Sustainable Solutions to Secondary Fiber Related Runnability Problems on Modern Paper & Board Machines

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Introduction

A unique convergence of business drivers is taking place in the Indian Paper Industry; increasing recycled fiber utilization, neutral/alkaline paper making, modernization & higher speeds, increasing energy costs, fresh water supply, tightening environmental restrictions, and increasingly stringent sheet quality requirements. All of these issues have been in play in our industry globally for many years but only in India, and perhaps China, do they seem to be occurring all at once.

Navigating this convergence is challenging and increasingly requires a more rigorous and comprehensive approach to problem solving and process management. Sustainable solutions require the papermaker to utilize not only his company resources but also his suppliers and other outside resources to adopt a more comprehensive, data driven, problem solving, approach that considers the interactions and dependencies between all parts of the process.

This paper will address some of problems arising on the papermachine from those key trends, some potential solutions, and a methodology for moving past the "quick fix" to sustainable solutions. I will not attempt to present extensive market data or case histories here but instead wish to propose a mindset and utilization of resources for achieving sustainable solutions for some of the papermaking problems we face.

Current Furnish & Papermaking Trends

Increasing domestic demand for paper and board, regional competition, limited indigenous fiber supply, and the high cost of imported virgin fibers leave us no choice but to use increasing quantities of recycled or "secondary" fiber. While the fraction of recycled fiber (RCF) is increasing the quality of the domestic and imported recycled fiber is in a downward spiral due to increased recycling rates globally. With increased recycling we see a mixture of different wood species, decreasing fiber length, increasing fines and "filler" content making stock preparation and papermaking more challenging.

As if this doesn't present enough challenges, at the same time we are pushing machine speeds to previously unimaginable levels, greatly increasing productivity (MTPD/m), our customers have also upgraded to more demanding high speed printing and converting operations, and our boxes have to maintain their strength with less fiber and double as an advertising platform! Finally, in addition to the economic challenges of having to make our product cheaper, faster, and better, we have a social and environmental responsibility to do it with a lower specific energy consumption, use less fresh water, and discharge fewer pollutants into our air and rivers.

Key Problems

Fiber Substitution & Filler Management: \

Increased ash content presents a number of problems to the papermaker. This recycled filler is typically a mixture of clay, talcum, chalk/GCC, and PCC depending on the wastepaper used. It is generally inferior to fresh filler in terms of its optical properties, or at the very least more variable. In addition its surface is "clogged" with a variety of papermaking materials making it very difficult to retain. This forces increased "fresh filler" loading to achieve required brightness, whiteness, shade, opacity, and smoothness at the expense of strength, bulk, and stiffness. Significant advances in stock preparation equipment, processes, and chemistry continue but even with these technology advances we are faced with an increasing need for better retention chemistry and dry strength additives.

Drainage, Pressing & Drying Efficiency:

Our equipment suppliers are providing a wonderful array of evolutionary improvements to a process that is fundamentally unchanged in well over 100 years. Clothing suppliers continue to innovate with new and better designs and materials. While these mechanical and operational advances are considerable we still have furnish that is more difficult to drain with higher fines and filler content. The result is that our retention and drainage chemical programs have to work harder and produce predictable and controllable results with aging as well as modern equipment designs and materials.

Contaminant Control:

Whether producing Printing & Writing, Newsprint, Cartonboard, or Containerboard the level and array of contaminants we must deal with is greater than ever. Indeed the "perfect storm" can occur in an integrated mill where "virgin pitch" (extractables) meet up with deinked pulp, coated broke, calcium carbonate filler at alkaline pH, and process fresh water consumption of $<10m^3$/tonne! This leads to a variety of primary and secondary stickies problems resulting in machine deposits and sheet contamination that result in quality rejections for "dirt", holes, and sheet breaks.

In addition to "stickies", problems with microbial contamination are generally more severe. Higher nutrient levels from starch in wastepaper, higher

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nutrient levels from more closed water systems, and neutral/alkaline pH create a perfect environment for bacterial growth. These process conditions also create an ideal environment for the growth of filamentous bacteria entering with the fresh water which can be particularly troublesome and contribute to severe microbial slime contamination, sheet contamination, holes, and breaks.

