Step Precision Winder or Digicone Winder

Overcome limitations of drum driven and spindle driven winders.

Problem of patterning prevented by changing the traverse speed proportionately with the package speed (r.p.m.) so that traverse ratio value remains constant over a period of time.

As package diameter increases, package r.p.m. decreases and traverse speed is also reduced in the same rate.

However, after certain time the traverse speed is raised back to the original value in one step to avoid decrease in wind angle and winding speed

Step Precision Winder or Digicone Winder

✓The driving drum gets motion directly from the motor.

✓However, the motion goes to the traverse guide through a cone drum combinations.

✓As the package r.p.m. reduces, the belt connecting the two cone drums are also shifted towards the left side in a controlled manner.

✓So, speed of traversing system decreases and traverse ratio remains constant over a period of time to avoid patterning

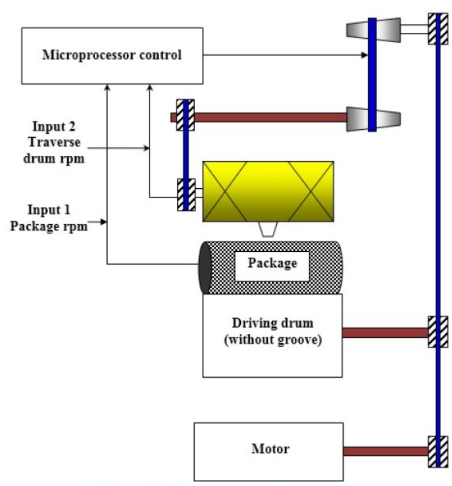


Figure 2.17: Step precision winder

Step Precision Winder or Digicone Winder

✓Traverse speed cannot be reduced continuously as it will reduce the winding speed and angle of wind.

✓Therefore, after a certain time the connecting belt of the cone drums is shifted towards the right to restore the original value of traverse speed.

✓Therefore, traverse ratio, reduces in steps from one convenient value to the other.

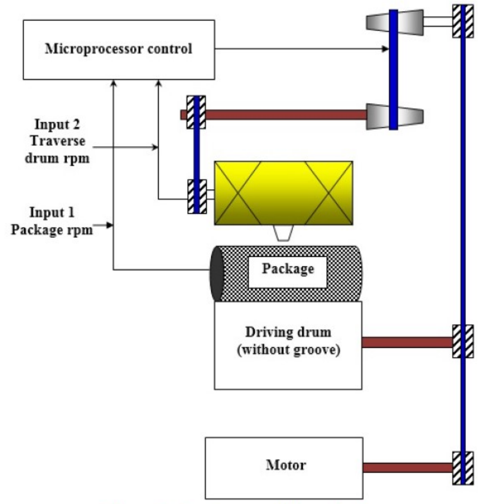


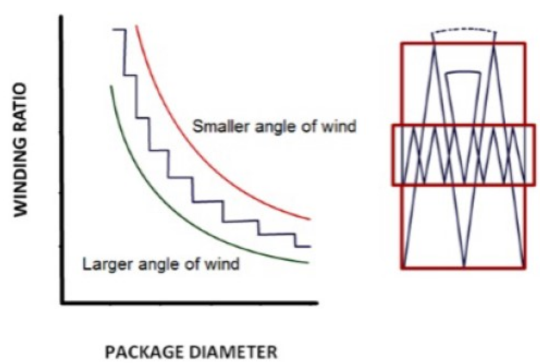
Figure 2.17: Step precision winder

Step Precision Winder or Digicone Winder

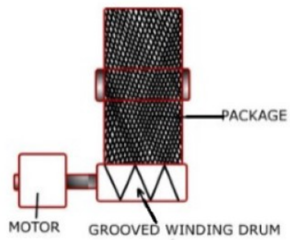
Figure depicts the change in traverse ratio with increase in package diameter.

Angle of wind (θ) changes by a small amount (1-2°) when V_t is gradually reduced

But it regain the original value when the V_t is raised back to the original value.



