

DUSENBERY® CONVERTING SYSTEMS

SLITTING TECHNIQUES GUIDE



PARKINSON TECHNOLOGIES INC

DUSENBERY® CONVERTING SYSTEMS
MARSHALL AND WILLIAMS PLASTICS
PARKINSON WINDERS
KEY FILTERS

DUSENBERY® CONVERTING SYSTEMS

SLITTING TECHNIQUES GUIDE

As a US manufacturer with over a century of manufacturing expertise in Dusenbery converting systems as well as winding and web production orientation systems, Parkinson Technologies has gained valuable expertise and insight regarding the effective use of slitter rewinders. The company readily shares information in this Slitting Techniques guide to help you achieve greater efficiencies, reduce down time, and consistently deliver superior quality.

The guide addresses some typical questions and issues you may encounter during the slitting and rewinding process and provides an overview of the various methods being employed today. These include; *razor blade slitting, shear slitting, wrap slitting, kiss (tangential) slitting, and score cut slitting*. Topics such as *material conditions, winding and center winding, differential rewinding, cores and adapters, individual top riding rolls, preventing gauge band build-up, surface-center winding, mechanical conditions/drum hardness, and unwind tension* are also addressed.

While this information will help determine which methods may be best for your application, it's important to remember that every project has different goals and uses varying machinery, materials and processes. Please contact the Dusenbery sales and engineering team at **sales@parkinsontechnologies.com** to discuss the specifics of your slitting and rewinding project, the capabilities of Parkinson Technologies' state-of-the art R&D lab, and the expert technical and field support available.

Please review the comprehensive line of Dusenbery slitter rewinders at **www.parkinsontechnologies.com**.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Contents

I. Defining Problems	2
I.1 Material Conditions	2
I.2 Surface Air.....	2
I.3 Equipment Design.....	3
II. Basic Slitting Techniques.....	4
II.1 Razor Blade Slitting	4
II.2 Shear Slitting	6
II.3 Score Cut Slitting.....	12
III. Basic Winding	16
III.1 Center Winding	16
III.1.1 Differential Rewinding	18
III.1.2 Cores and Adapters	19
III.1.3 Individual Top Riding Rolls	22
III.1.4 Preventing Gauge Band Build-up	26
III.2 Surface Center Winding	27
III.2.1 Theory.....	27
III.2.2 Surface-Center Rewinding Arms	29
III.2.3 Mechanical Conditions	29
III.3 Surface Winding.....	31

DUSENBERY® SLITTING TECHNIQUES GUIDE

I. Defining Problems

I.1 Material Conditions

All films, coated materials and laminations are subject to some or all of the following variations:

Gauge Variation - A gradual uneven thickness across the web width from edge to edge.

Gauge Band - An abrupt change in thickness in a small area. Gauge bands run parallel to the main axis of the web and can exist for the length of the web, or only for short lengths.

Slack Zones - Slack Zones are caused by the uneven production of the original material. In this condition, the gauge can be even, but if the web is laid out on a flat surface and cut into strips parallel to the machine direction, the slack zone strips would be longer than the normal or tight zone strips (**Figure I-1**).

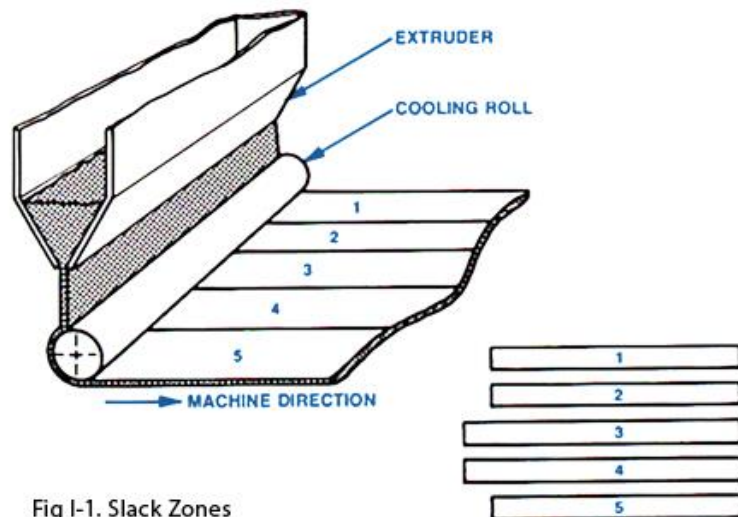


Fig I-1. Slack Zones

I.2 Surface Air

All materials carry a surface layer of air with them as they move through a machine. When films are slit and rewound, the layer of air is carried into the rewind roll. At low speeds, this layer of air can escape at the ends of the slit rolls without causing problems in winding. At high speeds, air is wound into the roll. This can result in the air acting as a lubricant or becoming trapped between the layers of material. When air acts as a lubricant between the layers of material it allows shifting of the second, third, and lower layers (from the outside in) within the axis of the roll (**Figures I-2 and I-3**).

DUSENBERY® SLITTING TECHNIQUES GUIDE

When air is trapped between the layers of material and is wound into the roll, it forms tires, balloons or bubbles, causing deformation and occupying volume as a secondary layer (**Figure I-4**). This causes poor roll formation and deformation of the web.

When air is trapped between the layers of material and is wound into the roll, it forms tires, balloons or bubbles, causing deformation and occupying volume as a secondary layer.

Fig I-2

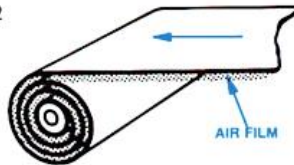


Fig I-3

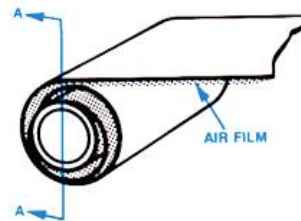


Fig I-2 and I-3. Air wound between layers showing the relative shifting of the material.

I.3 Equipment Design

Engineering equipment design and modification is often the outgrowth of one or several techniques developed on a theoretical and sometimes temporary basis to meet an immediate problem; and techniques in turn are inseparably related to machine operation. For the following discussion, the terms Engineering and Techniques are employed interchangeably as a single concept.



Fig I-4. Air Trapped in Rewound Roll

DUSENBERY® SLITTING TECHNIQUES GUIDE

II. Basic Slitting Techniques

The type and thickness of material determines whether shear cut, razor blade or score cut slitting should be employed. For example, soft films such as polyethylene, vinyl and polypropylene are cut quite easily by razor blades, as are the light gauges of polyester. Heavier gauges of polyester, starting at .002" thick should be shear cut, as should paper, foil, and most laminates of the above. Score cut slitting is usually employed where speed of set-up is more important than the quality of the slit edge or the material is too abrasive for shear or razor blade slitting.

II.1 Razor Blade Slitting

If original equipment cost, cost of knives, and speed of set-up alone were used as a criterion, only razor blade slitting would ever be used. But razor blades cannot be set to hold close slitting tolerances, nor are they capable of cutting through heavy, rigid, or abrasive materials.

Set-up of razor blade slitting in air is faster, but also results in a loss of accuracy in slitting.

The use of the grooved back up roll with the web wrapped around the roll, provides for a cleaner, smoother and more accurate cut because the roll gives very close support to the web as it is being cut. It cannot stretch or shift under the blade as it can when slitting in air between two rolls. If the web runs tangential to the grooved roll rather than wrapping around it, the benefits of the grooves are lost.

Set-up of razor blade slitting in air is faster, but also results in a loss of accuracy in slitting. The grooved roll requires more set-up time because the blade must be centered in the groove not touching either side or the bottom. Contact between the razor blade and the grooved roll quickly destroys the blade and tends to damage the groove. **Figures II-1 and II-2** also show the most commonly used method of having the blade penetrate the web. However, recent tests have shown that much clearer cuts are obtained by using the method shown in **Figure II-3**.

When hollow ground blades are used, there is less interference between the blade and the film being cut.

At nominal running speeds, say through 1500 FPM, the blades also tend to burnish the film as it is being slit giving a polished edge. Over these speeds heat is generated. If enough heat is generated to start melting the film, a bead can be generated at the slit edge. This bead can be very detrimental to achieving good winding of the slit strips.

The razor blade is the most economical of the knives used for slitting. Set-up is easily accomplished just by clamping a blade in place along a bar so that the blade penetrates through the web. Hence razor blade slitting can be recommended for quality and for fast set-up on any light, non-abrasive materials.

DUSENBERY® SLITTING TECHNIQUES GUIDE

The razor blade is the most economical of the knives used for slitting.

