

Paper Dryer Doctoring

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EXECUTIVE SUMMARY

Dryer doctors have a number of purposes in a paper machine dryer section: Sheet shedding, dryer surface cleaning, threading, and air handling and control. Paper dryer doctors are often overlooked in the papermaking process, but they need proper attention to maintain efficient dryer operation. This paper covers the main considerations in applying and servicing dryer doctors.

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INTRODUCTION

A dryer doctor blade is a cross-machine scraping device that is held in direct contact with the dryer surface. The doctor blade is held in a holder that is mounted to a cross machine beam type structure called a *doctor back*. The doctor back is mounted on journals that are supported by self-aligning bearings on the front and back dryer frames. The doctor back pivots on these journals, loading the doctor blade against the outside surface of the dryer, by gravity, by end-loading cylinders, or by pivoting blade holders (in which case the doctor back should be held firmly held in place with turnbuckles).

Doctoring systems are designed for specific applications. The application variables include blade loading, required reliability, roll temperature, sheet shedding needs, cleaning requirements, and expected wear life. When selecting a component or system, the application or duty requirement must be clearly outlined.

The penalty for doctor neglect includes roll damage, poor sheet quality, low machine efficiency, high draws, sheet breaks, and damage to doctors and adjacent machine clothing.

DOCTOR BLADE MATERIALS AND APPLICATIONS

Doctor blades can be metallic, composite, or plastic. The most common metallic blades are bronze, steel, and Monel. Bronze blades are used on to burnish new dryers. Steel blades are used for most intermediate dryer doctor applications. Monel blades are not normally used on paper dryers.

Composite blades are reinforced with fiber. Most common blade constructions utilize fiberglass, carbon fiber, a combination of the two, or Kevlar. The resin (i.e., glue) that holds the fibers together is typically a high temperature epoxy. Ceramic and other exotic materials are used for specific applications. When the dryer surface is dirty, it is common to use abrasive blades containing silicon carbide.

When there is no fiber reinforcement in the doctor blade, the blade is most commonly referred to as a *plastic* blade. Because of temperature limitations, plastic blades are not used on paper dryers.

From an application perspective, bronze blades are generally used to burnish the surface of new dryers or dryers that have been recently reground. These blades wear rapidly on dryers that run at high speed

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and they are usually replaced after burnishing. In the past, the replacement blades were steel. Today, it is most common to use composite blades that are designed specifically for continuous operation. Excessive use of bronze blades may lead to bronze deposits building up on the dryer surface, causing runnability and doctoring problems.

In high-speed applications, most steel blades will experience increased wear rates and over time will wear the surface of the dryer cylinder. Also, at high speeds steel blades tend to spark, causing a fire hazard.

Non-metallic composite blades are often used to minimize the wear of the dryer surface and to reduce the dryer drive load. As a general rule, composite blades do not spark. In recent years, dryer cylinders, especially after-coater dryers and dryers in lead-in positions, have been coated with Tungsten carbide and a surface release coating. The release coatings are often Teflon or silicone based. Composite blades are strongly recommended for these applications.

A recent doctor blade development for critical dryer applications is the carbide tipped blade. Carbide tipped bronze blades are used to help clean stickies off dryer cans. Baby dryers and other lead-in dryers are candidates for these blades because stickies have a special affinity for these dryers. Carbide tipped blades are self-sharpening, and carbide at the tip of the blade provides a continuous sharp edge that literally cuts under the stickies and scrapes them off the dryer surface. These blades are also very helpful on critical dryers after a coater section to clean coating color off the dryer surfaces.

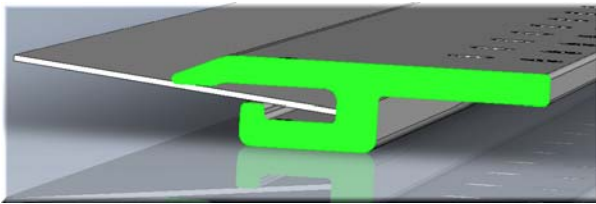
Another recent innovation is a composite blade with a thermally sprayed carbide tip. This blade does not spark even in severe duty applications.

