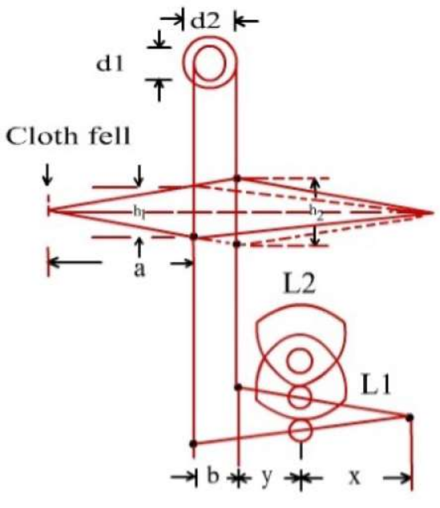
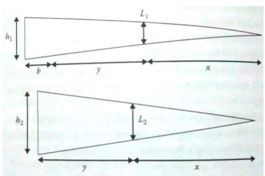
Lift (throw) of the Cam

- Higher vertical movement is required for the back heald to form distinct shed.
- However, effective length of the treadle lever is shorter for the back heald.
- If the lift or throw of the cams controlling the back and front heald is same, higher vertical movement will occur for the front heald (opposite to actual requirement)
- To overcome this problem, cam controlling the back heald possesses higher lift as compared the cam controlling the front heald.

Lift (throw) of the Cam

- ✓x is the distance between the fulcrum point of treadle levers and centre of treadle bowl.
- ✓y is the distance between the centre of treadle bowl and tip of the treadle lever tied with the back heald.
- ✓b is the distance between the front and back heald.
- ✓a is the distance between cloth fell and front heald.
- ✓h1 and h2 are the lifts of the front and back healds respectively.



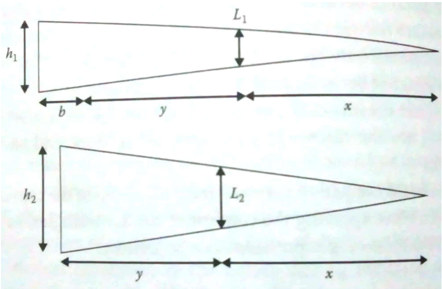


The lift of a heald is equal to the movement of the tip of the corresponding treadle lever.

Now, applying the concept of similar triangles, we can write

$$\frac{h_1}{L_1} = \frac{x+y+b}{x} \quad \text{so, } L_1 = \frac{h_1 x}{x+y+b}$$

$$\text{and } \frac{h_2}{L_2} = \frac{x+y}{x} \quad \text{so, } L_2 = \frac{h_2 x}{x+y}$$



$$\text{Therefore, } \quad \frac{L_2}{L_1} = \frac{(x+y+b)}{(x+y)} \times \frac{h_2}{h_1}$$

$$\text{At the front side of the shed, } \frac{h_2}{h_1} = \frac{a+b}{a}$$

$$\text{So, } \frac{L_2}{L_1} = \left(\frac{x+y+b}{x+y}\right) \times \left(\frac{a+b}{a}\right)$$

Therefore, the value of *L2 is significantly greater than that of L1.*

This implies that the lift of the cam controlling the back heald is significantly greater than that of cam controlling the front heald.

Diameter of the reversing rollers

- The shaft carrying the reversing rollers move clockwise and anti-clockwise to control the heald movement.
- The angular movement of the shaft during shedding is constant.
- However, it has to ensure that the back heald gets higher vertical movement than the front heald so that distinct shed is produced.
- This is attained by using two reversing rollers with different diameters.

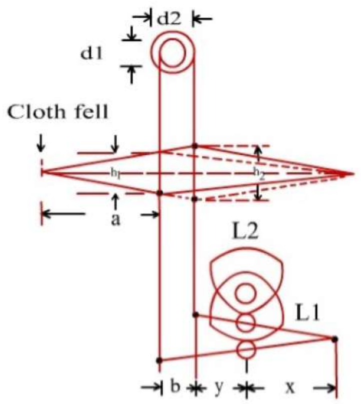
Diameter of the reversing rollers

➢The roller with bigger diameter is connected with the back heald and vice versa.