Comparison of different winding principles



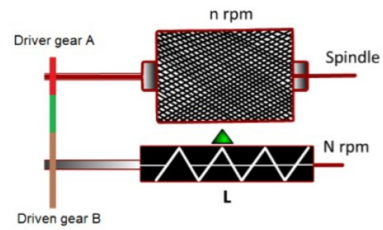


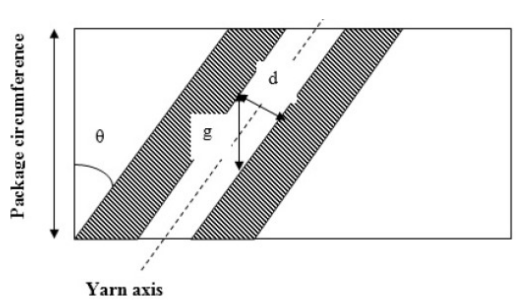
Table 2.1: Comparison matrix of winding principles

Parameter	Drum-driven	Spindle-driven	Digicone winder
Angle of wind	Remains constant	Decreases with increase in package diameter	Varies within a very small rang
Traverse ration	Decreases with increase in package diameter	Remains constant	Remains constants for some time and then decreases in step
Winding speed	Remains constant	Generally increases with package building	Reduces slowly due to the reduction in traverse speed and then increases to the original value
Package density	Increases drastically at the zone of ribbons	Increases with the increase in package diameter	Density does not change with package diameter

Linear Gain

Gain is the distance by which the winding point has to be shifted for avoiding patterning.

Linear gain is measured in the direction of perpendicular to the direction of package axis



$$\text{Linear gain} = g = \frac{\text{Yarn diameter}}{\sin\theta}$$

where θ is angle of wind.

Revolution Gain

Traverse ratio basically quantifies the number of package revolution within a certain time (one double traverse).

Therefore, linear gain cannot be added or subtracted with the traverse ratio.

However, linear gain can be divided with the package circumference to obtain revolution gain which can be added or subtracted with traverse ratio.

Pirn Winders

- Pirns are the yarn packages used within the shuttle to supply the yarns for pick insertion during weaving.
- The dimension of the shuttle is restricted by the shed geometry and the strain imposed on the warp yarns during shedding operation.
- Thus the pirn has to be a long and thin package

Pirn Winders

➢The winding principle of pirn is different than that of cones and cheeses.

➢If a cross-wound package is made then there will be lot of tension variation during weaving.

➢On the other hand, the parallel would package will give the problem of instability.

➢Therefore, pirns are made by overlapping short, conical and cross-wound sections

Pirn Winders

The pirns are made by overlapping short, conical and cross-wound sections

The process can be visualised as if one plastic cup (having cone shape) is placed over another and the process is continued to build a tall cylindrical column.

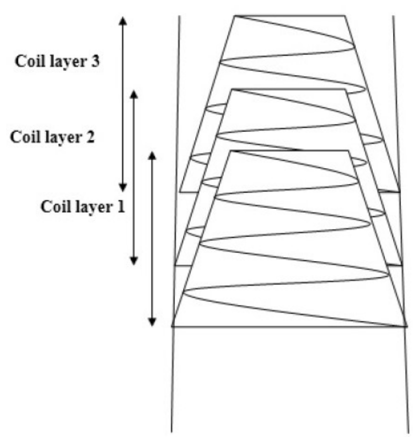


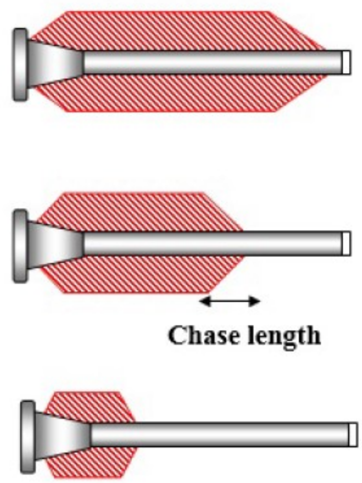
Figure 2.21: Building of a pirn

Pirn Winders

The pirn winding starts from the conical base and progressively proceeds towards the tip of the pirn.