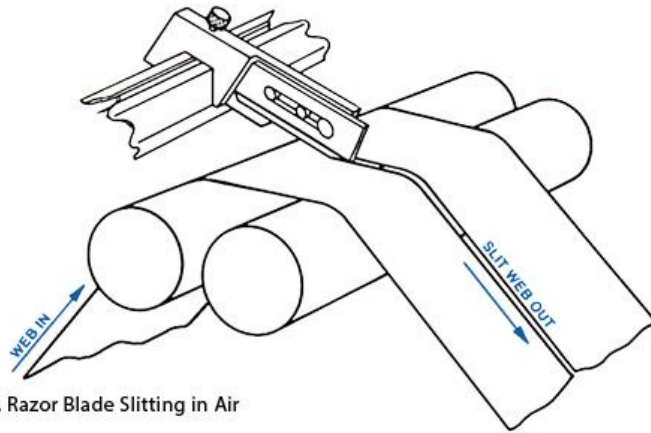


Fig II-1. Razor Blade Slitting in Air

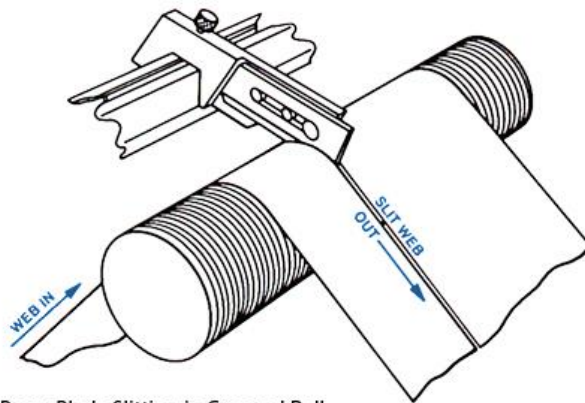


Fig II-2. Razor Blade Slitting in Grooved Roll

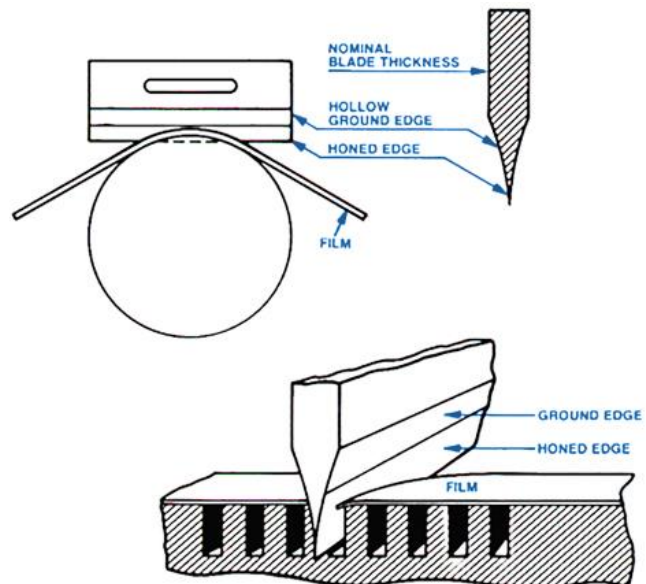


Fig II-3. Grooved Roll, Magnified Section

DUSENBERY® SLITTING TECHNIQUES GUIDE

II.2 Shear Slitting

As the angle changes, the cutting effect changes.

Shear cut slitting uses two rotary knives to produce the same cutting effect as obtained by using a pair of scissors. Scissors present a condition with two sharp blade edges crossing at an angle as is shown in **Figure II-4**. To cut the material it is necessary to apply force on the handle of the scissors. The cutting takes place at the junction of the two sharp edges, and as the scissors close, the angle of the junction gets smaller. As the angle changes, the cutting effect changes. There is an ideal angle at which a material will cut. We have all tried taking scissors, holding them open, and pushing them through a sheet of paper. At a certain angle they cut cleanly and very easily. Change the angle slightly, and the paper tears. This is exactly what happens with a pair of rotary knives. If the web is running slower than the knives, effectively the knife is closing in on the web or cutting it the way scissors cut. If the web is running faster than the knives, the effect is the same as pushing the material through the scissors.



Fig II-4. Shear Slitting Principle

This is why material can be effectively slit at a knife speed which is either slower than synchronous, synchronous with the web, or faster than synchronous. The angle of junction between the knife cutting edges is the critical factor.

Changing our analysis from scissors to two rotary knives, there are two circles that overlap and form a junction angle (**Figure II-5**) similar to that formed by the scissors. Squeezing the blades together creates a reaction force which pushes the blades apart. This is the same force that is used to squeeze the handle of the scissors. When a large number of cuts are being made, these reaction forces can bend a knife shaft. This is a factor that must

DUSENBERY® SLITTING TECHNIQUES GUIDE

be considered in all slitting applications. No table of the shearing forces required for various materials is available.

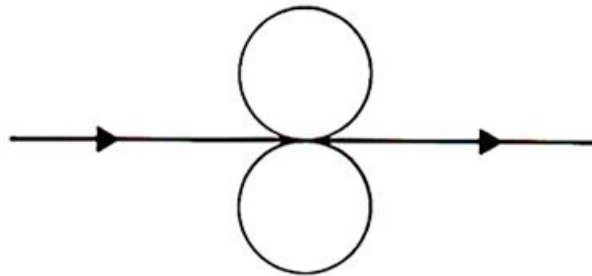


Fig II-5. Shear Slitting as Applied to Rotary Knives

At the present, we are using a figure of approximately a pound, to a pound and a half per cut, per mil of material thickness. Also uncertain, is the effect that the relative speed between the material and the knives has on the shearing force. We now feel that when the knives are running faster, the unit shearing force is less, because less material is being cut per knife revolution than would be at synchronous speed. Hence higher knife speed results in lower shearing forces. There is some indication that faster speeds are better for foil. To date most plastic films and paper are slit at synchronous speed with excellent results. On most materials, problems exist at speeds below synchronous. These are generalities that can be made about cutting effects and the relationship between scissors and shear knives.

Next, consider the configuration of the web and the knives in the machine. There are two primary arrangements: "Wrap Slitting" and "Kiss (tangential) Slitting". The preferred arrangement is "Wrap Slitting". Here the web actually wraps around the female knife and is positively supported while being cut as shown in **Figure II-6**.

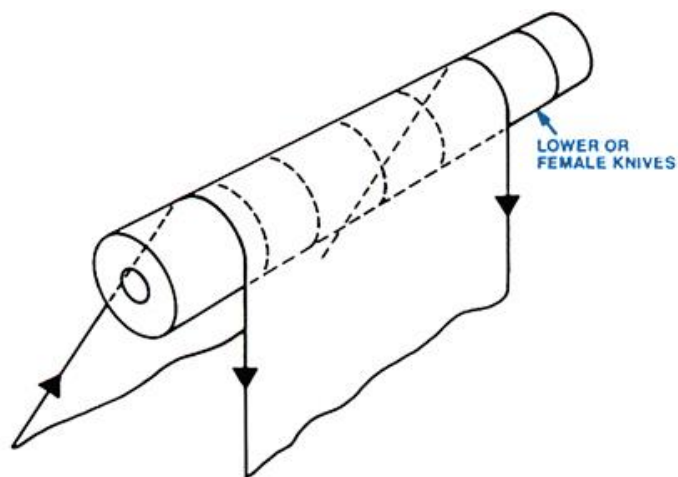


Fig II-6. Web Wrap Around Female Knife

DUSENBERY® SLITTING TECHNIQUES GUIDE

The arc of contact between the web and the female knife must be greater than the arc of contact between the male knife and the female knife. See **Figure II-7**. If the arc of web contact is smaller than the arc of knife contact, the male knife hits the unsupported section of the web.

If the arc of web contact is smaller than the arc of knife contact, the male knife hits the unsupported section of the web.

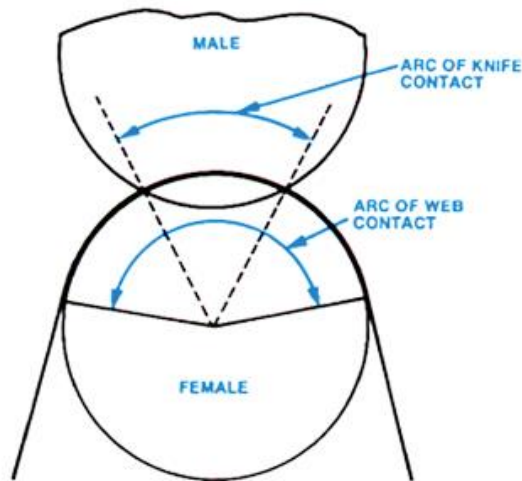


Fig II-7. Arc of Contact between Male Knife & Female Knife

The web is, therefore, torn rather than cut. This condition is illustrated in **Figure II-8**. Knives and spacers must be assembled on the shaft to form or to simulate a solid supporting shaft. Unless the web is supported by a shaft solidly stacked with knives and spacers, the web will pull or sag into the voids and irregular slit widths will result.