➢As the linear movement of reversing roller (angular movement × radius) is equal to the vertical movement of the corresponding heald,

$$\frac{h_2}{h_1} = \frac{d_2}{d_1} = \frac{(a+b)}{a}$$

$$\text{or} \quad \frac{L_2}{L_1} = \left(\frac{x+y+b}{x+y}\right) \times \left(\frac{d_2}{d_1}\right)$$



Numerical Problem

Calculate the throw (lift) of the cam controlling the back heald from the following particulars:

Throw (lift) of the cam for the front heald = 8 cm
The distance between the front and back heald = 4 cm
The distance between the fulcrum and bowl on the treadle = 20 cm
The distance between the bowl and the fastening point of the back heald = 20 cm
Diameter of small reversing roller = 5 cm
Diameter of large reversing roller = 6 cm

Numerical Problem

Solution:

The expression to be used for calculating the throw or lift of the cam is as follows:

$$\frac{L_2}{L_1} = \left(\frac{x+y+b}{x+y}\right) \times \left(\frac{a+b}{a}\right)$$

Here

L_{12}= Throw (lift) of the cam for the back heald

L_1 = Throw (lift) of the cam for the front heald = 8 cm

x = Distance between the fulcrum and bowl on the treadle = 20 cm

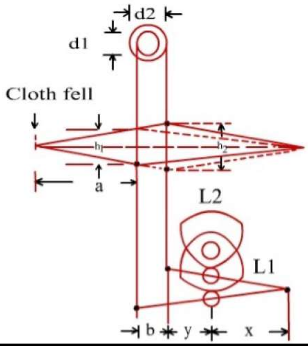
y = Distance between the bowl and the fastening point of the back heald = 20 cm

b= Distance between the front and back heald = 4 cm

d_2= Diameter of large reversing roller = 6 cm

d_1= Diameter of large reversing roller = 5 cm

a= distance between cloth fell and front heald (not given)



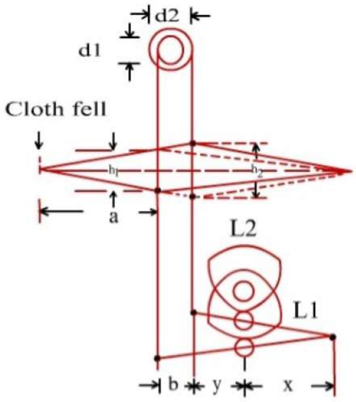
Numerical Problem

Now, $\left(\frac{a+b}{a}\right) = \frac{d_2}{d_1}$

So, $\frac{L_2}{L_1} = \frac{x+y+b}{x+y} \times \frac{d_2}{d_1}$

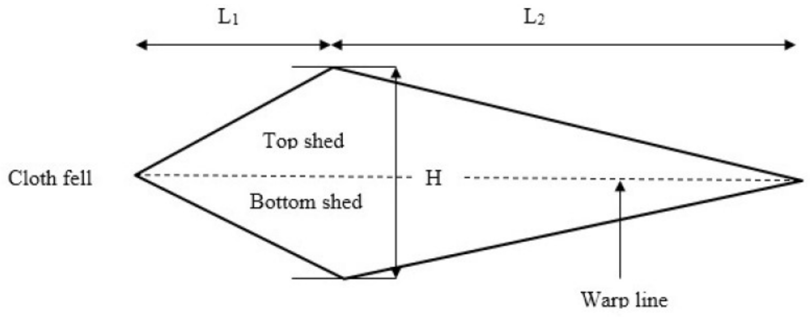
$$L_2 = L_1 \times \frac{x+y+b}{x+y} \times \frac{d_2}{d_1}$$

$$= 8 \times \frac{20+20+4}{20+20} \times \frac{6}{5} = 10.56$$



So, the lift of the cam controlling the back heald is 10.56 cm.

