SELECTING THE BEST IDLER SIZE

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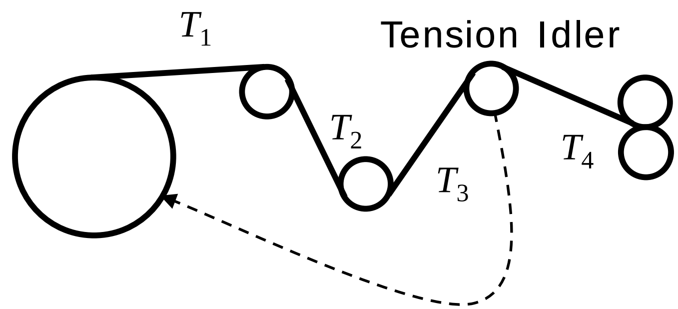
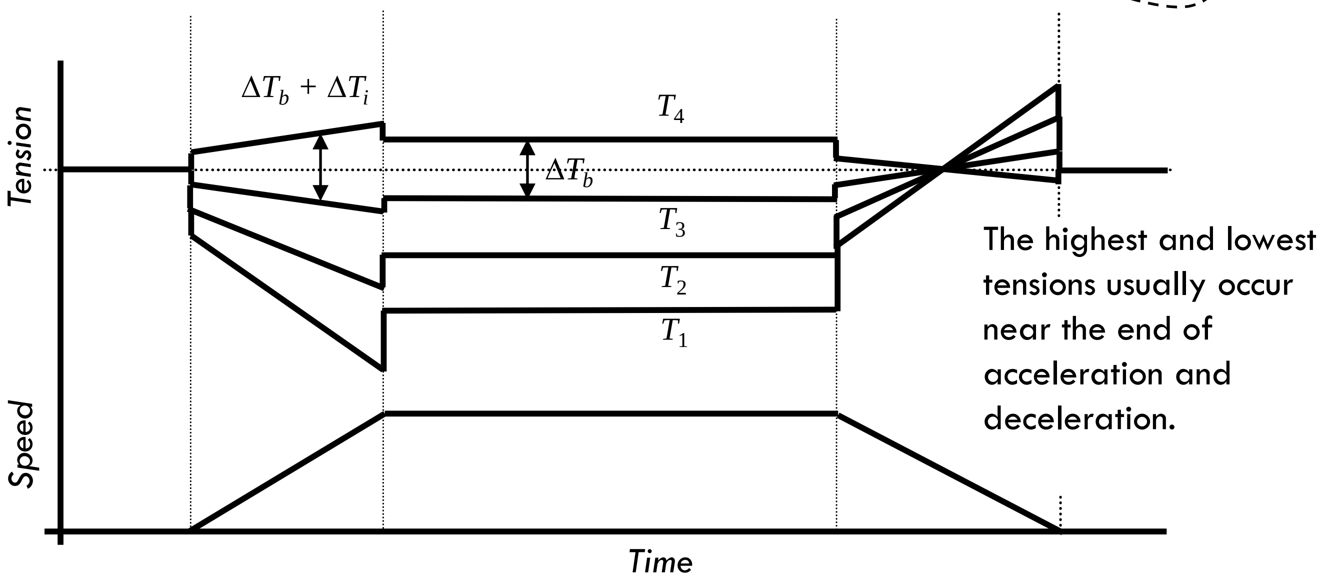
WHY IDLERS MATTER

- Idlers influence the highest and lowest tension we can run in a web path.
- Idler bearing drag and inertia upset tension during acceleration and deceleration.
- Idlers can defeat the most sophisticated tension control systems.
- Idler diameter affects a lot of things.

