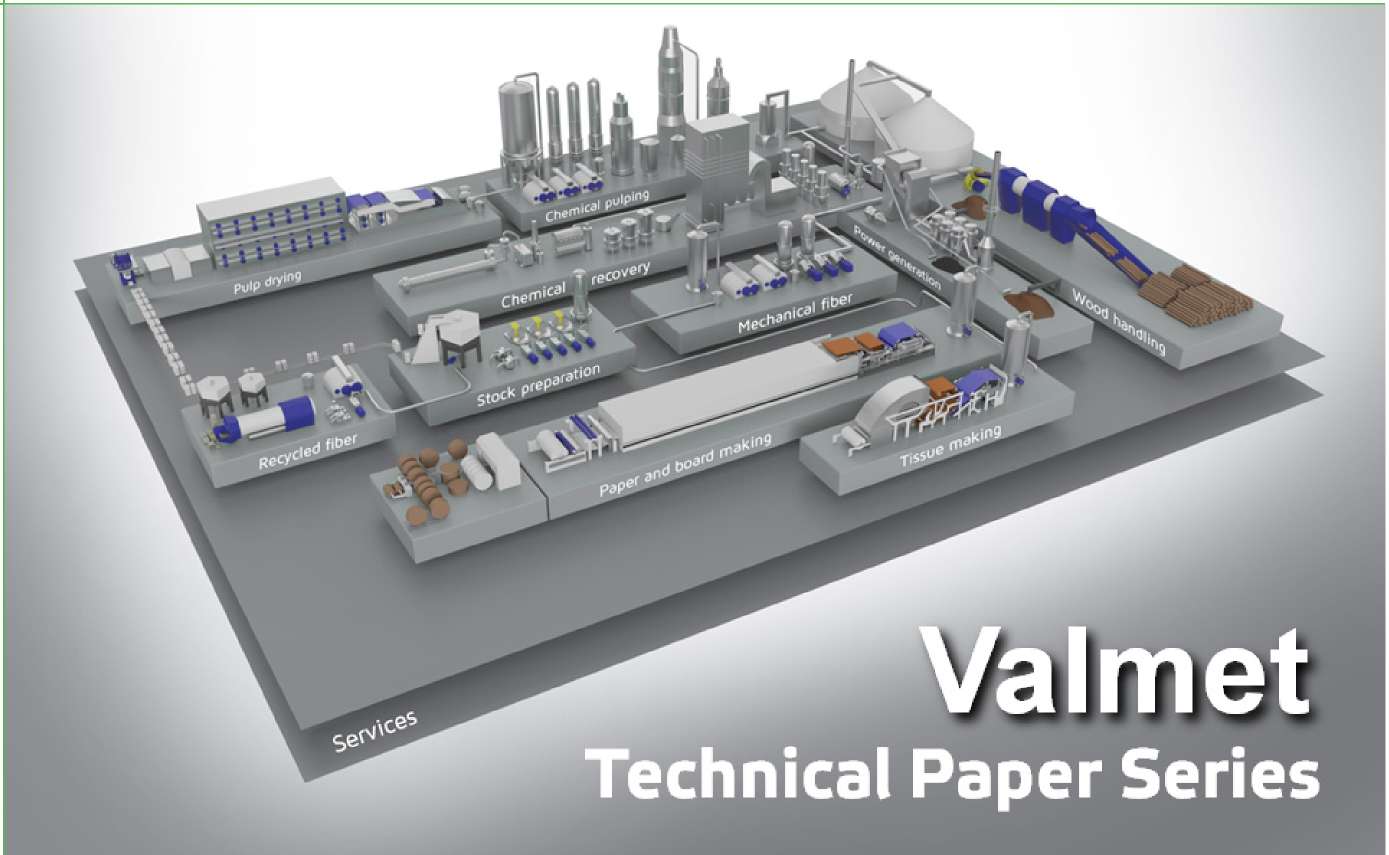

Doctoring 101

Executive Summary

Doctoring in paper machines is often considered to be a simple ancillary process and, as such, is often overlooked. However, use of good doctoring practices and the best available materials can result in:

- better machine runnability
- safer operations
- reduced water consumption
- energy savings

This technical paper provides a history and overview of doctoring, including the function and components of doctoring systems, the various types of blade holders and oscillation, the different blade materials, and doctoring auxiliary equipment.

(This white paper was written for the North American market.)

A brief history of doctoring

An English engineer, Doctor Frederick Vickery, invented the paper machine doctor in 1909. It is generally assumed that the name "doctor" stands for Doctor Vickery's title. Dr. Vickery noticed that excess water on roll surfaces as well as accumulating fibers and other papermaking raw materials were limiting paper machines' speed and runnability. Thus, the doctor blade was invented to remove excess water and impurities, keeping roll surfaces clean during paper machine operation.

Around the same time, the first rigid doctor blade holder was invented. The increased use of doctoring created a demand for better holders and in 1919 the first flexible doctor blade holder was invented.

Until the late 1950s all doctor blades were metallic (steel, bronze), which are still in use today in specific applications. During the Second World War the first composite material - "Bakelite" - was invented. This material was originally designed for use in aircraft parts but was adopted by the paper industry for doctor blade applications. The material became known as "Micarta" which actually is a combination of phenolic resin and cotton fibers.

In the 1970s and early 1980s paper machines became faster and wider and many new soft roll cover materials were introduced. During this time high-density polyethylene blades were introduced for doctoring soft covers in the wet end.

Steel, Monel, bronze, micarta and HDPE were adequate doctor blade materials for relatively low speed paper machines with granite center rolls. But, in the 1990s, as machine speeds were increasing and hard ceramic covers were replacing granite rolls, more advanced materials were required. Modern glass and carbon fiber composite blades were introduced to meet the more rigorous doctoring requirements. More recently we have seen the introduction of thermal coated metal blades such as ceramic and carbide.

Doctor operation

Effective, trouble-free doctoring is essential for modern, automatic and computer controlled paper machine operation. This ensures paper machine runnability and product quality. Doctoring is a relatively simple process but it is still important. It has three (3) basic functions in the paper machine:

1. Shed the sheet during sheet breaks or sheet threading operations
2. To remove water and contaminants from roll surfaces
3. Creping (Tissue)

Poor doctoring in the paper machine often leads to substandard performance and quality. Stickies, fiber flocks, and water rings on the roll surface limit the manufacturing performance by causing holes and web breaks. The breaks lead to unbalanced processes and poor paper quality. Poor doctoring increases the risk of damage to machine components and clothing when the sheet passes the doctor and wraps a roll.

The doctoring result is directly affected by:

- Doctor construction
- Doctor adjustments
- Condition of doctor components
- Condition or roll surface

The doctoring result is indirectly affected by:

- Roll cover material
- Roll/Cylinder temperature

- Stock properties
- Temperature variations
- Felt conditioning

Maintenance and troubleshooting

To make sure doctors perform as designed, it is essential to add doctor check-ups to mill maintenance agendas. For daily doctor maintenance when the machine is running:

- Check roll surface for cleanliness
- Check doctor for vibration
- Check behind blade for cleanliness, especially inside rolls
- Check lube/wash shower operation
- Check oscillation

For daily doctor maintenance during a break (if necessary):

- Change blade – clean the holder before new blade is installed
- Clean the doctor. NOTE: Wash out behind the blade also. Make sure drive side doctor is also washed.

Some solutions for the most common doctoring problems

Causes of doctoring problems are shown in **Figure 1**. The most common solutions include:

- Change blade material
- Check blade dimensions (thickness and length/width)
- Adjust loading according to blade type and application
- Adjust or add blade lubrication showers
- Check and service the doctor (oscillation, loading hoses, doctor alignment)
- Check bearings condition
- Recondition roll
- Train personnel (handling of blades, regular maintenance of doctor and significance of doctoring)

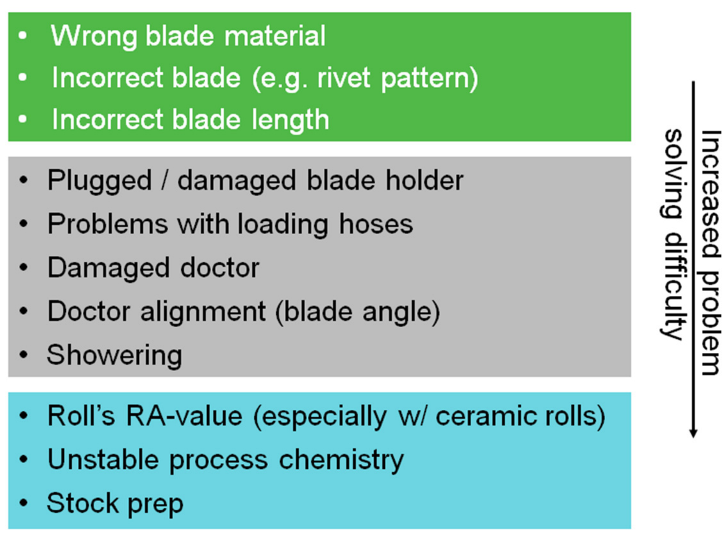

Figure 1. Causes of the most common doctoring problems

Forces acting on doctors

The two doctoring functions of sheet takeoff and roll cleaning impose different forces on the structure, and it is essential that doctor design takes into account these differences. Therefore the design of a sheet removal doctor is somewhat different than that of a cleaning doctor. Typical examples of this are the blade load and blade angle required, and the journal location on the beam.

