

PAPER MACHINES OF TOMORROW: DRYING TO SPEED

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**LEADING EXPERTS ON PAPER MACHINE DRYING SYSTEMS AND CLOTHING
MAKE PREDICTIONS AND VOICE OPINIONS ABOUT CONDITIONS AND OBSTACLES
ASSOCIATED WITH DOUBLING THE SPEED OF THE PAPER MACHINE.**

CONTINUING WITH *TAPPI JOURNAL*'s ODYSSEY into tomorrow, this article focuses on the dryer section of the paper machine. Previous Technology Spotlight articles appear in the January (machine overview), February (stock preparation), March (process control), April (headboxes and forming sections) and June (press section) issues.

Dryer system experts who responded to the questions include Gregory L. Wedel, Director, Product Management, Beloit Corp.; Frederic C. Elbert, Director of Engineering, GL&V, Black Clawson-Kennedy; Jon Hamaker, Director of Technology, Deublin Co.; Thomas A. Gardner, President, Gardner Systems Corp.; Al Hurd, Operations Manager, JHK Systems, Inc.; Jeffrey Monroe, Chief Operating Officer, and David Hall, Technical Director, The Johnson Corp.; Mark D. Longacre, President, Marsden, Inc.; Dennis Timmel, Vice President, Thermo Wisconsin; and Jyrki Jaakkola, Product Manager, Printing & Writing, Valmet Corp.

A related sidebar offers the opinions stated by paper machine clothing experts.

TAPPI JOURNAL: *Are current dryers capable of being dynamically balanced for machine speeds of 10,000 – 12,000 ft/min?*

Beloit: Yes, paper dryers are capable of being dynamically balanced for high machine speeds. Paper dryers are of sufficient diameter to be considered rigid rolls. That is, they do not experience the center-plane whipping associated with "slender" fabric and paper rolls. This makes balancing of paper dryers much easier than paper rolls. Paper dryers are normally balanced to ISO 1930 G2.5 or G1.0 specification. The amount of imbalance allowed by this standard decreases with increasing speed. Precision balancing must be used, but this is within current capabilities.

Deublin: The clearance between the siphon shoe and dryer shell is critical to condensate evaluation. This critical gap might be severely impacted by an imbalanced dryer can. In fact, the issue of imbalance is important at any speed. At high speeds, the industry is considering the use of CARB (compact angular roller bearings).

Gardner: Balancing cast iron rolls at speeds of 10,000-12,000 ft/min. is not the problem. The problem is the tensile stress in the shell as a result of centripetal force. The theoretical safe limit for cast iron used to be 6000 ft/min. surface speed. The stress increases with the square of the speed.

GL&V: Yes, machines that are candidates for speed increases in this range are manufactured with machined inside dryer diameters. This means there is a relatively small source of imbalance. These dryers could be rebalanced for higher speeds.

Johnson: Higher speeds are a challenge to any papermaker, particularly to retrofitted machines. So, a configuration, which balances the length of the single-tier section with the drying capacity requirements of the machine, is essential. Single-tier sections of the future should be as long as possible without compromising drying capacity. Single-tier dryers make sense because they reduce sheet breaks and unscheduled down time, compared with the traditional top and bottom dryer cans with an open draw. The paradox of single-tier dryers in the wet end is on one hand they assure runnability; but on the other, single tier dryers can limit the drying capacity of the machine. By adding turbulator bars drying capacity can be increased and single tier sections can be even longer.

In looking at the big picture, dryers can only be truly maximized at high machine speeds through on-line monitoring, troubleshooting, and diagnostics at the dryer section. Once this happens, optimal runnability will occur because of self-corrections during the drying process. Real-time diagnostics at the dryer section will measure critical dryer performance variables, resulting in a big improvement in dryer operation, sheet quality and energy use. Accurate control of drying through simulations, troubleshooting and predictive modeling will become routine.

