Recognition and Prevention of Press Felt Fiber Loss

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By knowing how to spot the causes of felt fiber loss on paper machines, papermakers can identify where it is occurring and take corrective measures.

THE INDUSTRY HAS ADOPTED THE TERM "FELT SHEDDING" to describe fiber loss situations. We believe the term "felt shedding" is misleading and does not appropriately describe the mechanisms of fiber loss. Thus, the first step is to see the problem, not as the shedding of batt from poorly designed or aging felts, but as the degradation of batt fibers due to mechanical and/or chemical forces.

Before addressing the question of press felt fiber loss, some basic concepts must be reviewed. **Figure 1** shows the cross section of a press felt.

The sketch illustrates the two main components of the press felt: the base fabric (woven part of the felt) and the fibers which are attached to the top and bottom of the base fabric. The fibers, often called "batt," are attached to the felt surface through a needling process, which entangles the fibers and locks them in place. The combination of the base fabric and the batt form the structure of the press felt. Today, nylon is the predominant material of choice for both base fabric and batt fibers in the press felt industry.

1. Cross section of press felt

The loss of press felt fibers occurs when an external mechanism damages the surface of the felt. Fibers subsequently loosen from the felt's structure and can contaminate the paper machine, causing unscheduled machine shutdowns and/or contaminate the paper produced. This situation can mean unexpected rejections or customer complaints due to printing problems caused by the contaminants.

FIBER DEGRADATION

There are three mechanisms that influence the loss of fibers from press felts:

1. Mechanical degradation
2. Chemical degradation
3. Manufacturing problems.

Mechanical degradation

The causes of mechanical degradation can be divided into three categories: high pressure showers, external abrasion, and internal abrasion. At the molecular level, the process of mechanical degradation is identical in all three categories.

When nylon fibers lose their integrity because of mechanical degradation, they separate from the felt surface and contaminate the paper machine. If the degradation continues, the entanglement of the fibers in the batt layers will progressively be reduced and fiber loss will accelerate.

High pressure showers. High-pressure showers represent the most important source of mechanical abrasion of press felts. These showers are used to avoid the contamination of press felts by foreign objects (paper fibers, pitch, fillers, etc.) Contaminants penetrate the felt during pressing and become entrapped. If not properly removed, contaminants can plug the felt and reduce its efficiency. Several types of high-pressure showers are used. The type can vary according to the paper grade produced, the machine speed, the press felt travel, or operational experience. Unfortunately, an improperly designed high-pressure shower system or one that is not well maintained can severely degrade the fibers of the felt, resulting in fiber loss. TAPPI Technical Information Paper TIP 0404-21 indicates recommended paper machine setups, including a section on showering guidelines. However, the appropriate combination for each individual paper machine must be determined by experience. The following are some of the most important items to examine around the high-pressure shower system:

1. Condition and state of shower bars and shower nozzles
2. Shower pressure
3. Shower angle in relation to the felt
4. Distance between shower and felt surface
5. Water quality and quantity used
6. The shower oscillation program.

External abrasion. All components that come in direct contact with the press felt during its travel generate a certain amount of frictional or braking force against the fibrous structure of the felt. Under normal operating conditions, press felts will lose very low amounts of fibers due to friction. Changing machine conditions and normal wear of machine components must be considered.

The components that generally come into contact with the felt are the Uhle box(es), felt rolls, stretch rolls, and press rolls. The condition of each of these components must be checked regularly. When any of these components become abrasive or show signs of uneven wear that could cause high-localized loads on the felt's surface, the component must be fixed or replaced.

When examining the Uhle box system, check both the box cover and the vacuum level of the Uhle box. The higher the vacuum levels, the more the felt rubs against the sides of the Uhle box cover, thus the higher the friction force. When examining press rolls, note the condition of the roll surfaces. The load applied to press rolls must also be closely reviewed. The higher the load applied by the rolls on the felt, the more the felt will wear.

Internal abrasion. Some fillers used in papermaking have very abrasive surfaces (titanium dioxide, calcium carbonate, and clay are among the most common). During the pressing phase, nonbonded fillers can penetrate the structure of the felt. The internal friction generated by abrasive fillers degrades the nylon fibers. If abrasive fillers are not adequately removed by the conditioning system (Uhle boxes and high pressure and chemical showers), degradation due to the internal friction forces damage fibers and cause fiber loss.

Chemical degradation

The molecular structure of nylon can also be chemically damaged. Hydrogen peroxide and chlorine ions are some of the most common elements used in bleaching of paper stock. These ions are, however, extremely damaging to the chemical structure of nylon. At the molecular level, chemical degradation varies from mechanical degradation.