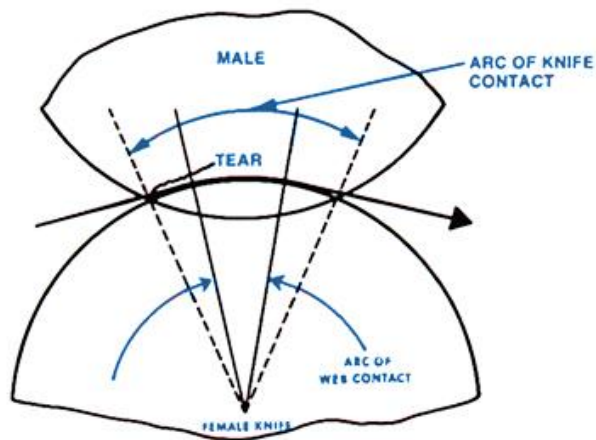


Fig II-8. Detail of Contact Arc

The second arrangement is tangential or kiss slitting. In this arrangement the web only kisses or touches the outside diameter of the female knife, it doesn't wrap around it. See **Figure II-9**. If the web hits the male knife before it hits the

DUSENBERY® SLITTING TECHNIQUES GUIDE

female, a cutting angle is not achieved. This is the same as taking scissors and trying to cut with only one blade. The web is ruptured, not cut.

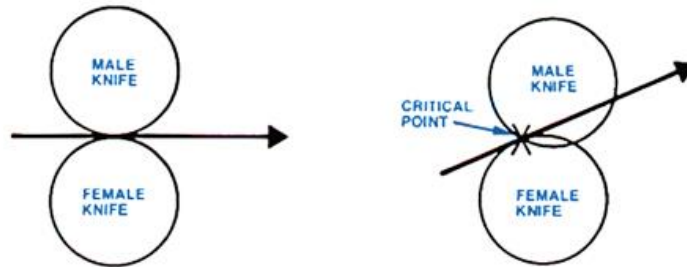


Fig II-9. Kiss Slitting

It is essential in kiss slitting that the female knife, the web and the male knife contact each other at the critical point.

Conversely, if the web hits the female knife first, nothing happens, but, when it leaves the female and hits the male, again the web is ruptured. A clean cut is not achieved. It is essential in kiss slitting that the female knife, the web and the male knife contact each other at the critical point. This critical point will change as the male knife overlap is increased; therefore, you cannot increase the overlap beyond an ideal condition without creating problems. This ideal condition is minimum overlap and point contact. Increasing overlap increases the arc of contact between the two knives and the male knife hits the web before the female.

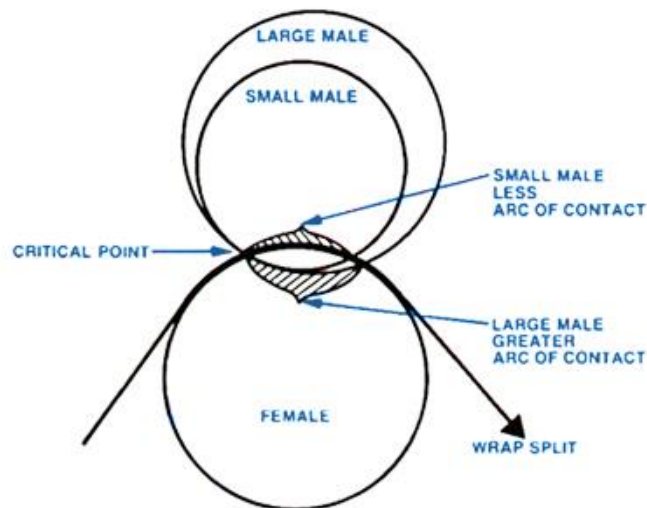


Fig II-10. Detail of Contact Arc Wrap Slitting

Using a male knife of a smaller diameter will give a greater overlap before reaching the critical point. See **Figure II-10**. The large diameter male knife has a larger arc of contact for the same overlap. Therefore, the smaller the diameter of the male knife, the greater the permissible amount of overlap. The greater the diameter of the male knife, the smaller the permissible overlap. The large radius will give a bigger arc as you increase the overlap. To this degree, the individual knives, permitting fine adjustment of each individual knife, give better control than multiple knives mounted on a single shaft where additive tolerances must be overcome by increasing the overlap.

DUSENBERY® SLITTING TECHNIQUES GUIDE

The advantage of kiss slitting is fast setup of individual female knives, the disadvantage is the buildup of fuzz and dust.

The advantage of kiss slitting is fast setup of individual female knives. These knives can be repositioned on the shaft without removing the entire knife shaft. Wrap slitting requires the removal of the shaft from the machine, taking off the knives and spacers and then putting them back in rearranged order. In kiss slitting, the knife is loosened, shifted to the next cutting position, and tightened again. It can be accomplished in a minimum of time in the machine without removing any parts from the machine. The disadvantage lies in the quality of cut achieved. The cut is not as good as that obtained by wrap slitting. In wrap slitting, the web wraps around the female knife. The male knife penetrates to the ideal depth and gives a good clean cut. In kiss slitting, the web comes in tangential to the female knife. When the web and the male knife come in contact at this same point the cut is clean. To achieve this geometrical arrangement the male knife must be offset toward the exiting side of the web. Looking at **Figure II-11**, you will notice that a good portion of the male knife now is underneath the web that has been cut. As the knife rotates out of the web, the web rubs both on the cutting side and the backside of the male knife, creating a frictional drag and filing the material that passes through. This is a decided disadvantage because it causes fuzz and dust.

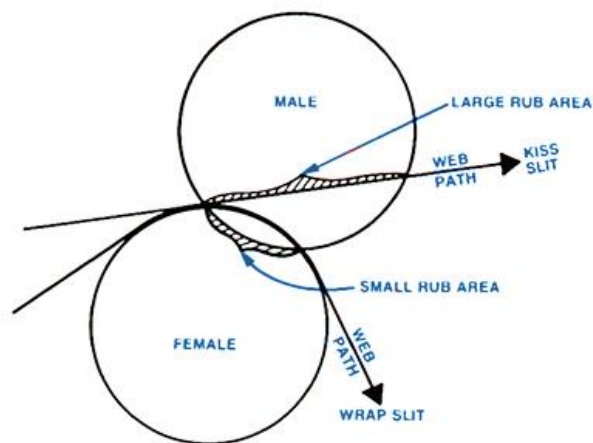


Fig II-11. Comparison of Rub Areas in Kiss Slitting Depending on Web Path

Looking at **Figure II-12** it is seen that when shear slitting a web, on the cutting side the male knife comes in and cuts clean and square. On the other side, the knife has pushed the web aside and down in the cutting operation. Consequently, the web, depending upon the condition or type of material being slit, can be permanently or temporarily deformed. The edge of foil, for example, takes a permanent deformation on the edge, and as it winds up layer after layer, builds a bevel on the edge of the rewound roll which eventually causes the sheet to tear.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Wrap shear slitting offers excellent slit width accuracy.

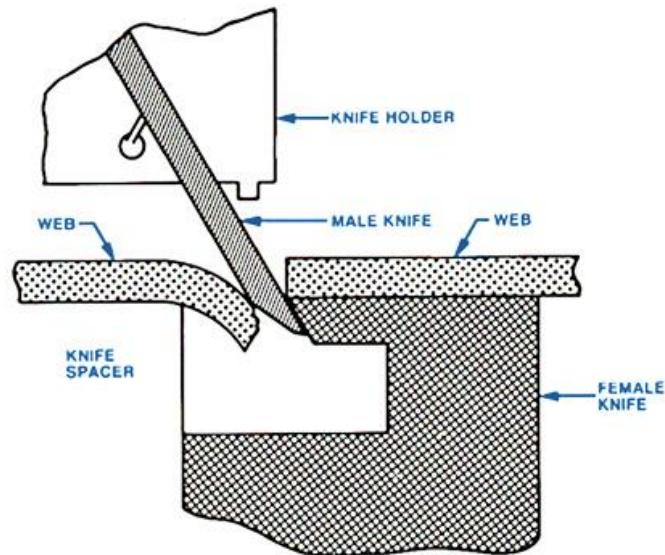


Fig II-12. Shear Slit Cross Section

In foil, this deformation occurs with both kiss and wrap slitting. There is a second problem that arises in kiss slitting. When the web comes straight out, there is a greater interference angle between the web and the male knife. As the male knife rotates out of the web, it has a rough grind on the back edge; it will tend to file the edge of the slit strip. The result on a hard material is filing action which causes little particles to fall onto the edge of the slit strip. These particles will create a buildup similar to that mentioned above with identical results. Kiss slitting is good for fast setups. The quality of the cut is not as good as in wrap slitting because of the greater interference between the male knife and the exiting web.