HOW IDLERS AFFECT TENSION

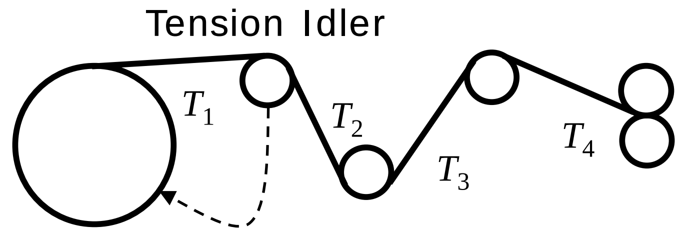
- A simple web path and its tension plot during a run

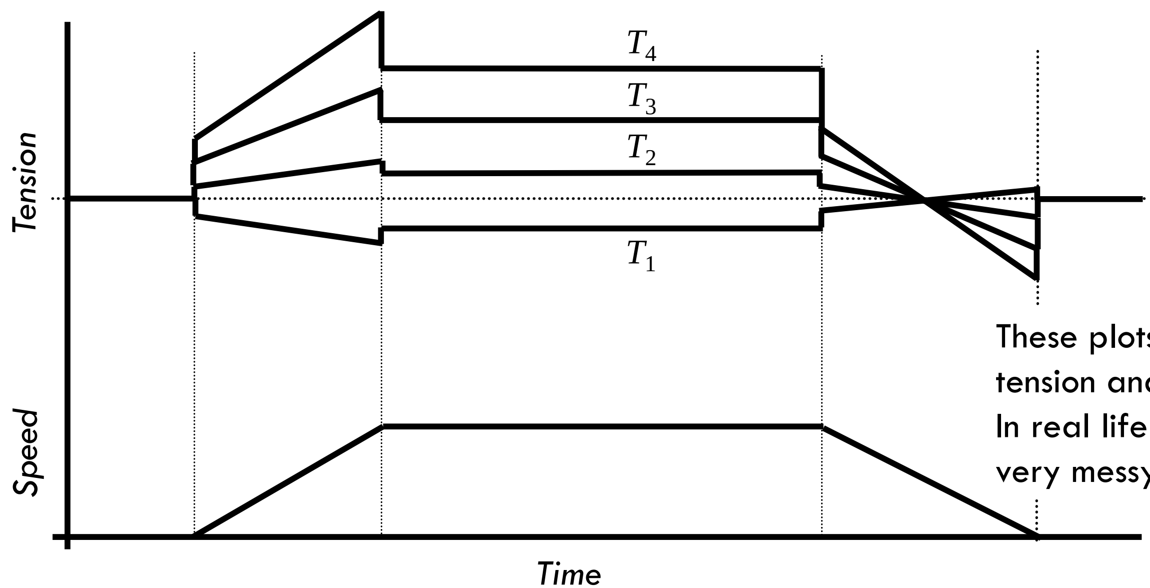




HOW IDLERS AFFECT TENSION

- The location of the tension idler matters.





These plots assume perfect tension and drive control. In real life they can be very messy.

BEARING DRAG

- A simple bearing torque formula

$$Torque.bearing = \tau + \gamma\omega$$

- Restated in terms of radius and tension difference across the idler, the bearing drag force is

$$\Delta T_{\mathrm{b}} = \tau/r_{\mathrm{o}} + \gamma V/r_{\mathrm{o}}^{2}$$

INERTIAL DRAG

- A simple formula for inertial torque

$$Torque.ineria = J\alpha \text{ where } J = mr_o^2$$

- Restated in terms of radius and tension difference, the inertial drag is

$$\Delta T_i = mA$$

- Calculating the mass from wall thickness, length and density, the tension difference is

