Paper machine rebuilds—some technical considerations

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Papermakers burdened with outdated equipment often dream of the rebuild that will solve all their problems. Without clearly established goals and careful planning, the dream rebuild can become a nightmare.

Paper machines are rebuilt to improve product quality, increase capacity, reduce operating costs, and minimize maintenance problems. Papermakers expect rebuilds to transform their machines into the dependable, efficient systems they dream about. The reality is that rebuilds can become nightmares. Too many mills have learned that poor decisions can lead to prolonged periods of lost production and off-quality paper.

Rebuilds gone wrong

Linerboard machines

A linerboard-machine rebuild included the purchase of two hydraulic headboxes sized to accommodate "future" production rates that were much higher than were being run. The secondary sheet was so streaky that a smaller headbox had to be purchased. Rubber stoppers were installed in the primary headbox inlet to achieve good stock velocities and acceptable sheet quality. It was almost 10 years before production rates were high enough to permit removal of the rubber stoppers.

On another linerboard machine, a shoe-type press was installed as part of a rebuild. However, the mill could not take full advantage of the press because the sheet was too wet off the fourdrinier. The problem was resolved by upgrading flatbox vacuum capacity.

On yet another linerboard machine, a rebuild permitted a significant increase in machine speed, but the mill failed to upgrade the reel. Running double sets resulted in turning up the reel every 15 minutes. The mill has since installed a new reel.

Fine paper machine

During a rebuild, a fine paper machine with a fourdrinier was outfitted with a new press section that did not remove any water from the wire side of the sheet. The result was severe wire-side linting. Three other fine paper machines in the United States also have no wire-side water removal in the press section, and they all have problems with wire-side linting.

All of these problems could have been avoided by thoroughly evaluating the capabilities of the machine and new equipment before the rebuild. This article provides an overview of technical factors that must be considered to develop an effective program for a paper-machine rebuild.

I. Top machine speeds, 1970–1993

	Speed, ft/min			
Grade	1970	1980	1992	Current design
Liner	1500	2000	2600	3000
Medium	1500	2200	2700	3500
Fine paper	2300	3000	3600	4500
News	3000	3800	4500	5000

New technology

Technology developed in the last 20 years has provided significant potential to upgrade existing machines. **Table I** shows the operating speeds on the fastest machines producing major grades in the United States in 1970, 1980, and 1992. Machines started up in 1970 that have not been rebuilt obviously have a difficult time being competitive with modern machines. Even 1980-vintage machines do not have all of the equipment necessary to make top quality paper for today's market. With fewer than 200 of the 1200 paper machines operating in the United States having been started up since 1970, the potential benefits of rebuilds are enormous. **Tables II-VII** show some of the changes that have occurred in the last 20 years. Many of the items listed will be discussed in more detail. Production rate increases of up to 50% have been obtained from paper machine rebuilds. In most instances, rebuilding existing machines results in greater economic return than installing new machines.

Planning the rebuild

Effect on total mill operations

It is important to know how the machine to be rebuilt fits into total mill operations. Increased production rates will require higher fiber tonnages and may result in changes in steam demand, power consumption, water usage, and effluent treatment.

A computer program can be used to determine average performance parameters for all operating areas and major process activities in a mill. Balances are developed to determine capacities and limitations of major process equipment. Input from marketing personnel is also required so that the future grade mix can be considered. In some cases, a paper machine rebuild cannot be justified because the capital cost of obtaining additional fiber and other services is prohibitive.

Fiber. Many integrated mills are recovery-boiler limited. Under these conditions, it is usually very expensive to increase pulping capacity. In such cases, the use of secondary fiber or the purchase of market pulp may be more cost effective than increasing virgin pulping capacity. Use of secondary fiber may require installation of a new processing facility or expansion of an existing plant. In nonintegrated plants, there must be sufficient storage and pulping capacity for virgin pulp to support higher production rates.

Steam consumption. Steam consumption may not change with a paper machine rebuild if a more efficient press is installed, if the performance of the steam and condensate system is improved, or if a high-solids size press is installed. Mills also may choose to eliminate steam-powered drive turbines on fan pumps or line shafts, and this will change steam requirements. Increased steam demands may require an additional boiler. Steam-line and valve sizes can be a problem in older mills. It is often the case that production rates have been increased since the original installation, so that line velocities are extremely high. Conversion of steam and condensate systems from cascade to thermocompressor systems may require installation of a separate line from the power plant to supply high-pressure motive steam.