In wrap shear slitting, accurate slit widths and close tolerances are possible through the use of spacers for measuring and positioning the knives. This combination of knives and spacers, stacked on the shaft, provide a complete support for the web, thereby reducing, to a minimum, the possibility of wrinkling, bagging or sagging. This results in excellent slit width accuracy.

In kiss slitting because there are voids between the knives, permitting the web to sag and wrinkle, slit width accuracy is more difficult to achieve.

In conclusion, we can say that shear cut slitting offers many advantages and can be used in several different ways. Careful consideration must be given to results that are desired or required in selecting the best arrangement for each application.

It is standard practice to incorporate driven rolls in all types of machines to maintain control of the web as it passes through the knives and to isolate the slitting tension from the unwind and rewind tensions. All driven rolls also serve to keep a constant tension in the slitting area, thereby maintaining the slit width.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Score Cut slitting is the oldest form of cutting known to man, and the first employed in slitting machinery.

A slight overdrive in web speed is maintained from driven roll to driven roll to hold tension constant. For speeds in excess of 500 FPM and film thickness below .001, it is necessary to positively drive all rolls since changes in web speed, due to undriven roll inertias, tend to distort the web and affect the quality of the rewound rolls. This is especially true when narrow webs of light plastic films are run on wide machines (i.e. webs less than 70 per cent of the maximum web width capacity of the machine).

II.3 Score Cut Slitting

Score Cut, also known as Crush Cut, slitting is the oldest form of cutting known to man, and the first employed in slitting machinery. As the name implies, it is crushing of the material to sever one part from another.

Since this method of slitting relies on the crushing of the material, it follows that the "knife" cannot be dead or razor sharp, because a very narrow knife edge will dull and chip almost immediately upon contact with the surface it is crushed against. Hence, the knife used in score cut slitting is one that is dulled (rounded) to the ideal condition before we start trying to slit with it.

Figure II-13a shows a fully sharp knife. **Figure II-13b** shows the proper edge configuration of a good score cut knife. **Figure II-13c** is an enlarged view of the cutting edge of the good score cut knife.

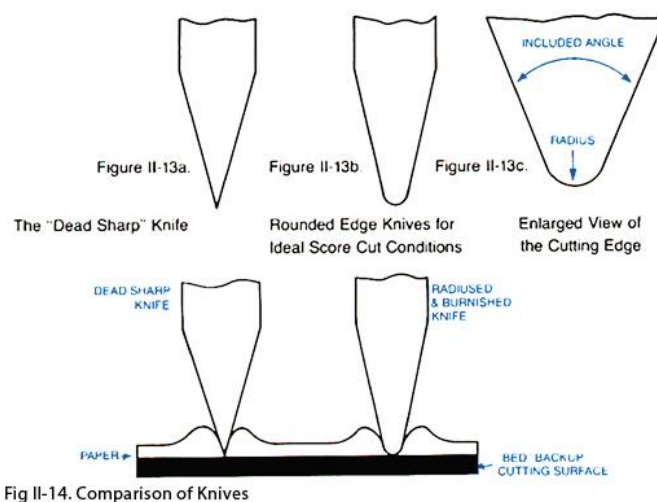


Figure II-14 shows these respective knives penetrating through a material and against the "bed" or backup cutting surface. This illustrates our original premise that pressure on the 'Dead Sharp' knife will dull this knife almost immediately, whereas the rounded edge of the other knife will not break down as easily.

When slitting a continuous web, it is obvious that a round backup or platen roll and round slitting knife must be used. With the knife pressed against the web with sufficient pressure to cut through it, we achieve "slitting". For best results, the web, the platen roll and the knife must all be moving at the same speed.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Since this method requires enough pressure to cause the web of material being slit to separate completely, it is again obvious that after a short running time, the platen roll will groove and the knife edge abrade. At this point, there is intermittent cutting only. To avoid this, we make both the platen roll and the knife of steel that can be hardened. Further, the platen roll is ground to a very smooth finish. The score knife itself after hardening is not only ground but the cutting edge is radiused and then burnished to a very high polish. The smoother the platen roll and the knife edge, the cleaner the cut and the longer the life of the blade and roll.

The oldest method, score cut slitting is very quick to set up, thus offering a very distinct advantage. It is, however, losing favor in many areas. As an explanation, let's examine this cutting method first on paper. When we crush the fibers of the paper web, a very fine powder of crushed paper fibers is created. If the knife is "sharp", that is smooth and highly polished, the slit edge of the paper will appear smooth. Years ago, this dust was quite acceptable, but in today's high speed printing presses and automatic packaging machines, dust accumulates faster and causes equipment malfunctions. For this reason, score cut slitting is becoming less acceptable.

In addition to "dust", score cut slitting paper may be undesirable in another way. As soon as the edge of the knife becomes slightly rough, the slit edge is no longer smooth. Instead, it has slight feathers or threads where the paper has not been completely pulverized. These feathers or threads tend to accumulate on the edge of a slit roll making it feel and look very rough. The normal tendency when this occurs is to increase the slitting pressure on the knives. This is usually successful, but only for a short time. The increased pressure causes further deterioration of the knife resulting in a still poorer slit edge.

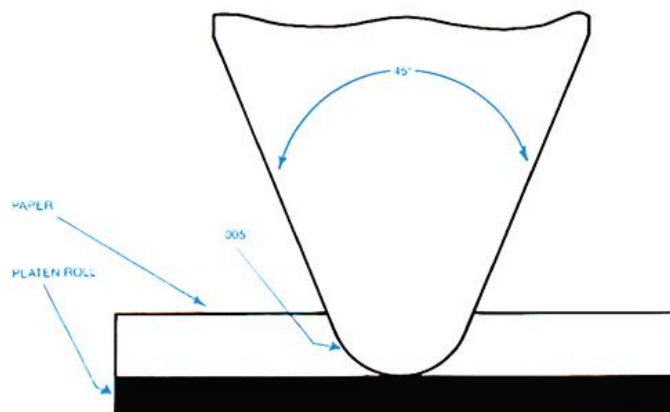


Fig II-15. Paper Displacement Producing Dust

Applying score cut slitting to plastic films and sheet, we have similar situations. On extensible, soft plastic films like polyethylene, a good smooth knife and platen roll yield excellent results. However, as soon as any defect appears in either surface, this defect creates a void and the film is squeezed into the void and is not separated. At first, these strings or ties tear to give

DUSENBERY® SLITTING TECHNIQUES GUIDE

On certain hard plastic film material score cutting causes minute cracks perpendicular to the slit web.

separation but they soon reach a point where adjacent sections of film stretch and deform causing rejects. (**Figure II-16** shows a good score cut slitting operation).

On hard plastic films such as cellophane, acetate and oriented polystyrene, the result is somewhat different. As the knife crushes its way through the material, it not only severs the web as desired but causes minute cracks perpendicular to the slit web. As shown in **Figure II-17** these cracks when put under slight strain tend to propagate further into the web. With wide webs, this is not too critical. On narrow webs, the only too frequent result is a tear completely across the web.

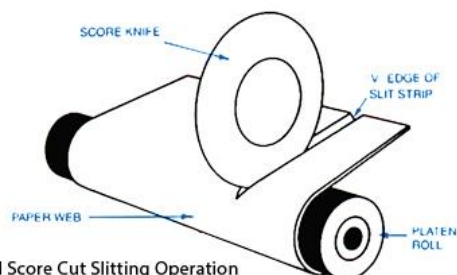


Fig II-6. A Good Score Cut Slitting Operation

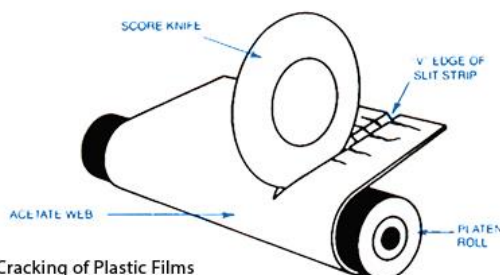


Fig II-17. Cracking of Plastic Films

DUSENBERY® SLITTING TECHNIQUES GUIDE

Score cut slitting is ideal where quick and easy set-up is required.

This brings us to the area where score cut slitting really shines: the slitting of paper pressure sensitive tapes. The nature of the material is ideally suited to this slitting method. **Figure II-18** shows a paper coated with pressure sensitive adhesive being slit into narrow tape. You will notice in this illustration the desirable separation of the paper web. In addition to this, you can see the adhesive is forced away from the edge of the paper. Also, the adhesive forms a small ridge on each edge.

These conditions give us a perfect result. When we wind up the strip, we have a roll that has a "dry" non-sticky edge. This is seen in **Figure II-19** where the adhesive is away from the edge of the roll.

Score cut slitting is ideal where quick and easy set-up is required. It can be used to some degree of satisfaction on most materials being slit today. However, before making a final decision on score, shear or razor blade slitting, a careful analysis of the desired results should be made.