Thermo Wisconsin: Theoretically yes, but at this time the cost cannot justify such a system. At the present time, there is no practical field experience for speeds this high, and 6000 ft/min. seems to be the upper limit of acceptable dryer performance.

TJ: *Are steam-filled dryer cans the best way to transfer heat to the sheet for drying, or are there other alternative technologies?*

Beloit: There are a number of alternative drying technologies on the horizon, but the steam-heated cylinders will continue to play an important role in the drying of paper for the foreseeable future. Even with the predicted advances in pressing (impulse drying, HTP systems, and flash pressing), the energy costs for drying will remain a significant contributor to the overall cost of paper production. Steam is produced at low cost as a by-product in many co-generation mills. This makes the use of steam a very economical alternative for the bulk of drying requirements. These low energy costs also ensure that steam cylinders will retain their position in the paper machine for some time to come.

There are, however, several auxiliary systems that will be required with these dryers. These include single-tier configurations, air impingement systems, new fabric designs, and high-tension fabric support systems.

Deublin: Inductive, infrared and microwave are other current technologies, but steam may be the least expensive and most efficient energy. Therefore, considering current technologies, steam is the best source for heating dryers.

Gardner: Steam-filled dryers are by far the best way to transfer heat for drying because heat transfer rates are quite high relative to other means and because steam heat costs less than a quarter of any of the other methods. In view of the huge heat requirements, even with advanced pressing methods, the cost of heat is the most important factor.

GL&V: Currently, steam-filled dryers are the most cost effective method to transfer heat into the sheet, however, some inefficiency is associated with this system. Condensate, shell material and thickness, scale, and the interface between the dryer and the sheet are all sources of heat resistance resulting in lost efficiency. Other technologies that more efficiently transfer heat into the sheet are being developed; but as far as overall operational issues are concerned, steam-heated dryers are still the most effective way to dry paper.

JHK: With the new design single-tier dryer, the efficiency of the steam filled dryers has improved. The use of the gas-fired dryer also has potential for replacing the steam dryer. When considering the overall energy cycle of a total plant, steam may very well be the best alternative.

Johnson: Steam-filled dryer cans still have a long life span in papermaking as the properties of steam are well known and understood. The direct relationship between pressure and temperature allows for adjusting the shell temperatures that directly effect sheet quality. But impulse drying, for example, has the potential to save energy and time, allowing papermakers the ability to sandwich the sheet between super-hot elements by driving a steam wave through the sheet. This means fewer dryer cylinders and less intensive maintenance requirements due to less equipment required for operation in the dryer section.

Marsden: Steam-heated cylinder dryers (cans) are used to conduct heat into the web while holding it in tension to limit shrinking. Both the cylinder temperature limitations and the web (water/fiber) to metal contact area govern heating effectiveness. After warm-up, the water in the web structure travels to the surface and evaporates at a constant rate. Farther down in the dryer section, however, there is insufficient water to keep the pores or capillaries filled, so the drying rate decreases. The web structure remains wet inside, while the outer layers are below liquid saturation. Typically this occurs when the total web moisture is 30%–35%. As a result, approximately two-thirds of a paper machine's drying cylinders are required in the falling-drying-rate section. Heat must be conducted through the insulating fiber structure and water must be transported to the outer surface. These heat and mass transfer limitations are intensified in low-density, bulky webs. Taking all these factors into consideration, evaporation rates for steam filled dryers are in the 1-5 lb/ft²/hr range. This low evaporation rate is why so many cylinders are required on paper machines.



Marsden's Two Row Gas Infrared Drying System provides one-second cool down.

When drying paper, an alternative to conduction heat transfer provided by steam-heated cylinder dryers is to utilize infrared provided by gas or electric IR systems. Infrared energy is a form of electromagnetic energy that falls between ultraviolet and microwave energy in the spectrum. Emitter temperature, emitter emissivity, paper emissivity, and the emitter surface area govern the heating effectiveness. Each modern IR system has emitters with a certain operating temperature, emissivity, and surface area. The evaporation rates for these IR systems is much higher than cylinders and is generally in the 25–50 lb/ft²/hr range. High performance IR dryers, mounted face-to-face (on opposite sides of the web) with mass transfer airbars, can produce evaporation rates exceeding 75 lb/ft²/hr.

