



Practical Application of Roller Performance Measurements and Models

Timothy J. Walker
tjwalker@tjwa.com
(404) 373-3771

Seventh International Conference on Web Handling
Stillwater, Oklahoma
June 2, 2003

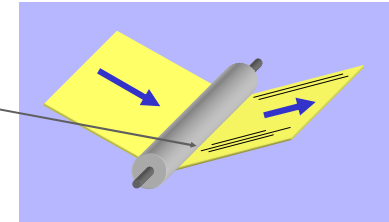
WWW.TJWA.COM | 1335 Church Street, Suite C7 | Decatur, Georgia 30030

Motive: Reduce Abrasion



Abrasion wear occurs when there is relative motion between normally loaded surfaces.

Scratches are formed by machine direction relative motion, most often from a slipping idling or driven roller.



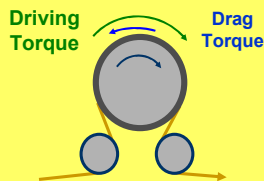
Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

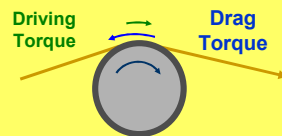
When Do Idlers Slip?



No Slip, No Scratch
Driving Torque > Drag Torque



Slipping & Scratching
Driving Torque < Drag Torque



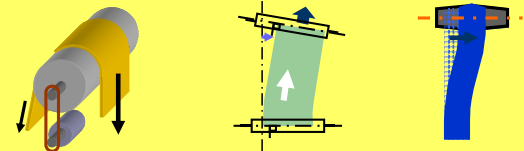
Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

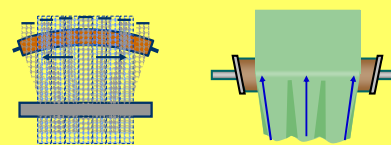
Other Roller Slip Problems



Tensioning Tracking Guiding



Spreading Anti-Wrinkle



Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

Traction Safety Factor

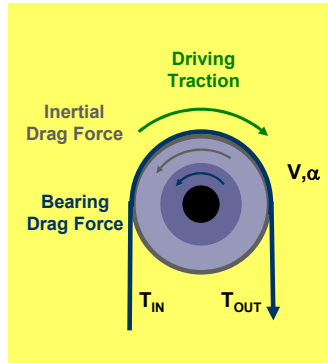


Steady-State:

$$TSF_{SS} = \frac{\text{Traction Force}}{\text{Bearing Drag Force}}$$

Acceleration:

$$TSF_A = \frac{\text{Traction Force}}{\text{Bearing Drag Force} + \text{Inertial Drag Force}}$$



Roller Analysis Protocol

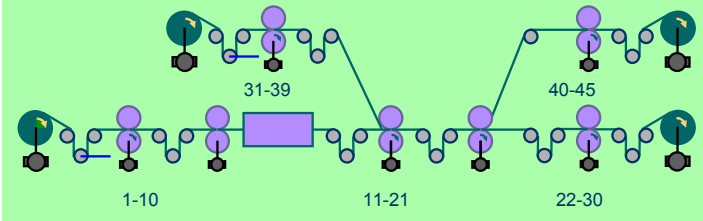


1. Catalog Roller Data
2. Complete Spin Down Tests
3. Calculate Roller Inertias
4. " Bearing Drag
5. " Driving Friction
6. " Inertial Torque
7. Calculate Traction Safety Factors
8. Review Performance by Bearing and Roller Type

1. Catalog Roller Data



Document all roller positions, noting their ID code, design style, and wrap angle.



Note: Actual web line not shown.

1. Catalog Roller Data



Collect the information on each roller:

Roller Web Path Data Sheet

- Roller ID
- X,Y Position
- X,Y Reference Pt.
- Rotation (CW or CCW)
- Tension Zone

Roller Design Data Sheet

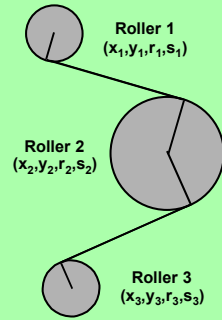
- Style Name
- Shell Details
- Shaft Details
- Mount Details
- Bearing Details
- Surface or Covering Details

1. Catalog Roller Data



Estimate wrap angles from observation or elevation diagrams.

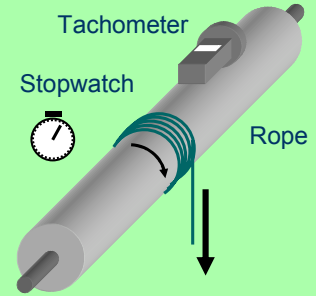
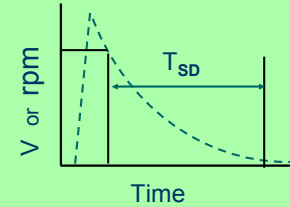
Wrap and path length can also be found from x-y relative position, radius, and spin direction.



2. Complete Spin Down Tests



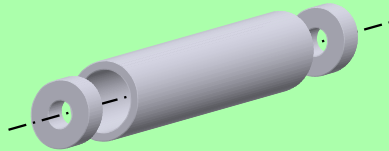
Spin Down testing measures deceleration time from a target starting rpm or surface speed.



