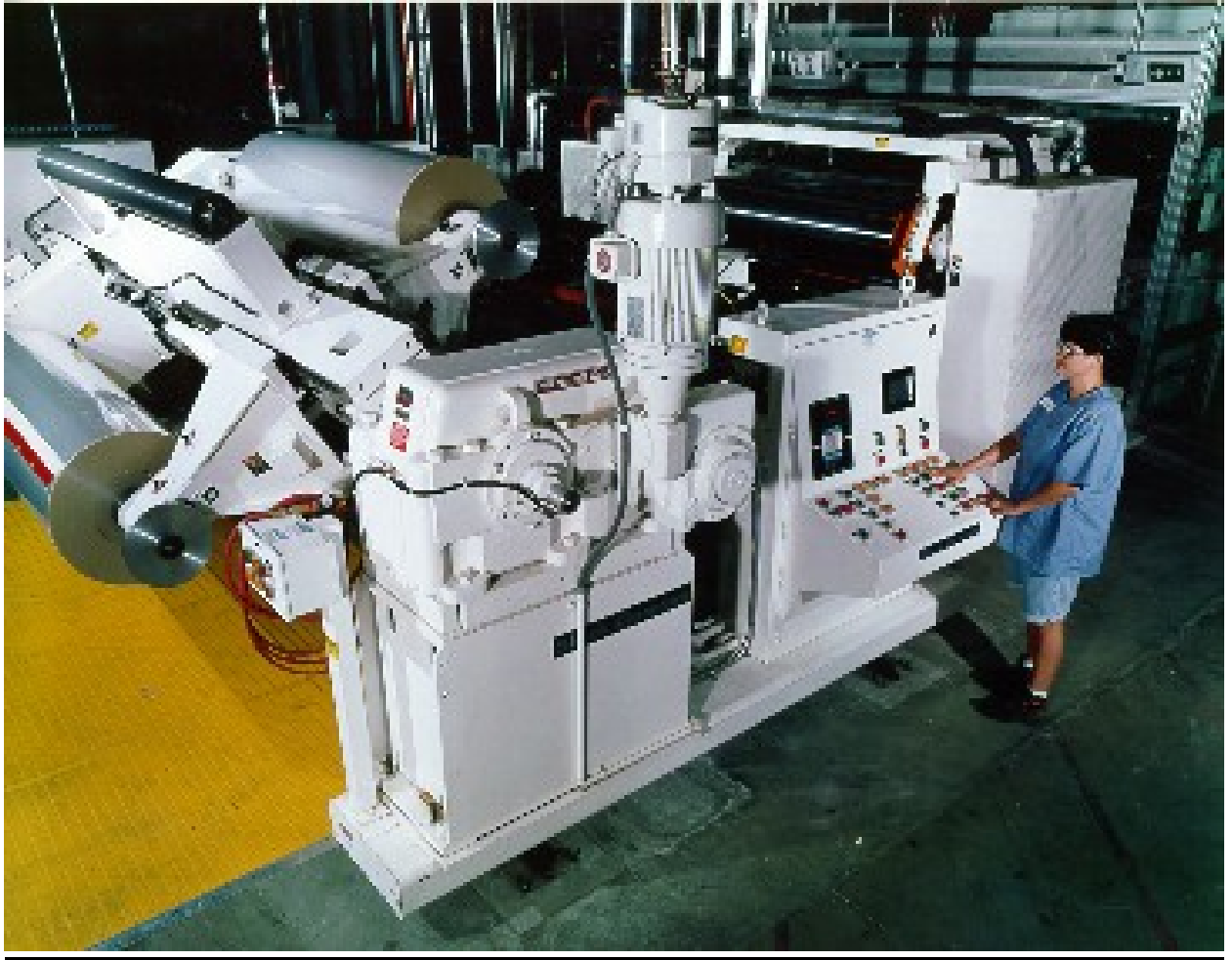


CONTINUOUS SPLICING TECHNIQUES FOR TURRET UNWINDS



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The key to *high productivity* in continuous web converting operations hinges on the ability to introduce new rolls of web material into the operation with *splicing accuracy approaching 100 percent*. This article will address the important components of the roll splicing operation and their effects on consistently producing a high quality splice on a continuous roll to roll application. Then, we will address the various splice control systems and applications. These systems range from a simple paste and cut system to the most modern automatic splice control system for precise tail length control at roll changing speeds up to 3000 fpm. A newly developed tail taping system will be introduced.

