter blades are placed in relatively narrow parent webs. To control potential web “steering” by multiple blades in tangent systems it may be necessary to alternate the left/right placement of upper slitters in order to “balance” any cross-machine web deflection. This is not possible with twin-arbor slitters, but relatively easy to do with individually mounted knifeholders which have the ability to reverse the blade cartridges from left to right.

4): MATERIAL RESPONSE IN THE SHEAR SLITTING NIP

Notch Sensitivity, Elongation, Rheology, and other Web Characteristics

- Notch sensitive materials (polypropylene) may develop microscopic cracks along the slit edge, or may even split uncontrollably in an undersped nip as web speeds increase.
- High elongation materials (polyethylene) may extrude in the nip, resulting in a ragged edge, or worse yet; slitter blade separation as speeds increase.
• High tensile plastic materials (polyester, styrene) may form “angel hairs” or fracture into small particles, creating high dust production.
• Weakly bonded laminates (labels, release films, etc.) may delaminate or deform along the slit edge.
• Coated materials (emulsion coated films, clay coated paperboards) may crack and/or delaminate along the edge.
• Strongly bonded laminates (thermoforming plastics, etc.) are more robust, delamination is a minor issue as speeds increase. Vastly dissimilar bonded materials (polyethylene on aluminum) may be unpredictable as speeds increase.
• Rheology of materials may vary as the web-to-nip velocity varies. A material may become “stiffer” and shatter more easily, or conversely, may become more “fluid” in the slitting nip sending a ripple wave through the material along the slit edge as speeds increase.

To conclude: increasing the speed of shear slitters involves more than “giving it more gas”. Some materials tolerate accelerated slitting without problems, but the machine itself may have inadequacies which lead to the misleading conclusion that a material cannot be slit above a certain speed. Some materials have physical properties that do indeed limit their maximum slitting speed. And, sometimes, operators need to recognize how various “adjustments” impact the slitting process as speeds increase. Recognizing the limiting dynamics, be they hardware, materials, or technique, is basic to successful high speed shear slitting.

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