The Load Force (L) and the Roll Force (RF) which act almost at right angles to each other (**Figure 2, next page**), can be represented by a single Resultant force (R) which will fall somewhere between the two. It is along the line of R that we place the doctor journal in order to keep RF and L in equilibrium.

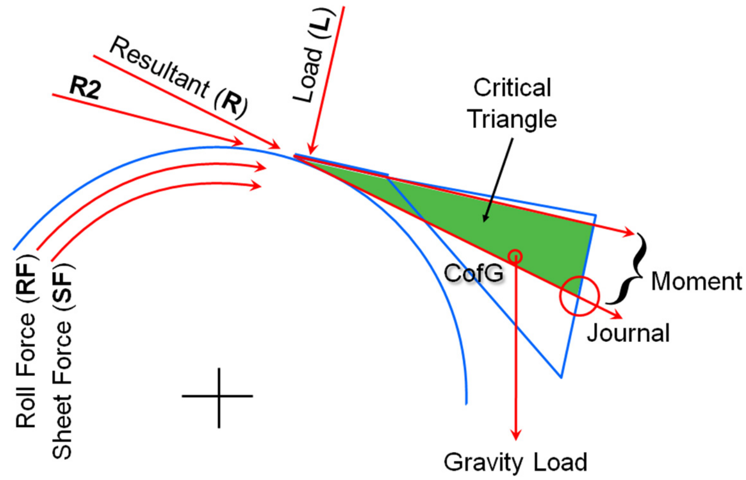

Figure 2. Loads and forces acting on a doctor blade and blade holder

However, the direction and magnitude of R will only remain constant if both RF and L also remain constant. Should either change, the direction of R must also change, altering the location of the journal.

Both L and RF will only remain constant when the doctor is being used for cleaning purposes. If the sheet has to be removed, the sheet itself will apply an additional Sheet Force (SF) to the blade, and this will be added to RF. The net result will be a change in duration and magnitude of R, which is represented by R2 in **Figure 2**. Normally, the force R2 will travel along a line drawn through the blade.

If the journal has been located along the original R line, R2 will now pass above the journal position, and an "overturning moment" will be created which will tend to lift the blade away from the roll. This would encourage a sheet skip.

Therefore when the doctor is used for sheet removal, the journal should be positioned somewhere along the R2 line. Unfortunately this is not always the solution, because when the doctor is not removing a sheet, only the force R acts on the doctor - not R2. This then creates a moment which tends to make the blade try to dig into the roll. This causes blade chatter and roll barring.

It can be seen then, that the location of the journal is determined by the intended use of the doctor. But either way, its positioning is critical to the doctor's performance. For this reason, the triangle created between the extended R force line and the extended R2 force line is referred to as the "critical triangle".

One way to position the journal to accept a resultant force line from any direction without creating a moment, would be to locate it at the apex of the critical triangle, and as near to the blade/roll contact point as possible. Unfortunately, this would also produce significant disadvantages, such as not being able to use gravity for loading purposes, and producing a potential safety problem for people working on the doctor. For these reasons, it is not an acceptable solution to the problem.

Blade loading

There are four basic methods of loading a doctor, they are:

1. Mechanical spring
2. Pneumatic/Hydraulic cylinder
3. Gravity
4. Holder loaded (hose loaded doctor blade holder), doctor locked by turnbuckles

NOTE: The cross-section of any doctor beam is very small in comparison to its length. The result of this is that the beam is very weak in torsion, and "beam twist" is difficult to control, especially if non-uniform forces are applied. The objective is to load the blade as uniformly as possible over its entire length, and this cannot be done if the beam is allowed to twist.

Mechanical spring blade loading

The mechanical spring loading device consists of a coil spring housed in a cylinder or fork mechanism, usually incorporating a cam lift-off device, operating handle, and several other features. In all cases, the loading force is applied by a coil spring.

Because this unit has to be operated manually, it can only be applied to the doctor on the tending side of the machine. The doctor beam is therefore loaded at one end only. Because the beam is by nature very weak in torsion, loading one end only will produce beam twist. This will cause the blade load to decrease over the length of the doctor (**Figure 3**). There is a beam length beyond which the use of single-end loading devices such as springs should not be used.

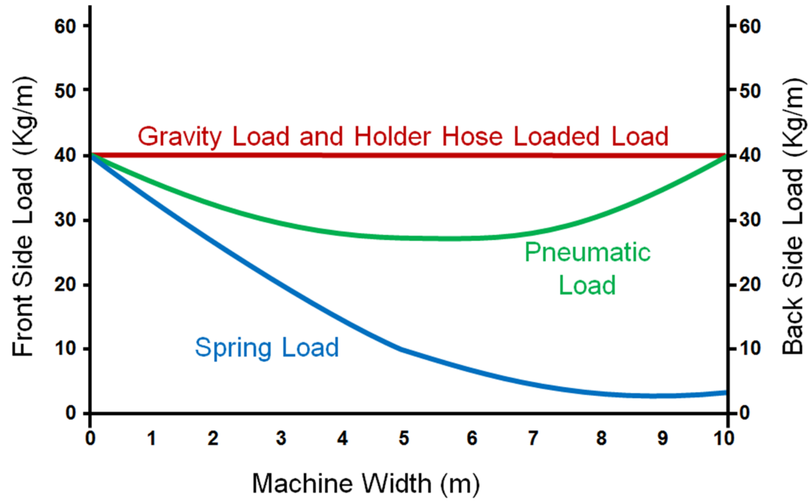

Figure 3. Blade load diagram for the four loading methods

Pneumatic loading

The majority of pneumatic end loading devices consist of air cylinders or load cells which apply load to the beam via a set of lever arms attached to the journals. The advantage of these units is that because they are not manually controlled, they can apply equal load to both ends of the doctor beam simultaneously.

However, twist is not restricted to the two ends of the beam, but occurs over its entire length. Applying load to the ends of the beam only must also result in a decreasing blade load towards the center. Again, **Figure 3** shows this clearly.

Gravity loading

Provided that the beam is made of uniform cross section throughout, gravity will act with equal force over its entire length and no beam twist will result. This is the ideal loading force since it will produce a uniform blade load at all times. This is shown as a straight line on the graph in **Figure 3**.

The downside of gravity loading is that once the beam has been fabricated and its journal position fixed, the load cannot easily be adjusted. In addition, it is difficult to achieve significant blade loads without increasing the weight of the beam to the point where natural deflection and/or material costs become significant.

Also, due to the journal location problem explained at the beginning of this paper (**Figure 2**), the designer must allow for some "lift-off" moment when positioning the journals to avoid a "dig-in" (or chatter) situation. This moment will of course be speed-sensitive, with a maximum usable speed for gravity loaded doctors.

Because gravity loading provides a uniform blade load under all conditions, it is obviously the best of the three methods available, within the limitations of each specific installation. It has become standard practice to build some gravity load into all doctors.

Holder loading

The hose loaded doctor blade holder (DST type holder) provides even loading similar to the gravity holder (**Figure 3**). When using hose loaded doctor blade holders the use of turnbuckles is recommended in order to lock the doctor beam in a solid position. Hydraulic or pneumatic cylinders may also be used to press to a mechanical stop. It is important that the cylinders' load is at least three times higher than the maximum total loading pressure the hose loaded doctor blade holder will use. One good option is to use a pneumatic locking cylinder.