Another benefit of infrared drying over conductive drying is the duration of the constant-rate-drying period. Infrared drying systems do not get into the falling-drying-rate period until the total web moisture is 12%–15%, as opposed to 30%–35% for the steam-heated cylinders.

Most infrared systems can also be zoned to provide cross directional moisture profile control. This capability is not available in steam-heated cylinders and can improve machine speed and paper quality, while reducing the amount of fiber required.

Early infrared systems were not very appealing to papermakers. The fire risk, reliability, and slow response of the IR emitters gave this promising technology some drawbacks. Fortunately for papermakers, the new developments in IR technology have brought instantaneously cooling and heating emitters to the marketplace. These advancements have reduced the risk of fires, reduced the recovery time following sheet breaks/stops, and improved process control.

Thermo Wisconsin: Depending upon the position of the machine, steam is good when the sheet is relatively wet. With the additional options of a combination of technologies such as infrared drying and air drying, the process could be honed for best results.

TJ: Are "blue-sky" technologies such as microwave drying and hot-air float dryers potentially feasible for paper machines in the next two years?

Beloit: No, these technologies are not likely to be used, except for very limited installations. The cost of energy for these systems can be quite high; web handling at high speed would be problematic; and limited research efforts are being directed into these areas.

Deublin: Microwave technology is every inefficient - safety would be an issue as well. No, we do not perceive any feasible technology in the next two years.

Gardner: "Blue-sky" technologies are unlikely to have any impact on paper machines at any time. In the "such as" examples, microwave is far too expensive as a heat source. As the inventor of the floater dryer, I can definitely rule it out based on web tension requirements alone and there are other problems. Floater dryers work well for drying coatings and printing inks, the original application.

GL&V: I think that there are several new drying technologies that in the future will provide alternative drying options, but I do not see these technologies emerging in the next two years as production alternatives.

We are working on a new technology project with Paprican that combines the use of large diameter dryers with two nip points and an impingement hood to more efficiently dry paper. This project will be ready for testing later this year.

JHK: The impact of such a "blue-sky" scheme on the physical properties of the product will undoubtedly take its toll on these two mentioned methods. Also, they will probably be an impact on the steam balancing of a plant.

Johnson: Microwave-dried herbs and raisins are quite common, so why couldn't this approach apply to a largely organic conglomerate material like paper? Microwave drying times do tend to be shorter at lower specific energy consumption levels. Hot air float drying has its merits, as well, particularly with coated sheets. The likelihood of either of these technologies becoming dominant in the industry will take a decade, even if they show impressive results. Another approach to be taken seriously is lower water content at the wet end, reducing the function of drying altogether. Whatever the approach, benchmarking and automatic adjustments will provide for the highest efficiency and runnability of any drying

technique, moving the focus away from machine efficiencies as a competitive advantage to superior sheet quality and value-added relationships with customers as true success drivers in the industry.

Thermo Wisconsin: New technologies are becoming available at a faster pace. In two years, combined infrared and air drying will improve the drying process and four years from now a combination of current and new technologies, yet unrealized but undoubtedly to be developed, will far surpass the performance of current systems.

Valmet: Microwave technology is not feasible due to energy costs. The base source of drying energy has to come from low cost steam. In the future we see impingement drying and Condebelt™ drying as potential possibilities.

In rebuild cases, machine length is often limited and conventional cylinder drying does not give possibilities for speed increase in a given space. Impingement drying by using JetRun™ modules is a potential alternative. In this concept, air is blown with high speed and temperature against a cylinder supported web, and remarkably, higher drying rates are reached with minimum effects to paper properties.

The other new drying technology, Condebelt™, has shown in board applications to greatly increase web strength. These technologies are expected to take some space in the market, even though the conventional cylinder drying will remain main stream.