The important components in a continuous roll splicing operation are:

1. *Preparation of the incoming roll of material.*
2. *The incoming roll's speed.*
3. *The splice tension.*
4. *The paster operation.*
5. *The cut-off operation.*
6. *The tail length.*

Splice Preparation:

Improper preparation of a new roll of material is the most common cause of missed splices. After a new roll is loaded into the unwind, the outer layers are removed until a clean, tear free sheet is obtained. The leading edge of the web is then prepared. Many operations use a "V" type leading edge, however, a square edge can be used on modern splicers which saves time, is easier to make, and uses less splice adhesive (Figure A). A square leading edge also allows splicing with a short, controlled tail length. The leading edge of the web is then adhered to the roll using tear tabs. These tear tabs need to be such that they are easily broken and need to be placed approximately every 12" along the leading edge so air will not be able to lift under the edge during the roll speed-up operation and break the tabs. Then one or two strips of double sided splicing tape are applied to the leading edge of the web. The release paper is carefully removed to prevent breaking the tear tabs.

Most splicers use an electric eye to detect the prepared splice. With these splices, the operator places a piece of reflective tape on the side of the roll at the starting edge of the web. Some of the newer splicers do not require the reflective tape. These machines use a reflector on a moveable disc and a photoeye. The operator prepares the splice on the roll and then rotates the disc to locate a mark with the prepared splice.

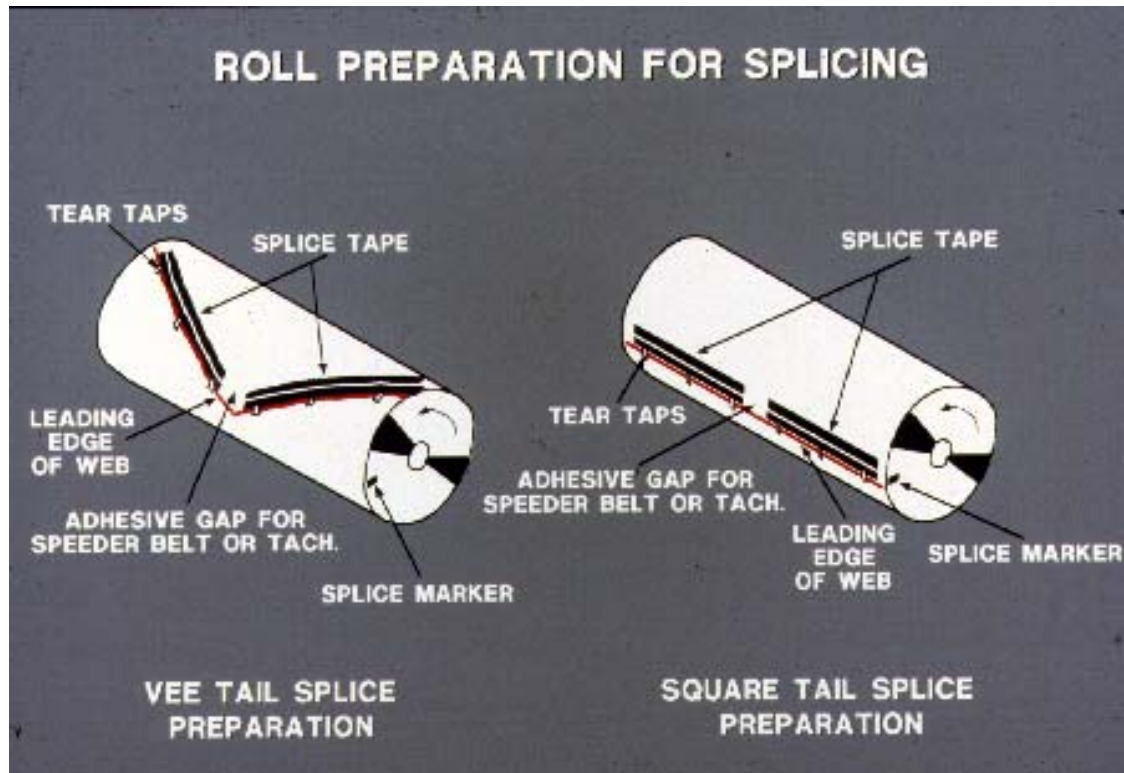


Figure A

The Speed-Up Operation:

