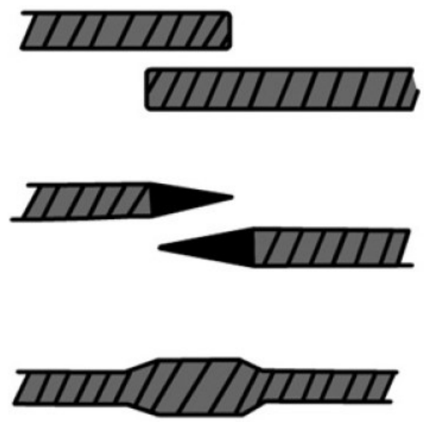
Splicing

Splicing is the process by which the **two ends of yarns are joined**.

Pneumatic splicers are commonly used.

The principle is to bring two ends of yarns inside splicing zone, **untwist** them and create wedge shape and **again twist** them together using compressed air



Splicing

Splicing introduces a **less severe fault** in the yarn

The quality of spliced yarn is checked by **retained splice strength** and **splice breaking ratio**

Higher retained splice strength (85-90%) and lower splice breaking ratio imply good splicing performance.

$$\text{Retained splice strength } (\%) = \frac{\text{Strength in spliced yarn}}{\text{Strength in original yarn}} .100$$

$$\text{Splice breaking ratio} = \frac{\text{No of breaks in splice zone } (\pm 1 \text{ cm})}{\text{Total number of tests}}$$

Splicing

The performance of a splicer is evaluated by **clearing efficiency** and **knot or splice factor**.

Higher clearing efficiency and lower splice factor (close to 1) signifies desirable performance of a splicer.

$$\text{Clearing efficiency} = \frac{\text{Nunber of objectionable faults removed}}{\text{Total number of objectionable faults in yarn}} \times 100$$

$$\text{Knot factor} = \frac{\text{Total number of yarn clearer related breaks}}{\text{Number of objectionable faults removed}}$$

Yarn Winding for Package Dyeing

Yarns are often dyed in **package form**.

Yarn packages intended for dyeing should facilitate uniform dyeing within and between the packages.

The **density of the package** should be **low but uniform**.

Low density will ensure **better penetration and flow of dye** liquor across the yarn layers.

Uniform density will ensure **no preferential channel** of fluid flow

Yarn Winding for Package Dyeing

Drum-driven random winders are not preferred for packages intended for dyeing due to patterning problem (density variation)

In case of precision winder, the angle of wind reduces as the package diameter increases. Thus the package density increases towards the outer side of the package.

In case of step precision winder or digicone winder, the angle of wind varies marginally, thus the density of the package remains nearly constant. **Digicone wider produces the best packages for dyeing.**

Density of the package

Density of the package can be varied by

✓Changing the angle of wind

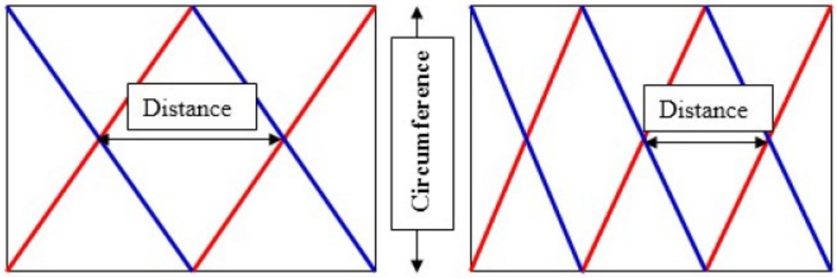
✓Changing the distance between neighboring yarns within a layer

✓Changing the pressure between the package and drum

✓Changing the winding tension

Density of the package

High angle of wind produces lower package density

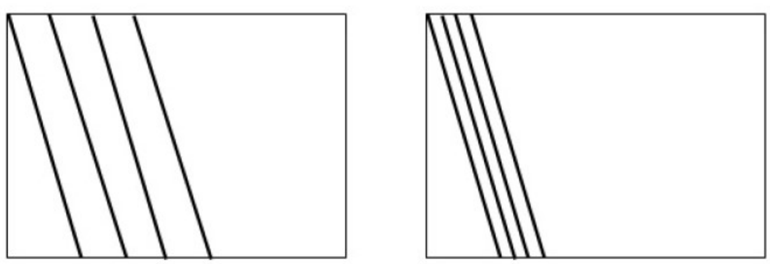


High angle of wind

Low angle of wind

Density of the package

Lower the distance between the neighboring yarns within the same layer, higher will be the package density.