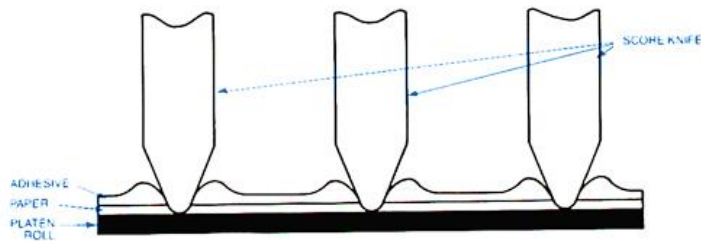


Fig II-18. Paper-Backed Pressure Sensitive Adhesive Slitting

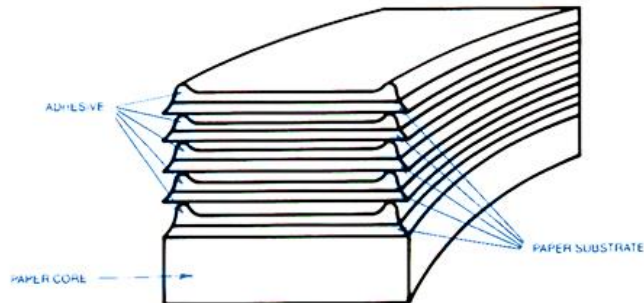


Fig II-19. Paper and Adhesive Configuration After Slitting

DUSENBERY® SLITTING TECHNIQUES GUIDE

III. Basic Winding

The initial approach to solving the problems of winding either full width webs or slit webs is through the selection of types of machines that will produce the desired results. Dusenbery winding machines are based on three basic types of winding techniques: center winding, center surface winding and surface winding.

III.1 Center Winding

Center winding is ideal when materials contact pressure cannot be applied.

On some materials contact pressure cannot be applied because the materials could become blocked or damaged. Here center winding becomes necessary.

Today center winding is the most prevalent type of winding, and the basic principles remain the same whether the operation takes place in a vacuum or in ordinary atmosphere or in a pressurized chamber.

In center winding (**Figure III-1**) the winding force is derived solely from the rewind shafts and is transmitted to the winding web through the core and layers of material that have already been rewound. The winding force is generated by an electric motor, a fluid motor, or a slip clutch.

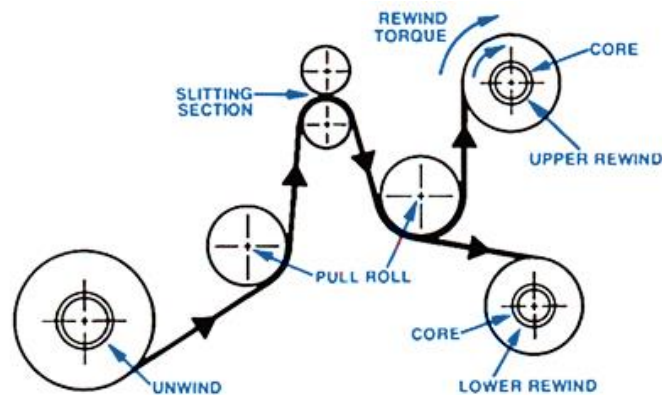


Fig III-1. Center Winding - (Duplex Winder)

The graph in **Figure III-2** shows the effect of constant torque input. This results when a slip clutch is used and no adjustments are made as the roll grows in diameter. As the roll builds up in diameter, the tension drops off. This puts a limit on the maximum diameter to somewhere between 12" to 14" if initial winding was started on a 3" I.D. core.

DUSENBERY® SLITTING TECHNIQUES GUIDE

It is seldom advisable to attempt constant tension winding in a center wind operation.

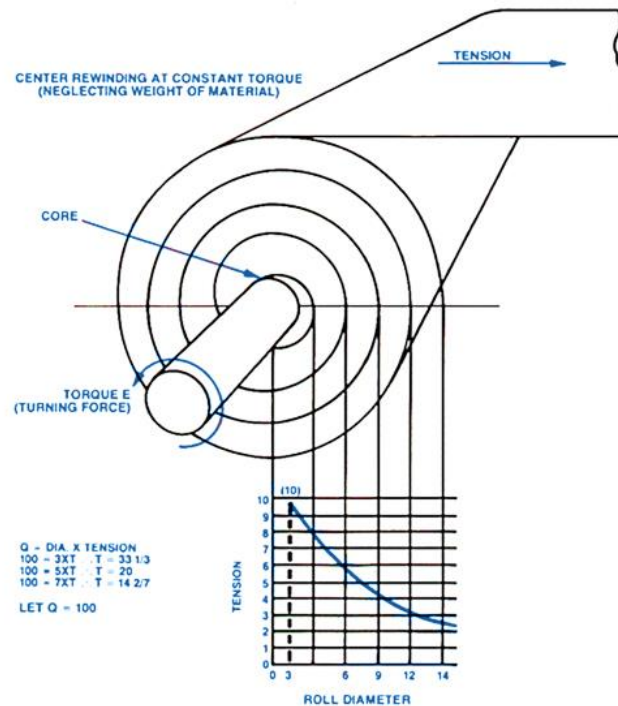


Fig III-2. Reduction in Tension as Web Diameter Increases During Winding

Keeping a 3" core, the only way to get larger rewind diameters is by increasing the input power or torque as the roll diameter builds up. The bottom line in **Figure III-3** shows the basic constant torque curve. As the roll diameter builds up, the web tension decreases. Normally after slitting there are two rewind positions, when center winding, generally located one above the other, to ensure positive separation of the rolls. Adjacent cuts are wound alternately on the upper and lower rewind mandrels.

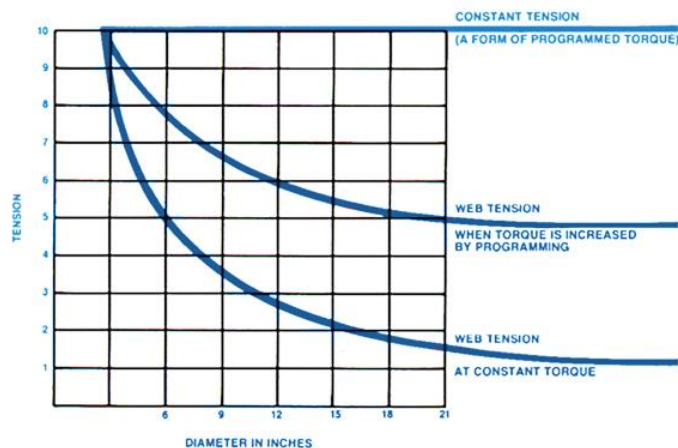


Fig III-3. Effects of Different Tensions in Center Winding

Therefore, in center winding it is easiest to wind at constant torque. When it is necessary to wind to larger diameters on a given core size, programmed torque is used. It is seldom advisable to attempt constant tension winding in a center wind operation.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Typical duplex center winders include the Dusenbery Series 335, 835, 935 and 1035.

The bottom line in **Figure III-3** shows the basic constant torque decreasing tension curve. The upper line is the constant torque curve. This is one form of programmed torque. The ideal arrangement for building a good roll is somewhere in between as is shown in the programmed torque curve. The exact ideal curve varies with the material and winding conditions and is usually best found by experimenting with varying programs until ideal performance is arrived at.

The above conditions hold true in all center winding operations.

III.1.1 Differential Rewinding

In slitter-rewinders, the most common type of center winding is the duplex type winder. The duplex center winder is an application of center winding utilizing differential rewinding. Typical of this type of machine are the Dusenbery Series 335, 835, 935, 1035 and their many derivatives. Differential rewinding is utilized in these machines. Engineered for versatility, differential rewinding is an arrangement whereby each individual rewinding roll is completely isolated from all others. This is essential to satisfactorily rewind materials of non-uniform gauge.

Without differential action, the heavy gauge areas of the material would wind tightly while lighter gauge areas would wind loosely. The former condition may result in stretching of the material and/or collapsing of the core. The latter condition may cause the roll to telescope and/or fall apart in handling. High quality rewinding, therefore, depends directly on differential winding. High quality rewinding, therefore, depends directly on differential winding (**Figure III-4**).

Differential rewinding is accomplished on duplex center winding machines through a system of alternating cores and spacers on each mandrel. **Figure III-4** shows this. The spacers are keyed so that they are free to slide axially on the mandrel, while being restrained from rotating. An adjustable air pressure system is used to exert a force axially along the mandrel. Each core is squeezed between the spacers adjacent to it. The rewind mandrel is driven faster than the slit strips are fed onto the core. Thus, the cores are held back by the slit strips and are forced to slip with respect to the mandrel and the keyed spacers. The adjoining faces of the cores and spacers act as slip faces of slip clutches, providing a driving torque on each core proportional to the axial pressure exerted. Each core therefore has the equivalent of its own individual slip clutch drive.