DOCTOR BLADE HOLDERS

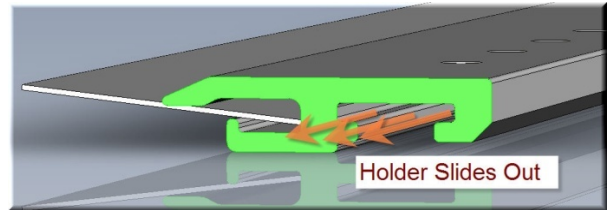
Doctor blade holders are also designed for specific applications. A rigid holder is generally used for light-duty applications or in positions where the penalty for neglect is not high. Rigid holders are often used in intermediate paper dryer positions. Rigid holders are not recommended for sheet shedding (i.e., take-off) positions. Most rigid holders are bolted directly to the doctor back. In order to replace a rigid holder, the doctor back must often be removed from the machine.

Recent advancements, however, have made it easier to maintain or change holders should the need arise. Holders that are mounted on T-slide systems are quickly becoming the norm rather than the exception.

Doctor blades are held securely in rigid holders and the blade tips deflect to fit the profile of the mating rolls. If the blade fit is poor, either due to a bent doctor back, a heavy roll crown, a damaged holder, or a worn roll profile, the doctoring efficiency will be poor. Additionally, these rigid holders do not have rotational flexibility in the cross machine direction. Hence, holders that are set up with a small misalignment, off level or off square to the roll, will have difficulty in conforming to the roll.



A Unimate holder is bolted every 3 inches into the doctor back. To replace the holder, all the bolts have to be removed.



A UniSlide holder has an interlocking T-slide mounting so the holder can be removed from the doctor back without removing any fastening bolts.

All these negative influences generally have an additive effect, so while each issue might be small, there may still be a major roll-to-blade fit problem. Hence, each problem needs to be addressed. Increasing blade loading is not recommended for improving the blade fit, except as a very short-term solution. Increasing loading to achieve a better blade fit results in increased wear of both the doctor blade and the roll surface.

More sophisticated blade holders have a self-conforming feature. These holders automatically adjust to match the roll crown or non-uniform roll diameters. These are the “DST” class of holders. These conforming styles of blade holders are held to the doctor back with a series of pivot pins. The doctor back is held in its operating position by a pair of turnbuckles. A cross-machine pneumatic tube is positioned under one end of the pivoting holder. When this tube is inflated, it pivots the holder, pressing the blade against the roll surface. These holders are flexible so that the blade loading will be uniform in the cross-machine direction.

Conforming holders are often used in critical dryer doctor positions (e.g., first and last dryers). Adjusting the pressure in the tube directly affects the blade pressure. Most conforming holders have two tubes:

One to load the blade and the other to unload the blade. The unload tube can be partially pressurized during operation to help seal the insides of the holder and keep it clean.

A discussion on holders would be incomplete without a brief description of what some consider a paradigm shift in holder technology: integrating T-Slides into conforming holders to improve their maintenance and repair. This has allowed conforming holders to be used in locations where previously only rigid or direct mount holders had been used. An example of a T-slide mounting is shown below in Figure 1.

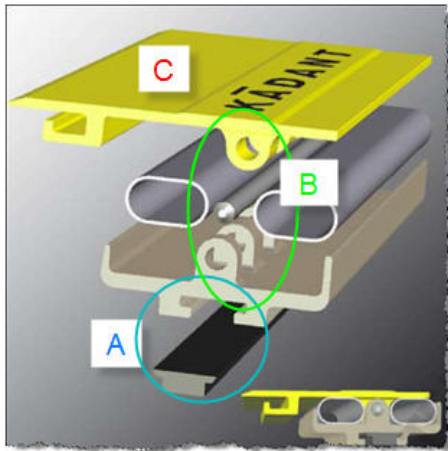


Fig 1 is a schematic of the Kadant UniSet holder. [A] The tube tray can slide out of the machine while the T-bar remains attached to the doctor back. This greatly reduces the time required to service the holder. [B] The pivot rod has continuous contact in the cross direction, providing a tight fit, reducing vibration and improving loading uniformity. [C] The integral top plate is conforming and able to reliably shed the sheet in tough applications.