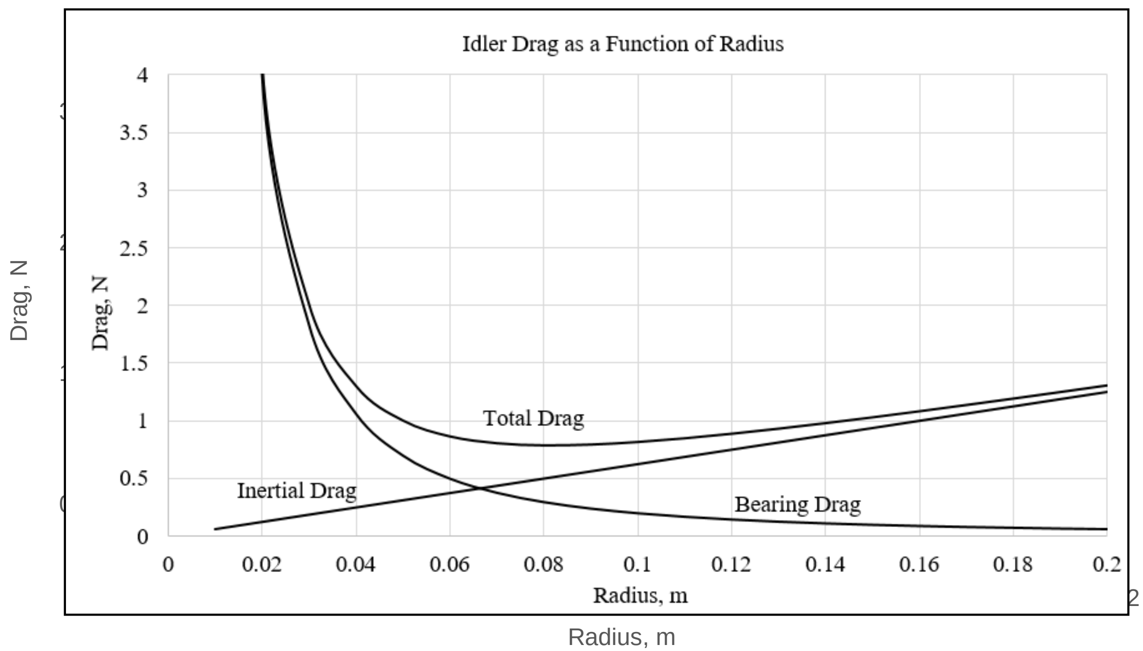
$$\Delta T_i = \pi (r_o^2 - (r_o - w)^2)\, l\rho A$$

COMBINING

- Combining bearing drag and inertial drag

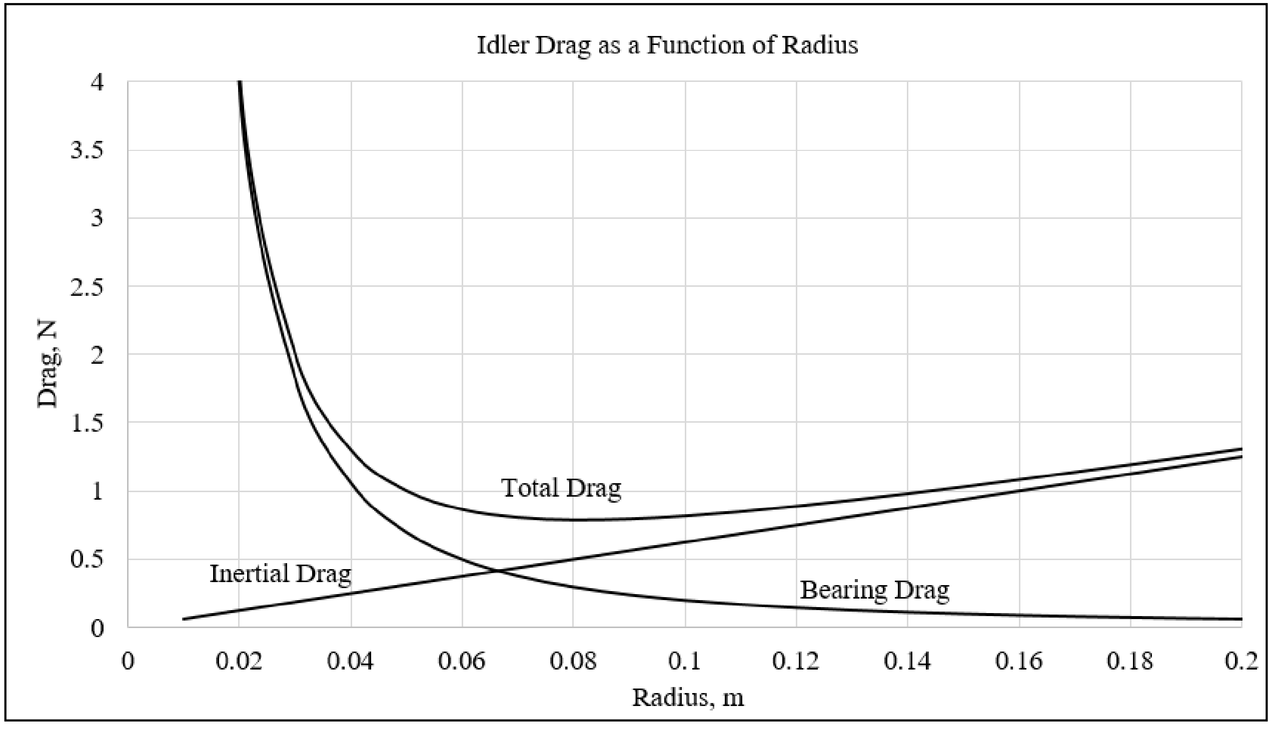
$$\Delta T = \tau/r_o + \gamma V/r_o^2 + \pi\,(r_o^2 - (r_o\text{-}w)^2)\; l\rho A$$

