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Paper machine performance guidelines

Scope

Paper company personnel, clothing suppliers, equipment suppliers, consultants, and others have developed paper machine performance guidelines. These guidelines have proven to be effective for evaluating paper machine performance. This TIP lists guidelines for major grades and provides suggestions for application.

Safety precautions

There are no specific safety requirements for application of the performance guidelines. However, efforts to improve paper machine performance should not include operation of equipment above proven safe operating levels.

Conversion factors

Multiply	by	to obtain
ft/min	0.305	m/min
ft ³ /min	1.699	m ³ /hr
ft ³ /in. ²	0.0044	m ³ /cm ²
ft/min/in.	0.12	m/min/cm
gal/ton	0.00417	m ³ /tonne
lb water/hr/ft ²	4.88	kg/hr/m ²
°F	5/9(F-32)	°C
short tons	0.907	metric tonne

Technical information

Paper machine performance guidelines were first developed in the late 1970s and have been continuously updated (1). Operating information has been compiled on a broad spectrum of machines. Current performance guidelines for liner, corrugated medium, fine paper, newsprint, bleached board, recycled paperboard, and bag are shown in Tables 1-7. Good performance targets are typically 90 percent of the performance achieved by top performing paper machines for each grade.

Zellcheming Association of Pulp and Paper Chemists and Engineers in Germany and the Finnish Paper Engineers updated the Zellcheming “production indices for the papermaking industry” in 2005 (2). The Zellcheming guidelines include:

- Time definitions in paper production
- Time related efficiencies
- Production definitions
- Area efficiency
- Overall efficiency
- Production capability

TIP Category: Automatically Periodically Reviewed (Five-year review)



Documents

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Since the Zellcheming production indices are very similar to the production reporting guidelines included in previous versions of this TIP, the task force decided to make changes to TAPPI production reporting guidelines so they would be the same as Zellcheming guidelines. A long term goal of the Zellcheming guidelines is to have all paper mills in the world use the same production reporting system. Integrating the TAPPI and Zellcheming guidelines is a move towards meeting the goal but it will take some time to develop world-wide acceptance. The Zellcheming guidelines go into paper machine efficiency calculations in more detail than information presented in this TIP and can be consulted should anyone want to apply the guidelines discussed below more rigorously.

Time definitions in paper production

Figure 1 gives an overview of the time categories used in the calculation of overall machine efficiency (2).

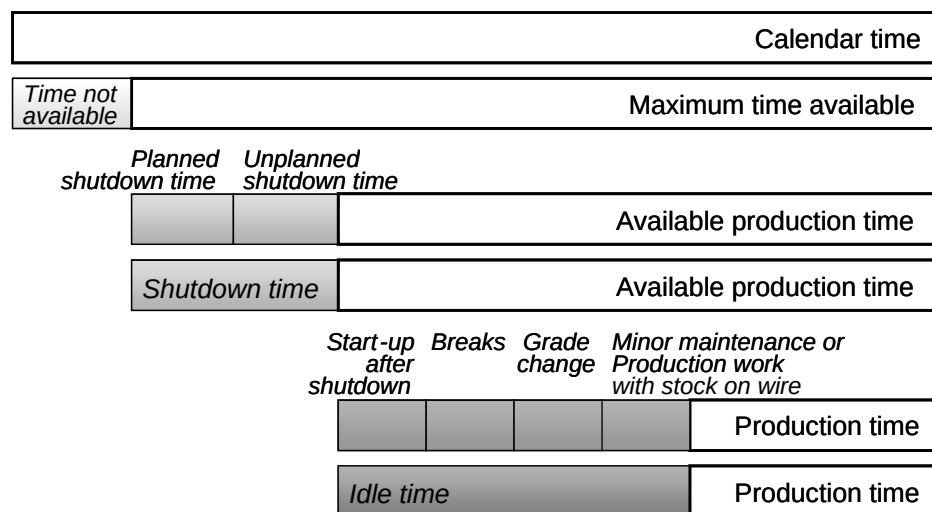


Fig. 1. Overview of the time categories used in the calculation of overall machine efficiency

Time not available

TAPPI has previously defined time not available as the annual hours for scheduled outages of 24 hours or greater. This would include holidays, extensive periods of scheduled maintenance, and downtime due to market conditions. Scheduled outages of less than 24 hours for field days and wash-ups were counted as available production time. Unscheduled outages were counted as available production time no matter how long they lasted. When availability of pulp, steam, power, maintenance support, and other factors cause unscheduled downtime, they have a detrimental effect on overall efficiency calculations and machine performance.

