Rush/Drag

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Introduction

"To rush or to drag, that is the question"? Then by how much? This question does not get the attention it deserves, especially since it has so much effect on sheet properties. In brown paper, where directional strength is most important, rush/drag has a very significant effect on fiber orientation and hence sheet directional strength for such tests as STFI, ring crush, fluted edge crush, etc. which are becoming increasingly important.

What is Rush/Drag

The velocity at which the jet is emitted from the slice compared to the wire speed determines rush or drag. A jet velocity slower than wire speed is drag and faster is rush. Absolute difference should be compared, although many mills have set up their computers to read ratio. The fibers have "no sense" of absolute velocity, only whether they have to accelerate or decelerate when they hit the wire. A jet/rush wire speed ratio of 1.02 is 20' rush at 1000 minute but 60' rush at 3000 FPM, whereas the same sheet properties are achieved at a constant absolute difference such as 20' rush.

Jet velocity is calculated from the formula $V = C\sqrt{2gh}$, where V = jet velocity, g is gravitational constant, h = head and C is discharge coefficient. The discharge coefficient ranges from 1.0 to 0.95, depending on the type of headbox and the slice geometry and cannot be determined empirically. For low turbulence, older type headboxes such as the holey roll type, C is approximately 1.0 and can be essentially ignored. For high velocity, high turbulence type such as converflow and step diffuser boxes, the discharge coefficient is normally supplied by the headbox manufacturer or calculated on the machine using pitot tubes mounted in the slice jet.

Using the basic formula and ignoring C, then

$$V = 138.9\sqrt{h} \qquad \text{or metric:} \qquad V = 26.58\sqrt{h}$$

Where V = jet velocity (feet/min.)	Where V = jet velocity (MPM)
h = liquid head (inches)	h = liquid head (CM)

Liquid Head

This is the most difficult item to measure accurately. It should be measured as the static head above the slice. However, some of this static head energy is converted to velocity energy through the diffuser block, lexan sheets, etc., so the measured head changes from the back of the headbox to the slice discharge point. Where do you measure the head to give a value that can be used to calculate the actual jet velocity? Checking the velocity with the slice mounted pitot tube and calculating the head correction is the most accurate. This is specific for that particular headbox only.

Another method is the measurement of reel width to determine the zero rush/drag point. Note the indicated head at that point and introduce a "correction factor" for future use in calculating rush/drag.

Zero Rush/Drag

The reel width is maximum when the slice jet velocity exactly equals the wire speed. To find this point, use the following technique.

1. Before any change is made, measure the width of the reel very accurately. Measure it while running or on the reel as soon as the reel is removed. Do not measure the width of the sheet taken off the reel as it has relaxed as soon as tension is removed.

2. The draw may have to be adjusted as the head is changed. However, make sure you measure the width of the reel after the head change, before the draw is adjusted.

3. Determine what head change is necessary to change jet speed by (say) 25' at existing speed. Example machine running wire speed 2000 FPM.

   $V = 138.9 \sqrt{h}$ or h = (2000/138.9) 2 = 207.3"

   For 2025' h = 212.5". Therefore, a 5" head change will change jet velocity by approximately 25'.

4. Increase head by an amount equal to 25' increase. Measure reel width and note actual head and wire speed.

   a. If reel got wider, continue to increase the head in increments equal to half the first change – i.e., 12' head increase. (2025' jet goes to 2037' jet, h = 215", i.e., a 2.5" further increase.)

      Continue to make the 12' head changes and measure the reel width (and note actual head and wire speed) until the reel width decreased when you made the last head change. You have just passed through the point of zero rush/drag. You then may want to make smaller head changes to pinpoint the exact head corresponds to zero.

   b. If reel got narrow, decrease the head by the initial amount (25') plus 12'; i.e., starting at 2000', we went to 2025' jet velocity and the reel narrowed. The next trial is 1988' jet velocity or h = 204.8". The reel width should have widened. Continue to decrease the head in increments of 12', measuring the reel width (and noting actual head and wire speed), until the reel width decreases with the last change. You have just passed zero rush/drag and use the same procedure to pinpoint zero.

5. Make up a table as follows and plot it graphically. In this example, the zero point was when the machine instrumentation indicated 18' push. At this speed, this indicates an error in the head measurement of 3¾"; i.e., head gauge reads 3¾" too high. This is relatively constant at all speeds (by experiment).

   If mill wants a run at 35' rush (push) at 2000 FPM, the head necessary is calculated by:

   2035 – $138.9 \sqrt{h}$ – i.e., h = 214½. Then add "error" of 3¾" for head = approximately 218¼".

Why Is It Important?