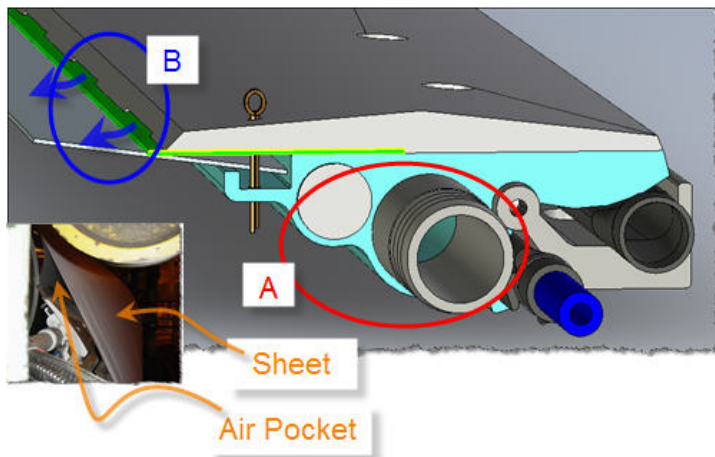
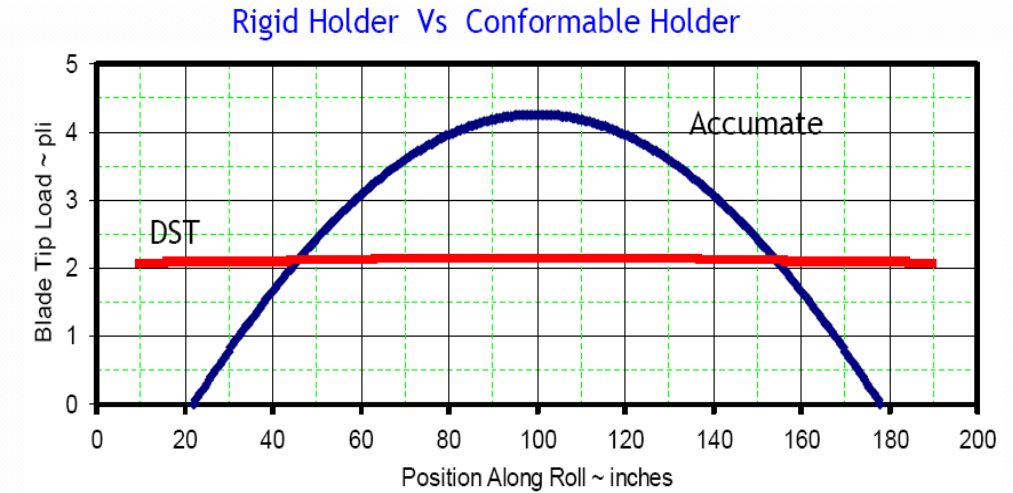
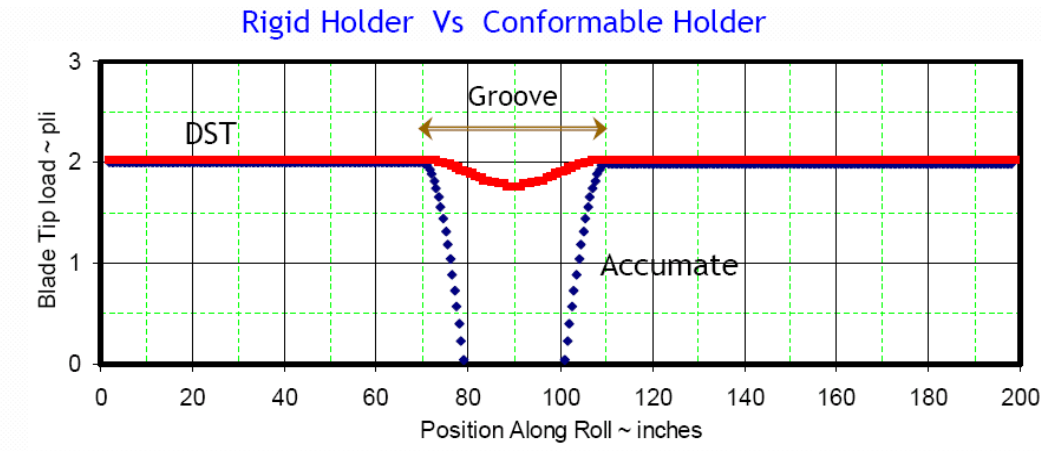


Fig 2 is a schematic of the Kadant UniFlow holder. These holders have been used successfully in sheet shedding positions where the blowing of air assists the sheet take off. [A] Air inlet and air distribution chambers. [B] Air discharges in the pocket between the blade and the sheet causing the sheet to billow out and fall into a broke pit below.