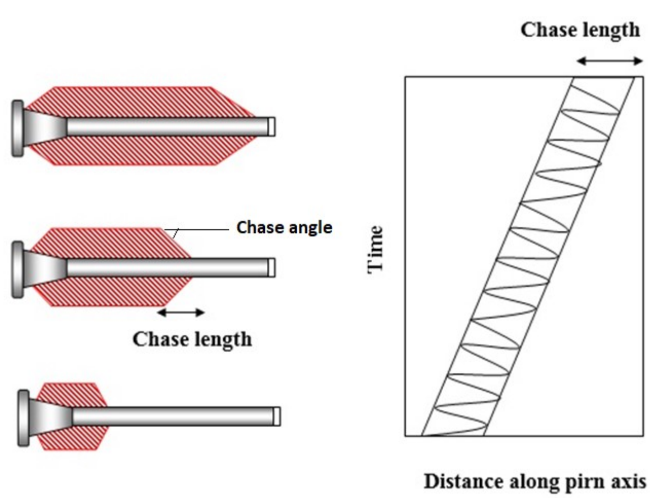
One layer of coils are laid on the conical base during the forward and as well as during the return movement of the traverse mechanism.

Thus the conicity of the package is maintained and the tip of the cone formed by the coils of yarn slowly proceeds



Pirn Winders

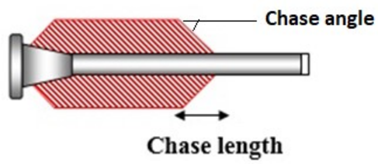
The distance travelled in one stroke of traverse is known as chase length.



Parameters of Pirn Winders

If the full and empty pirn diameter is D and d respectively, L is the chase length and α is the chase angle, then

$$\tan\alpha = \frac{D-d}{2L}$$



The chase angle depends on the type of yarn.

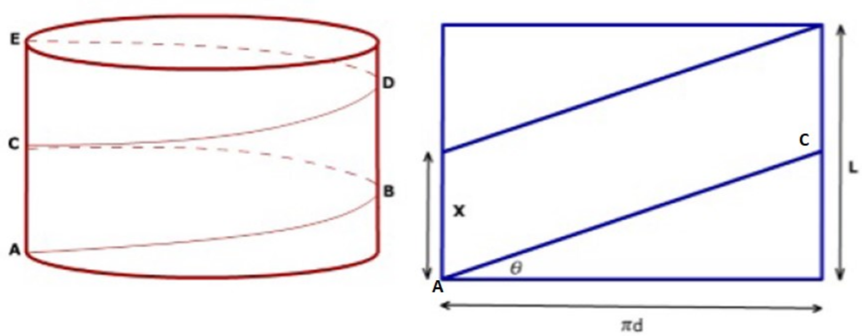
For spun yarns the chase angle could be as high as 15-18°.

However, for filament yarns with low friction, it could be as low as 6-10°.

Conditions for Uniform Package (Cheese) Building

The package should have very uniform density.

Assumption: Length of yarn wound per unit surface area of the package should be constant for uniform building of package.

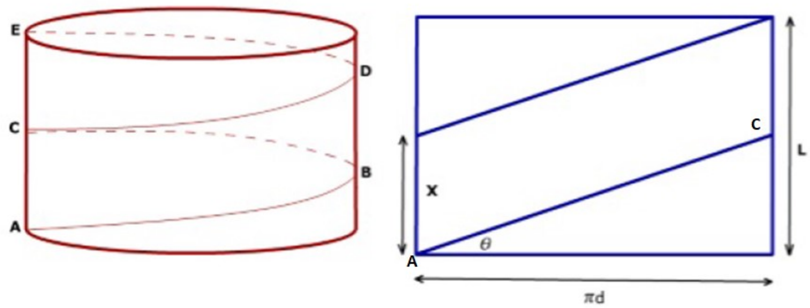


Conditions for Uniform Package (Cheese) Building

Diameter of package is d and height of the package is L

Legth of one coil= AC= $\dfrac{\pi d}{\cos\theta}$ (θ is angle of wind)

Number of such coils in one traverse $= \dfrac{L}{X} = \dfrac{L}{\pi d.\tan\theta}$