Power consumption. Power consumption usually goes up when a paper machine is rebuilt. Larger motors on pumps, refiners, electric drives, and additional vacuum pumps are often required. Additional substations or other changes to the electrical distribution system also may be required.

Water consumption. Water consumption usually does not change significantly following a paper machine rebuild. Many mills take advantage of the rebuild to tighten their white-water systems or reduce water consumption. Key factors are use of clarified white water on fabric showers and recirculation of seal water with liquid-ring vacuum pumps. Good white-water clarity must be maintained if white water is to be used on showers. Accordingly, effluent treatment requirements may not change significantly.

II. Stock preparation comparison

Parameter	*1970*	*1980*	*1992*
Refining	Total furnish	Single component	Single component freeness control
Furnish	High % long fiber	Less long fiber more hardwood some secondary fiber	Low % long fiber > Hardwood > Secondary fiber
Wet end chemistry	Acid	Acid	Alkaline
Instrumentation	Pneumatic	Electronic	Distributed control systems

III. Approach systems comparison

Parameter	*1970*	*1980*	*1992*
Fan pump	Fixed speed	Some variable speed	Variable speed Low impulse
Cleaners	Large diameter Single mount	Small diameter Canister	Improved deaeration
Pressure Screens	Holes Rejects return	Holes Secondary screens	Holes/slots Profile baskets Low impulse
Headbox	Air padded	Hydraulic - several problems	Hydraulic good profiles
White water system	Open		Tighter

Performance evaluation

Mill improvement programs are often poorly focused because the rebuild plans are not sound *(1)*. Successful rebuilds require a thorough understanding of current equipment and process capabilities, a working knowledge of new and practical technology, and followup to make sure that the projected goals are achieved.

Evaluation of current machine performance is a key step. Areas of the machine that require improvement can be identified by comparing results of a machine evaluation to performance standards for machines producing similar grades. Performance standards for bond, newsprint, corrugating medium, linerboard, bag, and coating basestock have been developed *(2–5)*. **Table II** shows the range of performances observed on several fine paper machines. The "good performance" targets represent practical standards that are being achieved on the best-performing machines.

The objective of the performance evaluation should be to compile facts on the machine and its capabilities. Documentation of current performance using standards is a good way to establish a base. Papermakers invariably have opinions about their machines' capabilities, but these opinions are not necessarily based on facts.

The effect of each parameter on overall machine performance must be determined. Some parameters can be well below the good performance level without causing a bottleneck to higher production rates. Areas of greatest significance must be identified so that

IV. Forming Section Comparison

Parameter	*1970*	*1980*	*1992*
Former-news	Fourdrinier	Twin-wire Top-wire	Twin-wire
Former-fine	Fourdrinier	Top-wire	Top-wire Twin-wire
Former-liner	Fourdrinier & 2nd	Fourdrinier & 2nd	Top-wire Top-fourdrinier
Former-medium	Fourdrinier	Fourdrinier Twin-wire	Fourdrinier Top-wire
Fabrics	Single layer		Double, triple layer

V. Press Section Comparison

Parameter	*1970*	*1980*	*1992*
Press-news	Twinver & third	Trinip	Trinip & fourth
Press-fine	Twinver & third	Trinip	Trinip & fourth
Press-liner	3 Straight through	Double felted	LNP Shoe
Press-medium	2 Straight through	Trinip tandem	Shoe LNP
Steam Showers	None	News	News, liner, medium

VI. Dryer Section Comparison

Parameter	*1970*	*1980*	*1992*
Dryer Configuration	News-conventional Fine-conventional Liner-unfelted bottom Medium-unfelted bottom	Unorun Unorun Bottom felts Bottom felts	Single tier Single tier Unorum, bottom felts Unorun, bottom felts
Syphons	Rotary	Rotary close clearance	Stationary Rotary CC
Steam & condensate	Cascade	Thermocompressor DP Control	Thermocompressor Flow control
Spoiler bars	None	Some	Extensive
Drive	Gears	Gears	Felt rolls Some dryers

capital expenditures and improvement efforts can be concentrated in areas of highest return.