DUSENBERY® SLITTING TECHNIQUES GUIDE

For best results, the ends of the cores must be smooth and square to the inside diameter.

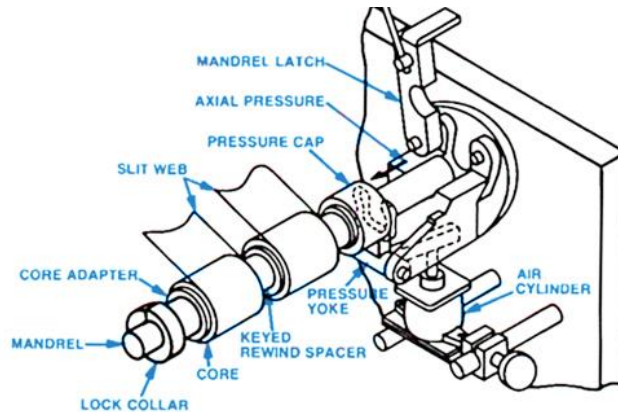


Fig III-4. Components of Differential Rewind Mandrel

The tension of all slit strips is the same since all cores are acted on by the same axial force acting on identical slipping surfaces. Each core is its own slip clutch and, therefore, each slit strip is free to wind at its own speed and tension regardless of the size or condition of the rolls being rewound on either side of it.

For maximum versatility, four sets of rewind tension controls, one at each end of each mandrel, are installed as standard equipment on this type of machine. Thus, by utilizing each of the four different tension control zones it is possible to slit and rewind up to four different slit widths concurrently from a single web and maintain the correct tension for each individual slit width.

III.1.2 Cores and Adapters

Cores are an integral part of differential rewinding and they are a critical factor in obtaining a good rewind roll. For best results, the ends of the cores must be smooth and square to the inside diameter. Any burrs or turned over edges on the inside diameter of the core will cause binding between the core and the mandrel. Burrs catch in the mandrel keyway or act as a point contact with the rewind spacer. These conditions cause an erratic slipping action resulting in erratic tensions on the rewind web strip.

Since the cores are stacked together with the rewind spacers, any cumulative size variation in the individual elements will cause successive increases in misalignment between the cores and the slit webs. Techniques here, therefore, necessitate holding close tolerance on the length or width of the core used.

Where commercially cut narrow-width cores are used and erratic operation exists due to poor core edges and/or excessive friction between the core I.D. and the mandrel body, core adapters have been developed. Core adapters are used to eliminate contact between the core body, the rewind mandrel, and the rewind spacer (**Figure III-5**).

DUSENBERY® SLITTING TECHNIQUES GUIDE

Adapters are employed where cores cannot be obtained to the tolerance required.

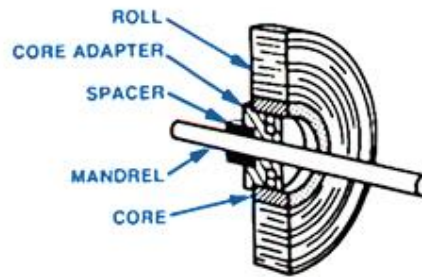


Fig III-5. Core Adapters

All core adapters serve to control the friction between the mandrel, rewind spacer and the core. By placing the core on the core adapter and utilizing a low friction insert in the core adapter as the slipping surface on the mandrel and against the rewind spacer, very fine tensions can be maintained on all operations, especially when thin, stretchy films are being rewound.

Selection of Basic Designs & Types of Core Adapters

Standard core adapter units to eliminate contact between mandrel and core for light tension control include the recessed adapter (**Figure III-6**) and flush-sided adapter (**Figures III-5, III-7, III-8**).

In the recessed type, rewind spacer length and core length are equal and this eliminates operator calculations. The recessed type utilizes thin-line design for fine tension winding and must be used carefully to avoid shoulder breaks. Design of the flush-sided adapter eliminates the weakness of the recessed type but requires the operator to subtract the width of the flange from the width of the cut to determine the length of rewind spacer required.

Adapters are employed where cores cannot be obtained to the tolerance required. Use of adapters, as shown in **Figure III-8** will eliminate the error introduced by the core length and will permit the use of varying core lengths on the same adapter by merely changing the spacers between them.

Spacer length for this type of core adapter is computed as follows: Spacer width equals $(2 \times \text{slit width})$ minus core adapter width.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Even a slight compression of the core due to tight winding could cause a locking of the core to the mandrel, eliminating the slipping and differential winding action.

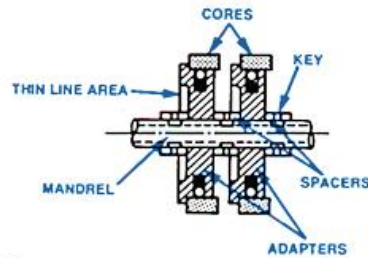


Fig III-6.

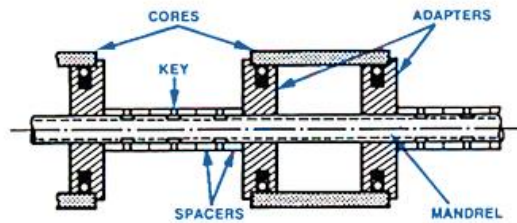


Fig III-7.

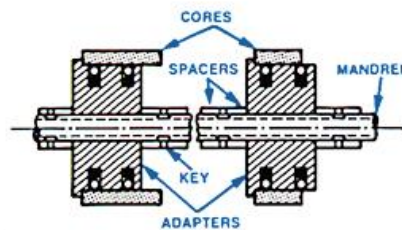


Fig III-8.

High torque core drivers (**Figure III-9**) are used to obtain rewind tensions higher than those that can be generated between the side of a paper core and a standard rewind spacer. This is in the range of 100 lb. or more. These core drivers act as individual slip clutches that drive the cores while serving as thermal insulators.

Careful attention must be given when winding at high tension directly on mandrels of the same diameter as the core I.D. Even a slight compression of the core due to tight winding could cause a locking of the core to the mandrel, eliminating the slipping and differential winding action.

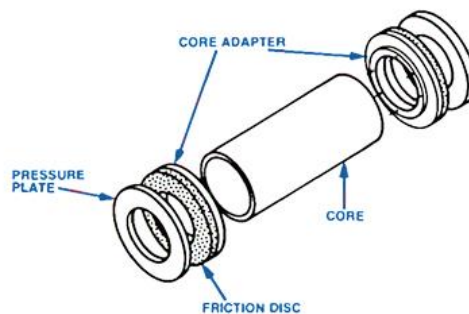


Fig II-9. High Torque Core Driver

DUSENBERY® SLITTING TECHNIQUES GUIDE

High torque adapters (**Figure III-10**) are used to obtain the higher rewind tensions while eliminating the problem of the core collapsing and seizing. Here the core is supported by the pilot of the adapters and not by the mandrel.

The development of the independent top riding roll permitted satisfactory, high speed winding of films and other off caliper materials because these rolls would positively maintain constant contact with the rewinding roll; thus preventing air from entering between the layers of film.

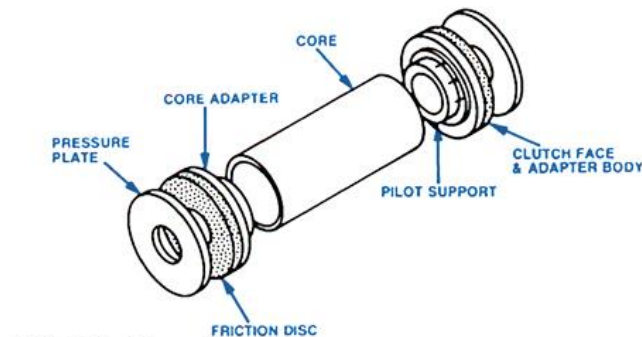


Fig III-10. High Torque Adapter

In both **Figures III-9 and III-10**, the brake lining (clutch face and the adapter body) act as a thermal insulator. This insulating quality protects the core and the rewound material from being subjected to heat that could be detrimental to the quality of the finished roll.

All types of core adapters can be used for rewinding on large size cores where mounting and handling make it impractical or expensive to use a mandrel of matching diameter. The type of core adapter selected depends on the intended use.

III.1.3 Individual Top Riding Rolls

Being constantly aware of the obligation to provide equipment capable of satisfactorily winding at high speeds, the individual top riding roll for multiple roll slitting was developed as still another refinement to an already production proven and versatile piece of equipment. The development of the independent top riding roll permitted satisfactory, high speed winding of films and other off caliper materials because these rolls would positively maintain constant contact with the rewinding roll; thus preventing air from entering between the layers of film (See **Figure III-11**). The incoming web is guided precisely to and brought into contact with the rewinding roll so that side shift and weaving are eliminated, and individual rolls are not affected by off-gauge conditions of materials in adjacent rolls.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Of all the progress which has been made with regard to the slitting and rewinding of these materials, the use of the individual top riding roll for each individual rewind roll is probably the most significant.