"Hard Scales" resulting from high inorganic loading from fillers and closed systems can cause considerable increases in energy consumption in vacuum pumps, equipment wear, and plugging or "choking" of drainage elements and suction rolls. Recycled and fresh fillers also contribute to building a deposit matrix on surfaces and in the headbox approach flow that require considerably more time and aggressive mechanical and chemical measures to remove.

Key Costs

We normally think of "costs" in economic terms, Rupees we had to spend or profits unrealized. These are examples of tangible measures we use to measure the consequences of action or inaction on a particular issue.
Papermaking costs from increased use of recycled fiber fall into the typical "buckets" of raw materials such as fiber, energy, fillers, clothing, labor and chemicals but we also need to consider operating and capital costs, particularly when investment in new or upgraded equipment or machine clothing can yield substantial ROI. Let us also not forget both the short and long term economic consequences of high fresh water usage, or poor environmental performance and compliance.

Two major areas of opportunity for cost reductions are optimizing fiber mix and increased filler substitution. For writing-printing producers DIP usage might yield \$300-\$400/tonne in fiber cost savings and filler substitution in the range of \$5-20/tonne. For the boardmaker the calculation is quite a bit more complex but savings from fiber and filler substitution are significant and energy cost savings even more so.

This is a complex topic, the major incremental savings are relatively straightforward to achieve, but we cannot afford to quit here because significant additional cost savings of hundreds of Rupees/tonne can be achieved in many areas.

The papermaking cost model is complex and every machine and grade is different, in some cases profoundly so. The key point is that in order to capture incremental savings you have to have a good process cost model for the paper machine that allows you a more comprehensive look at the net effect of changes, conduct modeling, and examine "what-if" scenarios.

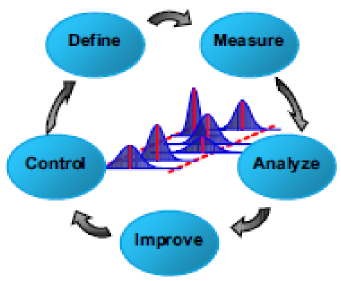
The real crux of the situation frequently seems to be that don't feel we can marshal and focus sufficient internal resources to realize potential savings. It just seems too hard, too complex, or too time consuming. This is where utilizing a disciplined approach and utilizing all available resources can reap substantial benefits.

Problem Solving Teams and Disciplined Problem Solving

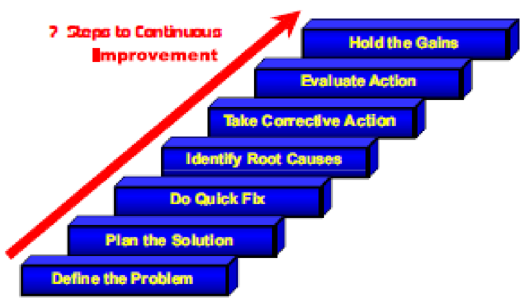
As papermakers we have a wealth of resources available to us if we utilize them effectively. Suppliers are perhaps too often thought of more in terms of entities concerned with short-term sales vs. allies in problem solving initiatives and implementing sustainable solutions. There are a number of suppliers with excellent technical resources having broad experience and expertise that are available for "free" or on a contract basis if we utilize them properly. Even non-technical sales representatives should have access to valuable benchmarking and reference information. The key is to identify a primary, preferred, or even sole supplier that meets your needs in each area or across multiple applications and develop a close, long term working relationship with them to achieve the best returns.

The pressures of the modern production environment sometimes result in adversarial relationships between production and other departments due to competing agendas and misalignment of goals that sometimes get in the way of effective problem solving. As papermakers if we organize these resources properly, along with key supplier resources, into a problem solving team with a defined mission and goals, with appropriate recognition, rewards, support, and leadership, we can quickly achieve measureable results. There are many fine resources available that discuss building teams and getting results, we have a "Team Effectiveness Handbook" that was developed internally from many different sources that we find to be quite effective.