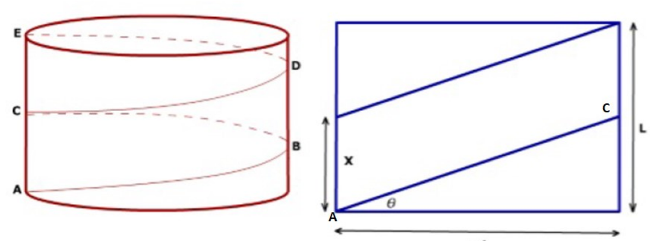
Conditions for Uniform Package (Cheese) Building

Length of yarn/ surface area

$$= \frac{\text{Total length of yarn wound at diameter } d}{\text{Total surface area of package at diameter } d}$$

$$= \frac{\dfrac{\pi d}{\cos\theta} \times \dfrac{L}{\pi d.\tan\theta}}{\pi d L} = \frac{1}{\pi d \sin\theta}$$

$d\sin\theta$ must be kept const for uniform building of the cheese.



Conditions for Uniform Package (Cheese) Building

Drum-driven winder

$$\tan\theta = \frac{\text{Traverse speed}}{\text{Surface speed}} = \frac{V_t}{\pi n d}$$

where d and n are package diameter and r.p.m.

$$V_t \cos\theta = \pi n d Sin\theta$$

For unifrm building $d \sin\theta$ should be kept constant.

For drum driven winder $\mathrm{n} \times \mathrm{d} = \text{constant}$.

So, $n \propto \frac{1}{d}$

$$\boxed{\text{So, } V_t \cos\theta \text{ should be changed} \propto \frac{1}{d}}$$

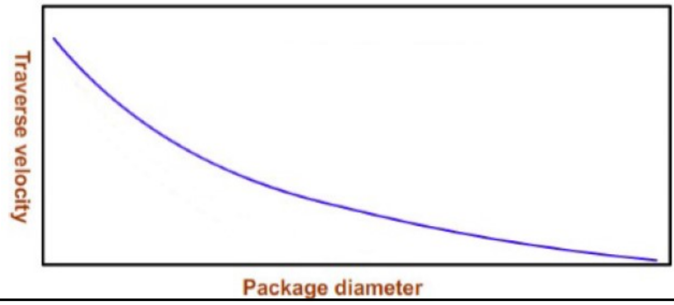
Conditions for Uniform Package (Cheese) Building

Drum-driven winder

Vt should be reduced with the increase in package diameter to attain uniform building.

But if Vt is reduced, θ will also reduce and Cos θ will increase.

So, Vt has to be reduced in such a manner that the **product of Vt and Cosθ** changes proportionately with 1/d



Conditions for Uniform Package (Cheese) Building

Spindle-driven winders

θ reduces (even when Vt is constant) as package diameter (d) increases.

So, Vt has to be reduced accordingly as reducing Vt will have further bearing on θ.

Conditions for Uniform Increase in Cone Diameter

In case of cone, the diameter of package reduces as the yarn traverses from the base to the tip.

It is important to maintain the conditions so that the diameter in the base and diameter at the tip increases at the same rate.

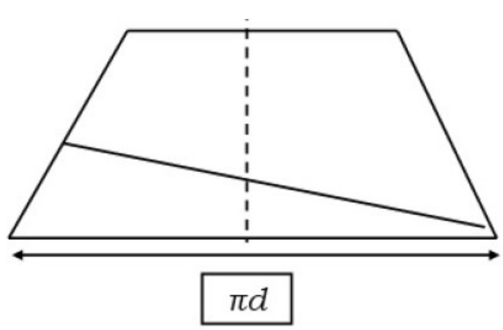


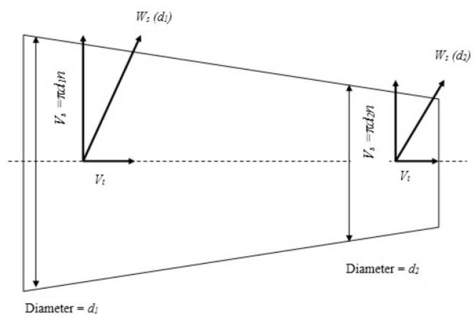
Figure 2.25: Yarn path on a cone

Conditions for Uniform Increase in Cone Diameter

Two sections of the cones having diameters d1 and d2 are being considered.

