TIP 0404-33

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Dryer section performance monitoring

Scope

Dryer section performance has a major effect on sheet quality, production rates, and energy efficiency. Regular performance monitoring can help ensure that dryer section operation is optimized and can direct maintenance and troubleshooting efforts before minor problems get worse. Monitoring can be done by mill operations, technical, engineering or maintenance personnel; clothing and equipment suppliers; corporate technical groups; and/or independent consultants.

Information on the importance of techniques for measurement and equipment suppliers for several measurable drying parameters are included. The Supplier Directory at the end of this TIP includes information on test equipment suppliers.

Safety precautions

Follow normal safety precautions when working around paper machinery. Do not allow loose clothing or equipment to contact rotating machinery. Beware of thermal and slip hazards around the dryer section, on the operating floor, and in the basement. Tag, disconnect, and lock out all dryer drives and steam systems and follow vessel-entry procedures before entering dryers.

Discussion

A good knowledge of dryer section equipment, design criteria, and operating conditions is important for understanding and troubleshooting the system. A list of important dryer section information is shown in Table 1, including data on the dryer arrangement, felting, the steam and condensate system, syphons, steam and condensate piping, doctors, dryer bars, and hood and air systems. It is recommended that this information be compiled for each machine and kept in a file for easy access. The information will be useful for anyone who works to optimize or troubleshoot the dryer section.

In addition to a completed information sheet, the following dryer section drawings should be kept on file:

- Dryer Layout Drawings
- Records of Pressure Vessel (dryer) Code Documentation
- Steam and Condensate System P&IDs
- Hood Air System P&IDs
- Sketches of the Rope Runs

Operating conditions

A sample data sheet for dryer section operating conditions is shown in Table 2. Sheets specific for each machine should be developed and filled out to provide baseline data on critical grades to allow for effective troubleshooting and problem solving. The top portion identifies the time, grade, and date that the data was collected. Weight and moisture profile this example, dryers 1–6 are in the warm-up zone, dryers 7–27 are in the “constant-rate” drying zone, and dryers 28–31 are in the falling rate zone.

Condensing loads can also be used to optimize differential pressure or flow control setpoints. Differential pressure can be adjusted and condensing loads monitored to determine the maximum condensing load for particular operating conditions.

Surface temperatures

Dryer surface temperatures provide a good indication of condensate removal and heat transfer efficiency. The operating temperature depends on a number of factors with steam pressure being the most important. Differences between steam and dryer surface temperatures should be in the range of 15–30°C (30–60°F) in well-performing dryer sections.

Surface temperatures should be analyzed in conjunction with condensing loads in order to fully evaluate the drying process. High condensing loads result in thicker condensate layers within the dryers, and the thicker layers can insulate the dryers and reduce surface temperatures. Poor sheet-to-dryer contact, on the other hand, can reduce heat transfer and condensing loads resulting in high surface temperatures.

Table 7 summarizes possible combinations of condensing load and surface temperatures.

Figure 2 shows a typical plot of dryer surface temperatures versus dryer number (*1*). Surface temperature at the wet end of the machine should be graduated (on most grades) to prevent picking from the sheet. Steam-to-surface temperature differences will usually be higher at the wet end than on the rest of the machine.

Temperatures through the constant-rate drying zone (also called the prime drying zone) should be consistent from dryer to dryer. Inconsistent temperatures are an indication of marginal dryer drainage. Top-to-bottom temperature differences can indicate dryer fabric tension problems or significant wire side/felt side sheet property differences. Top-to-bottom temperature differences have been noted on linerboard grades with multiple sheet layers.

Dryer surface temperatures tend to increase at the dry end of the machine as the sheet enters the falling-rate drying zone.

Surface temperatures should be measured prior to each shutdown to determine which dryers have condensate removal problems and should be repaired on the outage.

Accurate temperature measurement can be difficult. Contact pyrometers and infrared sensors are often used. Thermocouples mounted in Teflon blocks supplied by Swema are probably the most commonly used. A contact pyrometer developed by Electronic Development Laboratories is also widely used. This sensor consists of a stainless steel strip with thermocouples mounted on the back of the strip. Temperature readings are shown on a battery-operated digital display. These thermocouple mountings are designed to minimize frictional effects on the reading, but rough dryer surfaces, especially those caused by dryer picking, can result in inaccurate measurements.

