ROLLER DESIGN

The Great Span Debate: Part 1 – Mar 2009

What is the best span length? How far apart should rollers be? Is there a good rule of thumb on span length, such as "span lengths should be less than one (or one and a half) web widths?"

Whether this rule sounds good to you will depend on the webs with which you work. For a 60-in.-wide web, one roller every 60 in. or one every web width seems reasonable.

For paper or polypropylene film makers working with widths that can be more than 20 ft, having a roller every 20 ft is not reasonable. For narrow web handling, such as 2-in. wide tapes, it would be ridiculous to require a roller every 2 in.

There are at least half a dozen things that come to mind in the great span length debate. Let's review the checklist to figure out what span length is right for you.

Costs (since rollers don't grow on trees)

A 3-in.-dia roller can cost from $5-$10/in. of width. A 6-in.-dia roller will run closer to $20/in. ($40 if you want stainless steel).

If you need to transport the web 100 ft through an oven, ten 70-in. rollers will cost $14,000. The debate whether span lengths should be every 10 ft or every 2.5 ft (equal to 2× or one-half of a 60-in. web width) is a $42,000 question.

Roller costs, just like any piece of equipment, don't stop at the purchase price. Rollers have to be aligned. Their bearings and surface need to be maintained. When the webs break, each roller needs to be rethreaded. When slimed, each roller has to be cleaned. Suddenly this simple question is more complicated.

Ergonomics and Safety

Rollers in close proximity always should be considered a safety hazard. In some cases, a guardable nip point can be two rollers as far as 6 in. apart.

For ease of threading, roller spacing should start at 4 in. between roller-roller and roller-machine surfaces, unless process or space limitations trump this goal.

Gravity

Most CAD drawings of web lines show rollers and webs as circles with tangential connecting lines. Real webs will sag and flutter from gravity, web bagginess, and roller misalignment.

Gravity is most obvious and significant as spans are closer to horizontal, when it causes catenary sag (the same as the sag of high tension power lines between poles).

In a 20-ft span, a 1-mil polyester web at 1 PLI will sag 0.75 in. A 10-mil polyester web would sag ten times more or require 10 PLI tension to get back to 0.75-in. of sag.

Sag will increase directly with span length squared and inversely with tension. If you start adding loads onto your web, such as the mass of a wet coating or the force of air impingement, then the deflections will increase proportionally.

In vertical spans, the effects of gravity are often negligible. The tension in a web rising vertically will increase by the web span's weight as it rises from the bottom to the top of a vertical span (or drop the same amount in falling vertical spans). For a 10-mil thick polyester rising 20 ft, the tension change will be only 0.12 PLI — hardly worth talking about.

Bagginess and Misalignment

If either of these imperfections drives the web to slackness — look out. In a 50-in. span, just 0.040 in. of excess length or misalignment will allow the web to deviate from the web's plane by 1-in. That's less than a 0.1% error. Close spacing of rollers is required to prevent contact when passing through slots, a tunnel, or to avoid other non-moving elements.

Span length debate so far: Short spans are expensive; extremely short spans are hazardous; and long spans lead to flutter and out-of-plane problems. Next month we'll cover traction, tension, guiding, wrinkling, and spreading.

The Great Span Debate: Part 2 – Apr 2009

Here a roller, there a roller, everywhere a roller-roller. That may make an entertaining toddler's song, but it isn't a good strategy for web line design.

Last month, in The Great Span Length Debate | Part 1 we debated roller spacing (a.k.a. web span length) relative to cost, safety, out-of-plane deviations from gravity, bagginess, and misalignment. Let's continue the debate.

Traction

The length of span has no significant effect on web-to-roller traction. Longer spans don't increase the friction coefficient, tension, wrap angle, lubrication, or roughness/grooving. If sequential rollers are wrapped in over-under-over-under, more rollers will create larger wrap angles per roller. In arched or flat dryers where a series of rollers are all on one side of the web, more rollers means less wrap angle per roller. For rollers with less than two degrees of wrap, a one degree change can be the difference between stick and slip, but roller performance is the more likely solution to slip problems.

Air Turns

It is rarely a good idea to have an air turn controlling a long span, especially a long entering span. A web is perfectly happy to wrap helically around an air turn (which we like in a web flip) or shift back and forth violently (which we rarely enjoy). Prevent this with a roller (usually on the non-air turn side) as close as possible to the air turn's entrance and good air turn alignment.

Air Flotation

Whether using Coanda or impingement nozzles, the longest spans in converting are in well-designed air flotation ovens, but this special case falls outside the great span debate.

Tension Control

Span length is usually a non-factor in tension control. Total length increases a draw system's response time, and more rollers will increase MD tension variations within the zone, but neither specifically changes if any individual span is long or short. Short spans in and out of dancer or load cell rollers will increase the system mass-spring harmonic frequency and reduce the likelihood of problems in below 1,000 fpm speeds.

Guiding

Long spans are better. Long spans get more correction for a given angle change. Long spans have greatly reduced tension variations from bending and twisting, especially if a longer translation span means misalignment angles are smaller.

Wrinkling

This is the Catch-22 of span lengths. Longer spans are less sensitive to shear wrinkles from misalignment or diameter variations. Short spans are less sensitive to tracking wrinkles from deflection, baggy-center webs, or crowned winding rolls. I lean toward short spans in wrinkle-sensitive webs since good equipment design can prevent misalignment and diameter variations but can't stop baggy webs.

Spreading

Spreaders can spread more with less force if entry spans are long. Exit spans should be short to reduce post-spreader tracking and immediately upstream of your critical process if the spreading is for anti-wrinkle benefits.

Slitting

Short spans in and out of slitting are best to minimize slit quality problems of a web that flutters or sags away from the ideal cut point.

Winding

Of all the span problems I see over and over, lack of span control at winding is the most common. Old paper winders insensitive to wrinkling are ill-prepared to winding film product. Old turret winders that lose their optimized entry span control during indexing are a major cause of waste worldwide.

It's cheating, but true, to say the answer to the great span debate is “it depends,” but clearly it does. Here's my educated gut feeling on spacing transport rollers. I am comfortable with 1-6-in. web spans up to 6 ft, 24-80-in. up to 8 ft, and ultra-wide 100-200-in. webs with spans to 15 ft. I think you can double these lengths for purely vertical spans, since gravity doesn't pull the web out of plane.