Enhancing Press Section Performance By Optimization Of Press Fabric Cleaning

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ABSTRACT

Increasing usage of waste paper as raw material in papermaking is posing lot of problems especially in the cleaning of press fabric of paper machine. For better productivity steady operation of paper machine is imperative. This requires an efficient operation of showers and vacuum system. Beside mechanical means, chemical conditioning of press fabric also helps in achieving the optimization of press section which provides a mean to improve paper quality, machine productivity and efficiency while reducing the operating cost.

Introduction

Advancement in press section design monitoring tools and awareness among mill personnel and suppliers have provided significant areas of improvement in press section performance. Optimization of wet end chemistry, process operating parameter, felt design, showering, vacuum elements and chemical treatment improves press and dryers section performance.

The complexity of paper machine and paper making process often makes it difficult to determine the root cause associated with problems that affect press section efficiency. The increased use of recycle furnish along with increased water closure, provides new challenges in maximizing performance of the press and dryer sections. A properly designed press section optimization programme will help in the improvement of performance and productivity of paper machine. Several key areas must work together to provide optimum performance (Fig. 1).

There is a large number of variables that effect runnability and efficiency of press section such as permeability, surface condition and void volume of press fabric. If press fabric is constantly changing over its life; it is very difficult to establish good level of system control. Therefore, the achievement of steady state or nearly steady state operation is desirable. With steady state operation, control can be improved and efficiency can be increased. Along with proper clothing design, an intelligent application of cleaning systems can achieve this operation. Good clothing condition has a positive effect on dewatering efficiency and thus energy use, profile surface finish, bulk and a myriad of other factors as well as operating expense such as fabric life.

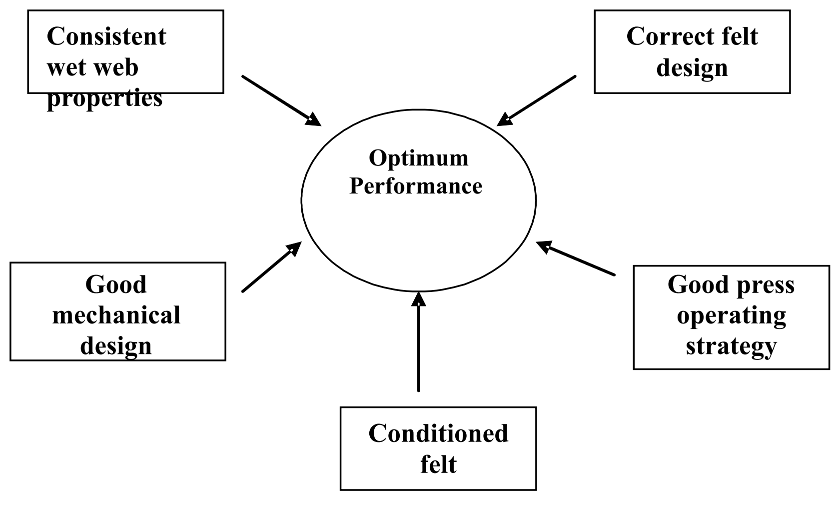

Fig. 1 Key Areas of Press Optimization

Need of cleaning or conditioning press and dryer fabrics

Contaminants, system unbalance in wet end chemistry, poor showering, press loading, mechanical cleaning of felts, machine retention and drainage, water chemistry, recycle fiber usage, water closure, machine operating temperature, pitch, fines, fillers and specific wet additives all contribute to felt filling, compaction and felt wear.

Cleaning most often means removal of contaminants. Contaminants can be affected by heat, chemicals and kinetic energy. Usually, fabric temperatures are kept as close to sheet or system temperature as possible to avoid negative impacts on dewatering or other adverse sheet interaction. Application of chemicals is an extremely powerful way to remove contaminants.

The most significant properties that must be maintained are consistent uniform water removal and prevention or removal of contaminants that will negatively impact paper machine performance. Consistent uniform water removal and inhibition of problem causing contaminants can offer following advantages.

- Improved sheet quality due to more uniform pressing
- Increased production due to

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reduced breaks and machine down time.