Temperature sensors can be mounted on aluminum conduit or a fiberglass pole to permit dryer temperature measurements inside the sheet run. Other suppliers of contact pyrometers include Solomat, and Service Tectonics. TAPPI TIP 0404-39, “Dryer Surface Temperature Measurement,” provides a thorough discussion of dryer surface temperature measurement.

Many mills use infrared sensors to indicate the temperature of dryer heads. The dryer head temperature may not change between a hot dryer and one that is partially water logged. Head temperatures are a good indication of problems only when a dryer is nearly completely water logged. Infrared sensors are affected by light emitted from incandescent bulbs, surface emissivity, and the viewing angle. Accordingly, they should be used for relative readings rather than absolute temperatures.

Surface temperature profiles

Cross-machine surface temperature measurements provide a good indication of syphon performance and possible effects on sheet moisture profiles. CD measurements can be taken on the tending and drive sides with hand-held temperature probes. One-foot increments are generally adequate, although closer spacing can be taken if necessary. These hand-held measurements are limited by safety and the length of mounting pole. True temperature profile measurements can also be performed across the full width of the pockets (*1*). Figure 3 shows a uniform cross-machine surface temperature profile of an average of six dryers with good drainage.

Energy consumption

The dryer section is the highest thermal energy consumer on the paper machine, so optimizing energy efficiency can help to cut operating costs. Dividing the total steam consumption by the water evaporated provides a good energy indicator (except for PV air heating). Top machines utilize approximately 1.3 kg steam/kg water evaporated (1.3 lb steam/lb water evaporated).

Table 9 shows a breakdown of where energy is consumed in the dryer section (*3*) on a good-performing machine. Sheet heating is a function of entering sheet temperature and any over-drying at the end of the reel. Press section steam boxes that heat the sheet and improve water removal ahead of the dryer section can significantly reduce dryer section energy consumption.

The energy required for evaporating water from the sheet is essentially constant and cannot be easily changed. Air heating requirements are a function of PV air volume and temperature. Temperatures of 82–93°C (180–200°F) are recommended for optimum performance. The biggest potential energy waste in the dryer section is venting steam to the atmosphere or to a heat exchanger. Steam and condensate systems should be designed so that no venting during normal operation. Sheet reheating can assume a greater percentage of total energy on a machine with open draws or no bottom fabrics.

Other variables

There are other variables that affect dryer section performance that should be noted and considered in a dryer section evaluation. These variables include steam and condensate system design, dryer configuration, dryer diameter, dryer shell thickness, dryer fabric design, machine speed, basis weight, sheet density, sheet thickness, and sheet smoothness.

Test equipment suppliers

A summary of dryer section process measurements and some test equipment suppliers are shown in Table 10. Addresses and phone numbers for the equipment suppliers are included in the supplier directory.

The supplier directory listing was prepared from information available to the committee at the time of publication. Suppliers wishing to be listed or de-listed in the next issue should so inform the Quality and Standards Department at TAPPI in writing, referring to TIP 0404-33.

Keywords

Dryers, Dryer Sections, Drying, Humidity, Temperature, Performance

Literature cited

1. Rosenberger, G. Walter and Jeffrey R. Reese, “Profile Testing Improves Dryer Section Diagnostics,” *Tappi* Journal, Vol. 73, No. 8, August 1990.
2. Reese, Jeffrey R. “Observations from Testing Dryer Section Performance,” 1992 TAPPI Engineering Conference Proceedings, p. 629.
3. Hill, Kenneth C., “Paper Drying,” Chapter XII, *Pulp and Paper Manufacturing*, Volume 7, Paper Machine Operations, Third Edition, The Joint Textbook Committee of the Paper Industry, 1991, p. 286.

List of tables

Table 2B Dryer Section Operating Conditions (Customary Units)

Mill	______________	Reel Speed	fpm	______________
Machine	______________	Production	tph	______________
Date	______________	Trim	in.	______________
Time	______________	Press Moisture	%	______________
Grade	______________	Size Solids	%	______________
Comments	______________	Starch Pickup	lb/ton	______________

Weight and Moisture Profiles

	Units	Average	Maximum	Minimum	Shape
Basis Weight	lb/ream				
Reel Moisture	%				
Bone Dry Weight	lb/ream				
Size Press Moisture	%				

Pressure and Differential Pressure Control

Section	Dryers	Pressure	Setpoint	Output		DP/Flow	Setpoint	Output
	No.	psig	psig	%, a/m		psi/pph	psi/pph	%, a/m
Lead 1								
Lead 2								
Lead 3								
Lead 4								
1								
2								
3								
4								
5								
6								