Just before the splicing operation, the new roll is accelerated so the outer surface is at or just below the line speed at the time of the splice. Proper speed match is extremely important in assuring a trouble free splicing operation. If the incoming roll's speed is:

- Rotating too fast, slack will occur in the web after the splice.
- Rotating too slow, resulting high tension after the splice can pull the splice apart.

Roll speed-up is accomplished by either a surface speed-up device or a center speed-up device. (Figure B)

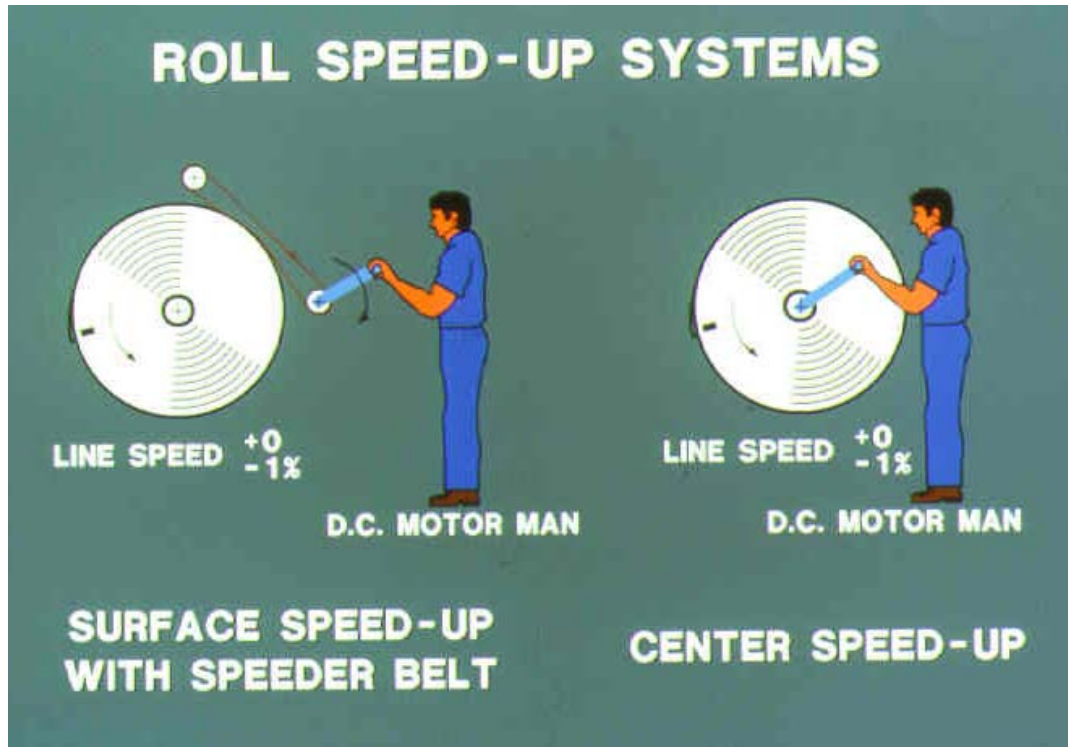


Figure B

Surface Speed-Up – The surface speed-up system typically consists of a speeder belt driven at line speed contacting the surface of the roll. This system requires the least amount of horsepower and does not require a diameter measurement of the incoming roll. The drawbacks of surface speed-up are:

- The possibility of shifting the outer wraps of the roll during the speed-up operation and breaking of the tear tabs.
- Splice adhesive can not be applied to the roll in area contacted by the speeder belt.

This type of speed-up system is normally used on unwinds having friction type braking systems and handling large diameter rolls of wide material. Applications are typically for heavier paper and paperboard turret unwinds.