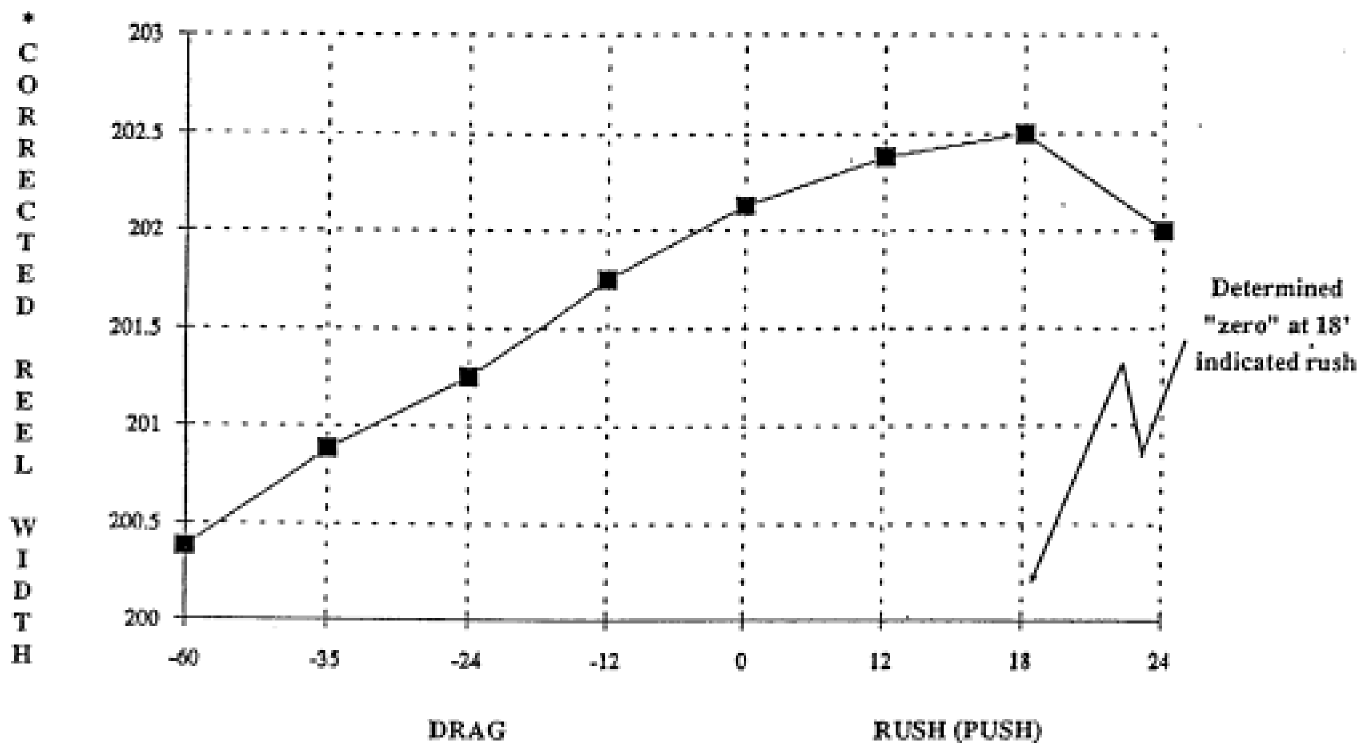
Some sheet strength properties are at their minimum level at zero rush/drag. For example, concora on corrugating medium is high at about 50’ drag, decreases as the zero point is approached, then increases again up to 35-40’ rush. Ring crush on the other hand needs cross machine fiber alignment and increases as the jet velocity is increased up to 35’ – 40’. Therefore, to maintain concora while achieving ring crush on STFI specification, best results have been achieved at around the 35’ rush value. This is largely independent of the furnish, type of machine and machine speed.

Problems can arise when, because of incorrect head measurement (or wire speeds), a machine is thought to be in a rush mode when in fact it is at the zero mode. Refining is increased to increase tests which slows the machine back or causes breaks due to a wet sheet off the fourdrinier.

Knowing where the exact zero rush/drag point is, then running at a pre-determined value such as the 35’ rush mode, has contributed to improved running performance of many machines.

	Actual Head	Calculated Jet Speed (FPM)	Actual Wire Speed	Indicated Rush/Drag	Change
Base Line	195”	1940	2000	(-) 60 Drag	Base reel width 200-3/8”
Trial 1 Head up 25’	200”	1964	(1999)	(-) 35 Drag	Reel width increased ½” to 200-7/8, No draw changes.
Trial 2 Head up 12’ (or down 37’)	202.4”	1976	2000	(-) 24 Drag	Reel width increased 3/8 to 201-1/4”. Had to tighten draw, reel width decreased to 201”.
Trial 3 Head up 12’	205-1/4”	1990	2002	(-) 12 Drag	Reel width increased ½” to 201-1/2”, no draw change.
Trial 4 Head up 12’	207-3/4”	2002	2002	Zero	Reel width increased 3/8 to 201-7/8, no draw change.
Trial 5 Head up 12’	210-1/4”	2014	2002	+12 Rush	Reel width increased ¼ to 202-1/8”, no draw change.
Trial 6 Head up 12’	215-1/4”	2038	2002	+24 Rush	Reel width decreased 3/8” to 201-7/8, no draw change.
Trial 7 Head down 18’	211-1/2”	2020	2002	+18 Rush	Reel width increased ½” to 202-1/4”.

	Actual Head	Calculated Jet Speed (FPM)	Actual Wire Speed	Indicated Rush/Drag	Change



Difference in speed (FPM) between jet and wire

*Corrected reel width is actual measured width plus or minus any changes due to draw.

Sheet Property Changes with Rush/Drag