TJ: *What are the limits to the width of current dryer cans? Do they become so thick that heat transfer is limited? Can we continue to cast dryer cans to close enough tolerances to balance them on high-speed machines?*

Beloit: The pressure vessel codes for dryers require that the dryer shell thickness increase with dryer diameter and steam pressure. The codes do not require an increase in shell thickness for wider machines. The width of paper machines reached a plateau several years ago. (Beloit built a 10.2 m wide machine in 1975 and the largest machines today are still not over 11 meters in width). The limitation in width is one of economics, not technology. The cross-sectional area of cross-machine paper machine components becomes exponentially larger as the machine width increases. These cross-machine components include forming shoes, press rolls, cross-shafts, center-shafts, cross ties, paper rolls, wire rolls, felts rolls, and calender rolls. That is, all of the expensive machine components get to be much more expensive.

Cast paper dryers have an additional limitation. High-speed machine operation will require larger dryer diam-

eters, higher fabric tensions and increased steam pressures. The resulting dryers will have thicker shells and lower heat transfer rates. The dryers will still, however, be capable of providing good thermal efficiencies. Most dryer shell castings are machined completely, inside and outside. The machining tolerances, not the casting tolerances, dictate the accuracy of the finished dryer shells. It is also possible to fabricate paper dryers from steel plate, if the foundry capacity is inadequate for the sizes required. Current Yankee and MG drying cylinders are cast to diameters of over 6.7 m and operate at speeds over 2100 m/min. The limit of the drying capabilities of steam-heated cylinders for paper has not been reached.

Deublin: It is a structural issue. We believe the dryer wall may indeed become too thick and impair heat transfer. No, we do not believe that dryer cans can be cast to close enough tolerances to balance them on high-speed machines. We believe the inside and outside diameters must be machined.

Gardner: The conductivity of cast iron is 70 times that of stagnant water. The shell heat transfer resistance of current dryers is in the range of 20% of the overall resistance. The condensate film thickness and its quiescence is the major problem as speeds increase.

GL&V: There are machines running in the range of 400 in. wide. If machines become significantly wider, then dryer design will require thicker walls with the associated loss in heat transfer. However, indications are that machines will not become much wider in the future. Since high-speed, wide dryers are machined inside and outside, balancing issues are not related to the casting process. Casting considerations include pour capacity of the foundry and pattern equipment.

JHK: If one continues to think in terms of today's conventional dryer cans, the practical width will be limited; however, the dryer can width will not be a limiting factor for paper machines, the wet end and press section will be. The dryer of the future may return to spoked dryers of the 1900s.

Johnson: Fewer cans are the way of the future with diameters up to 7 ft. Concurrently, the dryer section footprint will shrink. What's important here are the results of more compact drying, such as improved pressing with extended nip presses. Sheet moisture will be reduced as it enters the dryer section. Steam impingement drying means fewer dryer cans. No open draws will produce minimal shrinkage, opening the way for better sheet characteristics and increased production.

Thermo Wisconsin: Yes, we can continue to cast dryer cans and still maintain the tolerances. Current machine width limits are approximately 350–400 in. and the maximum width is not likely to increase much more. I believe the trend will be faster, but not wider, generally speaking.

Valmet: Dryer can wall thickness is not an issue because the main barrier to heat transfer is inside the can and between the can and the paper web. The main issue in cylinder drying at this high speed is runnability. The web tends to follow any smooth surface, such as the dryer can, and at the opening nip between can and paper, very high forces are needed to get the web to follow the dryer felt without creating bubbles.

TJ: *What are the issues with condensate removal from dryers at high speed?*

Beloit: The condensed steam ("condensate") forms a thin film around the entire inside surface of dryers that are operating above the "rimming" speed. There is virtually no turbulence in this thin film of condensate at high speed. This stagnant layer of condensate forms a significant barrier to the transfer of heat from the steam to the dryer shell. It is important for high drying rates that the condensate removal system be able to keep this layer very thin or else a system must be in place for generating sufficient turbulence in the condensate for high heat transfer.