- Plotting total drag vs. radius



COMBINING

- The lowest total drag of 0.79 N occurs at 0.082 m.

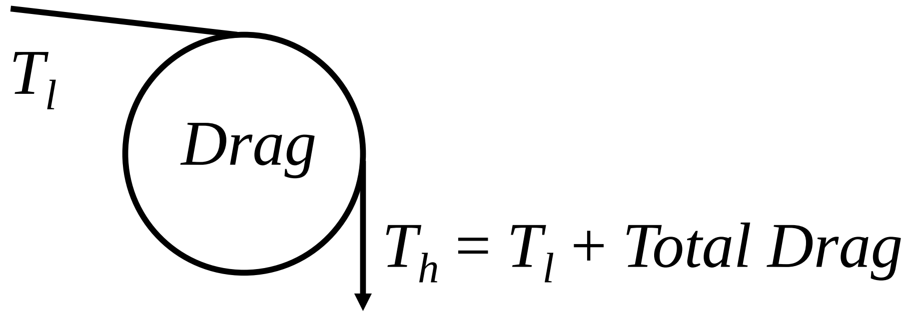


VALUES FOR THE EXAMPLE IDLER

l =	1	meters	idler shell length
w =	0.0025	meters	shell wall thickness
ρ =	1600	kg/m^3	material density
A =	0.25	m/sec^2	linear acceleration
V =	5	m/sec	linear velocity
α =	0.005	N-m	bearing static drag
γ =	0.0003	(N-m)/sec	bearing viscous drag
P =	50	N/m	resultant web load
k =	9.87		SI natural freq const
E =	7.00E+10	N/m^2	Young's modulus of shell

Table 1 - Typical idler values for a generic carbon composite idler

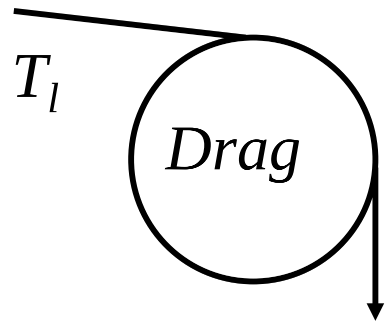
MINIMUM TENSION



- Lower Tension Failure Limit
  - Loss of traction with idlers defines a lower tension limit.

