EXPERTIP

Category	DRYER
Keywords	Dryer fabric, dryer fabric performance, fabric tension

Dryer Fabric Tension - Part 2

This ExperTip will cover in detail the in-mill tension trials discussed briefly in Part 1.

https://www.astenjohnson.com/media/1746/expertip-tension-part-1.pdf

For all grades studied in the in-mill trials, drying rates increased with increased fabric tension. The results indicate that elevated dryer fabric tension is beneficial to drying performance.

Paper and board products are typically dried on a series of steam-heated cylinders. Heat transfer from the condensing steam in the cylinder to the paper sheet is limited by a number of factors which is represented by this simplified equation:

$$R_{total} = R_{steam} + R_{shell} + R_{contact}$$

This attempts to take into account the thickness of the condensate layer, dryer scale, cylinder resistance, and contact resistance between the sheet and the cylinder. Typically, the contact resistance accounts for 35-70% of the overall heat transfer resistance.

The role of the dryer fabric in this process is to convey the paper sheet through the dryer section while increasing contact between the sheet and the dryer cylinder. Dryer fabric tension has a direct influence on the contact pressure and contact resistance at the fabric-sheet-cylinder interface. The contact pressure (P) is determined by the following equation:

$$P = \frac{T}{r}$$

where T is the fabric tension and r is the radius of the curvature of the dryer cylinder.

Though there is not a lot of mill data on the subject, laboratory tests and on-machine trials show that increased drying rate correlates with increased dryer fabric tension. Figure 1 shows the correlation.

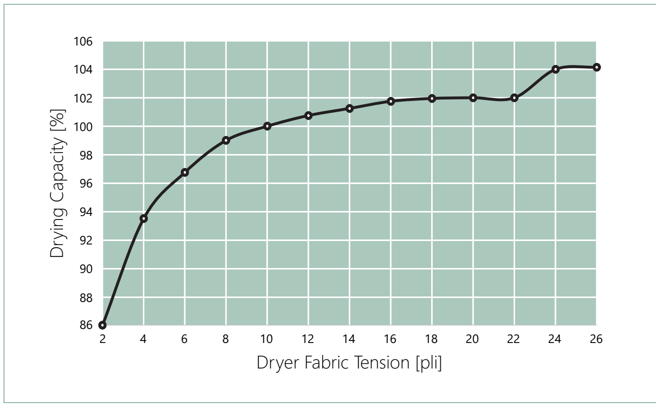

Figure 1. Dryer fabric tension vs drying capacity.

The Figure shows the change in drying capacity for an individual dryer versus a dryer at what is typically considered to be at 100% capacity (1.8 kN/m - 10 pli). Some important points that can be ascertained from this data:

- 1.2 kN/m (7 pli) results in a 2% decrease from 1.8 kN/m (10 pli).
- 2.6 kN/m (15 pli) provides 1.5% increase over 1.8 kN/m (10 pli).

Earlier research concluded that the main reason for operating at higher fabric tensions is to overcome the boundary layer air entrained between the sheet and the cylinder. A few researchers have performed laboratory studies to determine the effect of dryer fabric tension on drying rates and contact heat transfer coefficients. The studies suggest that optimum fabric tension for maximum drying capacity is primarily dependent on paper grade (basis weight and density) and cylinder temperature.

AstenJohnson Laboratory Tests and Mill Trials

AstenJohnson personnel conducted a series of drying tests at AJ's advanced product development center in Kanata, Ontario, Canada. The tests were conducted at "conventional" fabric tensions and obtained results similar to those mentioned above. It was then decided to conduct a series of mill trials with willing customers to determine if the lab results were representative of what happens on an actual paper machine with different fabric tensions.

Four mill trials were conducted: one on newsprint, two on linerboard, and one on fine (copy) paper. Condensing rate, sheet temperature, and dryer shell temperature were measured for a dryer group (to simplify the procedure and to limit interference with the operation of the machine, a single dryer group was chosen). The selection criteria for the dryer group was that it:

1) be in the constant rate zone and,

2) operate at constant steam pressure during the test (i.e. not be a control group for reel moisture content).

First, measurements were taken at the "as found" operating condition. Dryer fabric tension was then reduced to the lowest limit acceptable to mill personnel. Once steady state was obtained, usually 20-30 minutes, new measurements were taken. The tension was then increased, in steps to the design maximum of the machine.

Newsprint Trial

One trial was conducted on a newsprint machine operating at 1250 m/min on 48 gsm news. Condensate drawdown tests were carried out on the 4th section (double felted) at five levels of fabric tension from 1.8-2.8 kN/m (1.9-3.1 kPa contact pressure). The estimated solids content in and out of the 4th section was from 55-65%, which fell within the 50-70% range of the lab trials. Average dryer temperature was 109°C.

The results of the trial were compared to the lab results for 113°C and are shown in Figure 2.

The calculated drying rate is similar to the lab drying rate. Of greater importance, however, the mill data shows the same trend as the lab data and suggests a more pronounced effect of increased drying rate with increased tension.