Center Speed-Up – The center speed-up system uses a motor on each spindle which drives through the core. This system is used on regenerative type braking systems. It can also be used on friction braking system. In this case, the speed-up motor is clutched in during the speed-up cycle.

A center speed-up system has the following advantages:

- Doesn't affect the outer wraps of the roll's surface
- Allows full splice adhesive coverage.

The drawbacks of a center speed-up are:

- Requires higher horsepower for Speed-up
- Greater initial capital costs
- Requires roll diameter measuring system

The application for center speed-up systems include lightweight paper grades, extensible products and pressure sensitive grades.

Roll Diameter Measuring System- The center speed-up system must use the incoming roll's diameter to calculate the correct RPM to match the line speed. The diameter can be measured by the following methods:

1. Operator Measurement – The operator measures the roll diameter with a “pi-tape” and enters the diameter into the drive logic. The simplest and least expensive system, requires the operator to perform the measurement task.
2. Radius Calculation – These systems also index the incoming roll into a diameter measuring position. Radius measuring systems may use:
 - An arm which extends to the roll surface
 - A non-contacting system such as a sonic measuring system
 - An encoder on the indexing mechanism that measures the angle of the roll's center to the splice position

Radius calculation systems allow the full adhesive of the leading edge but are not as accurate if the process will be splicing rolls which are out of round. The radius may be measured at a high or low point in the roll resulting in the incoming roll's speed being too high or too low.

3. Circumference Measurement – This system indexes the incoming roll into a diameter measuring position. A lay-on tach then moves onto the rolls surface and the roll slowly turns a fixed RPM. The tachometer measures the footage during a revolution and the drive logic determines the required RPM to match the line speed. The tachometer then retracts and the roll is increased to this speed. This is the most accurate speed matching system. Its major drawback is that it requires an area on the leading edge of the incoming tail be masked off or left without splice

adhesive. This can be over come by using a two step process where the diameter is measured and then the release liner on the adhesive is removed.

The Splice Tension:

The web tension immediately after a splice occurs is referred to as Splice Tension. The importance of proper speed match on Splice Tension was discussed above. Then, after the splice occurs, the new incoming roll must switch from speed control to tension control without an upset in the process tension.

With Regenerative Braking Systems, drive logic determines the required braking torque from the diameter and tension settings. This torque is then applied to the speed-up motor as soon as the splice is made to maintain constant web tension.

With Friction Braking Systems, the automatic tension control system has decreased the brake pressure on the expiring roll. At core, this pressure has been reduced to only a few psi. The new large diameter roll requires much higher pressure to maintain constant tension. For these systems, the brake pressure line must be charged with what is known as “Splice Pressure”. Splice pressure is a predetermined brake pressure that is close to the air pressure required for the braking torque to hold constant tension after the splice. The tension control system switches to splice pressure at the point of transfer. This pressure is held only long enough for the constant tension control system’s air lines to be charged to the higher pressure. After this short time, the brake then switches to the constant tension control system. The splice pressure must be changed when new rolls of material are significantly different in diameter or width than previous rolls. Incorrect splice pressure is a major cause of splice tension upsets and missed splices on friction brake unwinds.

The Paster Operation:

The paster device irons on the expiring web to the adhesive on the tail of the new roll. Uniform and reliable pasting is critical for a constantly reliable splicing operation. The paste must be firm and uniform across the roll to assure a good splice. The pasting device can be either a paster roll or a paster brush. (Figure C) Each device has its benefits and drawbacks which must be considered when determining splicing needs.