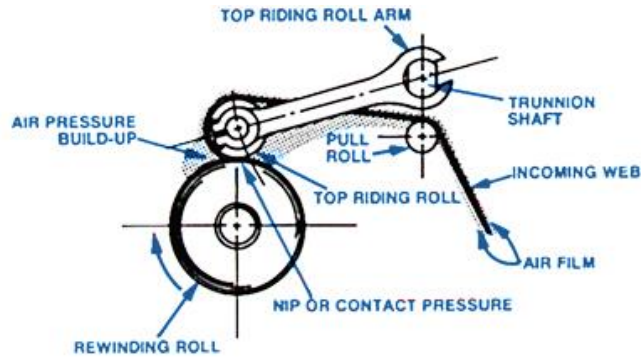


Fig III-11. Top Riding Roll

Individual top riding rolls are used to obtain straight, smooth sided rewind rolls, at high and low speed, when winding off-gauge, high-slip light tension "problem" materials. Of all the progress which has been made with regard to the slitting and rewinding of these materials, the use of the individual top riding roll for each individual rewind roll is probably the most significant. Efficient subsequent operations, to a large extent, depend on the smooth edged, even density rolls of packaging materials which can be produced on the slitting-rewinding equipment. Four major factors must be compensated for in order to produce the desired slit and rewind roll. These factors are: gauge variation, gauge bands, slack zones and entrained surface air, which acts as a lubricant when an excessive amount is trapped and wound within the rewind roll. (Refer to Material Conditions.)

All materials carry a surface air layer with them as they move through a machine. When films are slit and rewound, this air layer is carried toward and partially into the rewind roll. At low machine speeds, most of this air layer can escape as the web enters the rewind roll without causing a problem in winding. However, at high speeds, an excessive amount of air enters the rolls and this results in two conditions:

- 1 - Air becomes a lubricant, and acts as a frictionless separator between the layers of material allowing shifting of second, third and lower layers within the convolutions of the roll.
- 2 - Air is trapped between the layers of material and is wound into the roll. Once inside the rewind roll, it forms tires or balloons or bubbles, which can have various detrimental effects depending upon the characteristics required of the finished roll.

The top riding rolls may be 3" I.D. paper cores mounted on two flanged ball bearings, in turn mounted on aluminum tubular center shafts. These are held in position by easily removed arms and are quickly changed from one width to another by simply changing the paper core or the whole assembly.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Dusenbery has developed their machines so that the incoming web wraps around the individual top riding roll eliminating any possibility of web contact with the rewinding roll.

For maximum utilization of these individual top riding rolls, it is necessary to have the incoming web enter into contact with the rewinding roll at the point of contact with the individual top riding roll or better yet, to wrap around the top riding roll. If the incoming web contacts the rewind roll some distance ahead of the individual top riding roll, the tracking and guiding effect of the top riding roll is lost. Once this has occurred, it is extremely difficult, if not impossible, to force the air out. Therefore, Dusenbery has developed their machines so that the incoming web wraps around the individual top riding roll as shown in **Figure III-11**. This action positively eliminates any possibility of web contact with the rewinding roll other than at the immediate point of contact between the individual top riding roll and the rewinding roll. Hence, the best possible condition for the positive elimination of air exists. Further, the web tension assists in maintaining contact between the individual top riding roll and the rewinding roll.

Top riding rolls are available in four varieties: Paper Core, Aluminum Tube, Rubber Covered Aluminum Shell and Filament Wound Tubing.

The paper core top riding roll has advantages in the following areas:

- A. Fast, easy set-up.
- B. Economical.
- C. Works particularly well on materials which have a rough surface or materials with a high coefficient of friction.
- D. Works well with printed plastic materials.

Disadvantages of paper core top riding roll are primarily:

- A. Limits the running speed of materials with hi-slip characteristics to below 500 ft. per minute.
- B. Paper cores have a length limitation of 24", maximum as over 24" in length; paper cores normally are not straight.

The rubber covered aluminum shell top riding roll offers advantages in the following areas:

- A. Will permit machine speed to the maximum for the material being processed.
- B. Equally efficient at any length.
- C. Available as either a soft or hard rubber (durometer) consequently several different types can be kept on hand to provide for winding a complete range of materials.
- D. Particularly effective for materials in the "hi-slip" light tension classifications.
- E. Rubber top riding rolls tend to tract difficult material more easily.

DUSENBERY® SLITTING TECHNIQUES GUIDE

Disadvantages of rubber covered top riding rolls are primarily:

- A. Not as readily available as paper.
- B. Relatively more expensive.

Aluminum rolls offer advantages and disadvantages which fall somewhere in between the paper and rubber top riding rolls. Filament wound fiberglass tubing has all the advantages of the aluminum tubing and although it is more expensive, it is less susceptible to damage.

Numerous tests, both in Production and Laboratory Research, have resulted in the following table of recommendations for winding various types of materials at various speeds.

Key:

- A - Low web sped (Under 300 FPM)
- B - High web speed (to 1500 FPM) - Rough faced material (Hi coefficient friction)
- C - High web speed (to 1500 FPM) - High Slip (Low coefficient friction)
- D - Aluminum Foil
- NR- Not required but can be used
- X - Will not work - definitely not recommended
- Denotes that hold-down springs may be required

	Paper Core	Fiberglass or Aluminum Tube	Aluminum Tube Soft Rubber Covered
Under 24" Width	Yes	N.R.	N.R.
A	Yes*	N.R.	N.R.
B	X	X	Yes*
C	X	Yes	X
D	X	Yes	N.R.
Over 24" Width	X	Yes*	N.R.
A	X	X	Yes*
B	X	Yes	X

DUSENBERY® SLITTING TECHNIQUES GUIDE

III.1.4 Preventing Gauge Band Build-up

In addition to eliminating air from between the layers of the rewind rolls, individual top riding rolls can be utilized to overcome the problems caused by the build-up of gauge bands. For example, a roll with a gauge band build-up being wound without top riding rolls will develop tension concentration in the gauge band area resulting in uneven distribution of web tension across the full slit width. Hence, for a 10" wide roll winding at one pound per inch of web width (10 lb. total) all 10 lb. will be concentrated at the gauge band. Thus, if the gauge band is 2" wide we will have a concentration of 5 lb. per inch instead of the desired 1 lb. This excess tension will cause distortion of most plastic films causing further build-up of the gauge band. This in turn causes wrinkles to form in the web coming into the roll. Refer to **Figure III-12**.

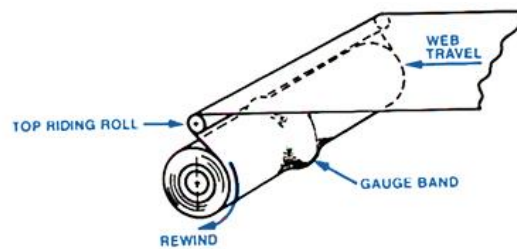


Fig III-13. Top Riding Roll Riding on Gauge Band

When individual top riding rolls are used, this tension concentration is immediately redistributed to the full web width as the web wraps around the top riding roll. Further, if the individual top riding roll is held parallel to the rewind mandrel, contact will be maintained only on the gauge band, thus permitting air to be wound into the rewinding roll at all of the other points. Refer to **Figure III-13**. The resulting roll will be tightly wound (without stretch) over the gauge band and soft throughout the remainder of the roll. This roll can then be handled easily without telescoping or damage and will feed into the next machine operation without any problems.

Conclusion

Because top riding rolls are maintained in constant positive contact with the rewind rolls, the air which would be trapped between the layers of film is ironed out. Top riding rolls are sometimes referred to as "lay-on rolls" or "ironing rolls". They also serve to distribute rewind tension evenly across the slit width. Because parallelism between the top riding roll and the rewind mandrel is maintained, uneven web tension due to build-up on the rewind roll is eliminated. This action produces a wrinkle free rewind roll; and the rolls are not affected by off-gauge material conditions in the adjacent rewinding roll.

DUSENBERY® SLITTING TECHNIQUES GUIDE

III.2 Surface Center Winding

The surface-center winder is the backbone and fundamental tool of web processing since this type of winding invariably produces the best results on the majority of materials used today. In slitter-rewinders, the most common type of center winding is the duplex type winder.

Typical surface center winders include the Dusenbery Series 220, 280, 400, 740 and 800.

This type of machine is designated 220, 280, 740 and 800 in the Dusenbery range. These machines have independent rewind arms for each slit strip.

The winding configuration used on these machines is that in which the web after slitting is partially wrapped around a driven roll known as a winding drum. The slit webs are then secured alternately to cores located on two banks of rewind arm assemblies positioned at front and rear of the drum.