The effectiveness of a conforming blade holder is shown in the following figure. With a rigid holder, the blade is unable to apply pressure to the shell over a groove in a shell with a 200" face, even though the groove is only 0.010" deep and 40" wide. Eventually, the blade will wear unevenly and into the groove, but this is far from the ideal solution. The DST holder, on the other hand, is able to apply a more uniform pressure, even on the damaged area of the roll surface.

Similarly, a conforming blade holder can accommodate a 0.030" total crown on a press roll, whereas a conventional rigid holder cannot. This is shown in the figure below.

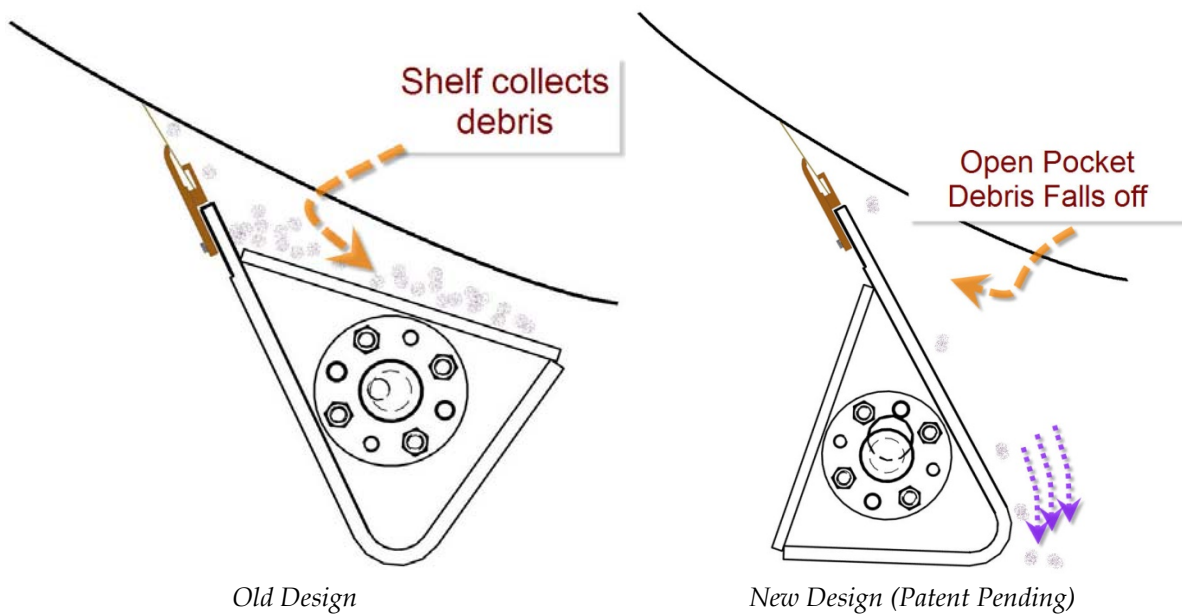


DOCTOR BACKS

The doctor back may be a simple angle iron or a more elaborate welded structure. Most doctor backs are either triangular or rectangular in shape, custom-designed for each dryer pocket. The back must meet specific stiffness and deflection criteria, to avoid vibration and chatter.

Mounting surfaces are machined on the doctor backs for the blade holders. Doctor backs that are machined for operating below top dryers will often be different than the doctor backs that are machined for operating above bottom dryers. This is because of the position of the pivot and the direction of the deflection of the doctor back.

It is important, particularly for doctors in top dryer positions, to be able to deal with debris that comes off the roll on the underside of the doctor blade. If a doctor back has a shelf, unwanted debris can collect and create a potential fire hazard and can increase the risk of a doctor jam if the sheet passes under the doctor blade. Modern doctor backs have surfaces that facilitate the fall-off of such debris.