Zellcheming defines time not available as time when the production line is shut down for external reasons with no minimum time: for example holidays, summer shutdowns, and strikes. The time not available also includes the time when the production line is unavailable for greater than 48 hours due to rebuilds or unforeseen crashes or greater than 24 hours for lack of orders or downtime due to lack of external power, steam or raw material supply.

The main difference is that the TAPPI guidelines included unscheduled outages in the available production time without a time limit. The Zellcheming guideline sets limits of 24 and 48 hours for different unscheduled occurrences in order to be included in the available production time. These differences have a very small affect on paper grade performance guidelines.

Uptime

Uptime is defined as:

$$\text{Uptime} = (\text{production time} / \text{maximum time available}) \times 100\%$$

Production time = annual hours the sheet is on the reel

Maximum time available = annual available hours

Zellcheming uses the term “time efficiency” for uptime.

Typical values for paper machine lost time are shown in Table 8. These values vary somewhat for different grades but are generally applicable to a broad spectrum of paper machines. This definition does not include a factor for machine speed. The highest reported uptime is 97% on a linerboard machine. The lowest uptimes are around 80%.

The Zellcheming guidelines categorize the lost time in shutdown time (planned and unplanned) and idle time. The idle time is the time when stock is on the wire or vacuum is on the wire suction roll but a web is not on the reel. The idle time typically includes times for breaks, cleaning, and tail threading and putting the web into pulper for grade changes or minor maintenance.

Lost-time due to breaks varies widely from machine to machine. For example, low-speed liner machines producing heavyweight grades have fewer breaks than high-speed fine-paper machines with size presses. Another factor that varies widely from machine to machine is average lost time per break. Obviously, it takes longer to thread a long, low-speed machine than it does a high-speed lightweight machine. However, lost time per break can vary by a factor of three on similar machines. Some mills organize their crews so everyone has specific jobs, and they get them done efficiently. Top-performing paper machines average less than 15 minutes lost time per break. Tracking break length can help focus resources on improvement. Intermediate processes such as on-machine coaters, on-machine calendering, etc. effect the lost time due to breaks.

Open draws have a significant effect on break frequency. The maximum speed with an open draw off the couch is around 2,200 ft/min (670 mpm). Break frequency at the couch can be minimized on open-draw machines by optimizing couch transfer geometry. The maximum practical speed for an open draw after one press appears to be between 2,000 ft/min (610 mpm) and 2,500 ft/min (762 mpm). Machines with no open draws until after the second press are achieving speeds over 3,500 ft/min (1,067 mpm). Sheet support in the early dryer sections is generally needed at speeds above 2,500 ft/min (762 mpm). Some high-speed machines with single-tier dryers have no open draws until the dry end of the machine. Having an adequate number of single-tier dryers after the press section reduces paper breaks especially if solids from the press and/or sheet basis weight are low.

Scheduled maintenance includes planned outages for major jobs such as roll changes and piping repairs. Many machines schedule 8 to 16 hour maintenance outages periodically. Efficient mills coordinate machine wash-ups, clothing changes, and carrier rope changes with scheduled maintenance outages to minimize downtime.

Unscheduled maintenance is downtime caused by mechanical or electrical breakdowns. Good preventive maintenance programs combined with vibration and process monitoring systems have greatly reduced unscheduled maintenance in many mills. Monitoring of bearings along with appropriate maintenance has been especially beneficial.