Geometry of Shed



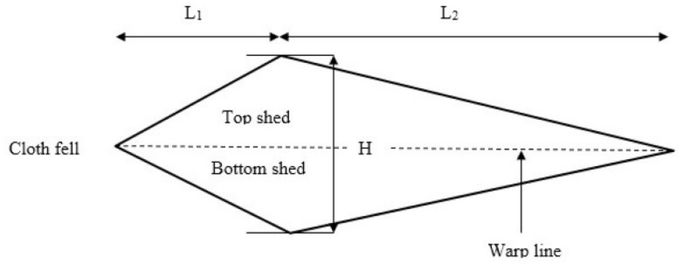
The main shed parameters are as follows:

- L 1: length of the front shed
- L2: length of the back shed
- H : shed height

Geometry of Shed

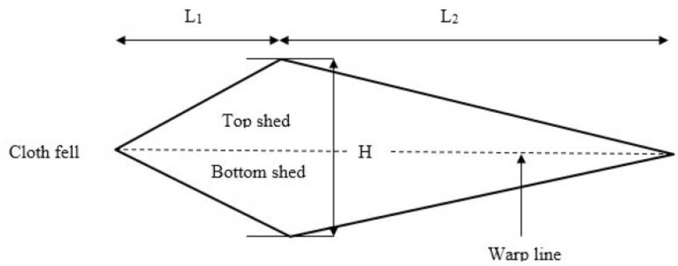
➢As the healds move away from the warp line, the warp takes a longer path.

➢Thus, warp yarns are extended which has to be compensated either by the extensibility of the warp or by the regulation of the yarn delivery system.



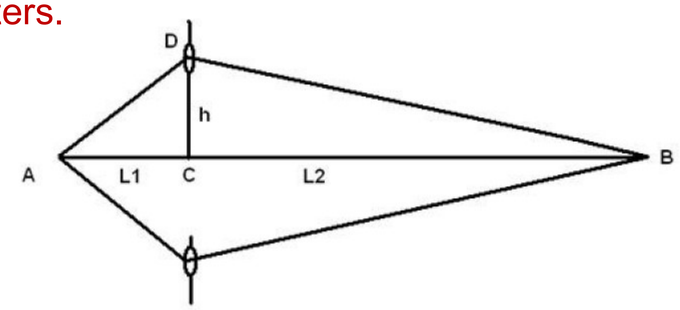
Geometry of Shed

- If the length of the back shed increased, then yarn extension is reduced (preferred for weaving delicate yarns like silk)
- However, shorter back shed creates clearer shed (preferred for weaving coarser and hairy yarns)



Calculation of warp strain during shedding

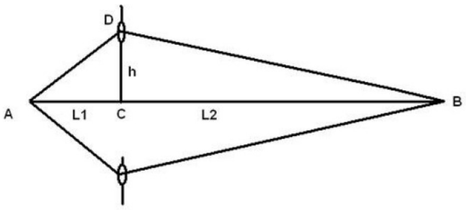
A simplified mathematical model has been presented to relate the warp strain with the shed parameters.



Let us consider *h as half of the shed height.*

Therefore, H = 2h

Calculation of warp strain during shedding



Elongation in the front shed = E_1

Now, $E_1 = AD - AC$

$$= \left(L_1^2 + h^2\right)^{\frac{1}{2}} - L_1$$

$$= L_1\left[1 + \left(\frac{h}{L_1}\right)^2\right]^{\frac{1}{2}} - L_1$$

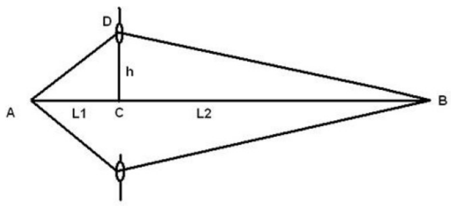
$$= L_1\left[1 + \frac{1}{2}\cdot\left(\frac{h}{L_1}\right)^2 + \frac{\frac{1}{2}(\frac{1}{2}-1)}{2}\left(\frac{h}{L_1}\right)^4 + \ldots\right] - L_1 = \frac{h^2}{2L_1}$$

(by neglecting higher power of $\frac{h}{L_1}$ which is <1)

The ratio of lengths of front and back shed is called shed symmetry parameter (*i*).