Let w1, v1 and s1 are the winding, traverse and surface speeds respectively at cone section diameter d1. Similarly, at cone section diameter d2.

For the analysis, a small time interval δt is considered.



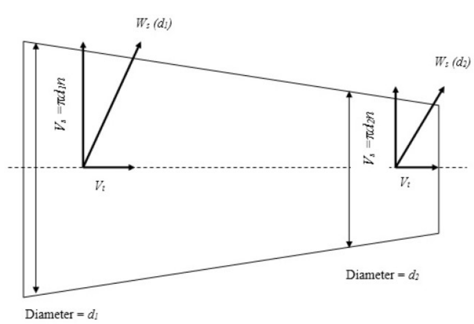
Conditions for Uniform Increase in Cone Diameter

Length wound per unit surface area at cone diameter $d_1 = \dfrac{w_1 t}{\pi\, d_1 v_1 \delta t}$

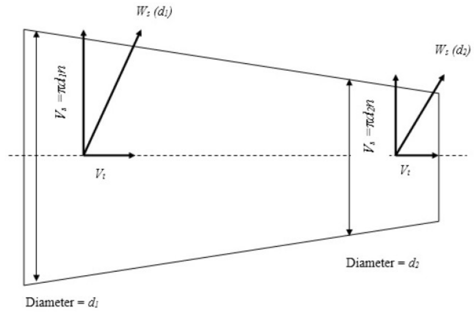
Length woundper unit surface area at cone diameter $d_2 = \dfrac{w_2 t}{\pi\, d_2 v_2 \delta t}$

For uniform increase in cone diameter, the boundary condition is

$$\frac{w_1 t}{\pi\, d_1 v_1 \delta t} = \frac{w_2 t}{\pi\, d_2 v_2 \delta t} \quad or \quad \frac{w_1}{w_2} = \frac{d_1 v_1}{d_2 v_2}$$



Conditions for Uniform Increase in Cone Diameter



It is known that $\tan\theta = \dfrac{\text{Traverse speed}}{\text{Surface speed}} = \dfrac{v}{s}$

Therefore, $\tan\theta_1 = \dfrac{v_1}{s_1}$ and $\tan\theta_2 = \dfrac{v_2}{s_2}$

and $w_1^2 = s_1^2 + v_1^2$ and $w_2^2 = s_2^2 + v_2^2$

$$\text{So, } \frac{w_1^2}{w_2^2} = \frac{s_1^2 + v_1^2}{s_2^2 + v_2^2} = \frac{v_1^2\left(1+\dfrac{s_1^2}{v_1^2}\right)}{v_2^2\left(1+\dfrac{s_2^2}{v_2^2}\right)} = \frac{v_1^2(1+Cot^2\theta_1)}{v_2^2(1+Cot^2\theta_2)}$$

$$= \frac{v_1^2 Sin^2\theta_2}{v_2^2 Sin^2\theta_1}$$

Conditions for Uniform Increase in Cone Diameter

From boundary condition we know that $\dfrac{w_1}{w_2} = \dfrac{d_1 v_1}{d_2 v_2}$

$$\text{So, } \left(\frac{w_1}{w_2}\right)^2 = \left(\frac{d_1 v_1}{d_2 v_2}\right)^2 = \frac{v_1^2 sin^2\theta_2}{v_2^2 sin^2\theta_1}$$

or $d_1^2 sin^2\theta_1 = d_2^2 sin^2\theta_2$ or $d\sin\theta = \text{constant}$

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

where d and n are package diameter and r.p.m. respectively

$$V_t\cos\theta = \pi dn Sin\theta$$

Conditions for Uniform Increase in Cone Diameter

For uniform increase of diameter d sinθ, should be constant.

Therefore, Vt cosθ should be constant during one traverse from base to the tip of the cone.

As we move towards the tip, the d reduces, so θ increases and cos θ reduces.

So need to increase Vt such that the Vt cos θ remains constant.