$$T_l > \frac{Total\ Drag}{e^{\mu\theta} - 1}$$

MINIMUM TENSION

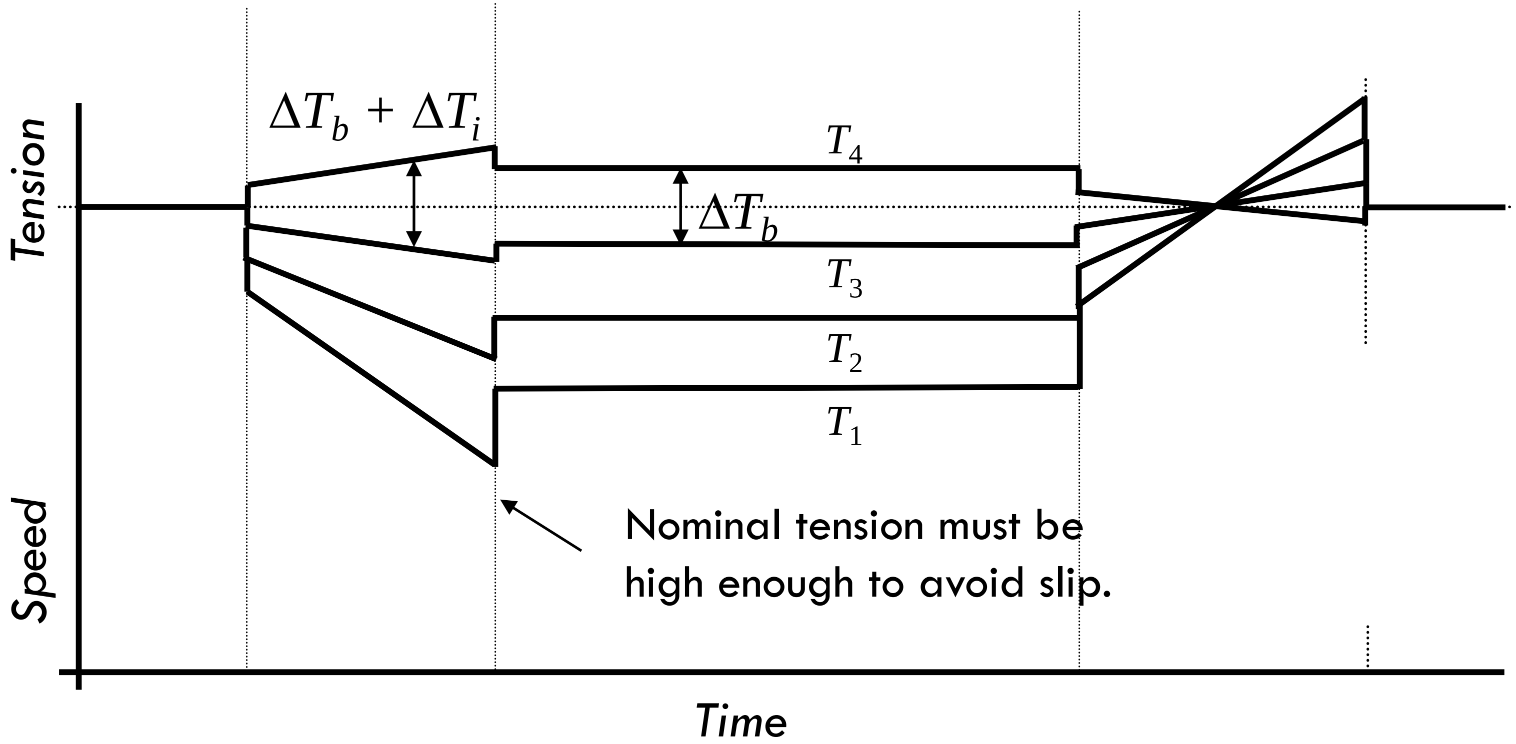


$$T_h = T_l + Drag + MA$$

- Lower Tension Failure Limit
  - Loss of traction with idlers defines a lower tension limit.