Therefore $\frac{L_1}{L_2} = i$ = shed symmetry parameter

Calculation of warp strain during shedding



Initial length of warp $= L = AB$

$$= L_1 + L_2$$

$$= L_1 + \frac{L_1}{i}$$

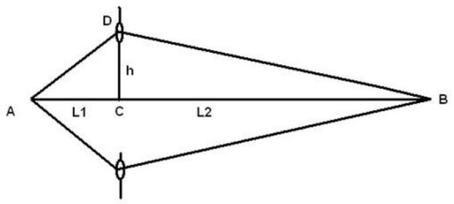
$$= L_1\left(\frac{1+i}{i}\right)$$

Total elongation $= E = E_1 + E_2$

$$= \frac{h^2}{2L_1} + \frac{h^2}{2L_2} = \frac{h^2}{2L_1}(1+i)$$

Calculation of warp strain during shedding

$$\text{Strain} = \frac{\text{Elongation}}{\text{Initial length}} = \frac{E}{L}$$
$$= \frac{1}{L} \times \frac{h^2}{2L_1}(1+i)$$
$$= \frac{h^2}{2L^2}\left(\frac{(1+i)^2}{i}\right)$$



- ✓ Warp strain increases with increase in shed height
- ✓ Warp strain reduces with increase in shed length
- ✓ Warp strain reduces as shed becomes symmetric (value of i increases)

Numerical Problem

Determine the ratio of strain created in the warp threads during shedding by the front heald and back heald if the total shed length (distance between the cloth fell and back rest) is 120 cm, front shed length for the front heald is 20 cm, distance between the front and back heald is 4 cm, diameters of reversing rollers are 5 cm and 6 cm.

Solution:

The strain in warp yarns can be expressed by the following equation.

$$\text{Strain} = \frac{h^2}{2L^2} \times \frac{(1+i)^2}{i}$$

For the front heald:

Front shed length (L_1) = 20 cm

Therefore, the back shed length = L_2= (120-20) = 100 cm

So, shed symmetry parameter = $i_1 = \frac{L_1}{L_2} = \frac{20}{100} = 0.2$

Numerical Problem

For the back heald:

Front shed length (L_1') = (20 + 4) cm = 24 cm

Therefore, the back shed length = L_2'= (120-24) = 96 cm

So, shed symmetry parameter = $i_2 = \frac{L_1'}{L_2'} = \frac{24}{96} = 0.25$

Now, $\frac{h_2}{h_1} = \frac{d_2}{d_1}$ and the total shed length L is same for both the healds.

$$\text{So, ratio of strain} = \frac{h_1^2}{h_2^2} \times \frac{\frac{(1+i_1)^2}{i_1}}{\frac{(1+i_2)^2}{i_2}} = \frac{h_1^2}{h_2^2} \times \frac{(1+i_1)^2}{(1+i_2)^2} \times \frac{i_2}{i_1}$$

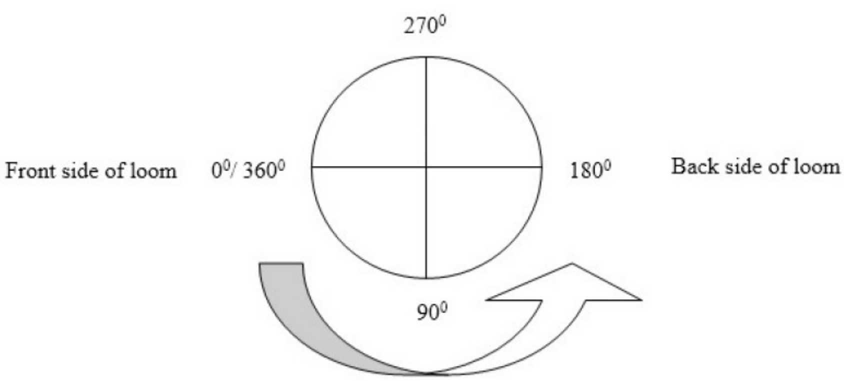
$$= \frac{5^2}{6^2} \times \frac{(1.2)^2}{(1.25)^2} \times \frac{0.25}{0.2} = 0.8$$

So, the ratio of strain is 0.8: 1 which implies that the back heald is creating more strain in the warp yarns.