Chemical degradation problems arise when hydrogen peroxide or chlorine ions are not totally eliminated during the neutralization process of the bleached stock. Chemical contamination on a paper machine can occur due to an ongoing process control problem (continuous contamination), or it can occur due to an upset of the normal operating conditions. If an upset in the neutralization stage has occurred and degrading ions did make it to the paper machine, the damage caused by these chemicals may only become noticeable as actual fiber loss several days after the contamination has occurred. This phenomenon is a result of the weakening of the molecular chain of the nylon fiber by the chemical upset that has now made the previously strong fibers vulnerable to normal operating conditions. When continuous contamination is experienced, press felt damage is usually more severe and often appears much faster. Even if the contaminant levels are low, when they are in the system on a continuous basis, damage will occur. The felt that is closest to the headbox is the most vulnerable to chemical degradation since it is closest to the contamination source and will see the highest levels of damaging chemicals.[1]

Chemical contamination weakens the fiber's molecular chain. Full degradation of fiber integrity (fiber loss) occurs due to an external mechanical force on the felt (such as high-pressure showers). This phenomenon makes the degradation mechanism identification difficult because of the presence of both chemical and mechanical degradation. Once a fiber is chemically damaged, the effects on the molecular structure of the nylon are permanent and irreversible. Exact threshold levels of chlorine and peroxide are difficult to assess because of the many factors that can accelerate chemical degradation. Under most operating conditions, the residual chlorine level should not get higher than 0.5 ppm, the residual chlorine dioxide level should be kept below 0.2 ppm, and residual peroxide levels should not exceed 100 ppm.

Acceleration. A few factors can impact the chemical degradation of nylon. Chemical degradation is very dependent on temperature, pH, and the presence of transition metals. As the temperature is increased, the chemical

[1]Although forming fabrics are actually the closest piece of paper machine clothing to the source of contaminants, the molecular structure of the material most commonly utilized in the manufacturing of forming fabrics (polyester) is not affected by elements such as hydrogen peroxide and chlorine ions. Very few forming fabrics contain nylon (polyamide). Verify with your clothing supplier the raw materials utilized in your forming fabrics.

degradation is intensified. The presence of transition metals (copper, manganese chromium, cobalt) always increases the degradation process. The most commonly used bleaching elements react slightly differently to pH levels. When chlorine is present under acid conditions, as the pH is lowered, the degradation process accelerates. When operating in alkaline conditions, as the pH is increased, the degradation process decelerates. When peroxide is present under acid conditions, as the pH is lowered, the degradation process decelerates. When operating in alkaline conditions, as the pH is increased, the degradation process accelerates.

Temperature and pH "shock" must also be avoided. The temperature and pH of conditioning water should be as close as possible to the temperature and pH of the stock, otherwise shock can occur. A shock of pH and temperature can render the nylon very brittle or can cause some contaminants to precipitate in the felt and remain imbedded in its structure. Special chemical and batch washes are often utilized to clean the felt from contaminants. Many of these washes utilize the effects of pH shock to dissolve contaminants. These are normally voluntary shocks and do not damage the felt's structure.

Do not hesitate to verify with your chemical supplier the felt and batch chemical cleaning method used to dissolve your contaminants. When changing from acid papermaking to alkaline papermaking, it is important to understand the ramifications of the changes. New fillers and chemicals will be utilized in the process and their behavior with respect to pH variations will be different. Particular precautions and excellent process control must be adopted to avoid unexpected fiber loss situations.

Manufacturing problems

The least frequent cause of fiber loss on paper machines occurs because of press felt manufacturing, application or design problems. The manufacturing of today's press felt utilizes highly sophisticated techniques, equipment, and materials, resulting in excellent fiber adhesion and protection. Although they occur less frequently, press felt manufacturing problems can occur. The main causes are discussed below.

Poor fiber adhesion due to needling technique. When a fiber loss problem is a result of poor needling technique, the problem will typically show up at the very beginning of the felt's life on the paper machine. Under most situations, the supplier can run tests to verify fiber adhesion (utilizing a manufacturing sample) and compare the results obtained with a previous felt. If the specific press felt configuration has never been supplied before, the adhesion results can be compared to products supplied on similar applications.

Inadequate felt design. Fiber loss problems resulting from inadequate felt design are very rare. When such problems occur, it is generally toward the end of the felt's normal operating life. The problem originates as a result of the flow resistance of the felt. As a felt ages, the base fabric and fibers compact, and the felt loses its openness. The now less-open structure increases the flow resistance in the nip and over the conditioning system. The hydraulic forces generated by the water and air trying to penetrate the felt's structure can weaken the fiber interlacing and loosen the fibers from the felt.

Note: Before modifying a felt design to prevent fiber loss problems, it is important to be certain that the root cause was not a unique operational upset that occurred at some prior point during the life of the felt.