Once the team is formed it needs a process to break down complex problems into root causes, plan and implement effective, sustainable solutions. There are many different methodologies that can be effective but the "6-Sigma" process and our "Seven Steps Problem Solving Guide", developed from the works of Deming, Juran, and Crosby, are two that I've seen



"Six Sigma" "DMAIC" Process Model



Nalco "7 Steps Problem Solving Process"

to be particularly effective.

The important point is to follow a process, that is proven to be effective, but not to get unnecessarily "bogged down" in it. The best way to get started is to appoint a "Chairperson" who is senior enough and has enough management "clout" to lead the team and focus resources in a way that everyone knows that "this is serious". Second you need an experienced and skilled facilitator to guide the team through the process. It sounds "complicated" and "hard" but it doesn't have to be, start small, with "bite size" problems, measure results, recognize and reward achievement, and you are well on your way to realizing significant cost savings and making everyone's life easier.

Potential Solutions

The thing that we love and hate about papermaking is that it is a complex web of mechanical, operational, and chemical ("MOC") interactions. Let's focus on the papermachine and some of the typical problems we face with utilization of recycled fiber.

Wastepaper quality and stock preparation play a key role in the type and level of contaminants that reach the paper machine. The fiber length, fiber length distribution, ash content, primary stickies, and soluble contaminants we receive to the paper machine is driven by wastepaper quality, mix, and stock preparation. In the following sections are some of the common problems and examples of sustainable solutions.

Particle Size Management and Retention:

Stickies (primary, secondary, & soluble) reaching high density storage plug flow towers tend not to agglomerate further due to limited mobility and opportunity to collide with each other. At this point the stock may look free of stickies, handsheets look "clean", brightness is acceptable, and stickies number and size is manageable. However, dilution to low consistency with papermachine white water, and subsequent mixing with other furnish components, and additives can result in various temperature, pH, and chemistry related "shocks" that result in agglomeration of stickies. This agglomeration often starts at the blending or machine chest and frequently becomes dramatically worse in the paper machine short circulation. The problem created is wire & felt filling, sheet contamination, holes, and breaks from stickies formed in the sheet and those that transfer from the sheet to rolls and fabrics then back to the sheet.

There are two strategies to employ here. The first is management of particle size in the thick stock and stickies passivation. This is typically a combination of a "fixative" to attach small stickies to the fiber, mineral detackifiers (talcum, proprietary formulations), and surfactant/ dispersant chemistries to minimize the tendency for stickies to agglomerate. In severe cases all three applications will be required while in some systems simple fixation is sufficient. The second, assuming you don't have a very "open" machine where your forming section is acting as a washer, is to maximize retention, particularly fines and filler retention. The reason for this is that the concentration of stickies on the machine will be highest in the backwater. These small particles, fines, and filler are the most difficult to retain, particularly in light weight sheets and even more so as conductivity increases and with fiber whose surface may be clogged with contaminants. For example, if you have a sheet with 20% ash content and 50% first pass ash retention (FPAR) the concentration of fillers and other "small stuff" will be 40%+ in the short circulation. This typically manifests itself as agglomeration of stickies in the short circulation.

So the key here is to keep the stickies small, try to make them less sticky, and minimize their opportunity to agglomerate by immobilizing them on fiber and retaining them in the sheet. It's a proven concept but the key is finding the proper chemistry and application for each machine.

Purge Points & Kidneys:

One of the most critical things to understand on each machine is the water balance, where to purge contaminants and where to recycle them. For example, the machine save-all is a "kidney" of sorts, its job is to remove solids from the excess white water. Drum, Poly Disc Filters (PDF), and Dissolved Air Flotation Units (DAF) all achieve this with varying degrees of success with the DAF units generally being the most efficient. Save-alls are often overlooked however and their efficiency can be poor. As a result we often end up sending more highly contaminated white water than necessary to machine showers where it plugs nozzles and accelerates wire and felt plugging or back to stock prep where the contaminants have an opportunity to agglomerate with fresh stickies and fresh pitch and come right back to the machine.