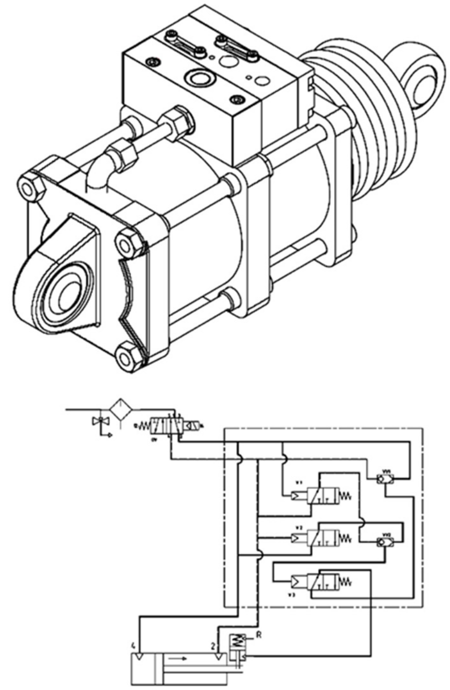

Figure 4. Locking cylinder: operation and circuit diagram

The pneumatic cylinder and integral mechanical lock function together automatically. The cylinder loads and unloads the doctor blade and moves to either its extended (out) or retracted (in) position. The valve automatically controls the mechanical lock operation such that the cylinder will be locked in its out or in position.

Figure 4 shows the connection ports 2 and 4, and the exhaust opening R for the locking cylinder valve block. The locking cylinder operates as follows. To open the cylinder from retracted (in) position to extended (out) position: switch pressure to port 2, until the cylinder is fully pressurized; then switch pressure to port 4. To open the cylinder from extended (out) position to retracted (in) position: Switch pressure to port 4, until the cylinder is fully pressurized; then switch pressure to port 2.

Doctoring system components

Doctor systems are made up of the following components:

- Doctor beam (or back)
- Doctor blade holder
- Bearings
- Auxiliary equipment
- Oscillation equipment
- Showers
- Loading and relief devices
- Doctor blade

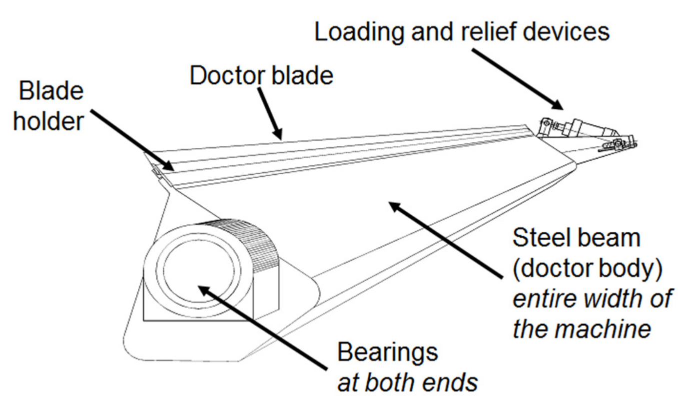

Figure 5. Single doctor, gravity loaded

Figure 5 shows a single, gravity loaded doctor, which is commonly used in cleaning applications on paper machines. **Figure 6 (next page)** shows a single, pneumatically loaded double doctor, which is commonly used on critical sheet removal and cleaning applications.

At higher machine speeds, a partial vacuum is created behind the doctor blade by the action of the roll passing the blade at high speed. This is known as the "foil effect". This foil effect is responsible for pulling furnish out of the pores of the roll, and this material (referred to as "crumbs") then accumulates on the back side of the blade. When these crumbs reach sufficient mass to enable them to escape the vacuum,

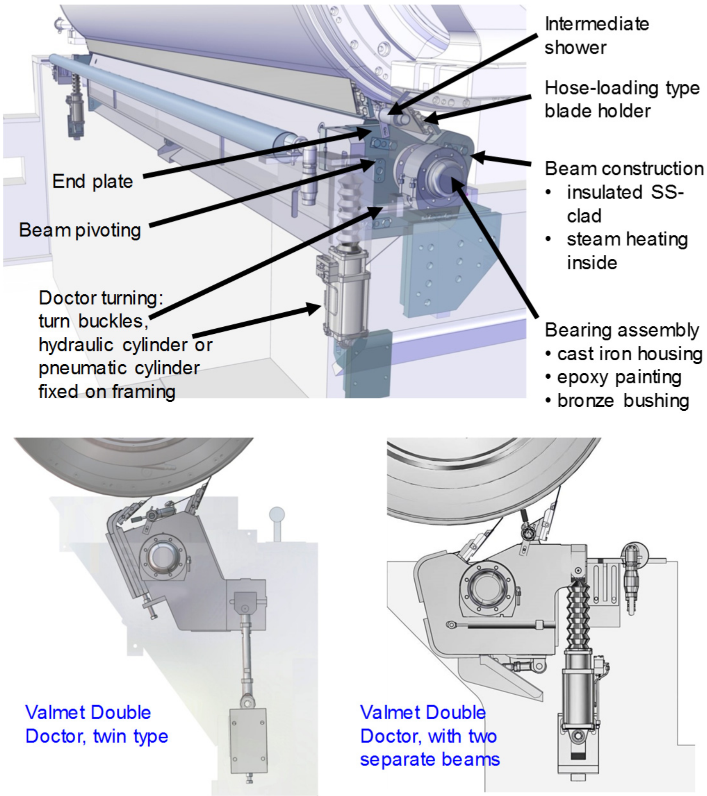

Figure 6. Center roll double doctor, pneumatic loading

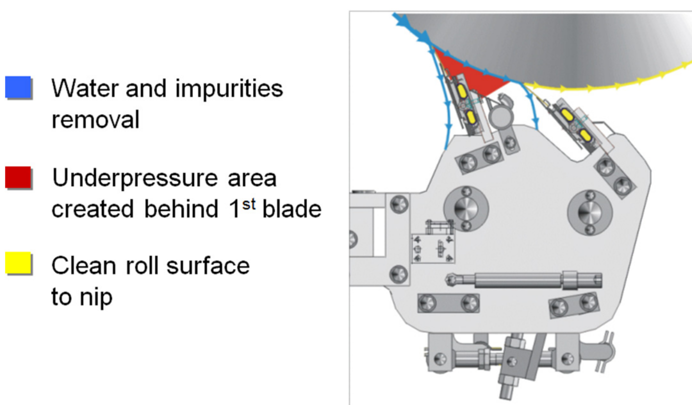

Figure 7. Operating principle of the double doctor

they can be dragged around the roll into the nip and cause the sheet to break, possibly causing serious felt damage; thus the need for a double doctor.

The first blade of the double (or twin) doctor acts in exactly the same way as a regular single bladed doctor; it is used to prevent the sheet from wrapping the roll and also removes any foreign material which may cause sheet marking (**Figure 7**). In between the blades is a wash shower that removes the crumbs of furnish from the roll that occur due to the partial vacuum after the first doctor blade. The second blade ensures that all the spent wash water is retained to prevent it from re-wetting the sheet.

The two doctor types shown previously are the most widely used models in the paper industry. There are also several doctors available for special applications. For instance couch, suction and grooved/drilled doctors. The best available doctor concept for these applications has been the use of an air blade. The disadvantage with this blade is the high cost for both the blades and the air consumption. Lately the use of the new Valmet Doctor Blade Dual (**Figure 8**) has proven to give the same water removal and sheet dry content after the press section. Since the new blade does not require any additional compressed air, its operating costs are significantly lower than those of an air blade.

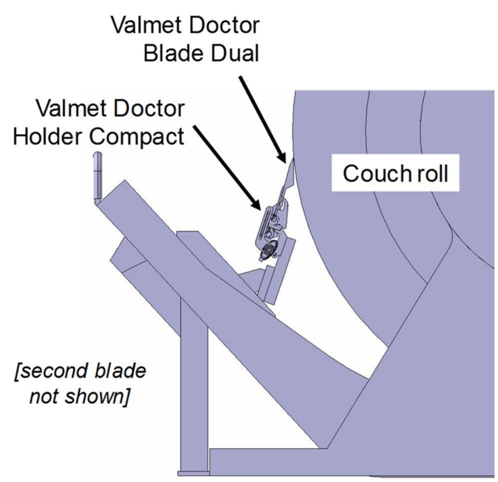

Figure 8. Valmet Couch Roll Doctor, showing first blade (Valmet Doctor Blade Dual) in a Valmet Doctor Holder Compact.

Doctor showers - cleaning

The cleaning efficiency of the cleaning shower located between two blades (**Figure 9, next page**) depends on several factors. These include: machine speed, porosity and hardness of the roll, trajectory angle of the water, water pressure, water temperature, and the nature of the contaminants (furnish) to be removed.