ANALYSIS TECHNIQUES

In most cases, a fiber loss problem will be identified when several fibers can be seen along the felt run or when fiber particles can be noticed in paper samples. In order to conduct a proper investigation into the source and causes of the problem, it is absolutely essential to keep samples of any fibers found on the machine and samples of the contaminated paper. These samples will be required for the proper testing of the contaminant.

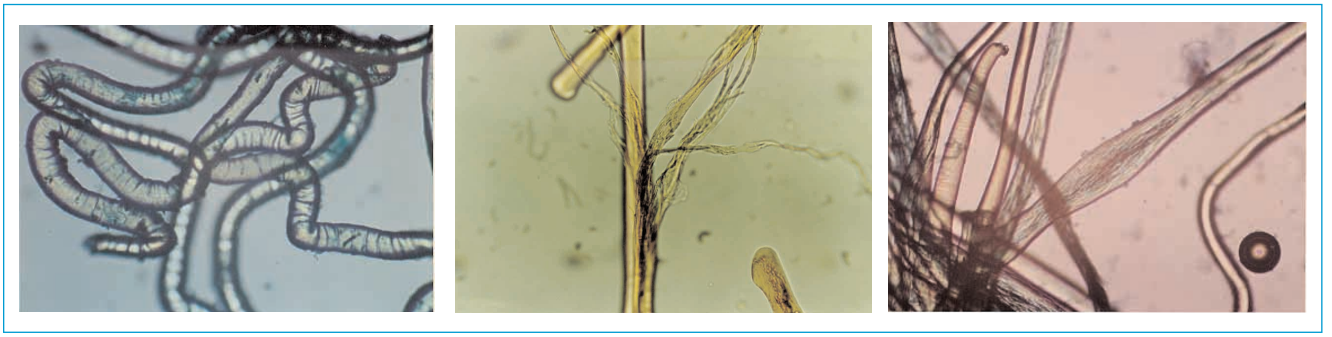
Contaminant identification

The first task in the investigation is to identify the contaminant. In order to identify the contaminant, a few simple tests must be performed. The first test is a dissolution test. Damaged fiber samples (fibers found on the paper machine and/or the paper should be examined if possible) are placed in an acid bath[2] (usually formic acid, but sulfuric acid may also be used), and the reaction is observed. If the fiber dissolves, the sample is probably nylon. However, if it does not dissolve, it is not nylon. If the contaminant is not nylon, it is important to verify if one of the felts running on the machine contains a material other than nylon. If no other raw material is utilized in the manufacture of the clothing running on the machine, the problem originates elsewhere in the papermaking process. If the fiber did dissolve, a melting point test must then be performed to identify if in fact it is nylon, and if so, what type.

These four types of nylon are used in the press felt industry:

Nylon 6	Melting point: 215°C
Nylon 6,6	Melting point: 254°C
Nylon 6,10	Melting point: 208°C
Nylon 6,12	Melting point: 206°C

[2] When working with or handling any type of chemicals, use in accordance with the manufacturers' recommendations and environmental and safety regulations.



2. Microscopic analysis. Left, fiber damaged chemically; center, damage from an external mechanical source; right, damage from an internal mechanical source.

Once the contaminant has been identified, the press felts utilizing the contaminant can be isolated and examined.

To determine the root cause of fiber loss or fiber contamination, it is important to assess the situation correctly. Once the contaminant and the felt(s) responsible for the source of the loose fibers have been identified, the next step is to ascertain when the problem started. Was it at the very beginning of the felt's life or near the end? This information is very important in order to compare the problem felt with previous felts used on the same position. When the felt is removed from the machine, a sample must be kept and sent to the supplier in order to perform some testing and identify the source of the degradation mechanism. The fibers found on the machine and/or the paper, along with the sample, must be assessed.

Visual assessment

The next test is a visual assessment of the available sample to evaluate the state of the fibers and to check if a reoccurring abrasive wear pattern can be seen. Sample integrity is also documented. A quick simple test can be performed immediately to get a feel for the degradation mechanism. Attempting to tear the sample can give the assessor an idea of what to expect. If the sample can easily be torn apart by hand, usually there is some type of chemical damage, as it would indicate that the base fabric yarns are also damaged. However, the simple fact that the felt sample can be torn by hand is not a total analysis of the degradation mechanism. In fact, if the felt has been subjected to excessive mechanical wear, it is possible that the wear was so severe that the felt was worn to the base fabric. This should, however, be noticeable by visual examination. Fiber length must also be documented. The shorter the fibers, the more the degradation has progressed. During all phases of the investigation, the fibers should always be compared to samples of fibers from the original felt.