Deublin: In many existing dryers, siphons are typically rotating. As speeds increase, the differential pressure required to evacuate the condensate rises. As a direct result of increased pressure differential, blow through rates increase as well, which may require larger piping and new or resized thermocompressors. Undersized piping could result in high pipe wear, steam dumping, wasted energy and/or wasted capital investment. In other words, at operating speeds in excess of 2500 ft/min., rotating siphon systems can lead to wasting profuse amounts of energy needlessly, simultaneously impacting runnability of the machine. The alternative to this historical thinking is the stationary siphon system proven in over 200 high-speed paper machine installations worldwide. This combination is a reliable, energy efficient and low maintenance way to remove condensate while optimizing the dryer drainage system. By nature, a stationary siphon stays in one location. The result is that condensate forces work with the siphon, not against it. Low differential pressure in the magnitude of 2–4 psi often is sufficient to evacuate the condensate through the vertical siphon tube. At high operating speeds in excess of 3000 ft/min., the stationary siphon uses the force of the rotating rim to

drive condensate out of the dryer, substantially lowering differential pressure requirements; in some cases as low as 0 psi across the joint. Papermakers can now set pressures to control temperature, not evacuation. This is particularly advantageous in the wet end dryers to — prevent picking — increase the sheet temperature slowly.

Gardner: The main issues in condensate removal become: means to reduce the residual condensate load, means to agitate the film (better spoiler bars?), and means to lower stress on stationary siphons.

GL&V: As the speed of the dryer increases effective condensate removal becomes more important. The condensate will be in rimming condition and as such acts as a barrier to heat transfer around the entire dryer. In addition to the heat transfer issue, improper evacuation of the dryer can lead to machine vibration problems that will be amplified at high speeds.

JHK: Internal pipe size and the dryer journal bore will limit the evacuation of dryers at higher speeds. Condensate rates, which are grade sensitive, will be a factor.

Johnson: The primary concern with condensate removal at any speed is to ensure it is happening. Since condensate is the greatest resistance to heat transfer, condensate removal efficiency is a key determinant to the productivity of the machine. At high speeds, issues involving differential pressure, blow-through steam and condensate levels will remain the focus of attention. Poor condensate removal results in uneven moisture profiles, cockle and wrinkling of the sheet and has a significant impact on machine runnability and overall drying capacity. Effective condensate removal is also dependent on a properly designed drainage system. The newest technology in siphon design will not provide the desired results if the dryer drainage system is not performing. A well designed system will be flexible and able to adapt to grade changes, allow for maximum control of steam pressures, minimize steam use and maximize control of blow-through steam and differential pressures.

Thermo Wisconsin: There are so many issues that could be discussed here, you could devote an entire article to this alone! However a synopsis of the main issues of high speed condensate removal are sheet quality problems, possible damage to the equipment with resulting loss of efficiency and the undesirable release of condensate into the mill itself.

Valmet: Condensate removal from the dryers has not shown problems in high speed machines and stationary

siphons should work well as long as the steam and the condensate system are able to take the load.

TJ: Can current siphon technologies work? Are other technologies needed?

Beloit: Current siphon technologies can work, even at high speeds. In the late 1970s, concern existed that the industry would reach a limit on condensate evacuation. At that time, rotating siphons were being used in the dryer cylinders of high-speed machines. These siphons were attached to the inside surface of the dryer cylinders, with a small opening, in order to achieve the thin condensate depths needed for high heat transfer rates. The differential pressure required to evacuate the rimming condensate using rotating siphons increases with speed. At high speed, differential pressures in excess of one bar are required.

