TIP 0404-47

ISSUED – 1997
REVISED – 2001
REVISED – 2006
REVISED – 2011
REVISED – 2016
REVISED – 2021
CORRECTED – 2022

Paper Machine Performance Guidelines

Scope

This TIP provides benchmarks for evaluating paper machine performance for major grades and provides suggestions for application. These benchmarks have been developed by paper company personnel, clothing suppliers, equipment suppliers, and industry consultants.

Safety precautions

There are no specific safety requirements for evaluating paper machine performance. Appropriate safety precautions should be followed when taking measurements on or around operating paper machines to avoid injury or equipment damage. Efforts to improve paper machine performance should not include operation of equipment above proven safe operating levels.

Conversion factors

USA Customary Unit	Conversion Factor	Metric Unit
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
ºF	5/9(F-32)	ºC
short tons	0.907	metric tonne

Table 1.

Technical information

Paper machine performance guidelines were first developed in the late 1970s and have been updated to reflect current machine operations (*1*). Operating information has been compiled on a wide range of grades: linerboard, corrugated medium, uncoated woodfree printing and writing, newsprint, bleached board, recycled paperboard, Kraft paper, specialty fine paper, market pulp, fluff pulp, dry creped tissue and towel, and through air dried tissue and towel. The guidelines are shown in Tables 3-14. Good performance targets are 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

TAPPI has adopted the Zellcheming production indices by reference.

Time definitions in paper production

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

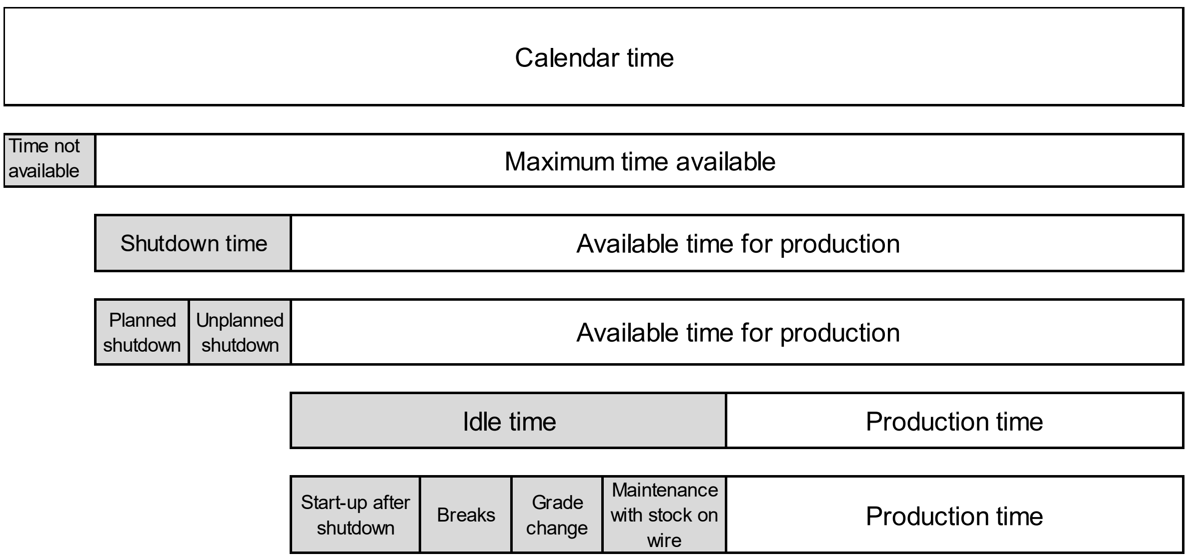

Figure 1. Overview of the time categories used in the calculation of overall machine efficiency

Time not available

The Zellcheming definition of "time not available", as adopted by TAPPI, includes time when the production line is shut down for external reasons for any length of time. This includes holidays, summer shutdowns, and strikes. "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.

Annual uptime

The annual uptime is defined as:

Uptime = (production time / maximum time available) × 100%
Production time = annual hours the sheet is on the reel
Maximum time available = annual available hours

Note that Zellcheming uses the term "time efficiency" for uptime.

Typical values for paper machine lost time (shutdown time and idle time) are shown in Table 1. These values vary for different grades but are generally applicable to a wide range of paper machines. This definition does not include a factor for machine speed. The highest reported uptime is 99% on a market pulp machine. The lowest reported uptimes are around 80%.

Shutdown time

Shutdown time is defined as that portion of available time when the stock is not on the wire. It is divided into planned and unplanned time and is typically comprised of scheduled and unscheduled machine maintenance.

Scheduled maintenance includes planned outages for major jobs such as roll changes and piping repairs. Many machines schedule 8 to16 hour maintenance outages periodically. Efficient mills coordinate machine wash-ups, boil outs, 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.

Idle time

Idle time is defined as that portion of available time when stock is on the wire and vacuum is on the wire suction roll, but a web is not on the reel. Idle time typically includes times for breaks, cleaning, tail threading, and temporarily putting the web into pulper for grade changes or for minor maintenance.

Lost-time due to breaks varies widely from machine to machine. For example, low-speed market pulp and liner machines producing heavyweight grades have fewer breaks than high-speed uncoated woodfree printing and writing 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 a specific job, and each person gets his job done efficiently. Top-performing paper machines average less than 15 minutes per break. Tracking break time can help focus resources on improvement. Intermediate processes such as on-machine coaters, on-machine calendaring, etc. tend to increase 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 currently 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.

Miscellaneous operating lost time includes wash-ups, carrier rope changes, clothing changes, and similar activities 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:

Percent salable product = (salable tonnage/reel tonnage) × 100%

TAPPI has adopted the Zellcheming definition of percent salable product as area efficiency. 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 the winder respectively. Area is used instead of weight in the calculation of saleable product due to changes in moisture through some converting processes. Evaporation should not be considered as lost production. In most cases, moisture loss is negligible and thus there is practically no difference between area efficiency and weight efficiency. If area is used, no correction is required for the addition of coat weight when using off-machine coaters in the production line. Because tonnage is easier to track, many mills use weight instead of area to calculate 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. On 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 can be significant. 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 diameter.

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 normally not exceed 5% of machine production. Some mills only count first quality tons in overall machine efficiency calculations. The definitions here, however, includes all saleable tons.

The highest percent salable figures observed are 100% on market pulp machines. Some specialty fine paper machines report values as low as 80%.

Overall machine efficiency

Overall machine efficiency is probably the best indicator of overall machine performance. However, it is often difficult to make comparisons between mills because different 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.

Note that Zellcheming guidelines define the overall efficiency of paper production as time efficiency multiplied by area efficiency as shown in Figure 1. 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 because trim losses are not included.