Conditions for Uniform Increase in Cone Diameter

Example

A cone is having varying section diameter from base to tip. However, at a particular instance, the entire cone revolves at the same r.p.m. (*n*). *Even if the traverse speed (Vt) is constant, the winding speed changes due to the change in surface speed as* the winding point moves from base to the tip.

Conditions for Uniform Increase in Cone Diameter

Let us consider two strips having unit width at cone section diameters *d1 (10 unit) and d2 (8 unit).*

The length of yarn wound within these strips is *a and b respectively*

So, for uniform increase of cone diameter,

$$\frac{a}{b} = \frac{d_1}{d_2}$$

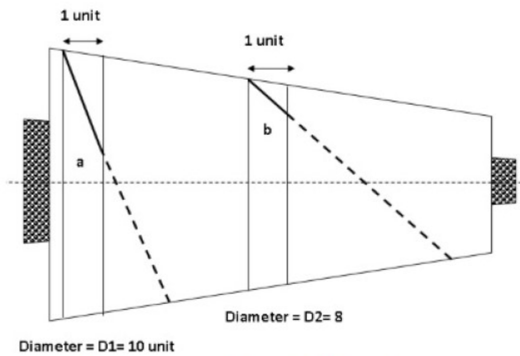


Figure 2.27: Uniform building of cone

Conditions for Uniform Increase in Cone Diameter

Now, if the length of yarn wound within the strip of cone section diameter d1 is 3 unit, then the length of yarn wound within the strip at cone section diameter d2 :

$$b = a.\frac{d_2}{d_1} = 3.\frac{8}{10} = 2.4 \text{ unit}$$

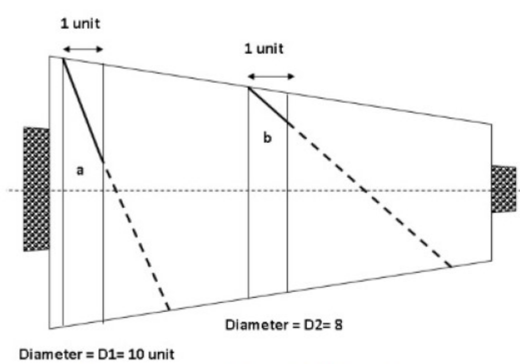
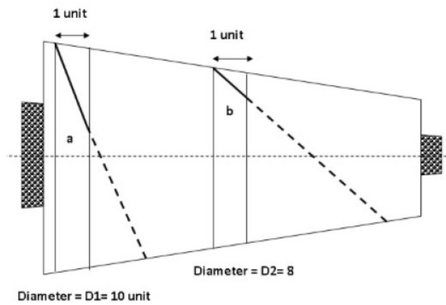


Figure 2.27: Uniform building of cone

Conditions for Uniform Increase in Cone Diameter

As the width of each strip is 1 unit, the angle of wind at different cone section diameter is



$$sin\theta_A = \frac{1}{3};\ \text{So}\ \theta_A = 19^0 27'$$

$$V_t\ (\text{at diameter}\ d_1) = V_s \tan\theta_A = \pi.10n.\tan 19^0 27' = 11.09n$$

$$sin\theta_B = \frac{1}{2.4};\ \text{So}\ \theta_B = 24^0 37'$$

$$V_t\ (\text{at diameter}\ d_2) = \pi n 8.\tan 24^0 37' = 11.52n$$

Conditions for Uniform Increase in Cone Diameter

Now, consider that the maximum and minimum cone section diameters are 12 and 6 units respectively, then the angle of wind and traverse speed at different cone section diameters

Cone section diameter (cm)	Angle of wind	Traverse speed (cm/min)	*dsinθ*(constant)
12	16°8'	10.90n	3.36
10	19°27'	11.09n	3.34
8	24°37'	11.52n	3.35
6	33°45'	12.60n	3.34

It should be noted that the value of d sinθ is constant irrespective of the cone section diameter

Conditions for Uniform Increase in Cone Diameter

Grooves on Drums of Cone winding

The grooves cut on the driving drum of a cone winder have increasing pitch from the base to the tip of the cone so that the traverse speed increases towards the tip of cone