- Increased production due to increased speed and reduced rejects caused by moisture variation (via minimization of wet streaks)
- Increased production due to the elimination sheet spots, holes, cracked edges, crushing etc.
- Increased profits through reduction of steam consumption
- Increased production due to reducing down times to batch wash fabrics.

The present paper concentrates on different means of contaminant removal from press fabric both by mechanical and chemical means.

Contaminant removal by Mechanical means

Showers

Shower is a system that apply fluids. Basically, two different types of showers are employed on paper machine: Fan showers and needle or jet showers. Fan showers are used to apply fluid (liquid and usually water) evenly, across the whole cross machine width of a fabric. Needle jets are used to directly apply energy via a high velocity stream of liquid, almost always water, to the surface of a fabric. Even though these showers are both designed to apply liquid, they are very different in design and application.[1]

Fan showers

They are designed to apply liquid evenly across the width of a fabric. Fan showers do not clean fabric by direct application of energy with the water stream. Rather, water is applied in relatively large volumes and flushes or floods contaminants away. A lubrication shower is used to apply a surface film of water between a fabric and stationary element such as suction box. Optimally, the lube water applied should do its friction - reducing duty and is then removed before it has a chance to be wicked into the fabric. For flooding, chemical or lube showers, the most important factor to judge efficiency of operation is profile of water volume applied. Ideally, there is exactly the same volume per width applied for every unit width of showered fabric.

The fan shower can be best judge by how effectively it can apply cross directional distribution of water to a fabric. For fan showers, each orifice is ground such that the water is dispersed or "fanned" out, evenly in the CD. The quality of CD water distribution is therefore mostly determined by the evenness and efficiency of the CD dispersal through each nozzle.

There are two types of variation between nozzles of the same type. The first is total flow volume through each nozzle. The second is the distribution of that volume in the CD length showered by each nozzle. As it happens, total volume variation is very small. Good nozzles will vary within 1% total flow in a population of the same type. Even the cheapest nozzles are within 4%.

The largest variation in nozzles flow is in the pattern of application. Fig. (2) shows flow distribution of nozzle generated at 45° fan and has an orifice of 0.050 inches. It showed great side to side variation (about 2/3 of peak volume) which gives much greater effect on overall profile rather than volume differences. To compensate for this variation, nozzle patterns are overlapped. Every nozzle has a nominal pattern width usually defined as angle. This angle assumes the orifice is a point outward the fabric (Fig.3). The coverage width is calculated as [2]

$$\text{Coverage width} = (\text{distance between nozzle and fabric}) \times \tan \delta/2$$

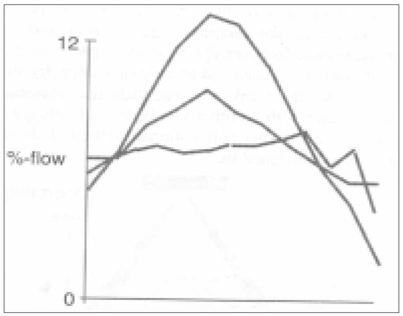

Fig. 2: Flow Distributions for a Typical Nozzle type

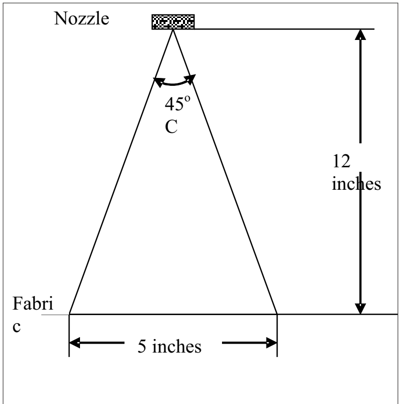

Fig. 3: 45° Fan Nozzle

If there tends to be variation in a system of components, the system is designed to average. However, if nozzles are spaced on a pipe to the average pattern width and two narrow nozzles end up side by side, a dry steak will occur. While wet streaks are undesirable, dry streaks are absolutely unaccepted. Therefore, nozzles are spaced on the narrowest width. In other words, patterns are over lapped most of the time. This is a conservation and very conventional method of shower design. Fig. 4 illustrates a full width profile of water volume application for a typical shower. This is a nominal profile with no plugged nozzles. The maximum to minimum peak vacation is over 2:1. An easy way to eliminate these peak to peak variations is to oscillate the shower. Fig. (5) illustrates the same shower except the shower is oscillated. The difference is that the peaks are "smeared" to adjacent area, so that the net variations are essentially eliminated.