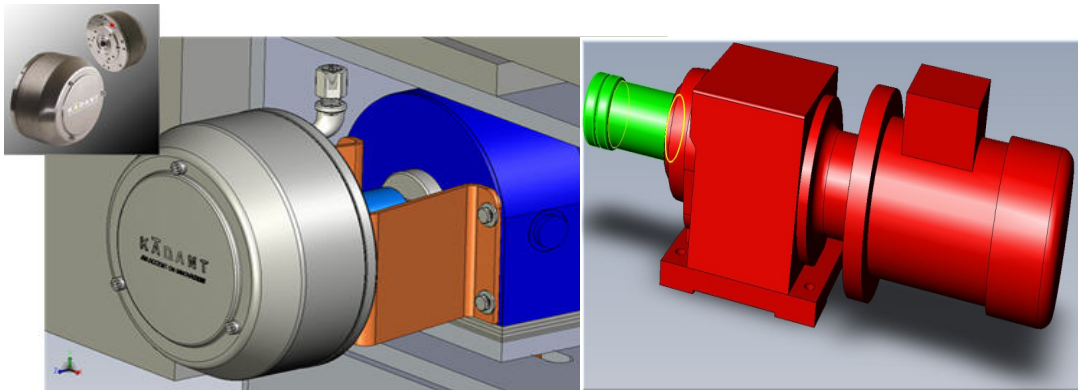
DOCTOR OSCILLATORS

Doctor backs are often oscillated using pneumatic or electrical actuators. This oscillation helps to cut debris that has collected under the blade and spread out any tendency for the blade to wear narrow bands on the dryer cylinder surface.

Oscillating frequencies are quite low, typically only 5 to 15 cycles per minute with a stroke of 12 to 18 mm. Some oscillation strokes can be lower in stroke distance (e.g., 6 mm), but higher in frequency.

Electromechanical oscillators have been the workhorse of the industry for many years. In many parts of the world, such as Europe and Asia, they still regularly used. These oscillators are reliable in operation and are relatively trouble-free.

In North America, pneumatic oscillation is preferred for many reasons, including: (1) Uninterrupted supply of clean filtered air is economically available for continuous use, (2) oscillation stroke length and frequency can be set per application requirements, and (3) the compact design fits into many a location where real estate is a premium at the end of a doctor back (such as between machine frames).



Kadant Varimatic pneumatic oscillator.

Kadant MN23 electromechanical oscillator.

DOCTOR BLADE ALIGNMENT

In order to achieve consistent and reliable doctor performance, the doctor blade must be properly set up, carefully aligned, and correctly fitted to the roll surface. A new blade should be set up to contact the roll surface in a line that is parallel to the dryer axis. The journals of the doctor back should then be parallel and level with the dryer axis as well. The blade pressure on the dryer surface should be uniform in the cross-machine direction.

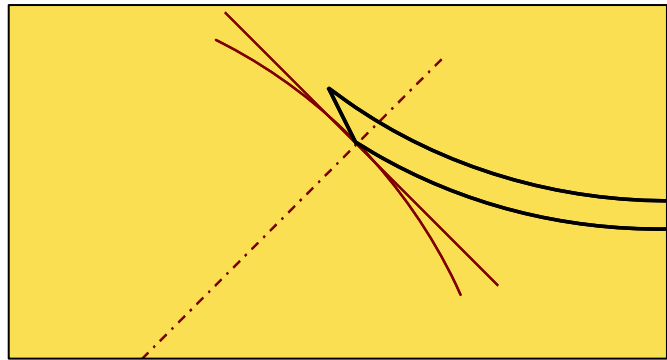
The blade angle on dryer doctors is typically set to 25° to 30°. This angle is especially important on sheet shedding positions, where the recommended angle is about 28°. Blade angles are easily measured using modern digital gauges as shown in the figure below.



The most common device for setting doctor blade angles is the AngleStar. This photograph shows the unit being used to take reading on a roll. A new smaller angle gauge is shown in the insert for comparison. The compact gauge is handy for taking readings in cramped locations such as secondary positions on double doctors.

DOCTOR BLADE LOAD

Typical dryer doctor blade loading is 0.75 pli except for sheet shedding positions, such as the first and last dryers of a dryer section. The sheet shedding doctors are typically loaded 1.5 to 2.5 pli. If the cleaning duty is high, or if the sheet has a tendency to stick to the dryer surface, higher blade loads and blade angles are recommended. However, when the load is going to be increased, a new blade should be used to prevent the tip of the blade from “bird-mouthing” as shown in the figure below. On a sheet shedding position, it is extremely important to install a new blade before increasing the blade loading, to prevent sheet wrap-ups and damage to the blade, doctor, holder, and machine clothing.



DOCTOR BLADE FUNCTIONS

Doctor blades can affect sheet quality and production, both positively and negatively. In general, doctor blades are used to keep the outside surfaces of paper dryers clean. The blades are also used to control air flows, assist with tail threading, and prevent sheet wraps and resulting felt damage.