Large gap between yarns

Small gap between yarns

Density of the package

In a drum-driven winder, the distance between yarns within a layer increases with the increase in package diameter

Whereas it remains constant in case of spindle-driven or precision winder .

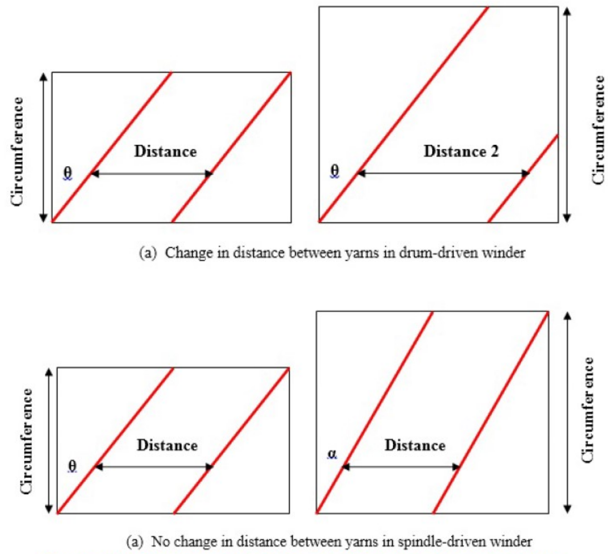


Figure 2.48: Gap between yarns at different package diameters

Density of the package

Higher pressure between package and winding drum and higher winding tension increases the package density.

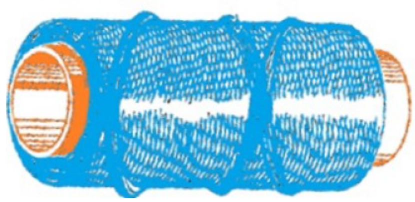
Pressure between the package and winding drum is reduced as the package diameter increases so that the outer layers do not become denser than the inner layers.

Defects in Winding

Some of the major defects observed in the wound packages are as follows:

- Ribbon or pattern
- Stitches or jali
- Soft tip or base
- Slough off

Ribbon or pattern



The ribbons are formed when the coils of two successive layers **rest over or very closely to one another**

Problem in unwinding and dyeing due to **density variation**

Patterning is prevented by **momentarily lifting the package** from the drum and thereby creating some intended slippage.

Stitches or jali

Stitches are formed when the yarn is **wound beyond the boundary** of the package.

It may happen due to

✓Improper traverse guidance of the yarn

✓Low winding tension

✓Improper contact between the package and the winding drum.

Soft tip or base

If the pressure between the package and the drum along the line of contact is not uniform then the package may have **different density at the tip and base** regions.

It may happen due to

✓Improper contact pressure

✓Poor alignment of winding drum and package

✓Non-central position of yarn guide

Slough off

Slough off is the problem of **removal of multiple coil from the package** during high speed unwinding.

If the package density or gain is not adequate, then slough off may occur.

Winding and Yarn Hairiness

The yarn hairiness increases with increase in winding speed

✓Abrasion of yarn with various machine parts

✓Transfer of fibres from one section of yarn to the other (redistribution of twist)

Numerical

1. The empty diameter of a spindle-driven cylindrical package is 5 cm. The spindle speed is 2000 r.p.m. and traverse velocity is 100 m/min. Determine
a) Winding speed and angle of wind at the start
b) Winding speed and angle of wind when package diameter becomes double

Solution:
a) Here, Spindle r.p.m. (*n)* = *2000*
Traverse speed (*Vt)* = *100 m/min*
d = diameter of cylindrical package = 5 cm

Numerical

Surface speed (V_s) = πdn

$$= \frac{\pi \times 5 \times 2000}{100} \text{ m/min}$$

$$= 314.16 \text{ m/min}$$

$$\tan\theta_1 = \frac{V_t}{V_s} = \frac{100}{314.16} = 0.318, \text{ where } \theta_1 = \text{angle of wind}$$

$$\text{or, } \theta_1 = 17.66^0$$

$$\text{Winding speed} = \sqrt{(V_t^2 + V_s^2)}$$

$$= \sqrt{((100)^2 + (314.16)^2)}$$

$$= 329.69 \text{ m/min.}$$

So, winding speed and angle of wind are 329.69 m/min and 17.66° respectively.

