TECHNOLOGY SPOTLIGHT

FOCUSING ON THE FUTURE OF PAPER MACHINES

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INDUSTRY EXPERTS DISCUSS THE FUTURE OF THE PAPERMAKING INDUSTRY

Editor's note: This year marks the beginning of TAPPI JOURNAL's series of Technology Spotlight articles, dedicated to focusing on current topics of interest for the industry as a whole. This month, we questioned several industry leaders on their opinions of the future of the paper machine. Can it be developed to run at 10,000 to 12,000 ft/min? What limitations do we face, and how easily can we move beyond these obstacles?

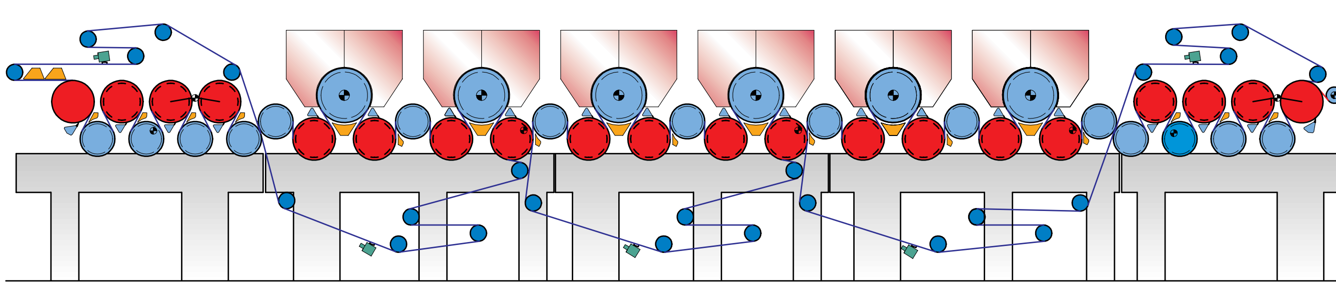
For this month's topic, we asked the opinions of Albrecht Meinecke of Voith Sulzer Papiermaschinen GmbH; Larry Chance of Beloit Corp.; and Markku Karlsson of Valmet Inc.

Each issue of the journal will introduce another subject and the opinions of different industry experts. If you are interested in contributing, or if you would like to share comments, please contact Matthew Coleman, director of publications at TAPPI, at +770 209-7250 or by email at mcoleman@tappi.org.

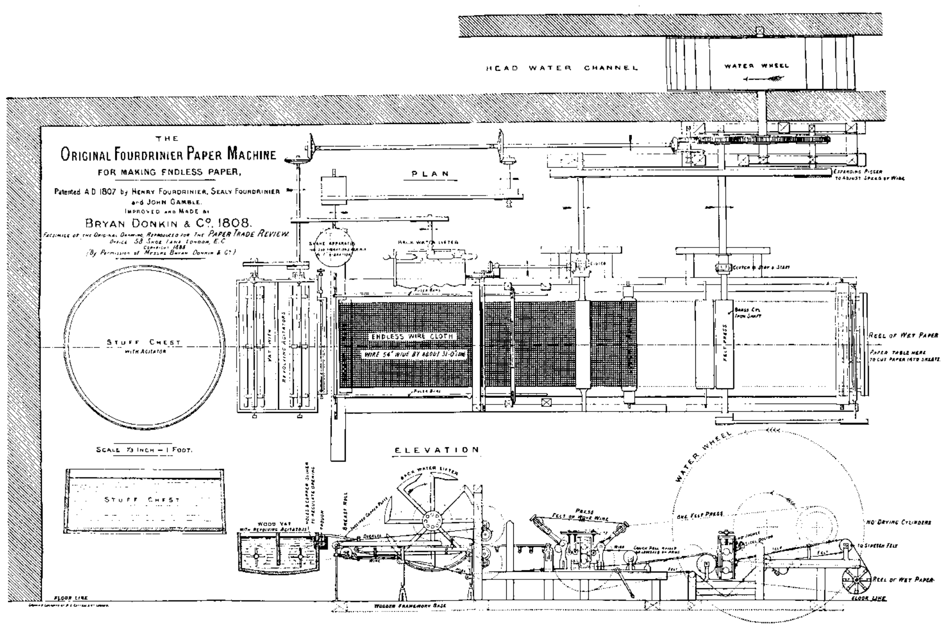
TAPPI JOURNAL: *What are the limits of paper machine speeds using the current technologies?*

Meinecke, Voith: Today, the fastest machine for printing grades runs 1700 m/min and is going for 1800 m/min. With today's technology—some changes might be necessary—2000 m/min seems possible. Tissue machines operate up to 2200 m/min (speed limited by drying capacity).