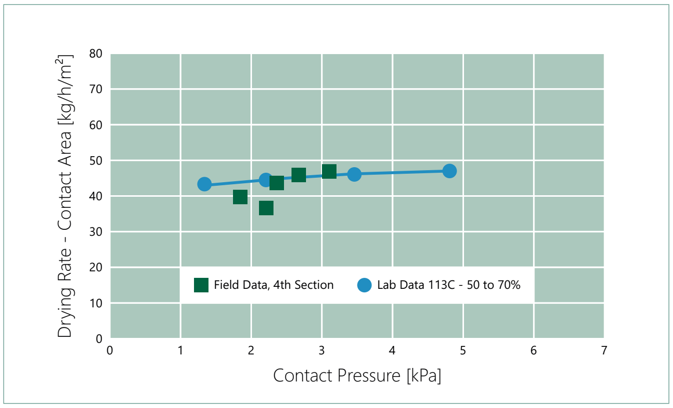

Figure 2. Newsprint machine drying rate vs contact pressure (lab and mill data)

Linerboard Trials

Trials were conducted on two linerboard machines. **Machine A** was a machine producing linerboard from 100% recycled fiber. The dryer section consists of one single felted dryer group followed by three double felted groups. The machine was operating at 650 m/minute producing 170 gsm linerboard.

Measurements were taken in the 2nd group (13 dryers) and the 3rd group (14 dryers) on separate days. Fabric tension was varied from 1.4-3.0 kN/m (1.6-3.3 kPa). The 3rd and 4th dryer groups were used as the control groups. With a cascade steam and condensate system, the pressure in the 2nd group varied from the 3rd and 4th (generally 0.75-1.0 bar below the 3rd group). Since the machine ran at constant speed (constant drying load), the condensing rate did not change significantly. However, from condensing rate data and measurements of shell and sheet temperature, an estimate of overall and contact heat transfer coefficients was made at the various fabric tensions. The results obtained in the 3rd group are shown in Figure 3.

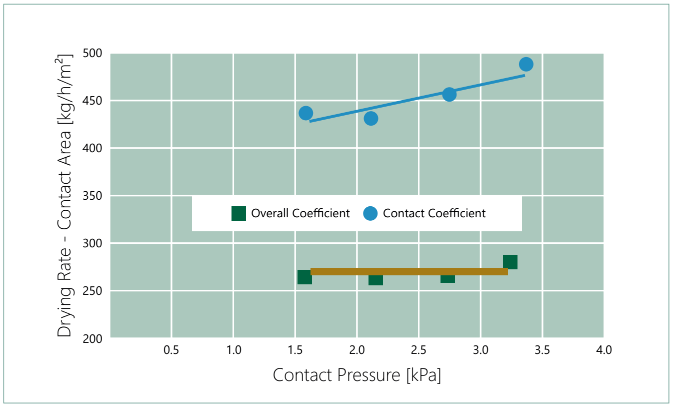

Figure 3. Linerboard Machine A heat transfer coefficient vs contact pressure

The average steam pressure in the entire dryer section was reduced from 9.7 to 8.5 bar (140 psig to 124 psig) and from 9.6 to 9.2 bar (139 psig to 133 psig) over the range of tensions for tests on the 2nd and 3rd dryer groups respectively. This suggests that the effect of fabric tension on drying rate was more pronounced in the earlier drying phase. While conducting the trial, the primary refiner power increased significantly, which suggested possible changes affecting furnish and drainage.

Machine B was a large machine producing linerboard from 100% recycled fiber. The dryer section consisted of four single felted dryers, two double felted groups, four single felted groups, and a size press. Four single felted dryers and two single felted dryer groups made up the after-dryer section. The machine operated at 680 m/min producing 205 gsm linerboard.

Measurements were taken in the 3rd section (double felted). Fabric tension was varied from 1.8-3.8 kN/m (2.0-4.2 kPa contact pressure). The estimated solids content in and out of the 3rd group was 53-58%, which falls within the 50-70% range of the lab tests. With steam pressure in the 3rd group at 3.5 bar, average cylinder temperature was 130°C, which is slightly below the temperature in the earlier lab tests.

The results of the mill trial trials are compared to the lab results in Figure 4.

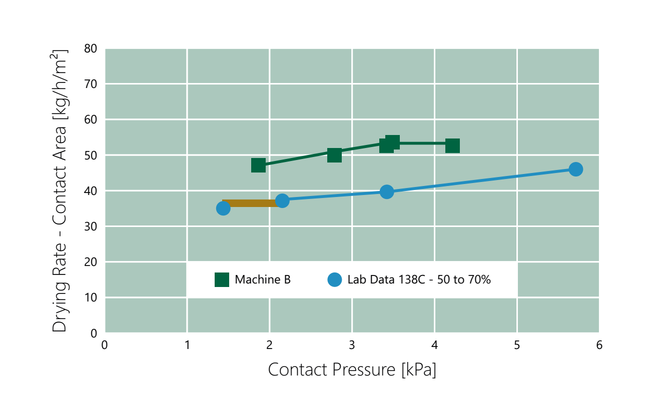

Figure 4. Linerboard Machine B drying rate vs contact pressure (lab and mill data)

Compared to other paper grades, the lab drying rates differed significantly from those calculated from condensing rate data. This may be due to differences in ventilation, fabric permeability, and perhaps more significantly, the fact that the lab tests were done with room temperature samples. The trends in increased drying rate with increased contact pressure are similar, however.