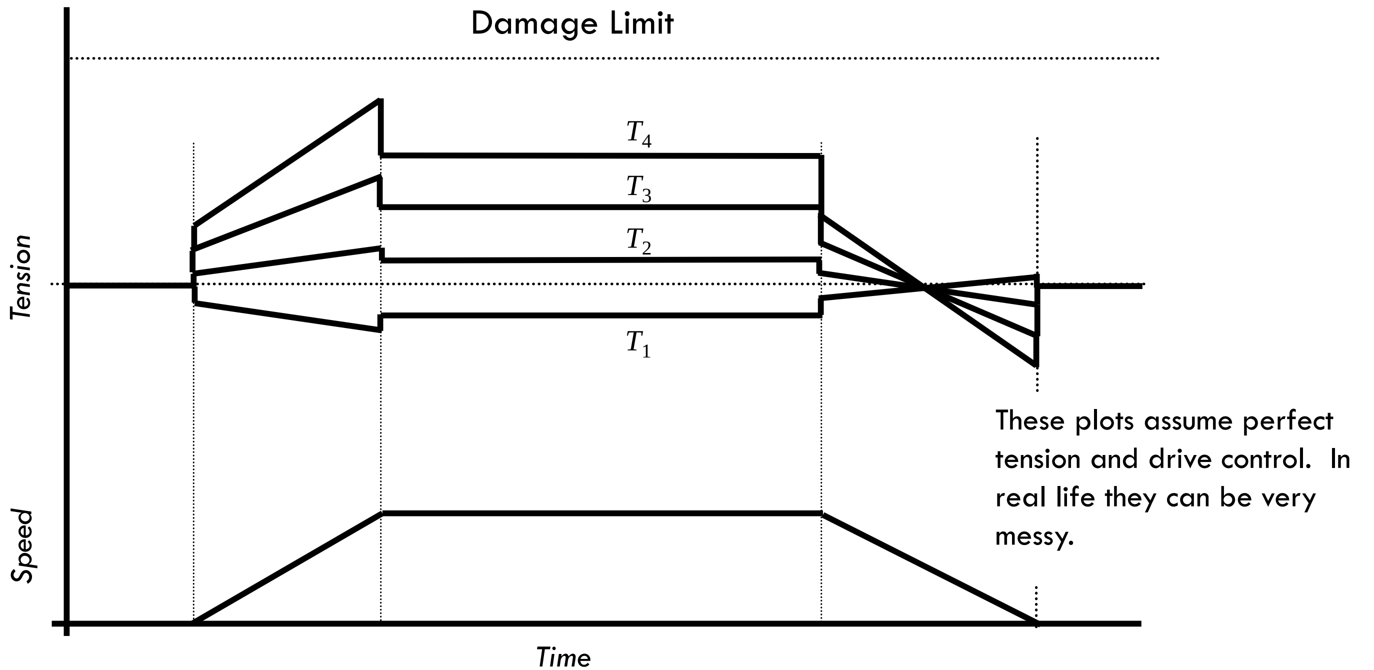
$$T_l > \frac{\tau/r_o + \gamma V/r_o^{\,2} + \pi\,(r_o^{\,2} - (r_o - w)^2)\,lrA}{e^{\mu\theta} - 1}$$

MINIMUM TENSION



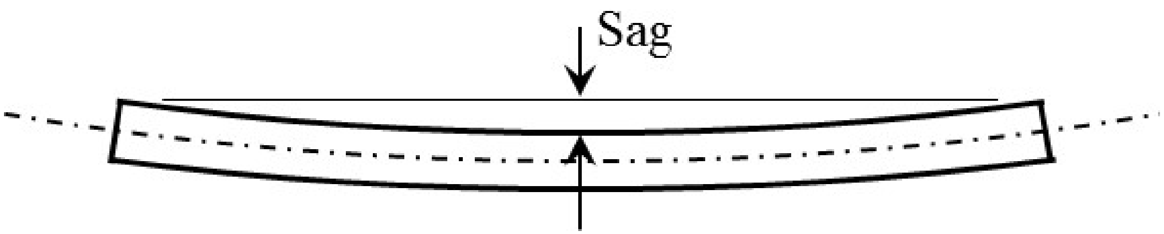
MAXIMUM TENSION

- Nominal tension must keep the peaks below the damage limit for the web.