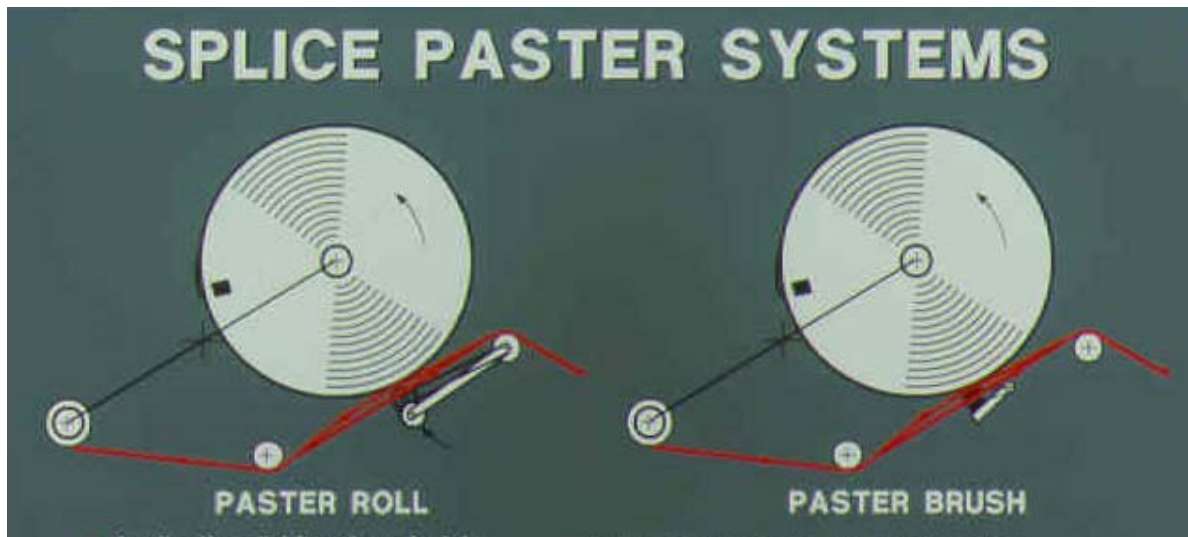


Figure C

Paster Roll – A paster roll operation fires a rubber covered roll to press the web against the new roll of material being spliced. The paster roll is web driven at line speed by either being wrapped by the web or belt driven from a web driven roll. Since it is a rotating device, the paster roll does not cause a splice tension upset when it contacts the web. The paster roll is also used to obtain a better paste between the web and the adhesive because of the higher nip pressure that can be achieved by its nearly line contact with the new roll of material. One of the disadvantages of a roll type paster device is that it does not provide a uniform paste when it is fired against a roll of material having high and low areas across its surface. The paster roll may only contact and paste in the center or on the ends if the new roll is of a larger diameter in those areas because of uneven web caliper. Also, on high speed operations, the roll may bounce off the new roll's surface if fired too fast or with too much fire pressure. This can result in missing splices if the bounce does not have a chance to settle down before the adhesive enters the nip. Another problem which may be caused by a paster roll is the shifting of the outer wraps of the new roll when the paster is fired against a soft roll of material. The hard paste can cause a pucker in the new roll, breaking the tear tabs causing the web to offset and possibly missing the splice.

Paster Brush – Using a brush as a paster device overcomes the disadvantages of a paster roll. It provides a more uniform paste on rolls of material with uneven surfaces since the brush bristles conform to the roll's surface. The soft bristles do not cause a bounce problem and the wider contact pressure prevents the outer wraps from shifting. Conversely, the

paster brush disadvantages are the problems which are overcome by the use of a paster roll. Since a paster brush is a non-rotating device, it causes an increase in web tension when it contacts the web. Because of its three to four inch wide contact surface, the brush may not provide sufficient paste pressure to ensure a consistently good transfer.

The application for a paster roll is typically on splicing operations handling light weight materials. These materials are unwound using light tensions (3 pli or less) and the rolls are normally fairly uniform in diameter across the face. The application for a paster brush is typically on splicing operations handling heavier weight materials that are non-extensible, unwound at high tensions (above 3 pli) and are prone to diameter variations across the roll. Operations handling both light and heavy materials need to have a splicer capable of using either a paster roll or brush to ensure consistent operation on both ranges of products.

High Speed Pasting – High speed splicers used to splice new rolls with diameters as small as 24” at speeds of 1200 fpm or greater must have very fast and accurate paster actuation with uniformly controlled paste pressure. To achieve this, modern high speed splicers must contain pasters that have very quick, controlled movement onto the new roll to be spliced. The paster has a soft (20 to 30 durometer) or collapsible covering. The paster contacts parallel to the centerline of the new roll but is able to collapse independently from side to side to contour against tapered rolls. Nip or paste pressure is controlled independently from the fire pressure to allow a soft paste.