Control Valve Positions

		Expected				Actual	
Section	Make-up	Thermo	Vent		Make-up	Thermo	Vent
Lead 1		X				X	
Lead 2		X				X	
Lead 3		X				X	
Lead 4		X				X	
1							
2							
3							
4							
5							
6							

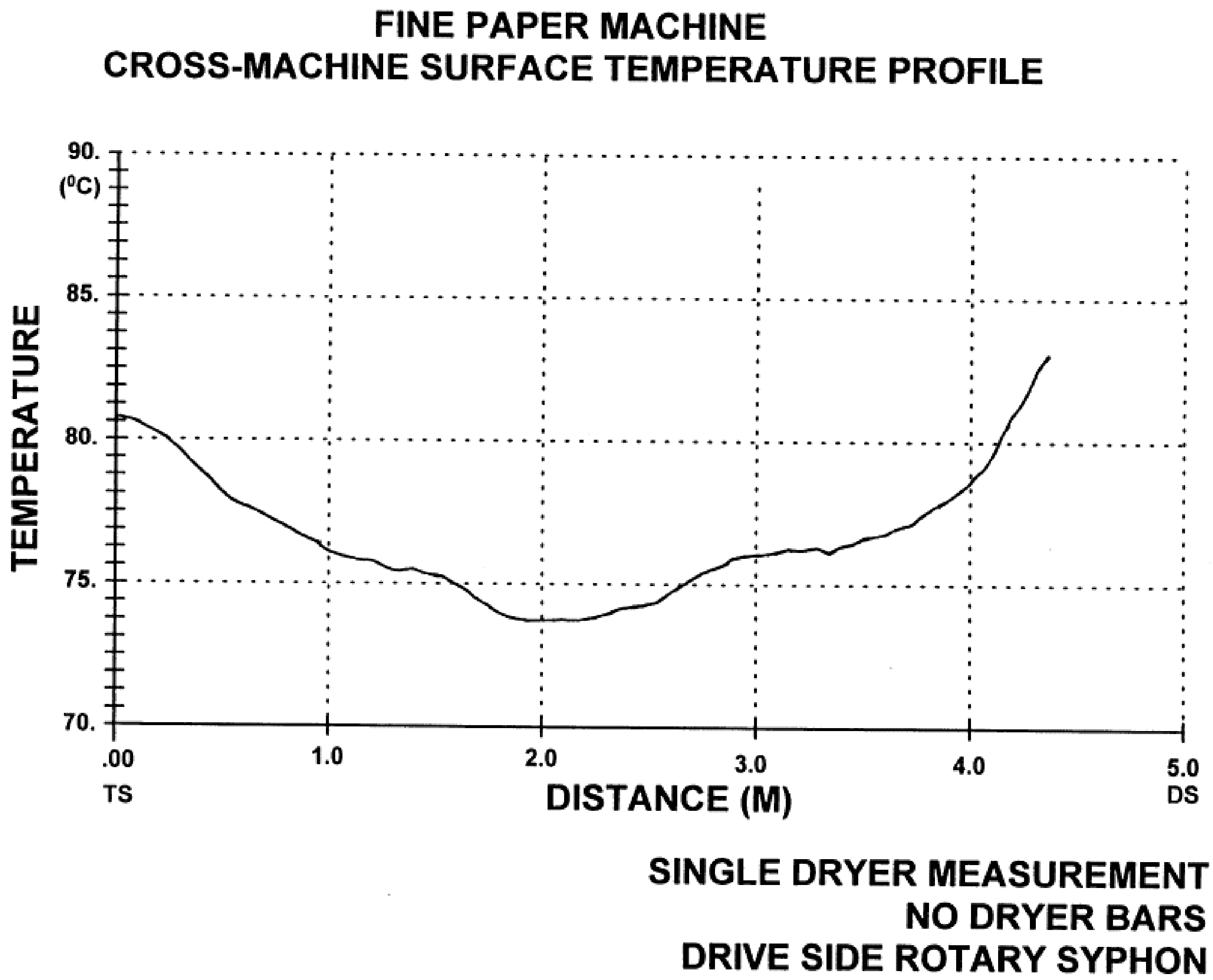
FINE PAPER MACHINE
CROSS-MACHINE SURFACE TEMPERATURE PROFILE
TEMPERATURE
(°C)
90.
85.
80.
75.
70.
.00
TS
1.0
2.0
3.0
4.0
5.0
DS
DISTANCE (M)
SINGLE DRYER MEASUREMENT
NO DRYER BARS
DRIVE SIDE ROTARY SYPHON