In this winding method, each slit strip has its own rewind mandrel (Figure III-14). In the 820 series, only one rewind mandrel is provided, because this machine is primarily concerned with rewinding. Slitting, other than edge trimming, is secondary.

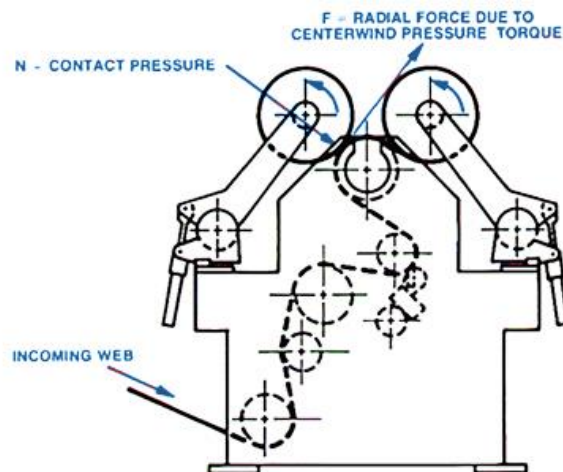


Fig III-14. Surface Center Winder

The rewind mandrels are mounted at the upper ends of a pair of arms, which are pivoted and can move in an arc as the material is wound upon the cores located on the mandrels.

III.2.1 Theory

Surface-center winding has as its objective the production of rolls that have been wound hard enough to ship and handle without telescoping and yet will not have distorted the material in the winding process. Our previous discussion describing air entrapment in the rewind roll applies here as well. **Figures I-2, I-3 and I-4** show various roll conditions depicting air bubbles and/or web shifting which could occur during the rewinding process. To achieve the desired roll density, air must be eliminated from between the layers as they are wound. The contact pressure "N", shown in **Figure III-14**, does this. The thickness of the air layer and the air pressure

DUSENBERY® SLITTING TECHNIQUES GUIDE

Any material with a coefficient of friction equal to 0.1 is considered special material and should be given special attention and tests.

created by this air film at the nip point (**Figure III-11**) increases as the surface speed of the web increases, therefore, contact pressure must be increased with web speed to prevent air from winding into the roll.

To control the tension in the web, it is unwound under controlled tension from the mill roll. Every roll in the machine prior to winding is driven at a controlled surface speed. The greater the accuracy of this control the less chance of imposing undo tension or sag in the web prior to reaching the winding drum.

As the material rewinds, it is under the influence of the two primary forces: contact force "N" and force "F", resulting from center torque produced by a motor driving each rewind shaft. Force "F" has, as its main purpose, the job of overcoming the internal bearing and rolling friction of the rewind core and its mounting.

In practice, if the material has a high coefficient of friction when rubbed upon itself (i.e. greater than 0.4), then no center wind torque should be necessary. As the coefficient of friction falls, the amount of center torque required increases.

Experience has shown that center wind torque exceeding the force derived from the contact pressure is seldom necessary. Consequently, its effect upon the tensions induced in the material during winding is very small. Therefore, the decrease in "F" with increasing roll diameter, and a constant center torque, is insignificant.

Any material with a coefficient of friction equal to 0.1 is considered special material and should be given special attention and tests.

Theoretically Perfect Rolling Conditions vs. Slip

When the two rolling surfaces have a high coefficient of friction, they roll together perfectly and there is no relative difference in their surface speeds. If one is driven (i.e. the winding drum), the other will follow perfectly. If layers of material are placed between them, then slip will occur proportional to the degree of slip between the material surfaces and to the amount of drag imposed upon the non-driven roll (i.e. the rewinding roll) by its bearings and weight.

The rewind roll must then be driven to the extent necessary to overcome this retardation while matching the driven roll surface speed. If the rewind is driven with a force greater than the friction forces between the contacting surfaces, it will attempt to go faster than the winding drum and the material between may be stretched.

DUSENBERY® SLITTING TECHNIQUES GUIDE

To overcome gauge bands, gauge variations and slack zones the Dusenbery 800 series machines are equipped with a separate winding shaft and a pair of rewind arms for each slit width.

Factors affecting roll density and tension in the rewound materials are:

1. Relationship between winding drum surface hardness and contact pressure.
2. Relationship between rewinding roll hardness and contact pressure.
3. Air wound into the rewinding roll.
4. Unwind tension of the mill roll.
5. Amount of overdrive between the unwind and rewind.
 - a. Between driven rolls in the machine.
 - b. Between winding drum and the remainder of the driven rolls in the machine (this is adjustable).

III.2.2 Surface-Center Rewinding Arms

Gauge bands, gauge variations and slack zones occur on almost all materials and must be carefully considered on surface-center winders. To overcome these problems, the 800 series machines are equipped with a separate winding shaft and a pair of rewind arms for each slit width.

The core is mounted upon ball bearing chucks which are driven by a motor and are free to rotate on the stationary shaft under the influence of the motor. Two air cylinders, one to each arm, work in unison to apply the necessary force for contact pressure. Theoretically, if the materials were perfect in thickness across the web width, there would be no need for individual rewind arms. Since this is seldom so, the reason for the use of individual rewind arms is the same as discussed in relation to center winding.

The effect of variation in web thickness raises a further problem in surface winding. If one part of the web width is thinner than an adjacent piece or strip, one roll will be smaller in diameter than the roll adjacent to it. If both rolls are mounted on a common shaft the smaller diameter roll will lose contact with the winding drum and change its tension pattern and density.

The individual arms overcome this problem by allowing the rolls to contact the drum irrespective of the size of the adjacent roll. The arms are also adjustable to various widths of cut.

III.2.3 Mechanical Conditions

Drum Hardness

If the winding drum and the rewinding roll are of a hardness that prevents their deformation by the contact pressure, then a perfect rolling condition exists and the material rolls from the winding drum on the rewinding roll without distortion or stress. This condition is shown in **Figure III-17**.

Should the winding drum be soft enough to be deformed, the path the material must travel before being wound into the rewinding roll, is lengthened by the amount of this deformation. This condition increases

DUSENBERY® SLITTING TECHNIQUES GUIDE

web tension and if the tension is high enough the material will be elongated at this point.

This condition is shown in **Figure III-16**. Conversely if the roll being wound is too soft, the same conditions exist. Therefore, it is obvious that these conditions must be matched to obtain ideal roll configuration. Once this relationship is understood these factors can be used to control roll deformation, unwind tension, and winding drum speed to help produce the type of rewind roll desired.

Unwind Tension

Unwind tension is a direct factor in the tension and density of the rewinding roll for there is no section in a surface-center winder (except at the winding drum) where material tension can be varied.

A high unwind tension contributes to a high rewind tension and a dense rewind roll. A light tension produces a softer roll.

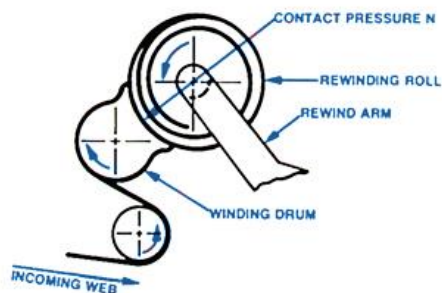


Fig III-16. Schematic Depicting "Soft" Wind Drum Condition

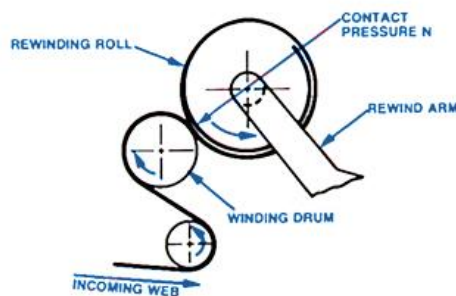


Fig III-17. Schematic Depicting "Perfect" Rolling Condition

Winding Drum Speed

Close control of the relative speed of the winding drum is obtained through the variable pitch pulley driving the winding drum. By increasing the winding drum overdrive, tension is increased in the material as it is pulled from the knife shaft to the winding drum. The converse is also true where lower tensions are desired.

III.3 Surface Winding

The ideal method of winding most materials is surface winding. Here the converter relies on the winding force produced by the winding drum which is always in contact with the outer layer of the material being rewound. If there is any variation in gauge the winding drum will be in contact with the largest diameter of the roll or wherever the gauge band exists. That section of the web that does not rest on the gauge band will follow along without undue stress.

In surface winding the tension in the web is created by the driven rolls in the system. Once the web gets on the winding drum it rolls onto the rewind without further tension being applied. Hence all stress is uniformly distributed throughout the length of the web going through the machine and no further stress is created at the windup.

If the winding roll is in contact at its largest diameter it will run at the surface speed of the largest diameter allowing the rest of the web to wind without tension on it.

An added advantage of surface winding is that one can build up to any roll diameter desired because there is no pull on the web emanating from the core, hence no stress, as is found in center winding.