The Cut-Off Operation:

After the splice paste has been made marrying the expiring web to the new roll of material, the final operation is to cut off the expiring web. To make a successful transfer, the splicer must:

- Make a clean cut.
- Keep the tail length as short as possible.

Web Cutting – The cut off operation normally consists of a serrated knife fired into the expiring web. The direction of the knife penetration should be opposite to the web travel to ensure a clean cut regardless of web speed. On difficult to cut materials, the knife may bounce off the web or may only make a partial cut. For these materials, special configurations need to be applied such as the patented Black Clawson Stationary Knife principle to ensure a clean smooth cutoff. (Figure D) The knife is rotated to form an interference angle with the web. An anvil bar is used to support the web at the cut point to ensure good penetration of the serrated teeth. The stationary knife then uses the web tension to pull the web through the knife making a straight, even cutoff.

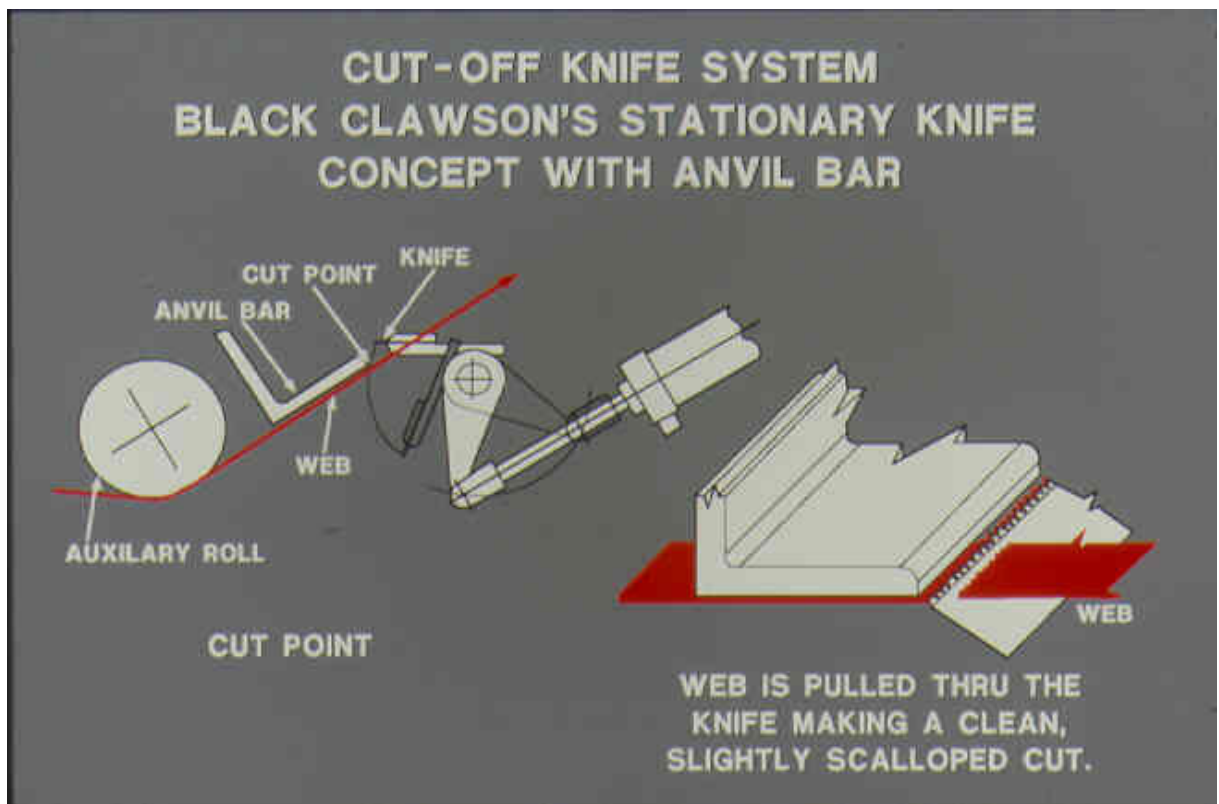


Figure D

Tail Length – The tail length is important in many operations ensuring that the splice will pass through the operation without the tail catching along the web path and tearing apart or causing other problems in the web converting or finishing operation. The cutoff operation needs to be initiated before the paste has been made so the cut coincides with the prepared tail at the paste point to obtain a short tail lap or butt splice. This is accomplished through the slice control system.