Another good way to determine machine limitations is to develop a bar chart similar to the one shown in **Fig. 1.** The speed capability of each machine component on major grades is on the horizontal axis. The capabilities are based on design capacities and industry guidelines at normal operating conditions. Use of a computer spreadsheet simplifies the calculations. Other limitations that may restrict upgrade capability should also be identified. These limitations may include:

- Base plate settling
- Open draws
- Machine frame instability
- Equipment mechanical condition
- Roll diameters and balance
- Space for expansion.

Other considerations

Engineers involved in a rebuild should utilize all available resources in evaluating machine capabilities. The literature includes many technical articles dealing with rebuilds. Many clothing, chemical, and equipment suppliers also offer free or low-cost services to assist in evaluating current capabilities.

Clothing companies routinely survey forming, press, and dryer sections to document current performance and identify opportunities to improve operations. Some clothing suppliers offer customized programs to determine requirements for machine rebuilds. Such programs can include pilot plant trials.

Chemical suppliers will survey wet-end chemistry, additives, and clothing cleaning systems and suggest strategies for improving performance. Equipment suppliers provide services ranging from application of a particular piece of equipment to a complete machine survey. Suppliers can also provide assistance in developing training manuals and training sessions.

For more extensive services, assistance is available for a fee. Services may include alignment, condition monitoring, and a comprehensive dryer-section analysis. Consultants often have broad experience from other machine rebuilds and are familiar with current technology. Experienced personnel can help develop the project scope and identify sound recommendations.

It is also important to talk with and visit other paper companies. The paper industry is generally very open, and most companies are willing to discuss their experiences. Checking references for major pieces of equipment is essential to minimizing problems. Reference checking should go beyond the lists supplied by vendors. You can often learn more from mills that have experienced problems with a particular piece of equipment than those that did not.

Scope establishment

Rebuild objectives should be developed based on uses of proven technology to address the limitations identified in the performance evaluation. Future grade mix, sheet quality requirements, and performance on other machines producing similar grades also should be considered.

Equipment upgrades included in the rebuild should be limited to the items necessary to achieve the performance objectives. Papermakers often want to install new equipment to solve all the problems they have ever experienced on a particular machine. This approach increases the cost of the rebuild and may cause the project to be rejected on the basis of insufficient economic return. Changes that do not contribute to achieving the objectives should be justified on their own merits.

Alternatives to upgrading the equipment should be carefully evaluated. Experimentation with new concepts often requires a great deal of time to achieve the project goals.

Machine rebuilds often do not achieve the results projected in capital-expenditure requests. Inadequate results can be caused by equipment problems, weak engineering, improper installation, or operating personnel simply not understanding how new equipment and processes are supposed to work. Re-evaluation of machine performance after the rebuild can identify problem areas and provide a basis for achieving the targeted goals.

