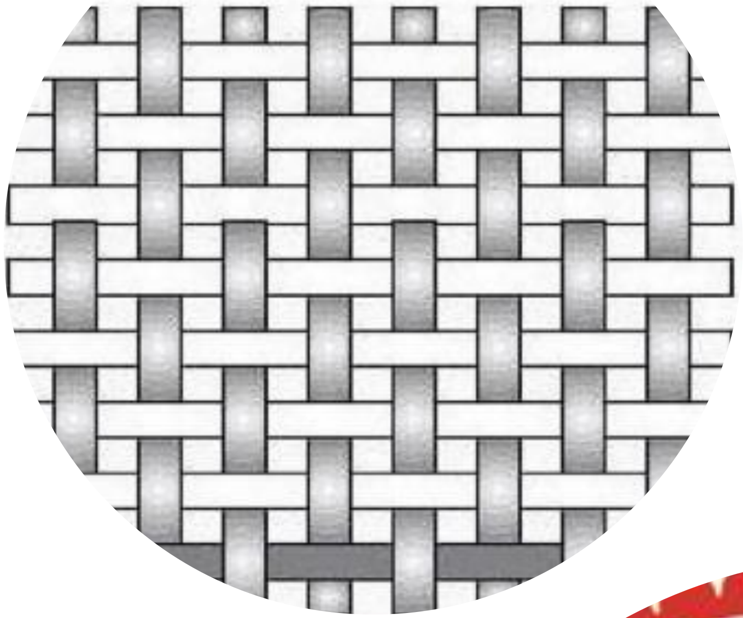
Fabric Manufacturing I (TXL231)



Dr. Sumit Sinha Ray

Asst. Professor

Department of Textile and Fibre Engineering

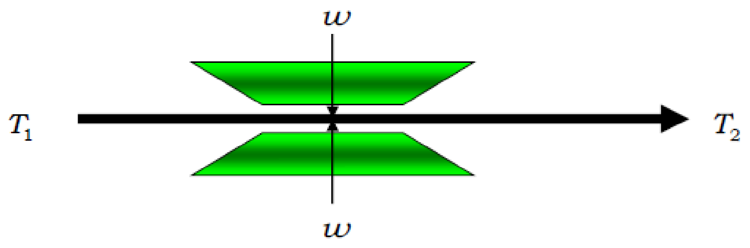
Yarn Tensioning: Why?

The primary objective of yarn tensioning is to build a package with adequate compactness

***As a rule of thumb, yarn tension in winding is around 1 cN/tex**

Types of Tensioning Device

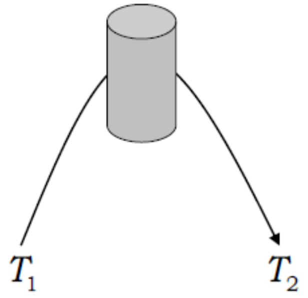
Additive type or disc type tensioner



The yarn is passed through two smooth discs one of which is weighted with the aid of small circular metallic pieces