Figure 4

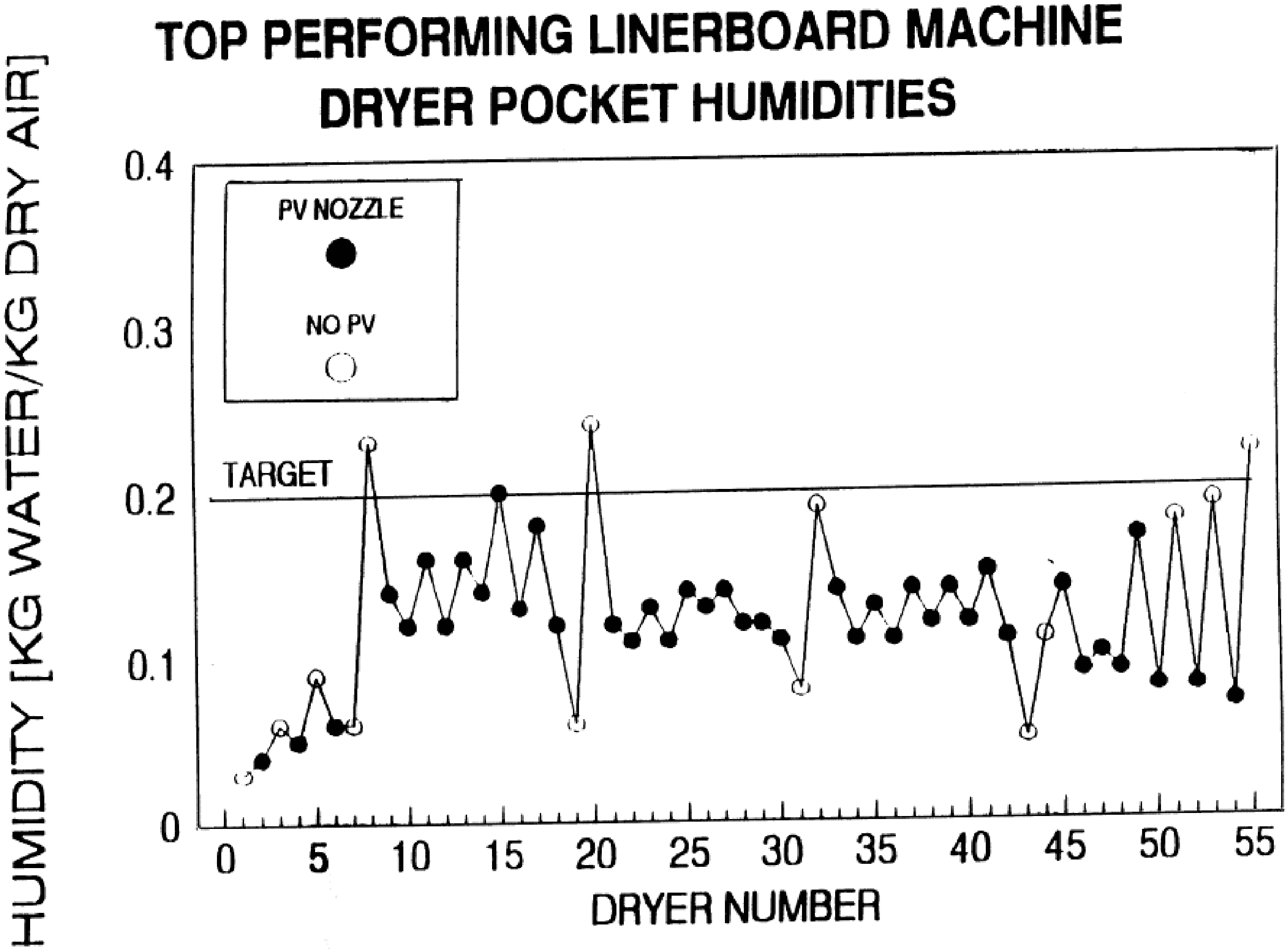
TOP PERFORMING LINERBOARD MACHINE
DRYER POCKET HUMIDITIES
HUMIDITY [KG WATER/KG DRY AIR]
0.4
0.3
0.2
0.1
0
PV NOZZLE
NO PV
TARGET
0
5
10
15
20
25
30
35
40
45
50
55
DRYER NUMBER

Figure 8