VII. Auxiliary System Comparison

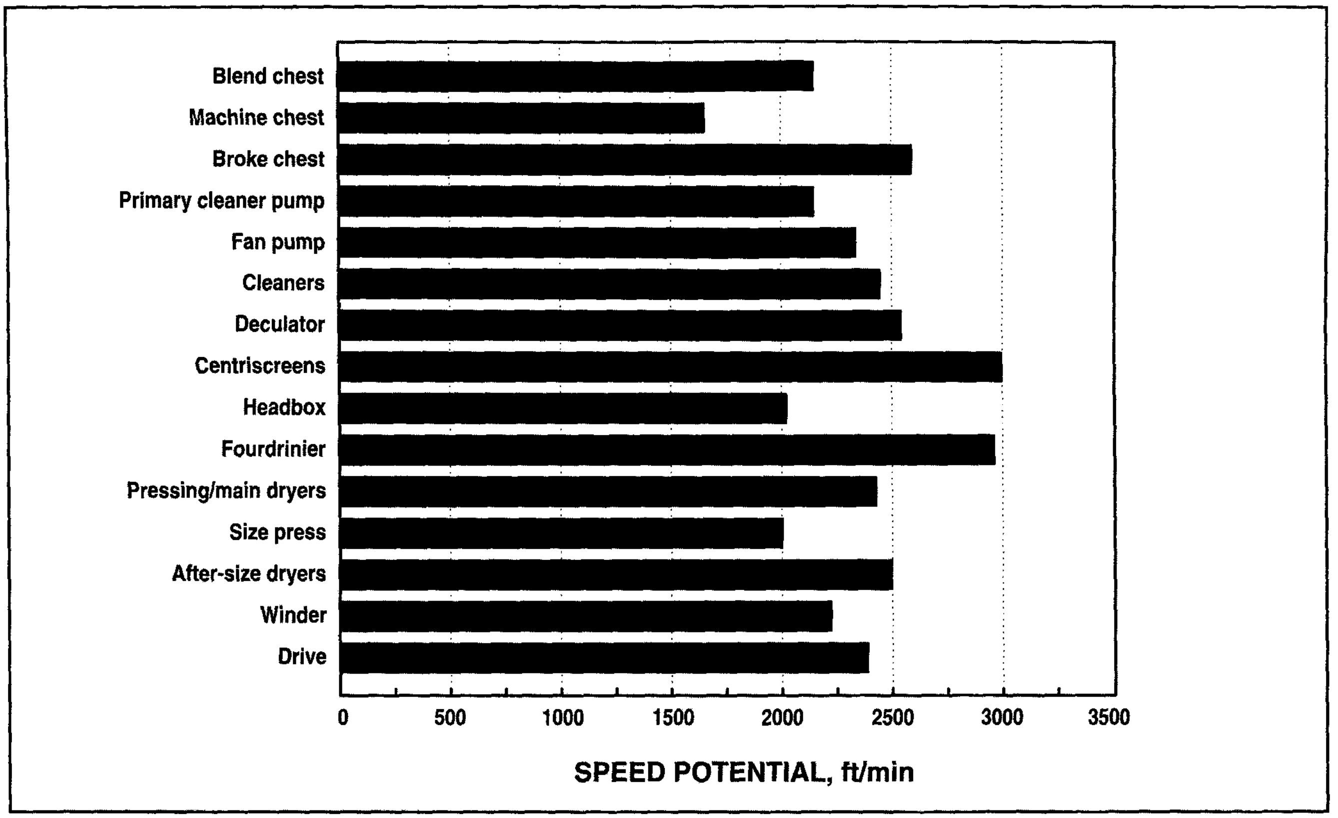
Parameter	*1970*	*1980*	*1992*
Breaker Stack	Middle of dryers	Middle of dryers	Near press section
Size press	Roll	Large diameter	Metering type
Calender	Multi-roll	Two-Roll	Two-roll Soft nip
Drive	Line shaft	DC Section electric	AC/DC section electric
Gauging	MD weight & moisture	Grade change	CD controls Improved sensors
Condition Monitoring	None	None	Lightweight High speed
Threading	Ropes	Threading chutes	No ropes Transfer boxes
First open draw	After 2nd Press	After 3rd Press	Dryers
Winder	Two drum, limited automation	More automation	Two winders Full automation Single drum belt

VIII. Performance indices for production of fine paper

Parameter	*Observed performance range*[a]	*Good performance*[b]
Overall machine efficiency, %	67–93	84–88
Uptime, %	75–94	92
Percent saleable, %	80–96	94
Headbox consistency, %	0.2–0.8	0.4–0.6
Flatbox vacuum, ft^3/min/in. fabric	2–12	5
Couch vacuum, $ft^3/min/in.^2$	1.9–8.2	6–7
Consistency off couch, %	8–22	20
Consistency after last press, %	25–46	40–42
Moisture entering size press, %	0.5–4.2	3
lb steam/lb water evaporated	1.2–1.6	1.3
TAPPI drying rate, lb water/h/ft^2	3–5.5	4.7 @ 60 psig
Basis-weight profile, % total variation	0.8–10.3	1 (automatic) 3 (manual)
Moisture profile (peak to peak), %	0.7–4.0	1 @ 5% avg.
Water consumption, 1000 gal/ton	2–40	3

[a]Observed on several fine paper machines
[b]Observed on best-performing fine paper machines

1. Speed capability of major components on a typical paper machine



Conclusion

The key to effective paper machine rebuilds is careful evaluation and good planning, combined with the knowledge of proven results from machines producing similar grades at comparable speeds. The first step in a machine upgrade program is to identify weaknesses and establish priorities for necessary improvements. Improvement efforts and capital expenditures must be focused in the areas that will have the greatest impact on overall machine performance and sheet quality. Significant improvements can often be achieved with little capital cost. Such projects should have high priority.

Good results require a thorough knowledge of current conditions on the machine and the best way to apply available technology. The major factors that must be considered include equipment capabilities, critical test requirements, types of clothing, and other variables. Machine performance should be monitored as changes are made. The results can be used to fine tune operations to achieve targeted goals. TJ

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