Overall, drying rates in the 3rd group increased by 10% over the range of tensions tested, with most of the increase observed from 1.75-3.2 kN/m (10-18 pli). From 3.2-3.9 kN/m (18-22 pli), the increase in drying rate was minimal. This indicates that for the steam pressure during the test, there would be little benefit in running a fabric tension above 18 pli. Lab tests at this and higher temperatures indicate that the drying rate should continue to rise.

Fine Paper Trial

The trial was conducted on a fine paper machine operating at 1255 m/min producing 75 gsm copy paper. The dryer section consisted of seven top felted dryer groups followed by a size press, with three top felted dryer groups in the after-dryer section.

Measurements were taken in the 4th group with fabric tensions being varied from 2.1-3.7 kN/m (2.3-4.1 kPa contact pressure). The estimated solids content in and out of the 4th group was 59-65%, which fell within the 50-70% range of the lab tests. Cylinder temperature in the 4th group varied from 115-121°C. The results of the mill trial compared to lab test results are shown in Figure 5.

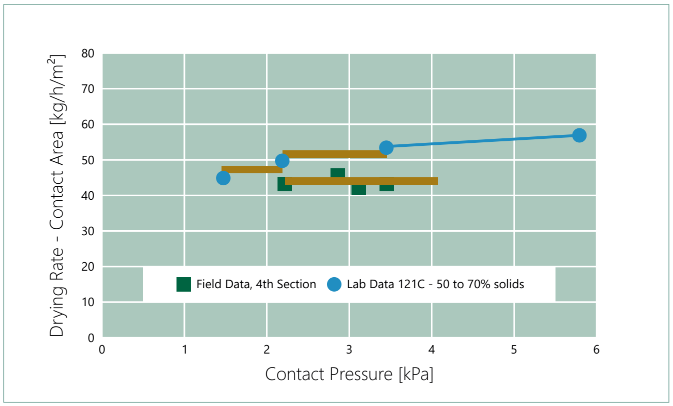

Figure 5. Fine Paper machine drying rate vs contact pressure (lab and mill data)

There is a reasonably good agreement both in terms of the magnitude of the drying rate and, more importantly, the trend of increased drying rate with increased contact pressure.

Just as fabric tension can be problematic if too high, if the tension is too low, drying performance will suffer. Low tension creates slack dryer fabric edges, which can lead to:

- Grainy edges on the sheet and sheet cockle.
- Hard edges on the reel due to nonuniform moisture profile.
- More steam required to dry edges for a uniform profile (over-drying and energy waste).

Heatsetting

One rule of thumb is to always heatset a dryer fabric slightly below the planned operating tension. Actual mill operating tensions must be verified. Especially when supplying a new fabric for a new position, it is important to know the operating tension so that proper heatset tension can be applied.

Why?

Heatsetting at a significantly higher tension than the operating tension can result in slack fabric edges. Heatsetting at a significantly lower tension than the operating tension can result in stretching of the fabric or opening of seam.

Some important things to remember regarding heatsetting:

- Standard heatset tensions are 1.5 or 1.7 kN/m (8 or 10 pli) depending on fabric. Other options are 0.7, 2.6, or 3.5 kN/m (4, 15, or 20 pli).
- Standard heatset tensions should work well on positions running between 1.2-2.6 kN/m (7-15 pli). For positions running higher or lower than this range, heatset tension probably should be adjusted.

Summary

The drying rates in our mill trials were calculated from condensing rate data and compared to drying rate data from our lab tests for similar paper grades.

For all grades studied, drying rates increased with increased fabric tension. The results indicate that elevated dryer fabric tension is beneficial to drying performance. In fact, the results seem to suggest that machine builders should consider designing rolls, bearings, and other fabric-loaded components to withstand higher loads than in the past.

However, until that becomes a reality, the fabric tensions should remain within the limits established by the machine builder. Mills would be well advised to verify and respect the felt tension rating of their equipment before operating at elevated fabric tensions to avoid equipment failure or damage to dryer clothing.

Never operate a tensioning system beyond its design limits. Failure to observe this rule may result in equipment failure and/or personal injury.

Got Questions?

We are here to help. We distribute **ExperTips** to help you improve the performance of your paper machine. Not just fabric performance, but the overall efficiency, reliability, and productivity of your mill.

If you have questions about anything you see here, please contact us by emailing **expertip@astenjohnson.com** or visiting our website **www.astenjohnson.com/expertips**.

And, if you have suggestions about other topics you would like to receive an ExperTip on, we would love to hear from you!