Numerical

(b) When package diameter becomes double i.e *d'= 10 cm*

$$\text{Surface speed } (V_s') = \pi d' n$$

$$= \frac{\pi \times 10 \times 2000}{100} \text{ m/min m/min.}$$

$$= 628.32 \text{ m/min}$$

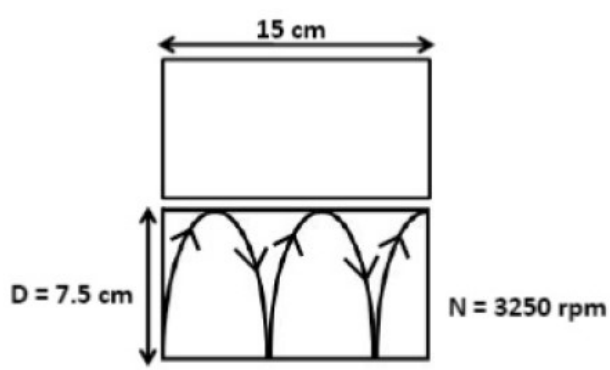
$$\text{Now, } \tan\theta_2 = \frac{V_t}{V_s'} = \frac{100}{628.32} = 0.159$$

$$\text{or, } \theta_2 = 9.04^0$$

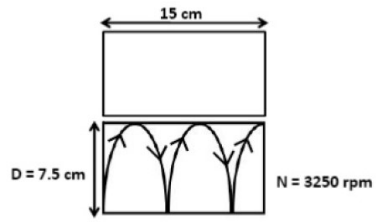
So, winding speed and angle of wind are 628.32 m/min and 9.04° respectively.

Numerical

2. A cheese of 150 mm traverse length is wound on a rotary traverse machine equipped with 75 mm diameter drums of 2.5 crossings. Calculate the winding speed and coil angle if the drum rotates at 3250 r.p.m.



Numerical



Surface speed of drum (V_s) = πDN

where D= diameter of drum = 75 mm = 7.5 cm

N = r.p.m. of the drum = 3250

$$V_s = \frac{\pi \times 7.5 \times 3250}{100} = 765.76 \text{ m/min.}$$

Traverse speed (V_t) = $\frac{2LN}{S}$

Numerical

$$V_t = \frac{2 \times 15 \times 3250}{5 \times 100} = 195 \text{ m/min}$$

Now, S (no. of drum revolution for double traverse) = 2× crossings = 2×2.5 = 5

So, winding speed $= \sqrt{(\pi DN)^2 + \left(\frac{2LN}{S}\right)^2}$

$= \sqrt{765.76^2 + 195^2} = 790.2$ m/min

$$\tan\theta = \frac{V_t}{V_s} = \frac{195}{765.76} = 0.255$$

So, θ (angle of wind) = 14.3^0

Therefore, coil angle = 75.7^0

Numerical

3. The diameter and length of the drum of a random winder is 100 mm and 300 mm respectively. If the drum is rotating at 4000 r.p.m. and crossing on drum is 3 then calculate the slippage% if winding speed is 1200 m/min.

Solution:

The drum diameter (D) = 100mm= 10 cm

drum length (L) = 300mm= 30 cm

drum r.p.m. (N) = 4000

No. of revolutions of drum per double traverse (S) = 3×2 =6

Numerical

Let, the translation ratio between package surface speed and drum surface speed is x.

Therefore, $\frac{\text{Package surface speed}}{\text{Drum surface speed}} = x$

Considering the slippage, the expression of winding speed will be as follows.

$$\text{Winding speed} = \sqrt{(\pi DN.x)^2 + \left(\frac{2LN}{S}\right)^2}$$

$$= \left[\left(\frac{\pi \times 10 \times 4000 \times x}{100}\right)^2 + \left(\frac{2 \times 30 \times 4000}{6 \times 100}\right)^2\right]^{\frac{1}{2}} = 1200 \text{ m/min.}$$

or, $1256.63x = 1131.37$

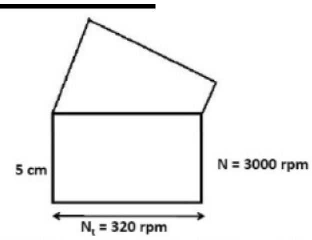
or, $x = 0.9$

So, slippage is 0.1 or 10%

Numerical

4. A cone having negligible conicity and maximum mean diameter of 200 mm is being built using a 50 mm diameter cylindrical winding drum rotating at 3000 r.p.m. The traverse per minute is 320. The cone was running at 960 r.p.m. when the mean package diameter was 150 mm. What is the slippage % between drum and package? Assuming no change in contact point between the cone and drum during package built up, calculate the cone diameters at which patterning may occur.

Numerical



The rpm of the cone (n) is 960 when package diameter (d) is 150mm = 15 cm

Therefore, the slippage is $= 1 - \frac{\pi dn}{\pi DN}$

where d = mean package (cone) diameter,

D = drum diameter,

N = r.p.m. of the drum.

$$\text{Slippage} = 1 - \frac{15 \times 960}{5 \times 3000}$$

$$= 0.4 \text{ i.e. } 4\%$$

Numerical

Maximum cone diameter (average) = 200mm

Patterning will occur when traverse ratio $\left(\frac{n}{N_t}\right)$ will be integer,

where N_t is the traverse/ min.