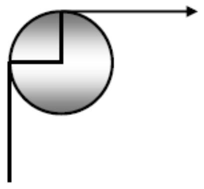
$T_2 = T_1 + 2\mu w$

Multiplicative type tensioner

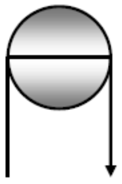


The yarn is passed round a curved or cylindrical element

$T_2 = T_1 e^{\mu\theta}$ **θ is the angle of wrap (in radian)**



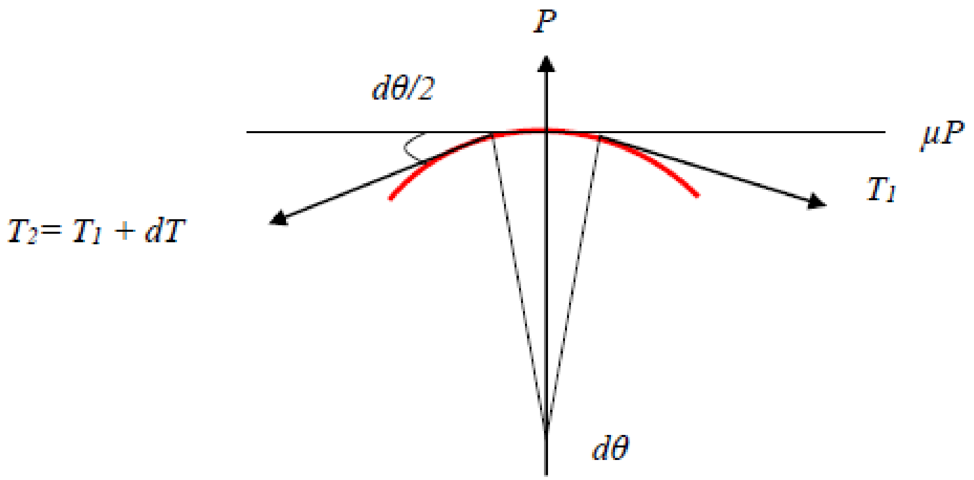
Angle of warp = $\pi/2$



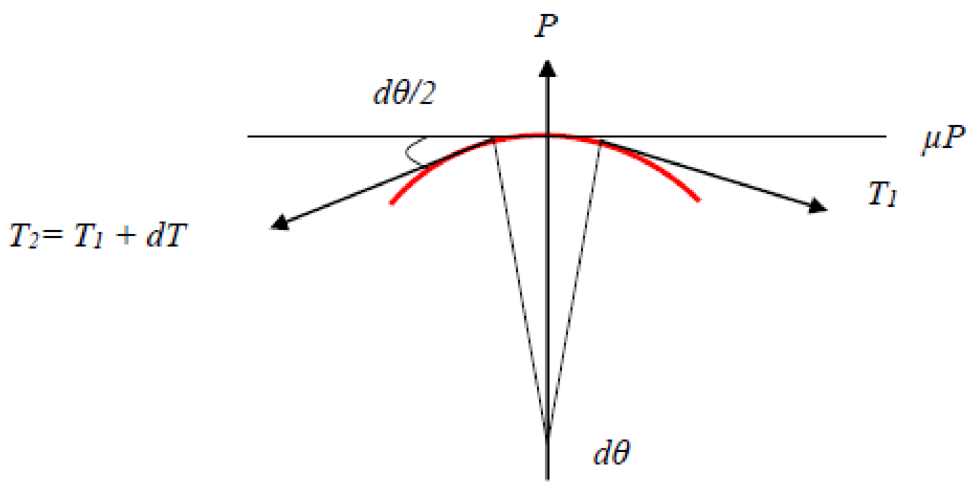
Angle of warp = π

Relation between Input and Output Tensions in Multiplicative Tensioner

The contact region between the curvature and yarn has created a small angle dθ at the centre of the assumed circle. The yarn tension in the input side is T_1 and tension in the output side is T_2. The difference in tension is dT. The difference between the horizontal component of T_2 and T_1 will balance the frictional resistance which will depend on coefficient of friction between the yarn and tensioner (μ) and the resultant vertical component of T2 and T1



Relation between Input and Output Tensions in Multiplicative Tensioner



For the vertical components

$$P = (T_1 + dT_1)\sin\frac{d\theta}{2} + T_1 \sin\frac{d\theta}{2}$$

$$\cong 2T_1 \sin\frac{d\theta}{2} \quad (\text{as } \frac{d\theta}{2} \text{ is small, } \sin\frac{d\theta}{2} = \frac{d\theta}{2} \text{ and product of } \frac{d\theta}{2} \text{ and } dT_1 \text{ can be ignored})$$

$$\cong 2T_1 \times \frac{d\theta}{2} = T_1 d\theta \quad \textbf{(a)}$$

For the horizontal components

$$\mu P = (T_1 + dT_1)\cos\frac{d\theta}{2} - T_1 \cos\frac{d\theta}{2}$$

$$= dT_1 \cos\frac{d\theta}{2} \cong dT_1 \quad (\text{as } \frac{d\theta}{2} \text{ is very small, } \cos\frac{d\theta}{2} \approx 1) \quad \textbf{(b)}$$