Stationary siphons could not achieve the close tolerance to the shell surface, because of the inherent mechanical instability of their long cantilevered supports. In the late 1970s spoiler bars were developed for paper dryers. These spoiler bars were fitted on the inside surface of the dryers to induce turbulence in the condensate and maintain a high heat transfer rate through the condensate layer. High turbulence could be generated, even in thick condensate layers, allowing larger, more manageable siphon clearances to be used. This, in turn, allowed the commercial return of the stationary siphons. Stationary siphons use scoops to direct the condensate out of the dryers, with very little differential pressure. Although there are several other alternative technologies, there are no inherent limitations to using stationary siphons for condensate evacuation at high machine speeds.

Deublin: Into the foreseeable future, current stationary siphon technology is suitable for not only today's applications but also as machines are sped up in the future. As paper machines are rebuilt for higher productivity, the limiting factors are probably going to be bearings, balancing, and other issues. The stationary siphon technology should be quite adequate for high-speed paper machines many years into the future.

Gardner: Stationary siphons are the only workable method at high speeds. Further work is needed with stationary siphons.

GL&V: High speed stationary siphons in theory will work even better at higher speeds since the condensate impacting against the pick up shoe actually helps with evacuation. Another important consideration is the

increasing effect of speed on the differential pressure required to evacuate condensate. With a stationary siphon, differential pressure is not required to overcome the centrifugal forces that act on the condensate since the evacuation tube is not rotating. Lower differential pressures have the benefit of lower blow through and less erosion of steam equipment. A critical consideration is the mechanical rigidity of the siphon not only to prevent failure but also to ensure consistent, proper clearance between the pickup shoe and the shell.

Johnson: A technological leap as significant as the switch from stuffing rags into the ends of dryer cans to the rotary siphon revolution will be difficult to repeat. But, much can be gained by reducing dryer flooding by converting to stationary siphons and zero-differential pressure siphons.

On rebuilt machines, converting from rotary to stationary siphons reduces dryer flooding problems and provides more consistent and reliable dryer operation. For new machines stationary siphons are particularly important when using felt driven dryer sections. By preventing dryer flooding stationary siphons minimize dryer speed variation and reduce breaks. Zero differential pressure siphons will allow the papermaker to continually evacuate the dryer can and avoid any potential flood, resulting in maximum heat transfer to the web. These siphons will allow for flexible system design and operation because of the "zero." differential pressure requirement. Changes in grades, machine speed or other operating parameters will not require changes in siphon operating characteristics. Condenser energy losses resulting from meeting siphon differential pressure requirements are eliminated and overall machine efficiency is improved.

New rotary joints will generate information like pressure measurements, flow rates, differential pressure, blow-through flow measurement on each joint will provide papermakers with the ability to identify poor performing dryer cylinders and take actions to correct the problem. Increased efficiency and reduced downtime will result from "smart" joints that can indicate the life of the internal components and inform the operator when to perform maintenance on the equipment.

In addition, full width Turbulator bars will provide uniform cross-machine drying and increase drying capacity. This is important in a rebuild, since it allows the single tier drying section to be longer. Looking beyond siphons and bars to include the overall efficiencies of your steam and condensate system can be important, too. With the right on-line monitoring system, siphon technology can be boosted considerably, based upon an operator's ability to quickly respond to a trouble spot, or

adapt the drying operation to a higher level of efficiency. Even fuzzy logic based on operator intelligence captured in software could be applied.

TJ: *Can current dryer fabrics function on a 10,000 – 12,000 ft/min. paper machine? What guidance changes will be needed?*

Beloit: Dryer fabric technology will require several advancements for high-speed operation. Dryer fabric tensions must increase in order to maintain good thermal contact between the web and the dryer cylinder surfaces at such high speeds. The fabrics must be designed to support these loads. The fabrics must also be designed to transmit the higher drive loads to the dryers through surface contact. The fabrics must have high-temperature resistance, in order to handle the increased drying rate demands of high-speed production. Felt rolls of sufficient diameter to withstand this increased tension must support the fabrics. Felt rolls will be too large to fit inside the "pockets" of most conventional dryer sections. This will require the use of alternative dryer configurations. Fabric surface construction will have to be improved, to reduce the amount of air entrainment and web disturbances. The response time of fabric guiding systems must also be improved, to avoid wear of the fabric edges.