Here $N_t = 320$

So, values of n will be $= 320 \times x$ where $x \subset K$ (x belongs to the set of natural numbers i.e. K)

Now, considering that the slippage between the drum and cone is constant,

$$n \times d = 960 \times 15 = \text{constant}$$

So, $320 \times x \times d = 14400$

Now, considering *x = 1, the value of d becomes 45 cm which is not acceptable. Because, 45> 20 cm (maximum* mean package diameter). The values of *d at which patterning may occur are 15 cm, 11.25 cm, 9 cm, 7.5 cm* etc *(corresponding values* of *x are 3,4, 5 and 6).*

Numerical

5. What is the nearest value of traverse ratio to 3 to prevent patterning in a cheese when the diameter is 5 cm? The yarn is made up of cotton fibre and the count is 20s.

Diameter of cotton yarn $= \frac{2.54}{28\sqrt{Ne}}$ cm

$= \frac{2.54}{28\sqrt{20}}$ cm = 0.02 cm

So, linear gain is 0.02 cm.

Revolution gain $= \frac{\text{linear gain}}{\pi d}$

$= \frac{0.02}{\pi \times 5} = 0.0013$

So, nearest value of traverse ratio is 3 ± 0.0013.

Numerical

6. a) For a spindle-driven winder when the package diameter is 10 cm the wind angle is 20°. Determine the angle of wind when package diameter is 15 cm.

b) In a drum-driven winder the angle of wind is 30°. The drum having 5 cm diameter makes 5 revolutions for one double traverse. Calculate the length of the winding drum.

Numerical

(a) For spindle driven winders

$$\tan\theta = \frac{\text{Traverse speed}}{\text{Surface speed}}$$

$$= \frac{V_t}{V_s} = \frac{2LR}{\pi dn} = \frac{\text{Constant}}{\pi dn}$$

R = no. of double traverse/min.

d = package diameter

n = package (spindle r.p.m.)

As, $\frac{R}{n}$ and L are constants, so $d\tan\theta$ = constant

So, $\tan\theta_2 = \frac{d_1\tan\theta_1}{d_2} = \frac{10\times\tan 20^\circ}{15}$

or, $\theta_2 = 13.64°$

So, the angle of wind will be 13.64° when package diameter is 15 cm.

Numerical

b) For drum-driven winders

$$\tan\theta = \frac{Vt}{Vs} = \frac{\frac{2LN}{S}}{\pi DN} = \frac{2L}{\pi DS}$$

where L = Length of drum

N = r.p.m. of drum

S = Drum revolution for one double traverse

So, $\tan 30^\circ = \frac{2L}{\pi \times 5 \times 5}$

or, $L = 22.67$ cm.

So, the Length of winding drum is 22.67 cm.

Numerical

7. A precision winder with traverse length of 20 cm is operating at constant winding speed of 1000 m/min. The spindle r.p.m. is 3000 when the package diameter is 10 cm. When the package diameter increases to 20 cm, what will be the spindle r.p.m.?

Solution

Constant winding speed = *w = 1000 m/min*

The spindle speed has to be reduced, with the increase in package diameter, to maintain constant winding speed.

The traverse speed (*R) will also be reduced as it is connected with spindle drive.*

Spindle r.p.m. (*n1) = 3000 when package diameter (d1) = 10 cm = 0.1 m*

Traverse length = L = 20 cm = 0.2 m

Increased package diameter (*d2) = 20 cm*

Numerical

Let $\frac{R}{n} = k$ (constant)

or, $R = nk$

Now, $w^2 = (2LR)^2 + (\pi d_1 n_1)^2$

$= (2Ln_1k)^2 + (\pi d_1 n_1)^2$

So, $w^2 = n_1^2(4L^2k^2 + \pi^2 d_1^2)$

or, $1000^2 = 3000^2(4 \times .04 \times k^2 + \pi^2 \times .01)$

or, $k^2 = \frac{0.0124}{0.16} = 0.0776$

Numerical

In case 2:

$w^2 = n_2^2(4L^2k^2 + \pi^2 d_2^2)$

$1000^2 = n_2^2(4L^2k^2 + \pi^2 d_2^2)$

$= n_2^2(4 \times 0.04 \times 0.0776^2 + \pi^2 \times 0.04)$

So, n_2 = 1567.1 r.p.m.