Equate (a) and (b) to get $T_2 = T_1 e^{\mu\theta}$

Reversal Point at Cylindrical Package and Wind Angle

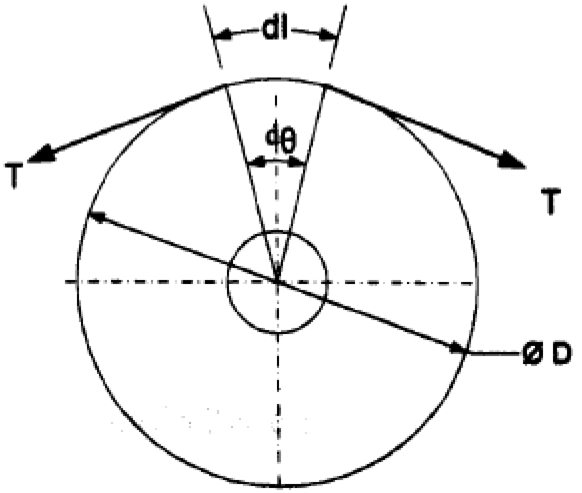
The problem of hard edges on cross wound packages is caused by the inability of the traversing mechanism to sharply reverse the direction of traverse at the edges of the package

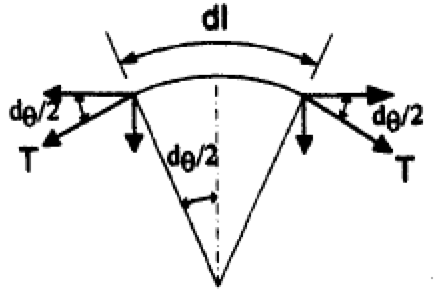
Two distributed loads act on the yarn at a reversal point on the package surface

- Normal load due to the friction between the yarn and the package surface
- Tangential load as a component of the yarn tension at the turn

The yarn reversal is in equilibrium until the radius of curvature ρ reaches its minimum value at the point of reversal. In this condition the product of normal tension load P and coefficient of fibre friction μ must equal the tangential load Q

α	-	wind angle	degree
α_{max}	-	maximum wind angle	degree
T	-	yarn tension	g
P	-	distributed normal load	g/cm
Q	-	distributed tangential load	g/cm
l	-	length of the yarn	cm
θ	-	radial angle	degree
φ	-	peripheral angle	degree
ρ	-	radius of curvature	cm
μ	-	coefficient of friction	-
ϵ	-	stroke ratio	-
D	-	diameter of the package	cm