DEFLECTION-SAG

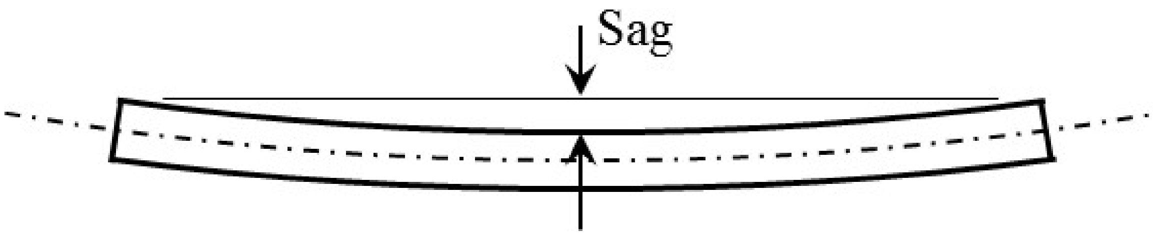
- Sag of the shell is important for a symmetrically and simply supported hollow shell idler.



$$\text{Sag} = 5Pl^4/(384EI) \quad \text{and} \quad I = \pi(r_o^{\,4} - r_i^{\,4})/4$$

DEFLECTION-SAG

- For an acceptable mid-point sag of 0.00015 m/m, any shell greater than 0.045 m is acceptable.



Radius, m	0.04	0.045	0.05	0.055	0.06	0.065	0.07	0.075	0.08	0.085
Sag, m	0.000201	0.000139	0.000101	0.000075	0.000058	0.000045	0.000036	0.000029	0.000024	0.000020

DEFLECTION-SAG

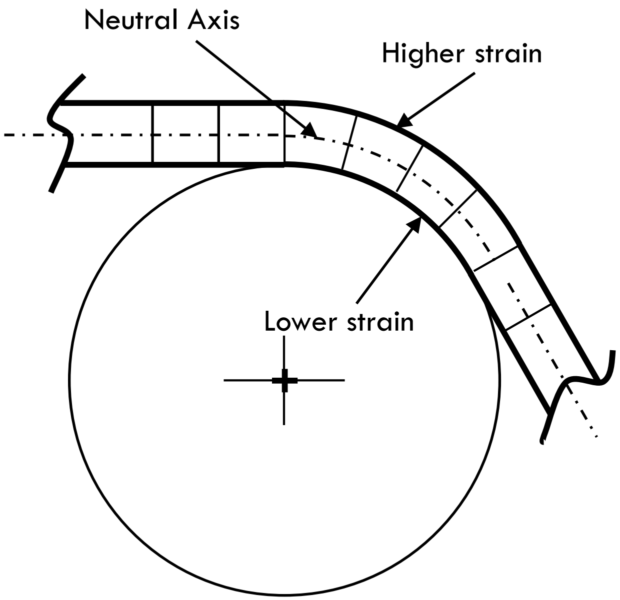
- A 0.045 m radius idler designed as in Table 1 will have 1.13 N of total drag; 40% more total drag than the 0.79 N of a similarly designed idler with 0.082 m radius.
- Its steady state drag will be 0.85 N vs. 0.28 N for the optimum idler diameter; 300% higher.

- Smaller is not always better!