Chance, Beloit: Today, paper machines for newsprint, supercalendered, and coating raw stock are limited to speeds around 1600 to 1700 m/min (5200 to 5600 ft/min). Current problems include runnability in the wet end dryer groups and efficient sheet threading in the dry end. Modern paper machines today have no open draws in the forming section through the press, and runnability at high speed is not a big issue. In recent years, the bottleneck to higher speed has been in the dryer part. And with the advent of the single-tier, no open-draw dryer sections, runnability has been greatly enhanced. But windage and the sheet sticking to the early dryer cans can still cause edge flipping and other runnability problems at very high speeds. The new threading systems that use vacuum rolls to replace ropes have significantly improved the efficiency of threading the dryer section. But as speeds go higher and windage becomes a bigger problem, more positive threading technologies will be required.



Concept paper machine (courtesy of Valmet Corp.)



No. 17. Plan and elevation of the Fourdrinier paper-making machine of 1807, copied from the original drawing of Bryan Donkin.

Patent application, 1808, for the Donkin Fourdrinier (from "The Paper-Making Machine, Its Invention, Evolution and Development", R.H. Clapperton)

On fine paper machines, the biggest bottleneck is clearly the size press. After the sheet is rewet in the size press long open draws are provided to allow the sheet to expand. In order to run 3000+ m/min (10,000+ ft/min) there can be no open draws. So the question becomes how does one eliminate the open draw and at the same time provide means for sheet expansion after it has been rewet in the size press? That's a technical problem that needs to be solved.

Looking at packaging grades, just the length of the dryer section is a major issue in terms of capital cost. Perhaps new technologies, such as impulse drying, can dramatically reduce the length of the dryer sections.

Karlsson, Valmet: It has taken about 30 years to double the speed of today's machines. And to do so in the future would require repealing some of the laws of physics affecting such items as material properties, fluid dynamics, and heat transfer, just to name a few. For example, how fast can a damp web move? How much pulling and stretching can it stand before it breaks? Technology is one thing, but the physical properties of wet paper is another.

Current technologies can produce machine speeds up to 2000 m/min. These speeds are a result of significant recent advances in supported-web technology, shoe pressing technology, and the ability of surface treatment sections to deliver superior sheet runnability with high efficiency.

TJ: *What are the critical limit points of papermaking at high speeds? Sheet formation? Water removal at the press? Sheet breaking at web transfer points? Machine control? Drying/heat transfer?*

Meinecke, Voith: Critical limit points include the sheet run after the press section. The stress on the wet and still relatively weak web at transfer or turning points creates high elongation of the sheet (edge fluttering). This might cause more sheet breaks. A fully supported sheet run will be necessary. The controlled turbulence of the free jet of the headbox is another issue. The water removal at the press shall be solved by shoe presses. In the dryer section means have to be applied to increase heat transfer and vapor transport.

Chance, Beloit: Threading, sheet breaking at transfer points, and sheet formation are all critical issues if machine speeds are to reach 3000 m/min.

It is desirable to have a certain degree of turbulence in the headbox jet to keep the fibers well dispersed to give good formation. But if the turbulence level gets excessive the jet gets very rough and can lead to sheet defects. Since the turbulence in the jet increases with the speed squared, new forming technologies need to be developed that eliminate or minimize the web draw and stress at the transfer points in order to run efficiently at these high speeds.

Also, as the sheet travels around rolls, it is subjected to a centrifugal force, which increases with velocity squared. This force is resisted by the wet web tensile strength, which will not be sufficient at 3000+ m/min. Vacuum may be required at high speed on all paper rolls to counter this centrifugal force. New, more positive threading methods will be needed, especially in the dry end of the machine.

Drying will be a major issue in the tissue drying process, as the sheet needs to be dried in less than one revolution of the dryer cylinder. This means that at 3000+ m/min the sheet must be completely dried in about 0.25 seconds. New technologies are needed to reduce the thermal drying load to the Yankee dryer.

Karlsson, Valmet: A paper machine is a linked set of variables—change one of those variables and everything else changes as well. Also, we're dealing with a wet web of paper. There is a limit to how quickly it can be handled in each unit process.

The critical limit is high speed sheet formation with severe challenges in high speed de-watering and web runnability, particularly early in the drying section.

To double the present speed, the web must be fully supported from headbox to reel, or it will break. Technologies to do this are under systematic development and evaluation. The forces required to peel the web off a surface and change its direction are proportional to the square of the speed. There are a number of such transfer points to address on a modern paper machine. As far as forming the web at such speeds, one has to contend with the enormous volumes of pulp to de-water in a very short time. Water handling, fabric cleanliness, and ventilation all present difficulties. Controlling web properties such as formation, directionality, and streaks are also critical issues.