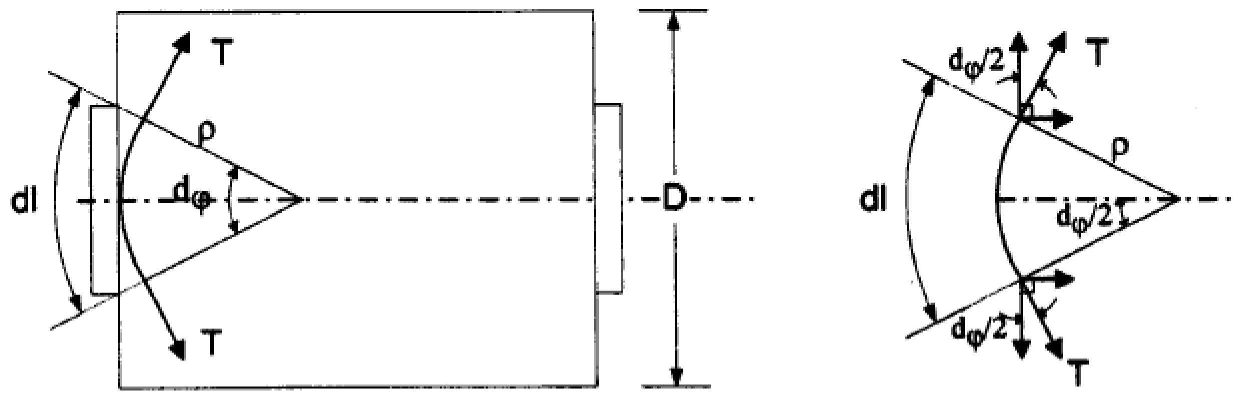


$$\mu . P = Q$$

Reversal Point at Cylindrical Package and Wind Angle

From the previous calculation set--------, For normal load $2T \sin(d\theta/2) = P.dl$ and $dl = D/2.\, d\theta$ and $\sin(d\theta/2) = d\theta/2$

So $P = 2T/D$



From the previous calculation set--------, For tangential load $2T \sin(d\phi/2) = Q.dl$ and $dl = \rho.\, d\phi$ and $\sin(d\phi/2) = d\phi/2$

So $Q = T/\rho$

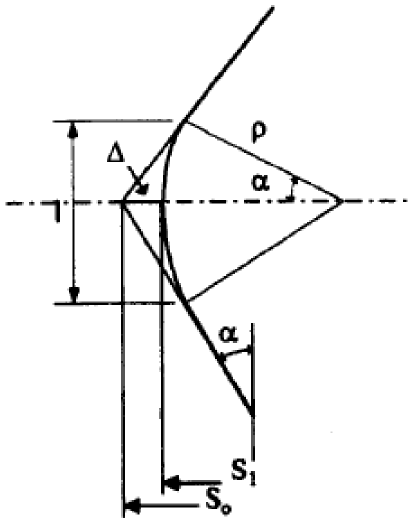
But for ρ to be minimum $\mu 2T/D = T/\rho_{min}$ the minimum reversal radius depends on the radius of package and the fibre friction

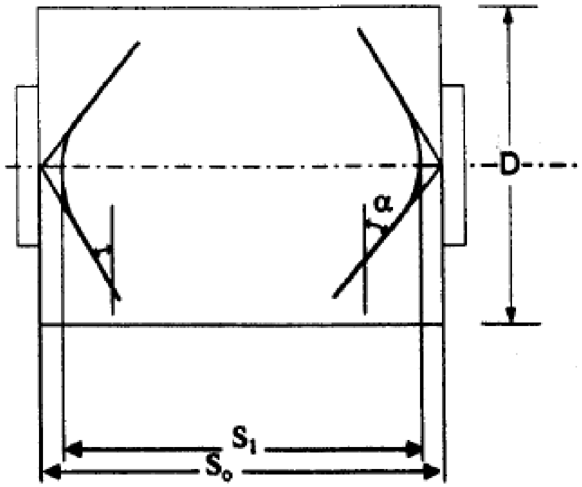
$P_{min} = D/2\mu$

Reversal Point at Cylindrical Package and Wind Angle

Yarn reversal is assumed to be a circular arc

So, $\cos\alpha=\rho/(\rho+\Delta)$





The stroke ratio is a measure of the reduction of the traverse stroke. It can be defined as

$\varepsilon=S_1/S_o$

S_o - theoretical length of package
S_1- actual length of package

$$\Delta=(S_o-S_1)/2= S_1/2.(1-\varepsilon)/\varepsilon$$

$$\text{So, } \rho=S_1/2[\cos\alpha/(1-\cos\alpha)][(1-\varepsilon)/\varepsilon]$$