Splice Control Systems

The splice control system can range from a manual operation to a fully automatic splicing system utilizing microprocessor control. The process speed and the required tail length for an application will normally determine the degree of automation required. These systems can be grouped into three categories:

- 1. The Bump and Cut System.**
- 2. The PLC Two Count System.**
- 3. The Microprocessor System.**

Bump and Cut Controls – The bump and cut control system provides manual controls for the operator to fire the paster roll and then on the next revolution, the cutoff knife fires completing the splice. This type of system is generally used when process speeds do not exceed 500 fpm (150 mpm). The operator marks the prepared tail location on the side of the roll. As the expiring roll unwinds down towards the core, the operator manually performs the following sequence of events:

1. Indexes the prepared roll into the splice position
2. Engages the speed-up device to accelerated the roll to match line speed.
3. As the expiring roll approaches the desired splice diameter, he or she fires the paster roll.
4. After the marked leading edge passes through the nip, the operator fires the cutoff knife, completing the splice.

At 500 fpm, (150 mpm), the tail length would typically be 5 or 6 feet (1.5 to 1.8 m) long and may be considerably longer or shorter depending on the skill of the operator.

PLC Two Count System – The next level of splice control automation we will call the PLC Two Count System. This system uses the programmable logic controller (PLC) to automate the splice controls. The operator marks the prepared leading edge with reflective tape or positions the disc to leading edge as previously discussed. As with the bump and cut system, the operator:

1. Indexes the prepared roll into the splice position
2. Engages the speed-up device to accelerates the roll to match line speed
3. As the expiring roll approaches the desired splice diameter, he or she presses the splice button. The first time the prepared leading edge passes

the paster device, it is automatically fired. On the second revolution, the knife is automatically fired, completing the splice.

At 500 fpm (150 mm), the tail length would typically be 2 to 2 ½ feet (.6 to .75 m) long. At 1000 fpm (300 mpm), the tail length would be as long as 4 feet (1.2 m) and 7 to 8 feet (2.1 to 2.4 m) tail lengths can be expected on a 2000 fpm (600 mpm) operation. Splice control systems of this type make the tail length independent of the operator's skill but the length will vary depending on the speed of the splicing operation.

Microprocessor Systems – Microprocessor based splice control systems provide fully automatic splice control for precise and consistent splicing operations. The operator marks the prepared tail on the new roll to be introduced into the continuous operation as previously discussed. The operator then presses a “Roll Ready” pushbutton.

Most microprocessor splice control systems incorporate what is called a “*core detection*” system. The core detection system constantly tracks the unwinding roll and continually updates pertinent data which is displayed to the operator. This data includes:

1. The unwinding roll's diameter.
2. The time in minutes until a splice is to be made.
3. The targeted splice diameter.
4. The calculated web thickness.

The operator programs in the following set points into the system:

1. The auto roll index diameter.
2. The speed-up diameter.
3. The target splice diameter.
4. The alarm diameter (the diameter to which an alarm will sound if the “Roll Ready” pushbutton has not been pressed).

All of the above functions will happen automatically as the roll reaches each preset diameter.

Microprocessor splice control systems having precise tail length control are web length control rather than a time control systems. This makes the splice tail length independent of line speed and also compensates for any speed match error between the expiring web and the roll being spliced. These systems precisely measure the web length during a revolution of the roll to

be spliced. The reaction time of the paster and knife in terms of web length is determined. The microprocessor then synchronizes the paster and knife mechanisms so the cut web coincides with the prepared tail at the paste point (Figure E). Adjustment allows the operator to vary the tail length desired.