The spindle speed will be 1567.1 r.p.m.

Numerical

8. A cheese of 20 cm traverse is being wound on a precision winder with traverse ratio of 5/2. When the cheese diameter is 10 cm, what should be the traverse ratio nearest to 5/2 for the prevention of patterning? The yarn is made of cotton fibre having packing fraction is 0.6 and count is 4 Ne.

Numerical

$$\text{Traverse ratio} = \frac{\text{wind/min}}{\text{double traverse/min}} = \frac{5}{2} = 2.5$$

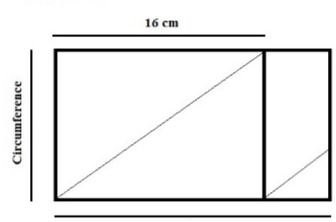
Therefore, wind/traverse = 1.25

1.25 coils occupy 20 cm of package width.

Therefore, one coil will occupy 16 cm of package width.

$$\tan\theta = \frac{\text{package width occupied by one coil}}{\text{package circumference}} = \frac{16}{\pi \times 10}$$

So, $\theta = 27°$



Numerical

$$\text{Yarn diameter (cm)} = d = \frac{2.54}{28\sqrt{4}} = 0.045$$

$$\text{Linear gain } (g) = \frac{d}{\sin\theta} = \frac{0.045}{\sin 27^{o}} = \frac{0.045}{0.454} = 0.099$$

$$\text{Revolution gain} = \frac{g}{\pi d} = \frac{0.099}{\pi \times 10} = 0.003$$

$$\text{Revolution gain} = \frac{5}{2} \pm 0.003$$

So, for avoiding patterning, traverse ratio should be 2.503 or 2.497

Numerical

9. A precision winder with constant spindle speed is being used for the production of cheese. The traverse length 150 mm and the traverse ratio is 6. If the minimum angle of wind is 8^{o}, determine the maximum package diameter.

Numerical

Traverse length of cheese (L) = 150 mm= 15cm

$$\text{Traverse ratio} = \frac{\text{Package rpm } (n)}{\text{Double traverse per min } (R)} = 6$$

In case of precision winder, the angle of wind (θ) reduces as the package diameter (d) increases.

Therefore, $\theta_{\min}$ corresponds to d_{max}

$$\tan\theta_{\min} = \frac{V_t}{V_s} = \frac{2LR}{\pi dn} = \frac{2\times 15\times R}{\pi\times d_{\max}\times n} \quad \text{(for spindle-driven machines)}$$

$$\text{or, } \tan 8^0 = \frac{30}{\pi\times d_{\max}}\times\frac{1}{6} = \frac{5}{\pi\times d_{\max}}$$

$$\text{or, } d_{max} = \frac{5}{\pi\times\tan 8^0} = 11.33\text{cm}$$

So, maximum cheese diameter is 11.33 cm

Numerical

10. A cheese having 150 mm height, 50 mm core diameter and 125 mm maximum diameter is being wound on two different machines as follows:

a) A groove drum rotary traverse winder where the drum diameter is 75 mm and the drum is making 5 revolutions per double traverse.

b) A constant spindle speed precision winder on which the spindle rotates 6 times per double traverse.

For machine (a) determine the traverse ratio at package diameter 50 mm and 100 mm; for machine (b) find the angle of wind at the same diameters.

Numerical

Traverse length (L) = 150 mm =15 cm

Minimum diameter of the cheese (d_{min}) = 5 cm

Maximum diameter of the cheese (d_{max}) = 12.5 cm

a) Drum diameter (D) = 75 mm = 7.5 cm

Revolution of drum per double traverse (S) = 5

Traverse ratio = $S \times \frac{D}{d}$

when d= 5cm, traverse ratio = $5 \times \frac{7.5}{5} = 7.5$

When d= 10cm, traverse ratio = $S \times \frac{D}{d} = 5 \times \frac{7.5}{10} = 3.75$

So, the values of traverse ratio are 7.5 and 3.75.

Numerical

b) $\tan\theta_1 = \frac{V_t}{V_s}$ (spindle rotates at 6 time per double traverse)

or, $\tan\theta_1 = \frac{2LR}{\pi dn}$, here $\frac{n}{R} = 6$

$$= \frac{2 \times 15}{3.14 \times 5} \times \frac{1}{6} = 0.3184$$

or, $\theta_1 = 17.67^0$

Again, $\tan\theta_2 = \frac{V_t'}{V_s'} = \frac{2 \times 15}{\pi \times 10} \times \frac{1}{6}$

or, $\theta_2 = 9.05^0$

So, the values of angle of wind are 17.67^0 and 9.05^0