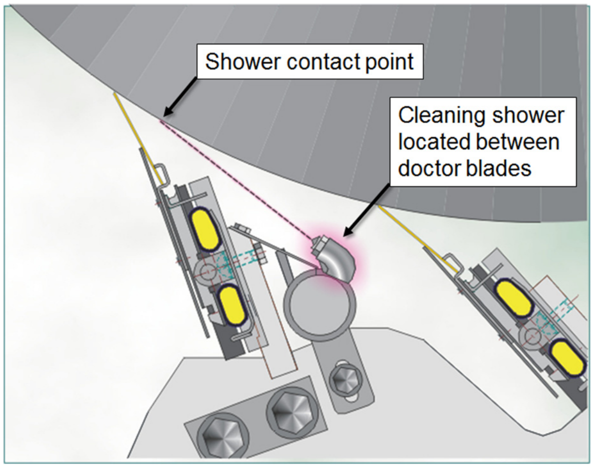

Figure 9. Doctor cleaning shower

It is extremely important to ensure that the cleaning shower water temperature is virtually the same as the sheet temperature or +5º. Failure to achieve this can lead to roll stress which at best results in unacceptable roll (and hence sheet) profiles, and at worst can cause roll failure. For wider machines with a small dimension shower pipe it may be necessary to feed the shower from both ends. The shower should contact the roll surface behind the leading blade.

The continuous supply of hot water in large quantities and at high pressure can be expensive, and the control of the water temperature to within a few degrees can also be difficult. In addition, the large volume of spent water from the shower has to be dumped into the broke pit which can cause significant dilution of the stock. Furthermore, some blade holders are poorly designed and inefficient when used as water seals in the second position.

For these reasons, some operators use their double or twin doctors with the cleaning shower turned off or at a reduced volume. The result is a significant loss in efficiency. However, since these operators may have never experienced maximum efficiency from their double doctor, and since it does offer considerable improvement over the single doctor, they are content to continue operating with a reduced or nonexistent cleaning shower.

Doctor showers - lubrication

The cleaning shower incorporated between the blades of a double doctor should never be confused with a blade lubrication shower which is normally applied to the roll face just in front of the first doctor blade in some applications.

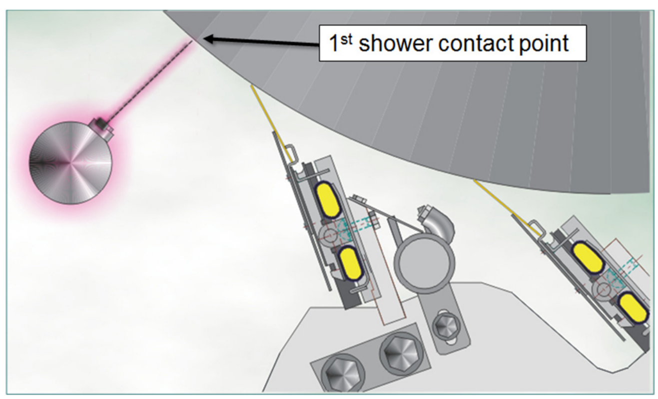

Figure 10. Doctor lubrication shower

Lubrication showers (**Figure 10**) are intended to lubricate the roll surface, reducing and regularizing the friction between the blade and the roll. Reduced friction results in less wear, so the blades last longer, and more significantly roll regrinding is minimized. Making the friction equal over the roll width (regularizing) eliminates the uneven blade wear that leads to uneven roll wear.

The most important positions for the application of a lubrication shower are those which experience high friction. This friction is usually the result of an abrasive furnish, a porous (or rough) roll face, a high blade load, or differences in roll face moisture. It is critical that the shower contact the roll surface, **not** the doctor blade.

Since wet-end rolls (wire and felt rolls) are exposed to more fluid furnish than are the dry-end rolls, and since furnish in this form can be abrasive, these rolls tend to be the ones requiring lubrication showers. Most press rolls are also subjected to abrasive furnish materials. They also use porosity for sheet release which can trap abrasive particles. In addition, they are subjected to relatively high blade loads for sheet removal. In consequence, press rolls experience significant friction between blade and roll and therefore require the use of a lubrication shower to reduce and regularize this friction.

Ideally, the lubrication shower should be of minimal pressure and should wet the roll face thoroughly and uniformly with 100% coverage over the roll's entire width.

Shower additives

There are a number of different products available that will take care of roll deposition or roll release problems. Some of the problems generally seen are pitch deposition, sheet picking and process additive deposition on roll surface. These different types of issues can be addressed with cationic base polymer in the case of high anionic demand from the headbox. One of the most common issues is pitch deposition on the roll surface; this will be best addressed with the use of surfactant/solvent base product.

The doctor beam

The doctor beam (**Figure 11**) has to span the width of the machine, and hold the blade under load in a straight line. Like any other beam supported only at the ends, it sags as a result of its weight. We call this sag "natural deflection." To minimize the effect of this phenomenon on supporting the blade in a straight line, very tight standards are used for beam design.

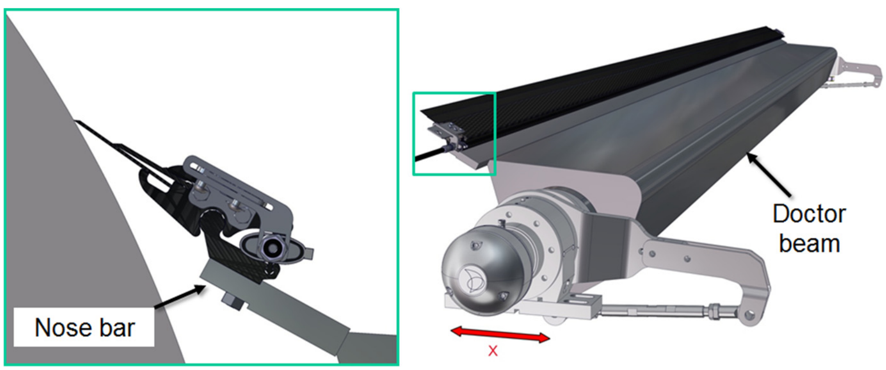

Figure 11. Doctor beam

The unmachined beam will have a natural deflection after fabrication. Once fabrication is complete, the beam is then placed in its operating position, wherein the actual deflection can then be measured and removed by machining the "nose bar" - the part of the beam which carries the blade holder (**Figure 11**). The finished nose bar is perfectly straight to within the same tolerance as the machine used to make it. This straightness tolerance will only remain true when the beam is oriented in its intended operating position; which is one reason why doctors should never be moved from their design position.

In addition to the natural deflection (caused by gravity), the designer also considers the bending moments caused by the mechanical loads which are to be applied to the beam. The fabrication must be made sufficiently stiff to withstand these loads without bending.

Correctly sizing the beam members is the only way to handle all these forces. However, any increase in the size of beam members also increases the beam weight, which in turn increases the beam's natural deflection. The end result is a compromise between weight, size, and beam stiffness.

In addition to the above, the designer also considers the natural frequency of the beam. He ensures that the natural frequency is higher than the harmonic frequency of the machine on which it is to operate, within the intended speed range.

Another factor to take into account when designing doctor beams is possible distortion caused by ambient thermal activity. It is of little use to produce a straight beam if it bends in service as a result of local heat (or cold) within the machine. Additionally, because the beam is a large mass of (initially) cold steel, it can produce condensation during start-up if used in a humid area. Condensation can cause sheet breaks and/or corrosion.

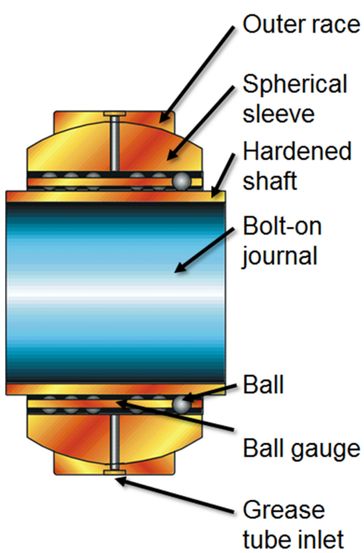

Figure 12. Doctor oscillator ball bearing

To avoid these problems, doctor beams are often insulated. The insulating material, which is normally mineral board or fiberglass, is usually held in place by stainless steel cladding. In severe problem areas, the beam can also incorporate pipes within its structure to allow for the use of steam to heat the beam to a uniform temperature.

Doctor bearings

Doctor oscillator bearings (**Figure 12**) are one of the more critical components in the overall doctoring process – equally as important as the blade, holder and method of oscillation. It's not uncommon that doctor oscillator bearings are the cause of an erratic or malfunctioning doctor that can adversely affect the papermaking process.

Traditionally, multi-row ball races have been used for doctor bearings because both a rotational and a reciprocating movement are required in most instances.