Surface cleaning. Uniform build-up on the dryer surfaces can cause a loss in heat transfer, over 5% on those dryers with heavy build-up. Non-uniform build-up can cause local small-scale variations in drying, that result in cockles and puffy paper. The build-up of stickies can cause sheet surface defects, such as fiber picks and linting. To avoid these problems, the dryer surfaces must be kept clean.

Contaminated dryer surfaces can also cause the sheet to stick to the dryer surface. Lightweight grades in particular often tend to stick to the

dryer surface and follow it for a short distance, rather than following the tangent path to the next dryer cylinder. This phenomenon, referred to as *sheet stealing*, can have an adverse effect on sheet runnability. Cleaning the dryer surface can reduce this effect, but the surfaces must be particularly clean to be effective.

Chrome plating has been used in the past in an attempt to prevent stickies from forming on the dryer surface. Unfortunately, the chrome plating has not proven to be effective in preventing the build-up of stickies and carbide tipped blades cannot be used on chrome surfaces without a risk of damage to the surface. Teflon-infused carbide coatings on dryer can surfaces are more effective in reducing the build-up of stickies and these surfaces can be effectively doctored as well

The cleanliness of the dryer surface can be maintained by continuous doctoring, by periodic loading of the blade (typically during a sheet break or prior to start-ups), or by chemical cleaning during extended shutdowns.

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Dryer doctors can cause dusting, particularly when running on wet end dryers where there is a lot of fiber picking. The dust and debris that is doctored from the sheet can fall onto the wet paper. If the paper is later coated, this debris can cause coater scratches and sheet breaks. Many coated paper machines will run with the doctor blades unloaded, to prevent dusting. The dryers are periodically cleaned by loading the doctor blades during sheet breaks and then unloading them after threading the machine.

Controlling air flow. When the doctor blade is loaded, or when it is running close to the dryer surface, it tends to reduce the amount of air that is entrained by the moving dryer surface. This can reduce windage and pumping, reducing sheet flutter and sheet disturbances. If the doctor blade is unloaded, however, it is possible for the air velocity to be increased, even though the amount of air that is entrained is reduced.

Tail threading. On high-speed machines, the location of the blade, the contour of the blade holder, and the shape of the doctor back are often designed to help direct the tail from one dryer to the next. With the assistance of edge air nozzles, the tail can in some cases be threaded without the use of threading ropes.

Sheet wraps. If the sheet follows the dryer after a sheet break, it is called a sheet wrap. The sheet wrap can be blown off the dryers with high-pressure air hoses, provided the sheet is a lightweight grade (such as newsprint) with a limited amount of wrap on the dryer. If the wrap is thick, and in particular if the wrap is a heavy weight board grade, it can take a long time to clear the wrap off the dryer. Oftentimes the dryer section must be stopped, the wrap “speared” off the dryer, and the slap of paper walked slowly down the machine to a section break, where it can be dropped into the basement. In both cases, there is a risk of damaging the dryer fabric, either from wads or from the broke poles.

Sheet wraps can be prevented by having the dryer doctors loaded when the sheet break occurs. If the blade loading is inadequate, if the blade fit is not tight, or if the blade bevel angle is open at the tip, the sheet can pass under the blade and wrap the dryer. A dryer wrap with a loaded doctor blade can take hours to clear. If the paper is badly jammed between the doctor back and the dryer, it may be necessary to dismount the doctor back and move it away from the surface to provide clearance for removing the broke. The shape of the doctor back can aggravate or minimize the severity of this type of "jam-up."

DRIVE POWER

The doctor load on the dryer surface produces a drag that must be overcome by the dryer drive motor. The drive load produced by the dryer doctors depends on the speed of the machine, the width of the dryers, the number of doctor blades that are loaded, the amount of blade load (pli), the blade material, the surface condition of the dryer, and the moisture content of the paper. The affect of each of these variables on the drive load is not well publicized, but general guidelines are available.