3. Calculate Roller Inertias



$$I = \frac{\pi \rho w (r_o^4 - r_i^4)}{2}$$



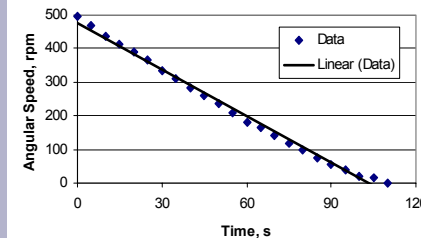
$$I = \frac{\pi \rho w (r_o^4 - r_i^4)}{2g}$$

- I Roller rotational moment of inertia (kg-m²)
- r_i Roller shell inner radius (m)
- r_o Roller shell outer radius (m)
- w Roller width (m)
- ρ Density (kg/m³)
- g Gravitational acceleration (m/s²)

4. Calculate Bearing Drag



Typical Spin Down Test Data



$$\alpha_{SD} = \frac{2\pi n}{60t}$$

$$M_B = I \alpha_{SD}$$

$$F_{BD} = \frac{M_B}{r_O} = \frac{I \alpha_{SD}}{r_O}$$

5. Calculate Driving Friction



$$F_{DR} = \mu T \theta$$

T Tension (N)
 μ Traction Coeff. (--)
 θ Wrap Angle (radians)

Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

6. Calculate Inertial Torque



$$\alpha_A = \frac{v}{rt_A}$$

$$M_A = I\alpha_A$$

Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

7. Calculate Traction Safety Factor

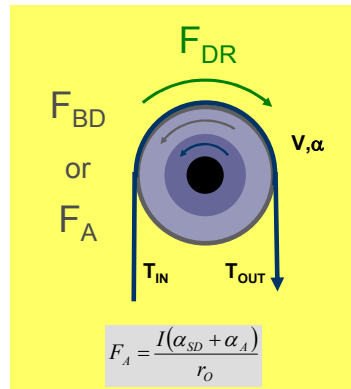


Steady-State:

$$TSF_{SS} = \frac{F_{DR}}{F_{BD}}$$

Acceleration:

$$TSF_A = \frac{F_{DR}}{F_A}$$



Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

8. Review Performance



Good News!...not surprisingly, no rollers with $TSF < 1$.

TSF _A Range	No. of Rollers
< 1	0
1-2	2
2-5	57
5-10	6
> 10	248

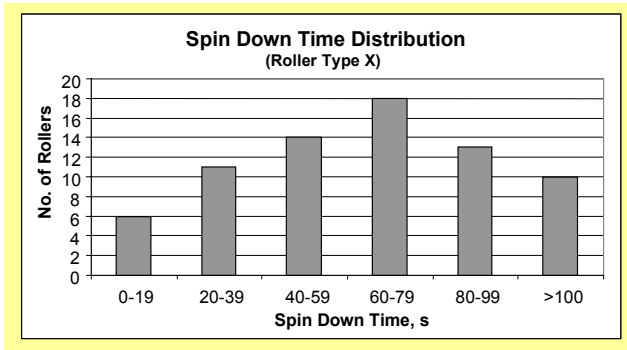
Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

8. Review Performance



Identical Rollers ☯ Identical Performance.



Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

8. Review Performance



Identical Bearings ☯ Identical Performance.

	Bearing Inner Dia.	Bearing Drag (mode of pop.)	Bearing Drag Range
Bearing A	5 mm [0.197 in.]	0.56 N-mm [0.005 lbs-in]	0.23-1.69 N-mm [0.002-0.015 lbs-in]
Bearing B	12 mm [0.472 in.]	3.39 N-mm [0.030 lbs-in]	2.15-14.8 N-mm [0.019-0.131 lbs-in]
Bearing C	22 mm [0.875 in.]	7.91 N-mm [0.070 lbs-in]	4.52-32.6 N-mm [0.040-0.289 lbs-in]

Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

8. Review Performance



Small Bearing = Good? Yes, but beware.

Parameter	Bearing A (low wrap)	Bearing A (high wrap)	Bearing B	Bearing C
Wrap Angle	5 degr.	180	90	180
Static Load Rating	1600 N	1600	3780	9140
Equivalent Radial Load	32 N	253	187	258
Bearing Life, L_{10}	539 yrs	1.1	37	197

Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

Poor Performance Causes



- Variability**
As high as 50:1 for “identical” rollers.
- Roller Assembly**
Don't assume that roller performance variation = bearing variations.
Poor assembly is a top suspect.
- Contamination** (a main motive of this study.)
Use labyrinth seal bearings to avoid this problem.

Timothy J. Walker, TJWalker+Associates, Inc.

www.tjwa.com

Poor Performance Causes



4. Thermal Effects

Not studied in this report, but a well-known roller performance detractor.

5. Oxidation

Rollers near a corona treater had outstandingly poor performance. Top suspect = ozone.

6. High Wrap, Cantilevered Rollers

Another significant poor performance observation. Top suspect = torsional bearing load.

Recommendations



Automated Roller Performance Monitoring

Use two tension-measuring rollers within a roller-plentiful tension zone (at extreme upstream and downstream position).

The measured tension differential will indicate collective roller performance.

Preventive Maintenance

Use Spin Down testing and this roller performance protocol for your web process.

Establish roller performance standards for all new rollers.

Conclusions



Cost / Benefit Analysis

Cost = downtime, maintenance, & analysis.

Benefit = waste savings, profit savings, & happy customers.

Simplified Measurements and Models

Decisions to use simplified models was intentional.

Goal: Lower threshold to understanding and use.