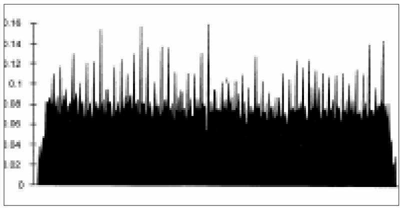

Fig 4: Shower profile for 300 inch wide shower with 45° nozzles spaced at 6 inches, ½ inch pattern overlap

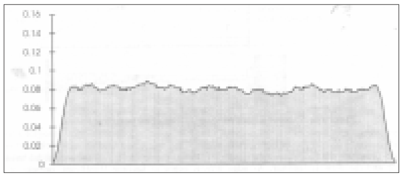

Fig. 5: Same shower as shown in figure 4, oscillated 12 inches

Needle Jet Showers

Needle jet showers used water as a mean to apply power to the fabric to dislodge contaminants usually at or near the surface. The energy of stream of water can be determined from the simple relationship

$$E = \frac{1}{2}mv^2$$

where E is energy, m is mass and v is particle velocity. Local cleaning is determined by instantaneous energy. Energy over time is power P, and can be calculated as

$$P = \frac{1}{2}mv^2$$

For a given orifice, with fixed diameter, the operational parameters that determine both mass flow and velocity to pressure.

Fig. (6) shows the four zones of needle jet. Just as the stream leaves the nozzle, the stream is clear & the flow is laminar. As edge effects begin to become significant, turbulence is introduced into the stream and the velocity profile becomes more uneven. The stream begins to contract in the second zone. In the third zone, air begins to mix with the water and the flow becomes two phase, but still remains concentrated. Eventually, in the last zone the flow begins to disperse and the jet becomes ineffective. Experiments have shown that the most effective point of cleaning is between zone 2 and 3, after the jet has contracted but before it is dispersed, and while the flow is in two phase. It is very interesting that laminar high pressure showering is relatively inefficient. Particle collisions as droplets of water strike the fabric apparently play a large role in cleaning effectiveness.[3]

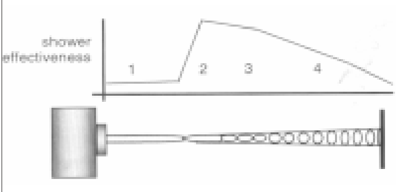

Fig. 6: Shower effectiveness vs. distance from the fabric

For practical purpose, the above translate to an optimum placement of a high pressure showers from 6 to 14 inches from the outside surface of fabric. Nozzle quality has a large effect on the jet character. A poor or worn nozzle will have a very short laminar zone and flow will disperse immediately. Condition of nozzle can be judged by looking the stream. If flow disperses immediately, nozzles should be replaced.

The application of power with a high pressure water stream is an effective way to clean a fabric. But, if needle jet is directed at a fabric for long enough duration and at high enough pressure, it will destroy the fabric. While it is optimum to oscillate fan showers, it is absolutely imperative that needle jet showers must be oscillated. Sometimes to reduce damage, especially for more delicate fabrics, needle jets are placed very close to the fabric. It eliminates fabric damage, but it also probably greatly reduces cleaning.

Oscillation of showers

Since needle jets work in a much localized areas of the fabric, therefore shower must move back and forth across the fabric so that the cleaning is performed over the whole area.

To optimize profile, cleaning must be done evenly over the whole fabric face. This is accomplished by mobbing the shower at a speed such that it moves one nozzle diameter for every felt revolution. Also, at the end of the oscillator stroke, turn around must be instantaneous to avoid over cleaned streaks in the fabric resulting from turn. Dwell proper oscillator speed can be calculated as

$$\text{Oscillator speed} = \frac{\text{(Machines speed x nozzle diameter)}}{\text{Fabric length}}$$

Press Fabric Dewatering

For proper functioning of press felt, the water added through showers must be removed form a fabric and maintain steady state moisture content. The water must be sucked out from press fabric with the whole box or suction box.