Gardner: Stress and strain in the warp will be huge for fabrics running at 10,000-12,000 ft/min. Guidance should not be a problem but considerable physical danger, not now evident, will be a problem in the event of component failure. Imagine a heavy fabric piling up at over 100 mph after snapping due to tensile failure.

JHK: During recent years, dryer felts have been redesigned for permeability and structure to meet the demands of higher speed and tension. The major problem with dryer felts at higher speeds will be guiding and preventing catastrophic dryer wreck from dryer paper wraps.

Johnson: For new machines felt driven dryer sections equalize speed differences created by dryer diameter differences. This impacts the requirements of dryer fabrics considerably. Dryer fabrics must be of a low caliper, or flat design. This improves runnability by reducing sheet

stretching as the sheet travels around the suction turning rolls. Another factor impacting the felts is high performance chemistry at the wet end, which is already boosting drying efficiency significantly through faster dewatering. Because less evaporation is required in the dryer section, this could significantly influence dryer fabric design.

Thermo Wisconsin: Yes, current felts could function. Faster response on guidance systems will improve with computer PLC technologies, which would provide the tight tolerances needed.

TJ: *What are the issues with sheet and clothing guidance on a very fast machine?*

Beloit: Web "guidance" is a runnability issue. There is one essential requirement for high-speed web runnability - the web must be positively supported at all times. Today, this support is provided by top-felted and alternating single-tier dryer sections (for example, the Beloit BelRun™ and Bel-Champ™ dryer configurations). In the future, this support system will have to be enhanced so that, at every step, the support provided to the web is both positive and controllable. There are several configurations being introduced today that will assist with these demands.

GL&V: Sheet control becomes increasingly important as machine speeds increase. The press to dryer transfer, felt-ing, and dryer configuration all have to be considered as machine speeds increase. This includes consideration of air handling equipment. Control of sheet flutter and control of air in the pocket is key to runnability at high speeds.

Current guiding equipment is mechanically capable of operating in this speed range. Felt location sensing might require a non-contact sensor to eliminate excessive wear. Additionally the control system would require faster response time.

JHK: With higher speed comes less reaction time to prevent damage to machinery. The ability to prevent sheet test properties deterioration will be less since the time in restraint will be less.

CLOTHING MANUFACTURES CONSIDER MACHINE SPEEDS AT A “MILE A MINUTE”

PATRICIA M. PAUKSTA

WHAT DO THE PAPER MACHINE CLOTHING manufacturers think about speed and the effects on the clothing? The following representatives offer their opinions: William A. Luciano, Technical Director, Albany International; Steven C. Young, Sales Service Manager, Dryer Fabrics, Appleton Mills; Rex A. Treece, Product and Applications Manager/Team Leader, Asten; and Richard M. Harper, Applications Manager, JWI Group.

TJ: *Can current dryer felts function on a 10,000-12,000 ft/min. paper machine? What guidance changes will be needed?*

Albany: We are half way there. We have fabrics that can run at 6000 ft/min. Certainly the dryer run will be single tier, augmented with vacuum to control the sheet. We know the 6000-ft/min. fabric must have a dense, uniform, smooth surface, and it must minimize sheet stretching. And we believe the surface will be enhanced, perhaps chemically, to increase the ability of the fabric to hold the sheet. The backside is important too because it must handle air contained between it and machine elements. And the seam must be perfect or a shrinkage mark results. That takes care of structure.

But drying will be more intense at 12,000 ft/min. because auxiliary elements like hoods over dryer cylinders will shorten the length of the dryer section. These elements will challenge the thermal limits of fabrics. Furnishes will complicate the challenge. Fabric contamination and wear will accelerate. The fabrics running 6000 ft/min. today will need to be made from different materials tomorrow - materials with better thermal resistance, abrasion resistance, and contaminant resistance.