Another area for close attention is in the press section. The press felt acts as a filter and any contaminants that are in the water pressed from the sheet or that transfer to the surface of the felt eventually end up in either the press water pit or uhle box seal pits. This is often some of the most highly contaminated water on the machine yet it frequently is returned to the couch pit or machine white water chest! To make matters worse, during felt cleaning cycles where the goal is to remove contaminants from the felts, this water continues to be returned to the machine. Unless special steps are taken we should take advantage of this purge point and sewer this water on most machines.

The key point here is to pay attention to the water and stickies balance and take advantage of opportunities to purge the system or clarify the water before re-use. Attempts have been made to use reverse osmosis (RO) or ultrafiltration (UF) for supplemental removal but to date these technologies have proven too costly.

Retention & Drainage:

RCF based furnish typically displays more variability in drainage due to variability in fiber length distribution, fines, and filler content. These characteristics also result in variation in retention, particularly FPAR, resulting in sheet quality variation (e.g. brightness variation in DIP newsprint), forming section drainage variation, and press dewatering problems.

This is one of the most critical programs to get right and proper application is even more important than chemistry. Improved understanding of the importance of chemical mixing has resulted in developments of technologies such as Nalco's PARETO™ system that delivers chemical, water, and energy savings. New and novel methods for increasing filler retention and filler loading are also being developed and showing excellent results.

The retention aid program should focus on controlling backwater (white water) solids is a key strategy for controlling stickies and stabilizing machine operation. On-line measurement and control equipment is readily available today to control retention aid dosage to minimize variation.

Microbial Deposit Control:

Microbial contamination in systems running at neutral to alkaline pH is far more severe than at acid pH. Close attention to microbial control by selecting the proper treatment program for not just the machine system but also the fresh water and additive systems is required. Microbial fouling of machine surfaces will result in sheet contamination, holes, breaks, felt plugging, shower plugging, and corrosion problems. The pH itself promotes bacterial growth and the increased supply of nutrients from recycled fiber, such as starch, provides an ideal growth environment.

Particular attention needs to be paid to fresh water treatment. The fresh water is normally the major source of filamentous bacteria which are particularly troublesome in forming high volume slime masses in neutral/alkaline systems. These organisms are particularly difficult to treat and require consistent application of an oxidizing biocide program coupled with consistent fresh water clarification. Effective kill with chlorine for example generally requires a minimum contact time of 30 minutes, with 0.5ppm or greater free chlorine residual. I cannot overemphasize the importance of implementing effective fresh water treatment and consistent monitoring and control. Once these organisms enter the papermachine and additive systems they are nearly impossible to kill at any cost. Effective fresh water treatment is essential for minimizing on machine treatment costs, minimizing boilout frequency and minimizing total cost of microbial control.

Specialized oxidizing biocide programs have been developed for neutral/alkaline systems and new monitoring tools, such as Nalco's on-line OxiPRO™ monitoring system provide real-time feedback on program performance and predictive information for when a boilout will be required.

A regular boilout program is a best practice with more frequent boilouts required for systems running RCF at neutral alkaline pH. Typically a thorough boilout will be required every 60 - 90 days and in some systems alkaline and acid boilouts should be alternated. Consult with your deposit control supplier for the proper program design for your system.

Strength Additives:

With utilization of RCF, reduction in basis weights, and increasing filler loading we are increasingly pushing the limits of sheet strength required for "survivability" in the papermaking process, converting, and end use. Traditionally starch has served us well but availability of quality starches, cost, environmental concerns (BOD), and effects on wet end chemistry, and opacity is resulting in increasing limitations. Increasing mill closure and utilization of large amounts of alum with neutral rosin sizing can severely effect wet end starch retention necessitating the usage of more expensive, higher "DS" ("Degree of Substitution"), higher cationic charge starches, in order to retain the starch on fiber.

The use of dry strength agents in recycled board has gained increasing popularity for strength development. Some of the newer offerings are delivering not only strength but also forming section drainage improvements, improved press dewatering, and increased machine speed in both board and fine paper grades, particularly on shoe press equipped machines.