The amount of water removed from a felt greatly depends on the length of time of fabric is exposed to vacuum, the dwell time, which is calculated as

$$\text{Dwell time} = \frac{\text{5 x no. of slots x slot width}}{\text{Machine speed}}$$

The air flow can be determined by expression

$$V = \frac{(0.069)\,\Delta P^{(0.476)} .\, t_d^{(0.11)} \text{ x } (\text{perm})^{0.916}}{M_{p1}^{(0.628)}}$$

Where

V = airflow in act m/in^2 of slot area

ΔP = vacuum in inch Mg

t_d = dwell time (ms)

perm = felt permeability in cfm/ft^2 at 1/2 inch WC.

m_{p1} = felt water content before suction box (lb. water /lb. felt)

Usually, a dwell time of 4 ms is adequate except for very fast machines where excessive slot width would be requested or for very open felts where airflow would be excessive. The value is about 3 ms.

The prime factor determining the dewatering effectiveness for suction box cover design is dwell time. There are operational considerations for slot width, such as propensity for felt damage (narrow slots are better), but dewatering is determined by slot dwell time, and dwell time alone.

Chemical cleaning of press fabrics

The purpose of chemical fabric cleaning or conditioning program is to complement the efforts of the mechanical devices such as showers and vacuum boxes. [4]

For chemical cleaning of press fabric it is necessary to identify the primary contaminants that cause felt filling. The

Table 1: Typical felt analysis with contaminants by paper grades

Paper Grade	% Solvent Extractables	Infrared Scan of Solvent Extractable compounds	% Alkaline Extractables	% Ash	Primary Ash Compounds
Newsprint	3 to 10	Fatty Ester, Abietic Acid Salt, Fatty Acid	4 to 9	1 to 2	Excess Alum, Talc
Unbleached Kraft	1 to 2	Abietic Acid Ester, Secondary Amide	5 to 7	1 to 3	Hardness Salt, Clay, Silt
Fine Paper	1 to 3	Abietic Acid, Ester	2 to 11	2 to 13	Clay, Titanium
Uncoated Publication	2 to 4	Abietic Acid, Ester	4 to 7	1 to 2	Excess Alum, Clay
Corrugated Medium	1 to 2	Abietic Acid, Ester	1 to 4	2 to 5	Calcium Salts, Clay, Silt
Secondary Fiber	3 to 5	Hydrocarbon, Fatty Ester, SBR, PVAc, Amide	3 to 8	3 to 7	Clay, TiO_2, Calcium

chemistry and mechanism chosen for product selection and application technology in a fabric cleaning and conditioning program are based on the contaminants identified the degree of contaminants loading and the primary location of contaminants. [5] Generally four basic classes of contaminants found in the felts are

- Fibre and filler: alum, clay, TiO_2, talc, cellulose, fines and pick out materials.
- Organic Material: pitch, tar, oil, grease, asphalt, wax, plastic, hot melts and stickies.
- Solvent and heat set cooling: latexes, SBR & PVAc.
- Sizing agents: resin, ASA, AKD and wet strength resin.

The contaminant quantity and type vary depending on paper grade, fluctuation in wet end chemistry, surface composition, water quality and press section operating conditions. Increased use of recycle fiber results in more felt filling, fabric, roll and surface deposits made of stickies, hot melts, waxes and plastic. Table 1 lists typical contaminants by paper grade.