BENDING RADIUS OF WEB

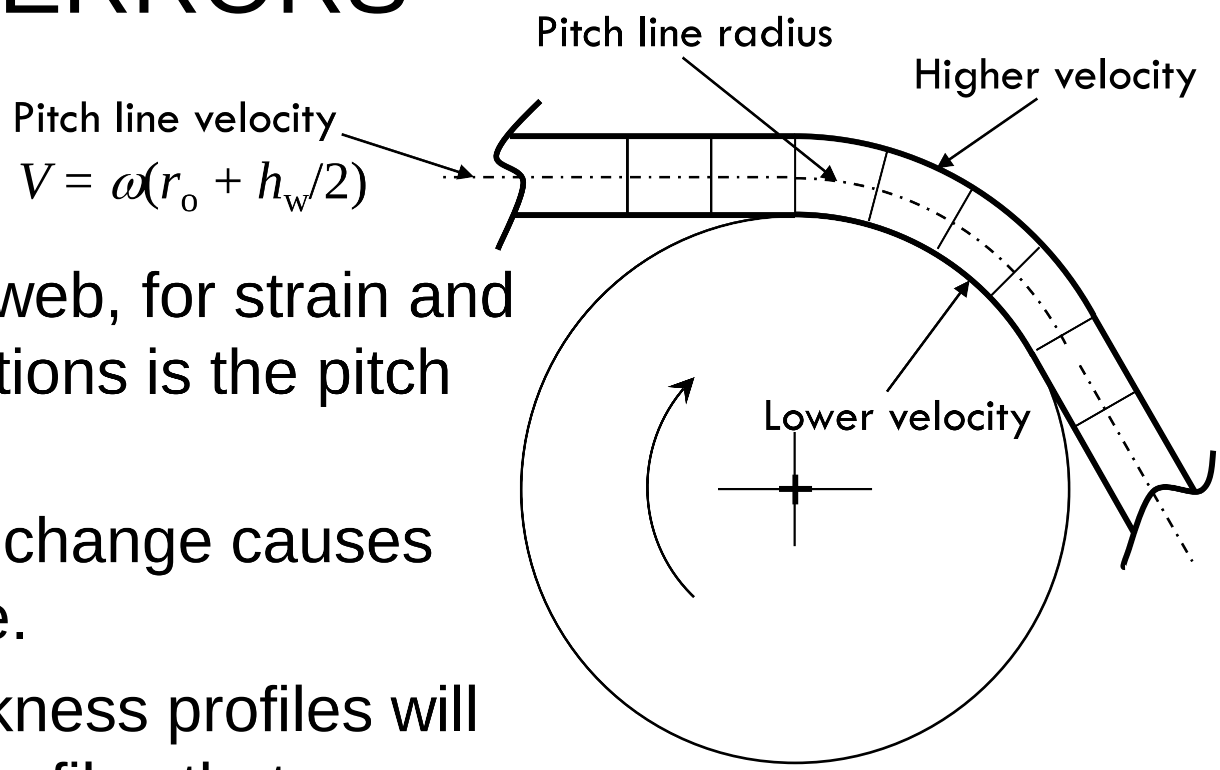
- Bending strain can damage the web in extension or compression.

$$\Delta\varepsilon \approx h_w / r_o$$



- Can be a factor for thick webs.

VELOCITY ERRORS



- Velocity of the web, for strain and tension calculations is the pitch line velocity.
- Web thickness change causes velocity change.
- Webs with thickness profiles will have velocity profiles that can cause wrinkles and off tracking.
- Larger radius minimizes both affects.

OTHER FACTORS

- Air entrainment $$h_a = 0.643 r_o \left[\frac{6\eta\left(V_{web} + V_{roller}\right)}{T/l} \right]^{2/3}$$
- Critical speed vs. RPM $$\omega_c = \frac{k}{2\pi l^2} \sqrt{\frac{lEI}{m}}$$
- Dent resistance
- Standard size materials
- Machine size
- $$

QUESTIONS?

Thank You

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