Microscopic analysis

Once the initial visual examination has been completed, a microscopic analysis should be performed to allow the investigator to examine the condition of the fibers from the felt surface as well as the fibers recovered from the paper machine and/or the paper. The fiber size (denier) is also measured. This will help the investigator determine the press felt that is responsible for the contamination. The microscopic analysis usually allows the investigator to determine if the damage is due to mechanical or chemical degradation. **Figure 2** illustrates the difference between a fiber damaged chemically, one damaged by an external mechanical source, and one damaged by an internal mechanical source.

The color of the chemically damaged fiber will be faded and the fiber wall will be swollen. The fiber damaged mechanically by an external source will not show the same discoloration. The fiber ends will not be swollen but rather have damaged fiber walls, and the ends of the fiber will be in a straight cut-like form. Finally, a fiber damaged mechanically by internal abrasion will show a more fibrillated structure.

Mechanical property analysis

The mechanical properties of a used felt sample are measured in order to compare them to the mechanical properties of the original felt. Machine direction and cross-machine direction breaking strength, air permeability, caliper, and unit-weight are all compared to original values.

A thorough filler analysis is completed. This analysis will determine the organic and inorganic as well as the ash content in the sample. All mechanical tests can be completed so the papermaker can make some immediate adjustments if necessary. This is important for assessing profiles and localized problem areas. Some samples should be kept for chemical testing.

Chemical analysis

Chemical analysis of the fibers will allow the investigator to determine if chemical degradation has occurred. These tests are important even if the microscopic analysis seems to indicate only the presence of mechanical degradation. In fact, microscopic analysis can sometimes be misleading, especially in the case of chemical damage caused by an upset in the bleaching system. Since the upset may have only weakened the fibers and the bulk of the damage was done mechanically, the microscopic investigation will probably only show mechanically damaged fibers. However, the mechanical degradation may have occurred due to the upset in the system that weakened the fibers and the fiber entanglement. Chemical tests are the most efficient to detect the presence of chemical contaminants.

The following tests are used to determine the presence of chemical degradation:

1. Relative viscosity
2. Residual carbon end group.

At least one of these two tests must be performed. Because chemicals such as hydrogen peroxide and chlorine ions modify the molecular chain of nylon by bonding to the carbon elements of the polyamide and forming radicals, a reduction in either the relative viscosity or the residual carbon end group will confirm the presence of some type of chemical degradation. Mechanical degradation simply ruptures the structure of nylon; thus the relative viscosity and carbon group count will be relatively the same. An expert should perform these tests, as they are relatively tricky and the data analysis requires some level of expertise.

Elemental analysis

Elemental analysis allows the identification of all the elemental components in a sample. This test is very useful to validate the presence of chlorine ions, which cause chemical degradation, and to find titanium or calcium, which cause mechanical degradation through internal abrasion. However, this test only detects elements heavier than oxygen. Thus this test will not detect the chemicals which cause peroxide degradation (peroxide is highly volatile and evaporates rapidly) or detect the presence of mechanical degradation caused by external sources. The data from the elemental analysis should be compared to a benchmark product from the same position that operated when no excessive fiber loss was experienced.

Correcting the problem

Once the degradation mechanism(s) have been identified, all possible causes must be checked. Several causes can be the source of fiber loss. The following are the most common:

1. Abrasiveness, type, and quantity of fillers used
2. Residual percentage of bleaching agents, such as chlorine and hydrogen peroxide
3. Uhle box water removal rate
4. Uhle box position (distance from the felt, alignment)
5. Lubricating shower (angle, pressure, overlapping, pH, water quality, temperature, condition, plugging)
6. High pressure shower (pressure, angle, condition, temperature, pH, oscillation program, distance from the felt, plugging)
7. Chemical conditioning (type, concentrations, application method)
8. Felt burns (is a spike being used to open up burnt areas?)
9. Roll condition
10. Felt filler levels
11. Felt life (has the felt run longer than normal?)
12. Water levels in felts (Scan Pros)
13. Felt design and manufacturing (needling techniques, parameters)
14. Wet end chemistry
15. Global state of felt run
16. Felt installation method (was the felt damaged?).

This section can be the most difficult and time consuming part of the investigation. However, if the root cause of the problem is not identified and corrected, fiber loss may periodically appear on your machine, resulting in downtime or customer complaints.

CONCLUSION

Press felt fiber loss could cause serious problems for papermakers and printers. When an abnormal quantity of fibers is detected on a paper machine or in the finished product, or if the printer notices an abnormal quantity of fibers on the presses, it is crucial to determine the source of the contamination and isolate the mechanism responsible for the problem without delay. The procedures described in this article can be used to help papermakers identify and understand the probable causes of fiber loss and take adequate corrective measures. **TJ**

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