TJ:*What are the limits of the paper machine itself at high speeds? Bearing failure? Dynamic instability? Synchronization?*

Meinecke, Voith: Today's design of the headbox, including the material used, has to be changed basically in order to withstand the excessive increasing internal pressure. With increasing speed the diameters of paper, wire, and felt rolls have to be much larger for dynamic stability. This means also much higher costs! Online calendering with soft nips will require higher line forces and/or temperature to compensate for the shorter residence time, so new materials for the soft covers have to be developed.

Chance, Beloit: Mechanically, I do not see any problem in running these machines at 3000+ m/min. It is common for winders to run at these speeds, and so it should be no problem to produce paper machines that can run mechanically at 3000 m/min. Sheet handling in the early part of the drying section and instabilities in the paper machine process are likely to be the limiting factors.

Karlsson, Valmet: Vibration is a critical issue at high speeds and will require increasing use of new materials and designs for rotating equipment. Another issue is high internal headbox pressure required for high speeds. Doubling the speed means more than five times the pressure.

TJ: *Are there different design paradigms for paper machines that companies should consider when planning for future paper machines?*

Chance, Beloit: My opinion is that machines of the future will be designed to be much more maintenance-free, so they will be able to run longer periods of time without shut-down. There will probably be a lot more robotics on the machine for changing wires and felts and removing rolls, things like this. Of course, controls will continue to get much more sophisticated, which means a need for extra personnel will be lessened, so I think you will be able to run these machines with fewer people.

The whole process is so interdependent that you really have to size everything in the mill for these higher speeds. The pulp mill, the flow of the fibers to the machine, the stock prep system—all of this has to be sized for whatever speed you are running, so it's not just the building, it's everything. You have to ask, "Okay, am I going to make a commitment and take the risk to put in this investment that would allow me to run 3000+ m/min?" The payoff could be quite large, but will paper producers be willing to take the risk?

Karlsson, Valmet: Yes. New market and industry requirements and constraints are stimulating more focused concept development in both machine technology and in the control and service aspects of the papermaking line. New design concepts are under development focusing, for example, on the demanding requirements of the urban mill, on incorporating new fast integrated automation systems in parallel with a very low machine service burden, and on increasing effectiveness of the investment commitment.

TJ: *What are the limits to the width of the paper machine? Roll deformation? Vibration dynamics? Cross-machine quality control?*

Meinecke, Voith: Roll deflection increases in proportion to the fourth power of roll width. This means a rapid increase in wire, felt, and paper roll diameter with wider machines. The higher costs may outweigh the benefits. Also, the control of the high forces on the headbox structure will require a very costly design.

Chance, Beloit: The width of the paper machine is determined by roll deflection. As widths go much beyond 10 m, the cost of the rolls to prevent excessive deflection become cost prohibitive today. In the future, rolls made of composites may allow paper machines to be built at widths substantially greater than 10 m. Today these materials are not cost effective.

Karlsson, Valmet: Roll deflection limits paper machines wider than 10 m. Further width increases would require large investments on the part of machine builders and clothing suppliers.

TJ: *Will the sheet itself have to change? Will we need to make thinner sheets (lower basis weight/thinner caliper)? Add fillers? Add adhesives to improve the fiber bond for sheet strength on the machine?*

Meinecke, Voith: At many paper grades, the minimum basis weight,in respect to the requested quality properties,has been nearly reached—e.g., opacity, shine through, or stiffness might be the limiting factor. New types of fillers—or filler inside the fiber structure—and means for improving fiber bonding will be helpful. A good example is the use of the size press for corrugating medium out of 100% recyclable paper.

Chance, Beloit: The trend towards lower basis weights will likely continue in order to conserve fiber and reduce mailing costs. In recent years we have seen newsprint from 52 g/m^2, then to 49 g/m^2, and today most is produced at 45 g/m^2. Some machines have produced weights as low as 40 g/m^2. This drive toward lower and lower weights will result in a weaker sheet, so sheet handling at high speed will be even more critical. More fillers will be needed to improve opacity, and perhaps adhesives eventually will be required to increase the sheet strength. Sheets will be engineered for optimum sheet properties for end use. For example, thermomechanical pulp could be added to the center of the sheet for maximum bulk, or ash could be added only at the surface for printability.

Karlsson, Valmet: In the future, there will still be a tendency to reduce basis weight for all grades and to increase the use of different kinds of fillers with the specific goal of increasing total area of information surface per ton of paper.

New solutions based on bulkiness and opacity using a mixture of chemical and mechanical pulp will enable production of "lighter" paper. This will provide significant production savings at the paper mill and further savings for the end user, such as lower mailing costs.

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