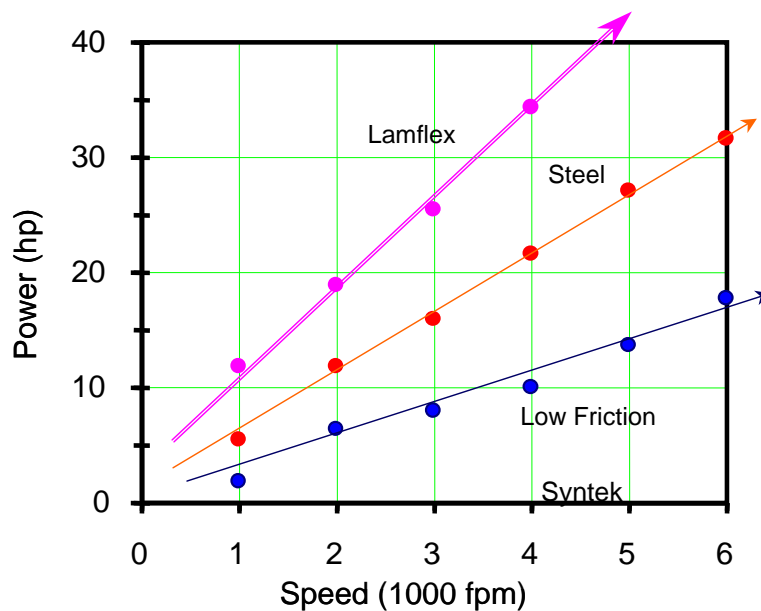
A typical guideline for drive load is the factor 0.0007 Hp per inch per 100 fpm of speed, for each pli of blade loading. For example, a 350" face dryer that is running 3500 fpm would be expected to add about 4.3 hp to the drive load when the blade is loaded to 0.5 pli:

$$\text{Hp} = (0.0007 \text{ Hp/inch}/100 \text{ fpm/pli}) \times (350 \text{ inches}) \times (3500 \text{ fpm}) \times (0.5 \text{ pli}) = 4.3$$

The drive load factor ranges from 0.0006 to 0.0012, with the lower values typical for low-friction synthetic carbon fiber containing blades and the higher values typical for conventional glass blades.

The graph on the following page compares the drive power for three types of doctor blades: cotton phenolic (Lamflex), steel, and a modern low-friction blade material. All three materials are capable of cleaning the dryer surface, but with significantly different friction factors.

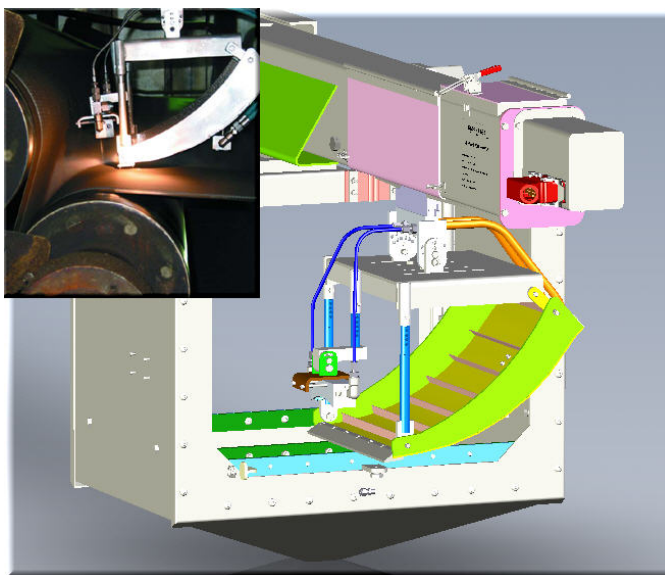
The Lamflex blade is a cotton phenolic blade, one of the first synthetic laminate blades on the market. A modern low-friction blade, such as Syntek, will consume much less drive power than a Lamflex blade. For example, with an electrical cost of \$0.07 / kWh, a 350" wide paper machine running at 4,000 fpm will use $(34-12) \text{ hp} \times 0.745 \text{ kW/hp} \times 24 \text{ hr/day} \times 325 \text{ operating days/yr} \times \$0.07 / \text{kWh} = \$8,950$ more in electrical costs, per dryer, for a Lamflex blade than for a low-friction blade.



HEAT TRANSFER

As noted earlier, dryers with heavy build-up can cause a loss in drying capacity. A typical board or paper dryer with a uniform build-up of 0.01" of paper fiber might lose 2 to 3% of its normal drying capacity. A uniform build-up of 0.05" of fiber might cause a loss in capacity of up to 10 to 15%, on those dryers that have this amount of build-up.