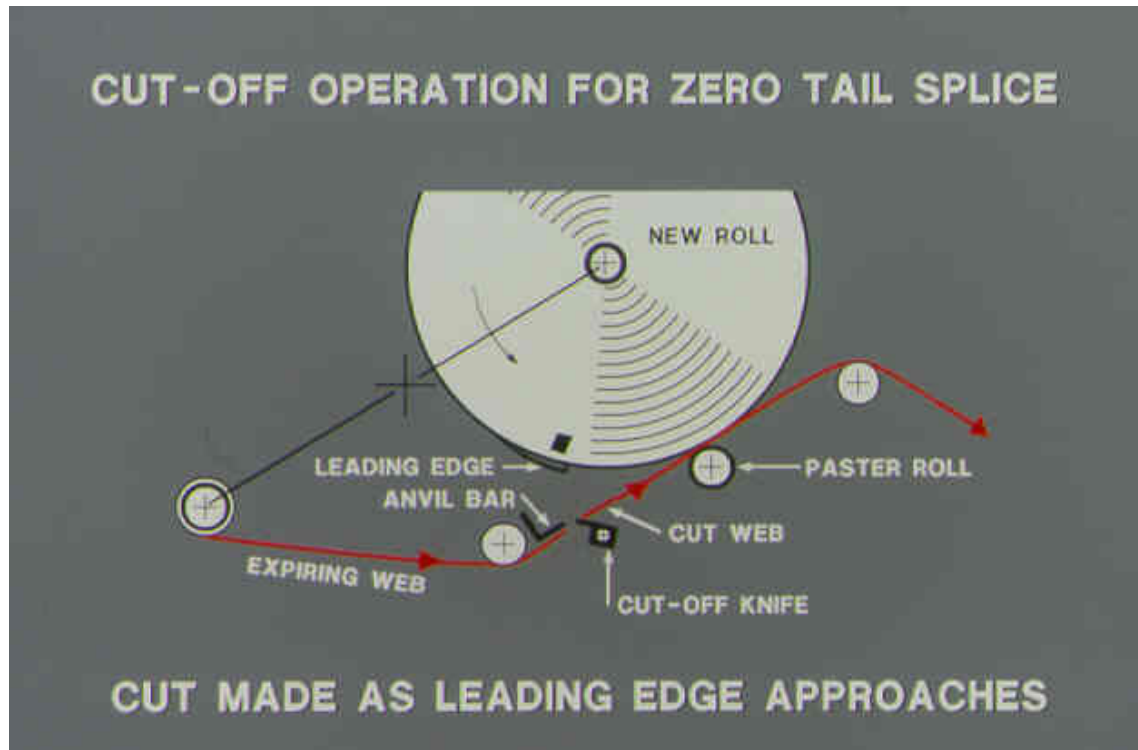


Figure E

A tail length control system, such as the Black Clawson Accutail™ splicing control system will be consistent within the repeatability of subsequent knife firing times. The microprocessor measures the knife firing reaction time each time the knife is fired. The system uses this measurement for determining the web distance required for the knife firing for the next splice. For a splicer having a knife capable of 2 millisecond repeatability time, the tail length would then be repeatable within 2 inches (25 mm) at a 2000 fpm (600 mpm).

Microprocessor splice control systems can also incorporate a *splice tracking system*. A *splice tracking system* tracks the location of a splice as it proceeds down the line. Signals are sent to alert the equipment that a splice is on the way. Nips can be automatically opened and closed as the splice passes. Splice Tracking can also initiate the winder roll change cycle so that the splice will end up as the outer wrap of the finished roll. The system can

predict a splice track so the process can be initiated before the splice has been actually made.

A microprocessor based systems splice control system also incorporates a diagnostic system that displays detected problems with the splicing operation. If a splice is missed, the diagnostic function allows trouble shooting and correcting the problem with minimal amount of downtime.



Typical Microprocessor Operator Interface Panel

Tail Taping System

Even a short tail can cause process problems. For example, when unwinding rolls with splices wound inside the roll, the tail now becomes a leading edge. For these applications it is important that the tails be taped down during the splicing operation. This requires a taping system such as the patented Black Clawson Tail-Taper™. The Tail-Taper™ is able to apply a piece of tape over the tail from the expired roll as it passes down the line with an accuracy of $\pm 1''$ per 1000 fpm.



Taped Tail by Tail-Taper System

Conclusion

Understanding of the important components of a splicer operation is the first step in obtaining consistently good splices on a continuous web converting operation. By breaking down the splicing operation into these components and analyzing each individually, it can be very beneficial in improving your splicing efficiency and total productivity.