Scale Control:

Systems utilizing RCF or making alkaline papers using GCC or PCC will encounter increasing problems with calcium carbonate based scales. These hard scales will build up in suction rolls reducing water handling capability, and in vacuum pumps resulting in reduced capacity and higher energy consumption. In addition anaerobic corrosion under these scale deposits can compromise the structure of expensive rolls. Scale and corrosion control programs for suction rolls, particularly the couch roll should be utilized and vacuum pump scale control programs can yield significant energy savings.

Wire Showering and Barrier Treatments:

Wire suppliers continue to evolve their wire designs to more effectively deal with recycled furnish. However, even with these new designs the importance of proper mechanical showering and shower maintenance cannot be understated. Proper shower design and regular replacement of nozzles before they are worn out will not only minimize fresh water usage but minimize contaminant build up in the forming fabrics. Temperature and pH of the shower water should be the same as that of the process to avoid temperature and chemical shocks.

On some machines mechanical showering is not enough and chemical treatments are required. Several formulations are available but the more successful ones generally employ a cationic polymer that coats the wire forming a repulsive and sacrificial layer to minimize stickies buildup. It is critical that these materials be applied uniformly through a minimum of a 100% overlap coverage fan type chemical application shower. These programs fail more often than not due to poor application as opposed to ineffective chemistry.

In cases where wire deposition is a continuing problem the installation of a fan type application shower for a caustic based surfactant, solvent wire cleaning solution during shutdowns is particularly beneficial. The rate of deposit buildup on any surface is generally exponential, dirty surfaces, be they forming fabrics, press felts, or dryer screens, get dirty faster than clean ones.

Felt Cleaning and Conditioning:

Chemical program selection is very dependent on the grades being produced, furnish, press clothing, and press design. Chemical programs are mostly focused on contaminant removal but use of "barrier chemistry" in the press section can also be a viable strategy for some machines. Proper mechanical showering, as discussed above, is the papermakers best friend. "Proper" showering minimizes fresh water usage and clothing damage, while maximizing cleaning efficiency and water handling capacity of the press clothing. By working closely with your clothing supplier and your chemical supplier and conducting routine press audits and felt analysis you can fine tune your clothing design and cleaning programs to maximum benefit.

Roll Treatment:

"Press picking" and draw variation can be severe on machines with un-felted presses and center rolls leading to holes, breaks, and linting & dusting problems due to loose material on the sheet surface. Draw variation due to drainage variation can be minimized through proper application of a retention & drainage program and control of backwater solids. Draw variation in the press is due to changes in adhesion between the sheet and the roll because of changes in the characteristics of the roll surface. CD moisture profile in the nip, proper doctor design and maintenance, and proper doctor lubrication/flushing (wet doctors) and modern double doctors, with double showers on center rolls are key issues.

Application of solvent, surfactant, and/or cationic barrier chemistries to wet doctors and center rolls play a key role in keeping the surface open and clean to minimize adhesion of the sheet to the roll and thereby minimize picking and reduce draw. These are generally quite low cost and very high return programs when properly applied.

Dryer Fabric Cleaning:

The benefits of keeping dryer fabrics free clean of fines, grease and oil to minimize sheet contamination and energy consumption are pretty well established. Use of recycled fiber only increases the importance of keeping dryer screens, rolls (particularly sheet side rolls) and dryers clean to minimize dryer section contamination, holes, breaks, and to maximize heat transfer and minimize energy usage. This is particularly critical in the first 3 to 4 dryer groups, even on machines with a "uni-run" first section. Dirty dryer fabrics result in higher initial dryer section surface temperatures and a steeper ramp up in sheet temperature all of which result in greater potential for deposition and problems.

Installation of fixed chemical application showers to apply either chemical solution spray or foam during shutdowns is a best practice. It is important to work with your dryer fabric and chemical suppliers to select the proper formulation and application rates for your machine.

Execute

The convergence of a number of key industry trends all at once in India presents some unique challenges. Fortunately many of these business drivers have been or are being dealt with successfully in other markets so a good deal of the technology and best practices already exist and only need to be adapted to the Indian context. What remains is to effectively utilize available resources, through well-led teams, utilizing established problem solving and process management tools, to effectively utilize recycled fiber and maximize its potential cost advantages.