Unfortunately, as a result of sheet impact loads on the doctor and vibration from the machine, the balls in these bearings soon develop flat spots which, because of the oscillation of the doctor, result in scoring (tracking) of the inner or outer races. To overcome this problem, a special bearing was developed which holds the balls in a spiral pattern within the race. Each oscillation then forces the spiral to rotate and move the balls to a different position, constantly placing different balls in the load bearing area. The result has been very successful, and has extended the life of the standard ball race bearing by three or four times.

The use of split bushings allows for their easy replacement for maintenance without removal of the doctor or the bottom half of the bearing housing. Similarly, a split housing with independent hold down bolts allows for the doctor to be removed from the machine without the need to remove the bottom half of the bearing housing. In both cases re-alignment of the doctor is unnecessary. For heavy load positions such as a press center roll it is preferred to use split bearings with bronze bushings (**Figure 13**).

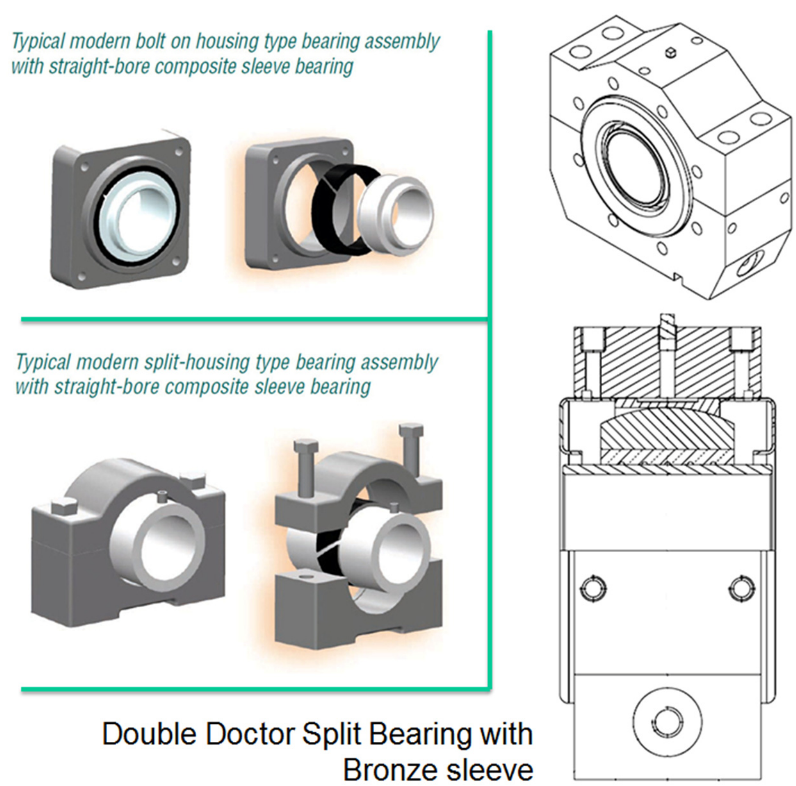

Figure 13. Valmet doctor oscillator bearings, bolt-on (top left) vs. split-housing (bottom left, right) types

Regular bearings need continuous lubrication. A single point lubrication system is recommended for all positions (**Figure 14, next page**). Most bearings need to be changed out every one to five years depending on lubrication maintenance. If the bearings are not properly maintained, the sleeve and even the journal may also need to be changed (**Figure 15**).

Some modern bearings use a self-lubricating bearing material that is chemically inert, will not absorb water, and has adequate compliancy to compensate for minor misalignment.

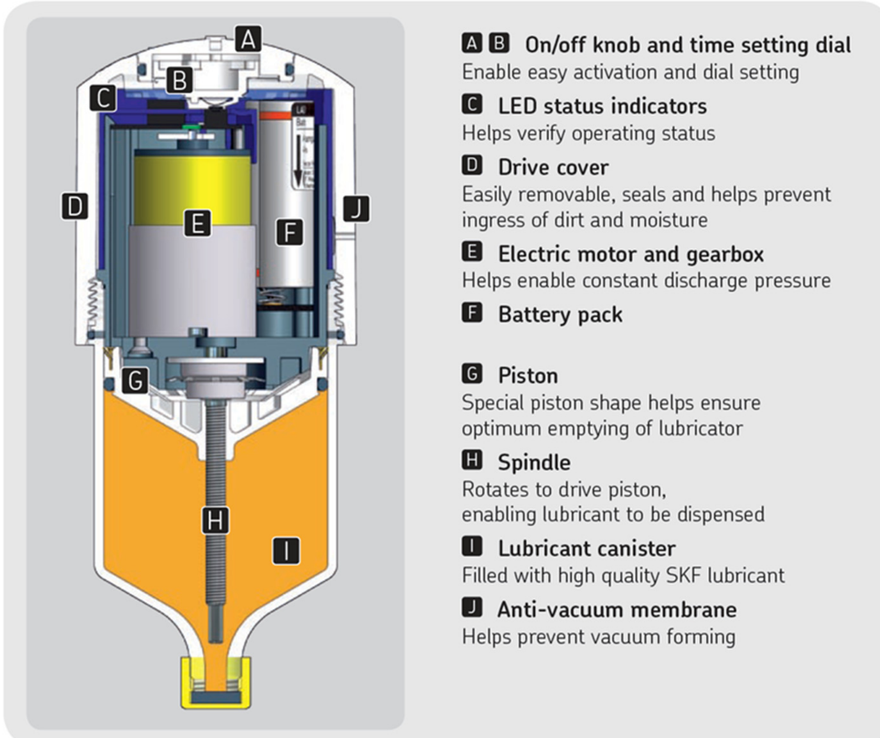

Figure 14. Automatic single-point bearing lubrication system (Illustration courtesy of SKF).

Oscillation

The reason for oscillating a doctor is very much discussed and debated. Oscillation is widely used, mostly in paper machine sheet shedding positions. Oscillation can be pneumatically, hydraulically or electro-mechanically actuated. Most common today are pneumatic oscillators which can be used all over the machine. They are less expensive to manufacture than the electro-mechanical style, and becoming more widely used in installations where instrument air is used with lubrication and filtering,

Pneumatic oscillators come in two basic styles, the air load-cell type (consisting of one or more pneumatic bellows with slide mechanism), and the piston and cylinder type. The bellows type is not recommended because of jerky oscillation.

Many electro-mechanical oscillators and air bellows oscillators are today being upgraded to pneumatic cylinder oscillators (**Figure 16**). When doing this it is very important to use instrument air with lubrication and filtering. The choice of the correct retrofit package (**Figure 17, next page**) is critical.

Figure 15. Center roll doctor beam bearings, worn vs. new

The best doctor oscillator available on the market today is the hydraulic unit. Its performance and reliability are unequalled, and it can develop massive thrust. On the down-side, it is relatively expensive and demands the availability of a hydraulic power unit for the supply of pressurized oil.

Figure 16. Valmet Doctor Oscillator, pneumatic

Best practices used to dictate that all doctors be oscillated. Recent mill experience shows that very good doctoring results can be achieved without oscillation. This has reopened discussions about the necessity of oscillation with modern composite doctor blade materials. When oscillation is used, however, the following parameters have been found to be good practice:

- Optimum number of strokes is 1 to 10 cycles per minute
- Stroke length 10 to 16 mm (0.39 to 0.63 inches)
- Smooth linear motion
- Moderate dwell at the ends
- No significant backlash in a drive mechanism

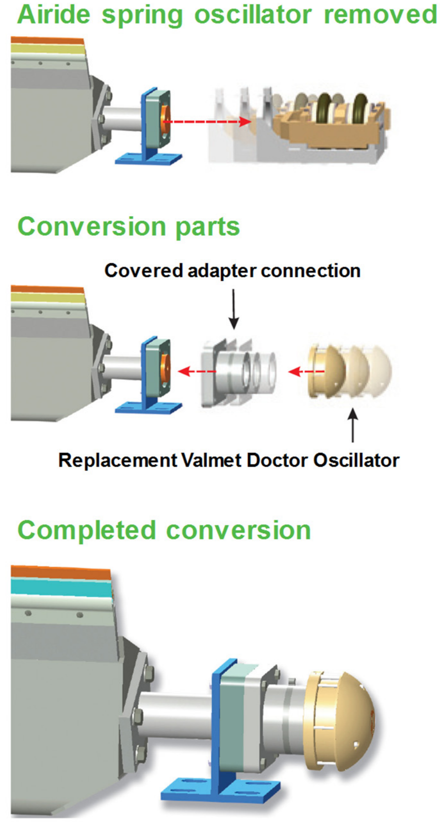

Figure 17. Bolt-on replacement of older Beloit double acting airide spring oscillator with modern pneumatic Valmet Doctor Oscillator.