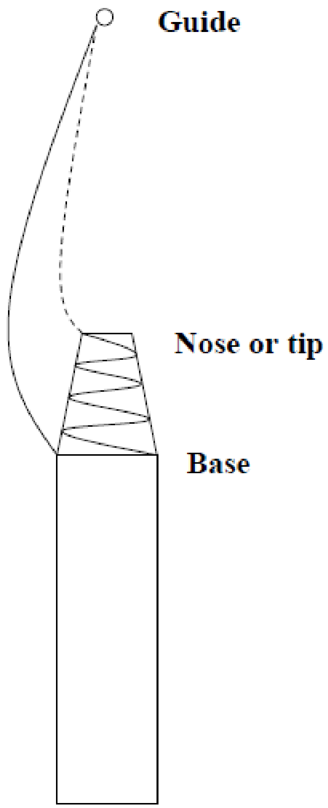
But for ρ to be minimum and a to be maximum

$$\mu=D/S_1[(1-\cos\alpha_{max})/\cos\alpha_{max}][\varepsilon/(1-\varepsilon)]$$

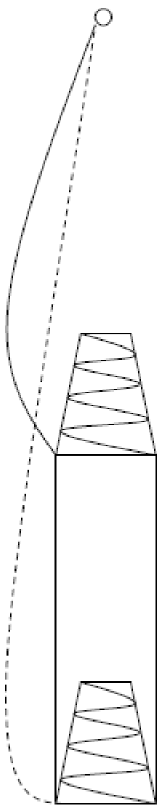
It shows that the maximum wind angle is a function of yarn friction, actual length of package, diameter of the package and stroke ratio

Tension Variation During Unwinding

During the unwinding of yarns from cop build packages (ringframe bobbin, pirn etc.) short term and long-term tension variation is noticed. Short term tension variation arises due to the movement of the yarn from the tip to the base and vice versa. On the other hand, long term tension variation occurs due to the change in height of the balloon formed between the unwinding point and the yarn guide



Short term

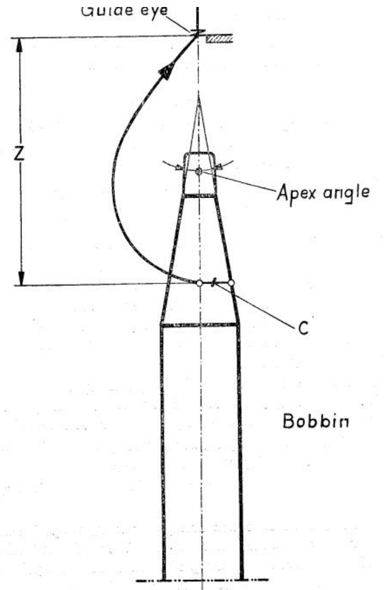


Long term

Padfield's empirical relation-

Unwinding tension= $mv^2[C1+C_2(H/r)^2]$
H is balloon height
r is package radius (varies between tip and base)
m is mass per unit length of yarn
V is unwinding speed

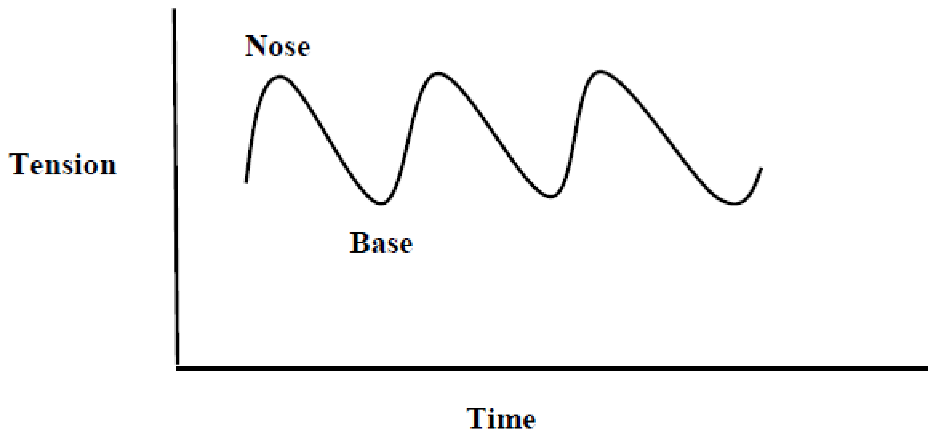
C_1 and C_2 are constants dependent upon yarn count climactic condition, apex angle etc.