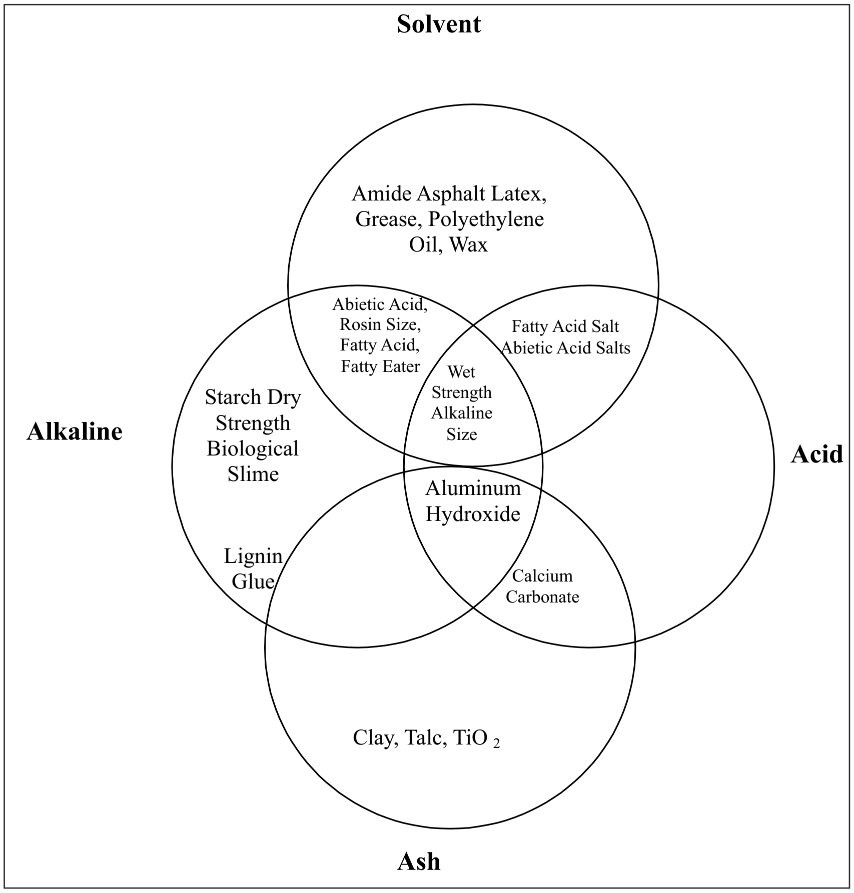

Fig 6: Solubility of typical felt contaminants

Fig. 6 shows organic contaminants typically found in felts that are classified as acids, alkaline or solvent extractables.

The basic chemical mechanism used by the majority of felt conditioning products is discussed below. Quite often the product will incorporate a blend of chemicals that employs a combination of the mechanism as a part of the treatment strategy.

The following chemistry mechanism can be used by felt conditioning products:

Wetting (Surfactants)-

Employs use of surface active agents. By adding agent to water it causes it to penetrate or spread over the surface of a deposit more easily by reducing the surface tension of water.

Surface Tension Reduction (Surfactants)

When a surface active agent is added to water, it reduces the attractive force exerted by the molecule below the surface upon those at the surface/air interface. This reduces the water's normal resistance to flow. This allows the felt to pick up more water from the sheet and to release more at the nip and uhle box.

Emulsification (Surfactants)

Non-water soluble contaminants (wax, oil, etc.) are suspended as fine particles in water where they can be flushed away from the press felts. Majority of felt conditioning products form oil-on-water emulsions.

Solubilization (Hydrocarbon solvents, caustic, acid, water)

These materials, when added to water or used next, dissolve certain solids and liquid contaminants so they can be more easily removed from the felt. Note that different contaminants require different solvents or combination of solvents for complete removal.

Passivation (Surfactants, polymers)-

Materials that absorb into contaminants and fabric surface to provide a protective layer that impedes the contaminant from further agglomeration or it's ability to adhere to fabric.

The general solubility's of typical felt contaminants were shown in Fig.6. Some contaminants are soluble in more than one type of material. A contaminant normally does not have to be completely soluble in a material in order for it to pass through or be removed from a felt structure. The mechanical showering and action of the press section often helps remove contaminants from the felts. The most effective way to remove contaminants that are soluble in more than one type of material is to use a chemical product that is a combination of those different types of materials.

It is very important that the speciality chemical supplier have a thorough understanding of how chemicals impact fabric material. The most common types of fibers used in the manufacturing of paper machine press fabrics are nylon derivatives. Forming and dryer fabrics are generally made of polyester materials.

Conclusion

With the increase in production capacity, demand for machine efficiency has become more important. This has increased the need for steady state fabric condition for which fabric conditioning system needs be properly designed and rigorously maintained. All showers should be optimized fabric condition and ultimately control sheet profile. Shower type should be selected to best accommodate the economic use of water.

The chemical cleaning of press fabric should be implemented only after optimization of process and mechanical parameters. The analysis of type of contaminant is very much essential before the selection of felt cleaning chemicals.

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