Doctor blades

There are only three basic types of doctor blade:

- Metal (steel, stainless, bronze, Monel and thermal coated, i.e. ceramic and carbide)
- Plastic (polyethylene)
- Composites (laminated resin structures which include a binding material)

The main metals available for use as doctor blades are carbon steel, stainless steel, Monel, and bronze. Until the late 1950s, all doctor blades were of the metal type.

In the late 1950s a phenol formaldehyde resin called Bakelite was taken into use as a doctor blade material. It took many years for this material to become accepted for doctor blades since its cost in those early days was relatively high compared to metal. But as the resin structures were improved and new resins and binders formulated, the advantages of reduced roll wear and better runnability became apparent to the mills and the materials started to gain popularity.

From the early 1980s, paper machines became considerably faster and wider, and soft rolls were introduced. The soft roll covers were easily damaged by both metal and composite blades and a new blade material had to be found. The result of that search was high density polyethylene blades.

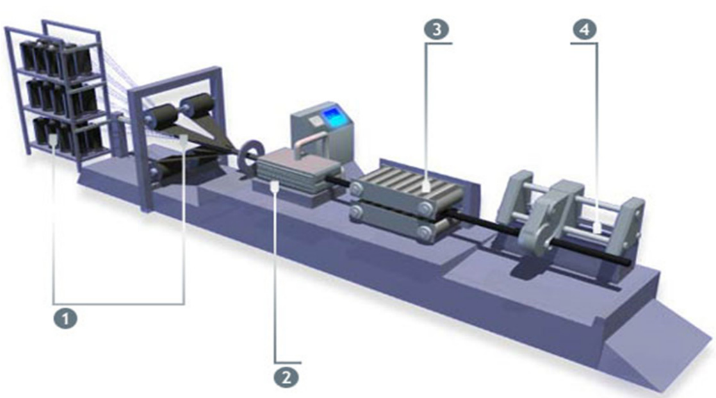

Figure 18. The pultrusion method of doctor blade manufacture is continuous and automatic.

Composite blades consist of a resin structure reinforced with numerous layers of a binding material, usually of the woven type. There are two types of manufacturing methods – pressing and pultrusion. When using the pressing method, layers of binders and resin are laminated under very high pressure and temperature for a specific time period. In contrast, the pultrusion method (**Figure 18**) is continuous and automatic, producing blades with a consistent shape. Blades can easily be optimized according to mill process requirements. For example, it is possible to use special resins to achieve high temperature properties.

1. Reinforcements
2. Resin injection mold
3. Pulling device
4. Cutting device

Doctor blade auxiliary equipment

Making the doctoring process safer and more cost effective is the goal of blade-related auxiliary equipment (**Figure 19**). Primarily, operators need to be protected from the sharp blade edges. This is possible with the appropriate blade storage, transportation and handling equipment. Additionally, specialty tools exist to measure blade angle and pull blades from the machine, as well as recycle or dispose of blades safely when they are used up.

Figure 19. Doctor blade auxiliary equipment

Doctor blades, their uses in different sections of the machine, their advantages and disadvantages and their auxiliary equipment are the subject of another detailed Valmet technical paper.

Doctor blade holders

There are several types of blade holders in the industry (**Figure 20**). Each type is designed to provide the best doctoring result in a given application. The most common holders are a rigid holder for the cleaning applications and a flexible holder for sheet shedding applications. Flexible and self-profiling holders have gained popularity as replacements for rigid holders due to their superior profiling capability

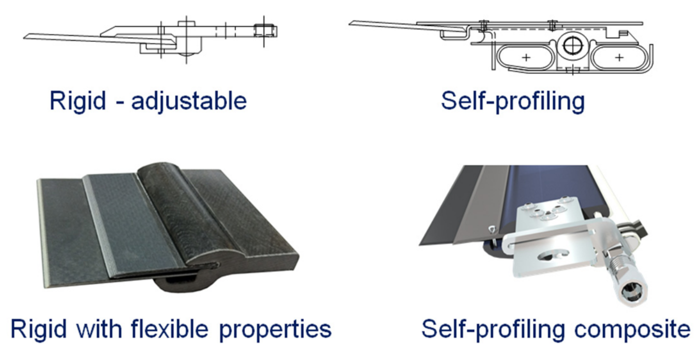

Figure 20. Doctor blade holder types

Blade holder overview

Traditional doctor blade holders have been metallic, usually stainless steel. Metals are well-established materials for equipment manufacturers and have many desirable properties for doctoring applications. Metal holders also have some drawbacks. Self-profiling and fluid supported metal holders require manual profile adjustments, contain a lot of parts in an open structure, are relatively large, collect dirt, yield on impact and are relatively heavy.

Composite holders were introduced to address the shortcomings of metal holders. Due to the nature of the material – resin reinforced fibers – composite holders have a very uniform structure that is tough enough to handle doctoring loads, yet is flexible enough to adjust to the roll shape without manual adjustments. Doctoring properties can be tailored for a given application by changing the blade support plate. The width and thickness of the plate can be varied to change the loading characteristics of the mechanism. Streamlined designs eliminate areas where impurities might accumulate, thus keeping them cleaner during operation and making them easier to clean during maintenance.

Composite holders (**Figure 21**) have other maintenance benefits. They are approximately half the weight of a comparable metal holder. Holders in even the widest machines can be handled by two or three people eliminating the need for a crane. Spare holders can be stocked undrilled, so they can be fit into any position in the machine.

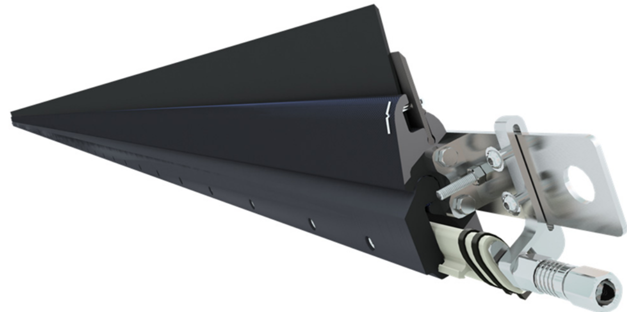

Figure 21. Valmet Doctor Holder Compact composite blade holder

Composite doctor blade holders are excellent for retrofitting old wet end and dryer doctors and are a recommended upgrade with wire roll changes. They also have proven to be very good for press rolls, both for center roll and separate press rolls.

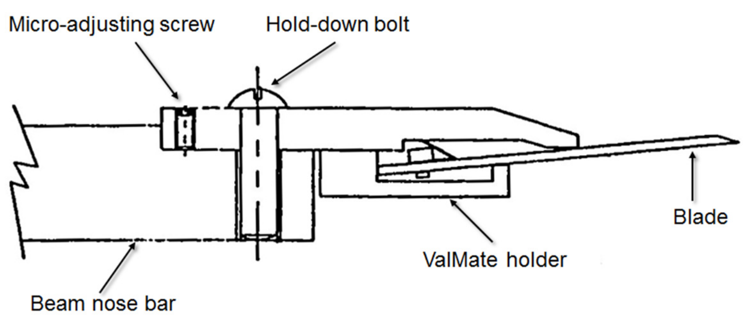

Figure 22. Rigid blade holder

The rigid holder

Figure 22 shows a typical rigid holder which usually employs a 75mm (3 inch) wide blade. The load force is applied to the blade through the front lip of the holder as shown. To every force, there is an equal and opposite force called a reaction force. In this case, there will be a reaction force from the roll, and another from the holder to keep the blade in equilibrium.

However, most rolls do not have a flat profile, and therefore to assist the blade to keep close contact with the roll, the blade must be very flexible in the cross-machine direction. This is easily achieved, but only if we do not allow the blade to bend in a lateral (machine) direction. If the blade bends laterally, it will "lock" and be unable to bend in the cross-machine direction.

According to the force diagram in **Figure 2**, there is a tendency to bend the blade laterally, and if this occurs, the blade will lock and will lose its ability to be flexible across the machine. Therefore we must limit the load force which we apply to this holder so that lateral blade bending does not occur.

Blade manufacturers choose the thickness of their blade materials such that they will accept loads of up to 18Kg/m (1 pli) before any significant lateral bending starts to occur. This is precisely why different blade materials are of different thicknesses, with the stiffer blades such as steel being relatively thin (1.25mm, 0.05 inches), and the softer materials such as HDP being relatively thick (5mm, 0.20 inches).