The 12,000-ft/min. dryer fabric will be an aerodynamically active structure made from superior materials to survive in a very aggressive environment.

Appleton Mills: There is no reason why dryer fabrics cannot perform at the 10,000-12,000 ft/min. level following some design and perhaps raw material changes; but that has always been the case when major technological developments have occurred. The critical performance areas will be guiding, sheet finish, sheet contact and air handling characteristics.

As to guidance changes, the speed of response will be even more critical. A transition to an optical or magnetic field type of detection/actuator is likely.

Asten: Dryer fabrics will function on a 10,000-12,000 ft/min. machine. Fine, low profile and low bulk seams will be required along with optical (non-contact) guide systems with a control bias system.

JWI: The majority of current dryer fabric designs will not be able to function on a 10,000-ft/min. paper machine! This speed implies some sort of restrained-drying dryer section. Laboratory tests have revealed accelerated fatigue rates with dryer fabrics that do not have the neutral line near the sheet side of the fabric on dryer sections of this type. Merely decreasing fabric caliper is not the answer. The dryer fabric that will perform well on a 10,000-ft/min. paper machine will have sufficient caliper to be robust with a weave pattern and yarn shape combination that places the neutral line very near the sheet side and a totally integrated seam area.

Assuming the driving force for drying is some sort of hot air drying, there is a tremendous concern about materials technology. Current polymers simply will not withstand the extreme temperatures associated with those drying methods. The highest temperature resistant material developed to date (PEEK) can withstand 400° F but has had very limited application because of economic considerations.

The other operational concern is the fabric's increased drive transmission function on modern "gearless" dryer sections. Drag loads will increase substantially with increasing speed and higher tensions will be

required to sustain sheet and fabric stability. This will require a dryer fabric to have a much higher elastic modulus.

Major material and processing technological breakthroughs must be achieved for high speed, high temperature dryer fabric application.

TJ: *What are the issues with sheet and clothing guidance on a very fast machine?*

Albany: As machine speeds pass the "mile a minute" barrier the industry has to consider non-contacting guides. We have developed fabric edges tough enough to withstand the heat and abrasion of fabrics against a guide palm. The problem is the palms often are severed and the fabric is lost and machine downtime results. Guide palm makers then develop products tougher than fabric edges. That solves one problem but creates another — the palms abrade the fabrics. Damaged edges cause raveling which leads to operational problems — stray monofilaments travelling at high speed can cause sheet breaks. Contact-less guide systems are good for any machine but are needed for high-speed machines.

Appleton Mills: Response time and air handling are the two most critical issues.

Asten: It will not be primarily a matter of sheet guidance but of sheet transfer and control. No open draws where the sheet is unsupported will be possible. Centrifugal force and sheet momentum will also be much more of an issue. If you wrap the sheet around a cylinder, the cen-

trifugal forces will try to throw the sheet off. Momentum will try to force the sheet to travel in a straight line. Dryer fabrics will play a very important role in addressing these issues.

Fabric guiding will require much more sophisticated sensors and guide control modes. The contact guide paddle/air control systems will not be fast enough to keep up. A paddle rubbing the edge of the fabric would destroy both the paddle and the fabric edge in a very short time. Multiple sensors may be required to allow the system to anticipate the fabric guiding requirements.

JWI: Most paper machine builders presently offer some sort of non-contact edge-sensing device. At 10,000 ft/min. the increased cycle times wear the dryer fabric edge very rapidly so a contact "guide palm" cannot be used.

When designed and operated properly, an automatic felt guide rarely moves — the manual portion of the guide is adjusted so that the automatic guide remains centered at all times. Given adequate angle of wrap on the guide roll, the robust stretch racks and guide mechanisms on modern paper machines now provide good guiding performance on the current premier high speed machines - and should continue to do so at the projected elevated levels. With high cycle times, an increase in guide response time will probably not be necessary.

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