Build-up on dryers can consist of various amounts of fiber, starch, size, coating inorganic materials, latex, pitch, hot-melt adhesives (i.e., stickies), rust, and other contaminants. The best cure for dryer build-up is prevention. Continuous dryer doctoring can often prevent contamination from becoming a problem. The doctoring system, however, must be tailored to address the type of build-up that is causing the problem. The build up of stickies on the early dryers is rarely uniform and is oftentimes a problem. It is not uncommon to have "buttons" of stickies on the dryer felts as well as on the dryer surfaces. Stickies cause a loss in runnability (sheet stealing, tear-outs, sheet breaks, poor transfers, limited speed) and sheet defects such as picked fibers, wrinkles, folds, sheet roughness, cockling, and poor moisture profile. Dryer fabric cleaning is just as important as dryer surface cleaning. There are a number of products in the market for dryer fabric cleaning.



The VersaKleen traversing shower system is an effective fabric cleaning system. Because of its traversing nature, it can be used on-the-run. It is much easier to keep a dryer fabric clean than to clean a fabric that is already contaminated. A collection pan minimizes misting and dusting that could otherwise hurt machine runnability.

With respect to dryer surface cleaning, the build up of fibers and inorganic materials can be much heavier than stickies and even fairly uniform. This build-up reduces drying capacity, although steam pressures in early dryers are often reduced anyway, to minimize the picking. A dryer doctor will remove stickies, fiber, and inorganic build-up from dryer surfaces, but this does not necessarily eliminate the tendency for fibers to pick. Even though the dryer surface looks clean, there can still be thin layers of stickie material smeared on the dryers that cause fiber picking and sheet stealing.

Recent developments in doctor blade materials have allowed paper mills to clean even heavy build-up from dryers and, with proper blade selection for continuous operation, to keep the dryers clean. Alternatives to periodic doctoring are periodic chemical cleaning, continuous chemical passivation of the dryer surfaces, and mechanical cleaning.

Mechanical cleaning includes blasting with sand, soda ash, or dry ice. Build-up can also be cleaned off by periodic grinding and by chemical cleaning. Chemical cleaning removes fiber and other surface contaminants, but it does not restore the dryer surface profile. The dryer surface

profile can be leveled with surface grinding, although this takes an extended downtime, reduces the shell code thickness, and can be quite costly. In some cases, dryer surfaces can be improved by careful use of abrasive cleaning blades, extending the dryer life and possibly avoiding the cost of grinding the surface.

It is also possible to reduce the tendency for contaminants to stick to the dryer surface by chemical means. The chemical passivation fluid is applied continuously and directly to either the dryer felt rolls or to the dryer surfaces. The chemicals can be applied with a single traversing nozzle or a series of spraying nozzles mounted to a cross-machine header pipe. These can be costly measures, but justified in severe cases.

DRYER DOCTOR BLADE RECOMMENDATIONS

<i>Doctor Blade</i>	<i>Features</i>	<i>Applications</i>
DriTek Steel	100% steel Ceramic coating Increased tip strength Reliable sheet shedding	Heavy duty dryer cylinder cleaning, last top and after-coater dryers, stickies and coating removal
Spartan	100% carbon resin Cross-machine flexibility Long life No sparking	Heavy duty dryer cylinder cleaning, last top and after-coater dryers, stickies and coating removal
DriTek Bronze	100% bronze Ceramic coating Increased tip strength Minimize sparking Reliable sheet shedding	Heavy duty dryer cylinder cleaning, last top and after-coater dryers, stickies and coating removal
SynTek Plus	Carbon / glass fiber Performance resin Operating temp 400 F Low friction coefficient	Press roll and dryer cleaning, last top and after-coater dryers, stickies and coating removal
ArmorTek	Metal blade Proprietary coating Low friction coefficient Corrosion resistant	Sheet shedding positions/intermediate cans, replaces mild and stainless steel blades
Abrasitek Y	Cleaning / polishing blade kit Abrasive particles on blade 0.250" reverse bevel	Yankee dryer surface conditioning, severe dryer contamination, reduce chatter marks, increase time between grinds

CONCLUSIONS

Doctoring equipment should be selected after a careful review of the application and duty requirements. This application review should be conducted by a specialist in doctoring technologies, who can pinpoint problem areas and offer the paper maker practical solutions and operating recommendations.

For dryers that are particularly difficult to clean, such as lead-in dryers, baby dryers, or the first position where the sheet is first exposed to dryer heat, a fluid-backed doctor holder and a carbide-tipped blade loaded at about 2 pli is recommended.

For last dryer positions, carbide-tipped blades or other carbon containing blades loaded at a minimum of 1.5 pli are recommended. A slide-out feature improves the ease of maintaining or changing the holder in case of damage. Oscillation, in all cases, is recommended.