Therefore the rigid style holder should only be used where the applied load will never exceed ~18 Kg/m (1.00 pli). This limits its use to:

- Wire rolls (recommended load = 9 Kg/m, 0.50 pli)
- Felt rolls (recommended load = 9 Kg/m, 0.50 pli)
- Cleaning dryers (recommended load = 18 Kg/m, 1.00 pli)
- Some intermediate calendar rolls (recommended load = 18 Kg/m, 1.00 pli)

Unfortunately, the rigid holder is often used for other more demanding applications, such as sheet take-off dryers, and problems are then experienced. Due to misunderstandings about the technical limitations of the holder, it is often used in places where a different style holder would be a much better choice.

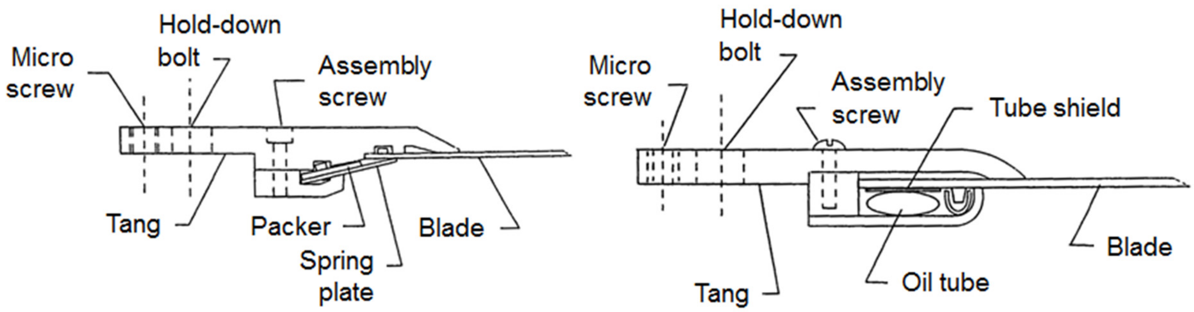

Figure 23. Typical cross section of two flexible holders, Inverflex (left) and Conformatic (right)

The flexible holder

Unlike the rigid holder, the flexible holder (**Figure 23**) allows the back edge of the blade to move by supporting it on a spring or other flexible member – typically a mechanical leaf spring or a tube partially filled with oil. The amount of movement allowed is only a few degrees before the spring (or tube) is fully compressed. Any irregularity in the profile of the roll is accommodated by allowing the spring (or tube) to deform at that point. As a result, the blade has fewer tendencies to bend laterally.

In this way, blade loads of up to about 24 Kg/m (1.35 pli) can be achieved without causing lateral blade bending. Once this load figure is reached, the spring (or tube) will be fully compressed and the holder will then act as a rigid holder.

The flexible holder can be used in any of the following positions:

- Anywhere that the rigid holder can
- Intermediate calendar rolls (recommended load = 18 Kg/m, 1.00 pli)
- Some single nip presses on slow machines (recommended load = 24 Kg/m, 1.35 pli)
- Some take-off dryers on slower machines (recommended load = 24 Kg/m, 1.35 pli)
- Reel drums (recommended load = 20 Kg/m, 1.12 pli)

The flexible holder is relatively expensive and is often more costly than its superior, the self-profiling holder.

The self-profiling holder

Profiling the holder to the roll is critical with regard to the alignment of doctors. Unfortunately, some rolls will change their shape when the machine is started, thus negating any prior alignment activities. Typical examples of this are:

- dryers due to thermal movement when steam is injected
- press rolls when nip pressure and/or steam box profiling is applied
- breast rolls when the fabric is tensioned
- calendar rolls when caliper control is used

For these applications, a blade holder which can continuously and automatically profile itself to the roll during operation is a necessity, i.e. "self-profiling" (**Figure 24, next page**).

Earlier in this paper, we discussed the difficulty which the designer had in placing the beam journals in exactly the right position so that a lift-off moment was not created at times of sheet take-off, and a dig-in moment was not created when sheet was not being removed. In most instances, the journal location becomes a compromise between these two extremes. We suggested at that time that we could overcome the problem by placing the journal at the apex of the critical triangle but that this would create other problems.

A further advantage of the self-profiling holder is its ability to provide a uniform blade load over its length. The self-profiling holder does not use gravity for loading, instead it uses air. But unlike conventional cylinder loading which is only at both ends of the beam, this holder applies the air under every single finger across the width of the machine. Since these fingers are very close together (50mm spacing), there is no tendency to cause beam twist, and the blade will therefore receive uniform loading.

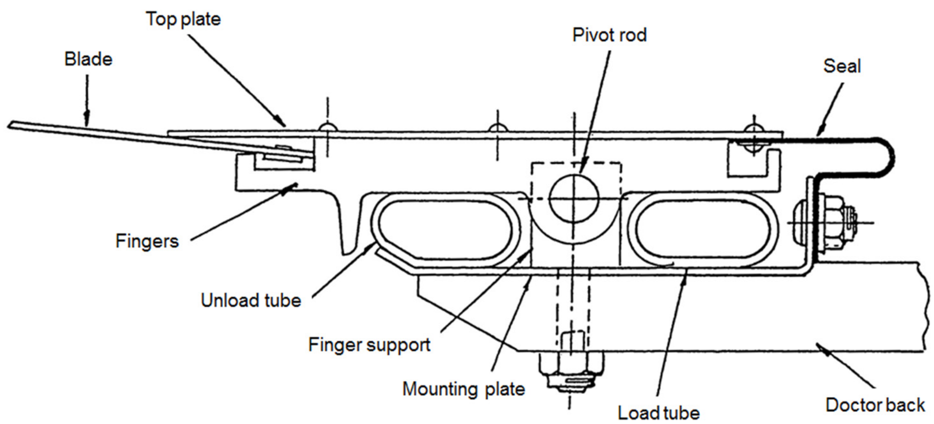

Figure 24. Self-profiling holder (DST-type)

Valmet blade holder development

In addition to conventional rigid and flexible blade holders Valmet is the world leader in self-profiling composite holder research (**Figure 25**). Valmet has developed a new generation of composite doctor blade holders that are produced to the specific mill process requirements. These durable, lightweight and corrosion-resistant holders eliminate vibration, keep rolls and cylinders clean, and are easy to install and maintain.

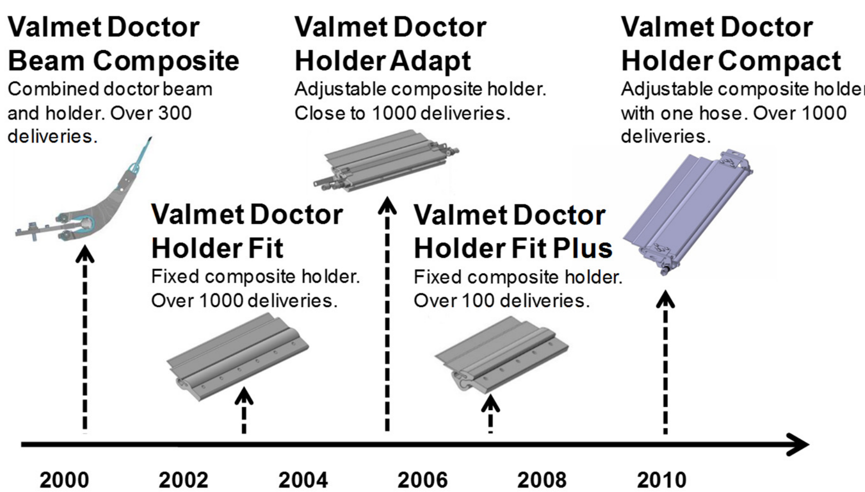

Figure 25. Valmet's composite doctor blade family (timeline)

Valmet Doctor Beam Composite

Developed in 2000, Valmet Doctor Beam Composite (**Figure 26**) is a unique forming and press section cleaning doctor with minimum space requirements. It enabled doctoring where it had previously been impossible due to limited space. The lubrication water is fed inside a pipe and led through holes between the composite body and the pipe. The water removes any impurities and ensures a proper oscillation movement. Oscillation is done with water lubricated slide surfaces and an integrated water inlet. The

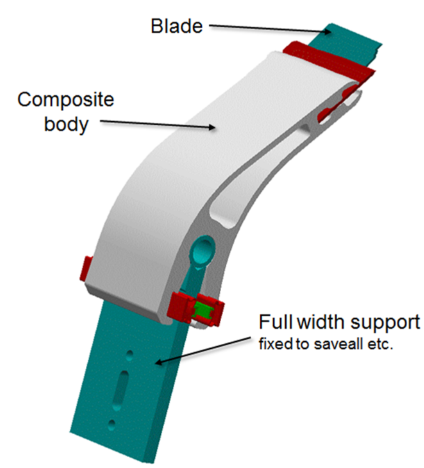

Figure 26. Valmet Doctor Beam Composite combined doctor beam and holder

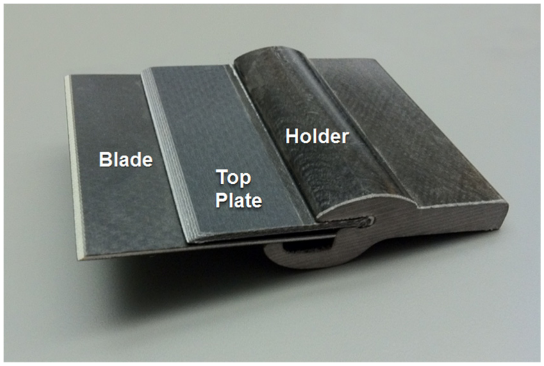

Figure 27. Valmet Doctor Holder Fit fixed composite holder

holder is suitable for all oscillator types and has seen over 300 deliveries since 2000.