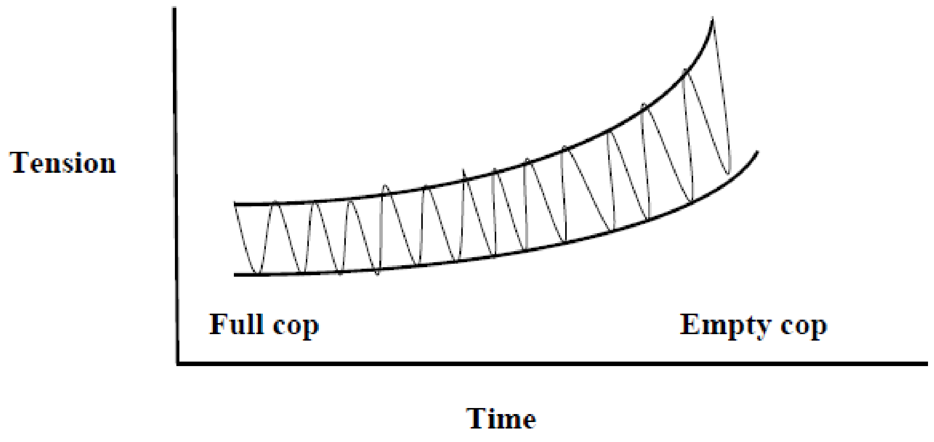
Tension Variation During Unwinding

Unwinding tension= $mv^2[C1+C_2(H/r)^2]$

Stronger function of r than H



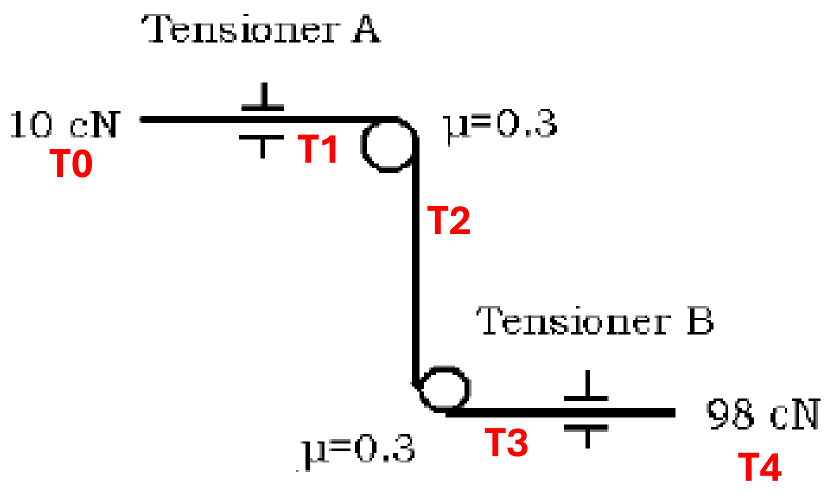
over a long period of time, successive conical layers of yarns are removed from Pirns and thus the conical section of yarns move towards the base of the pirn. Therefore, the balloon height increases resulting in progressive increase in mean unwinding tension



Tension Variation During Unwinding

Numerical Example

1. The tensioning system shown in Figure is being used in a winding system. The input and output tensions are 10 cN and 98 cN respectively. If disc (additive) type tensioners A and B are identical then calculate the weights used in tensioners A and B.



To solve, follow the red fonts in the image

T0 and T4 are given
T1/T0- additive
T2/T1- Multiplicative
T3/T2- Multiplicative
T4/T3-Additve