Improving maintenance effectiveness has been emphasized in many mills. These programs have led to improved paper machine uptime and reduced maintenance cost. There is a wide range of maintenance cost on paper machines. In some cases, maintenance cost per ton varies by a factor of two for similar-vintage machines.

Miscellaneous operating lost time includes wash-ups, carrier rope changes, clothing changes, and other operating problems that are not done on scheduled maintenance outages. Good operator skills and management are required to keep miscellaneous operating lost time below 1%.

Grade change times vary widely depending on grade mix and furnish change requirements. Good scheduling is a key factor in minimizing grade change lost time. Some mills minimize lost time on grade changes by adding dyes and other additives at various points in the wet-end system instead of shutting down, dropping water, and washing up. Some mills add bleach to the wet-end system while running to eliminate the need to shut down and wash up on color changes.

Percent salable

Percent salable product is defined as:

$$\text{Percent salable product} = (\text{salable tonnage/reel tonnage}) \times 100\%$$

Zellcheming defines percent salable product as the area efficiency. The area efficiency is the product of three efficiencies: length efficiency, width efficiency and finishing efficiency. The efficiencies are defined by length losses (reel to winder), width losses (at winder) and rejects/off grade losses after winder respectively. Zellcheming uses area instead of weight in the calculation of saleable product due to the changes in moisture through some converting processes and evaporation should not be considered as lost production. In most cases the moisture loss is negligible and thus there is practically no difference between the 2 methods. If area is used then no correction is required for the addition of coat weight when using off-machine coaters in the production line. Since tonnage is easier to track in a mill, most mills use weight instead of area to calculate the percent salable product.

For a typical paper machine, salable tonnage is the net tonnage off the winder. For machines with off-line coaters or supercalenders, salable tonnage is net tonnage off the winder following off-line equipment. Losses between the reel and winder include trim (width) losses, slab (length) losses, and off-quality paper.

Trim losses are high on some machines and have a negative effect on percent salable product. Some papermakers feel that trim losses should not be counted because they have no control over sheet width sold by the marketing department. In addition, for some paper machines trim is removed for on-machine coating and calendering. This improves the overall efficiency of paper machines having on-line operations compared to off-line operations. For the efficiency calculation, Zellcheming uses the winder as the reference rather than the paper machine reel for trim (width) losses. The trim losses from headbox to the winder are then calculated separately using Zellcheming definitions.

Slab losses between the reel and winder are significant on many machines. Some papermakers do not realize how high losses can be. Installation of reel turn-up devices has reduced the amount of losses on many machines. There are many systems available to calculate length, diameter, density, etc. and communicate winder information back to the reel for optimizing reel size.

Some mills downgrade tonnage as "seconds" or "job lot". This paper is normally counted as salable tonnage with separate accounting to monitor downgrading. Downgraded tonnage should not exceed 5% of machine production. Some mills only count first quality tons in overall machine efficiency calculations.

The highest percent salable figures observed are 99% on newsprint and liner machines. Some specialty fine paper machines report values as low as 80%.

Paper machine efficiency

Paper machine efficiency is probably the best indicator of overall machine performance. However, it is often difficult to make comparisons between mills since paper companies use different definitions of efficiency.

In this TIP, overall machine efficiency (OME) is calculated by multiplying percent uptime by percent salable product. This definition is similar to the formula used by the Canadian Pulp and Paper Products Council (PPPC) to rank newsprint machines.

The Zellcheming guidelines define the overall efficiency of paper production as time efficiency multiplied by area efficiency. The main differences between the TIP OME and the Zellcheming overall efficiency is in calculation of maximum time available and trim losses between the reel and winder. Zellcheming efficiency will be higher due to not including the trim losses.

Zellcheming uses an additional index that may be useful to be included in the reporting of PM efficiency data: operating rate.

$$\text{Operating rate} = \text{maximum time available} / \text{calendar time.}$$

Thus, if the unscheduled outages are high and the Zellcheming overall efficiency also is relatively high, then there would be a relatively low operating rate. For most mills not experiencing market shutdowns the operating rates are above 97%, with the good mills above 99%.

The highest observed overall machine efficiencies are shown in Table 9.