Valmet Doctor Holder Fit

The Valmet Doctor Holder Fit fixed composite holder dates from 2003 and has seen over 1000 deliveries. It is a commonly used general purpose cleaning blade holder that works with all current blade materials. Doctor Holder Fit is Valmet's first fully composite doctor blade holder. It is designed for paper machine cleaning positions that do not require the load adjustment precision of a hose-loaded blade holder. LiteFit composite blade holders incorporate unique engineering and materials technology that improve profiling performance and cleanliness. The holders are very lightweight at 20% of the weight of traditional metal holders. The lightness of Valmet Doctor Holder Fit makes it easy and safe to handle.

Valmet Doctor Holder Fit (**Figure 27**) comprises two distinct parts, a holder profile and a removable top plate for support. The holders are both sturdy and very flexible. Their composition provides good resilience and self-profiling characteristics. The blade holders are highly impact resistant and quick to recover even from the strongest physical shocks. Cleaning the holder is made easier by a removable top plate, which gives access to the rivet groove facilitating fast and effective cleaning.

Valmet Doctor Holder Fit Plus – for improved holder cleanliness

Extremely light and durable, the Valmet Doctor Holder Fit Plus doctor blade holder (**Figure 28**) makes blade replacement easy and safe. The holder, with over 100 deliveries since development in 2007, can also easily be detached for cleaning. The unique construction of these composite blade holders enhances doctoring performance and cleanliness while also making blade replacement easier. The holder works at all paper machine cleaning positions, but it is particularly well-suited for challenging applications that require regular cleaning of the holder.

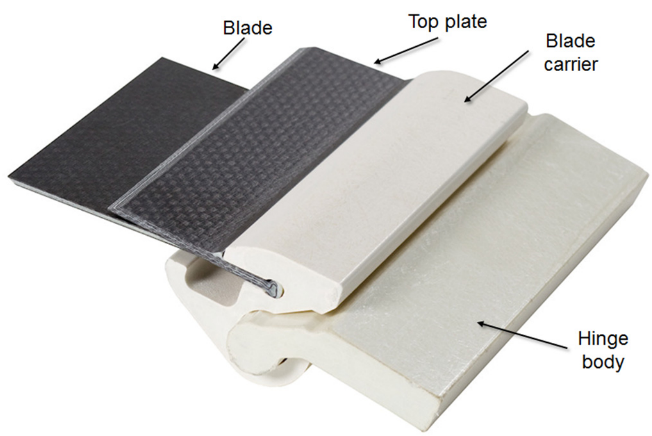

Figure 28. Valmet Doctor Holder Fit Plus removable composite doctor blade holder

The one-of-a-kind advanced composite construction of Valmet Doctor Holder Fit Plus blade holders makes them extremely durable and flexible. The holder consists of three replaceable components: articulated blade carrier, hinge body and top plate. The material and width of the holder's top plate can be tailored for the best possible doctoring result at each position. The holders are extremely lightweight which makes them easy and safe to handle. The composite construction of the holder also provides good vibration dampening properties, a low heat expansion factor, and exceptional corrosion resistance. The blade holders are highly impact resistant and quick to recover even from the strongest physical shocks. Valmet Doctor Holder Fit Plus, similarly to Valmet Doctor Holder Fit, is easy to clean due to the removable top plate. The blade carrier can also be pulled out of the machine for more extensive cleaning or service.

Valmet Doctor Holder Adapt

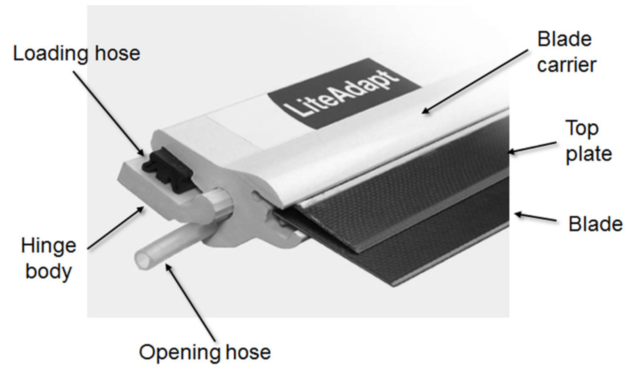

Figure 29. Valmet Doctor Holder Adapt hose-loaded composite blade holder

This hose-loaded adjustable composite blade holder developed in 2005 has seen over 1000 deliveries and was the first hose loaded composite blade doctor developed for the most challenging doctoring positions. The holder's adjustment and self-profiling capabilities are excellent and it is easy to install and service. The patented Valmet Doctor Holder Adapt holder (**Figure 29**) was designed as a replacement unit for nearly all commonly used holders. (Many mills have now retrofitted their Valmet Doctor Holder Adapt holders, previously called LiteAdapt, to the new superior Valmet Doctor Holder Compact holder.)

Valmet Doctor Holder Compact

The Valmet Doctor Holder Compact doctor blade holders with superior properties and performance enable the use of wider blades, extending blade life and the time between replacements. The first delivery was in November 2009 and now there are over 1000 deliveries. It is an adjustable composite holder with only one hose, allowing for faster and safer maintenance.

The key features of the Valmet Doctor Holder Compact blade holder are lightness, simplicity, easy use, and superior performance. The holder was designed especially for the most demanding paper takedown positions, but it is suitable for all doctoring positions throughout a paper or board production line.

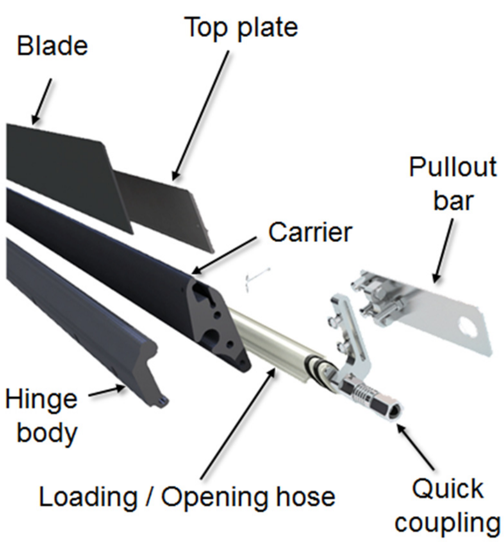

Figure 30. Valmet Doctor Holder Compact adjustable composite holder with only one hose

The construction of Valmet Doctor Holder Compact (**Figure 30**) combines a composite holder and a composite top plate. This results in excellent profiling properties, allowing the doctor blade to conform to the roll surface being doctored.

The large holder opening allows the use of a wider blade, for longer blade lifetimes and blade change intervals. It also makes holder installation easier.

The composite structure of the holder provides minimal thermal expansion compared with traditional steel holders. This ensures a better doctoring result, regardless of any changes in the process temperature or the surroundings.

The holder features improved composite profile strength compared with other Valmet composite holders. Such new materials as fibers and resins improve the holder's wear resistance in paper takedown positions.

The construction of Valmet Doctor Holder Compact employs only one hose to carry out both the opening and loading functions. The hose has factory-assembled fittings that ensure very fast and trouble-free hose changes. The surface is even, making it possible to install web guiding blows. The control box includes an air leak detector to help identify possible hose breaks.

Summary

In conclusion, doctoring in paper machines is often considered to be a simple ancillary process and as such is often overlooked. However, use of good doctoring practices and the best available materials can result in better machine runnability and reduced water and power consumption.

This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers' performance forward.