Timing of Shedding

One pick is equivalent to one complete rotation of the crank shaft.

The timing of the various loom operations are indicated corresponding to the angular position of the crank shaft

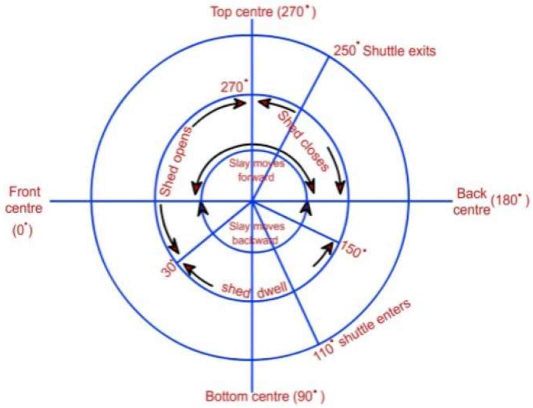


Timing of Shedding

- At 0°, the reed reaches the forward most position and performs the beat up.
- On the other hand, at 180°, the reed moves to the backward most position.
- The sley (and reed) moves forward and backward continuously during the entire 360°.
- However, the healds do not move continuously.
- When the shed is completely open, the healds remain stationary for certain time so that shuttle can pass through the shed without any interference. This is called the 'dwell' period of shed.

Loom Timing

Loom timing is defined as relative chronological sequences of various primary and secondary motions are expressed in terms of angular position of crank.



Loom Timing

Shedding (for early shedding)

30° : Shed is fully open

30° -150° : Heald dwell (shed remains fully open)

150° -270° : Shed closes

270° : Shed closed or shed level

270° -30° : Shed opens again (in opposite direction)

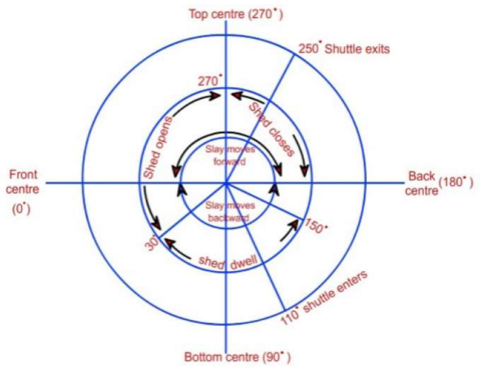


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

Loom Timing

Shedding (for late shedding)

120° : Shed is fully open

120° -240° : Heald dwell (shed remains fully open)

240° -360° : Shed closes

360° : Shed closed or shed level

360° -120° : Shed opens again (in opposite direction)

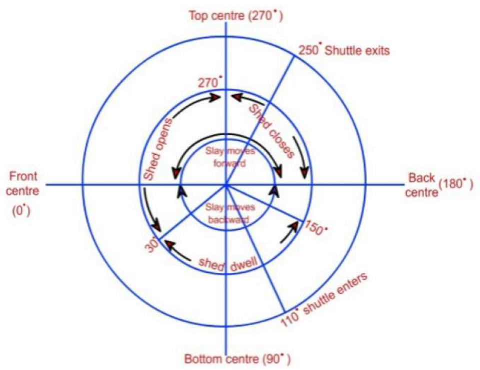


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

The operations have been delayed by 90° in case of late shedding.

Loom Timing

Picking and Checking

80°-110°:Picking stick operates

105°-110°:Shuttle enters in the shed

240°-250° : Shuttle leaves the shed

270° : Shuttle strikes the swell in the shuttle box

300° : Shuttle comes to rest

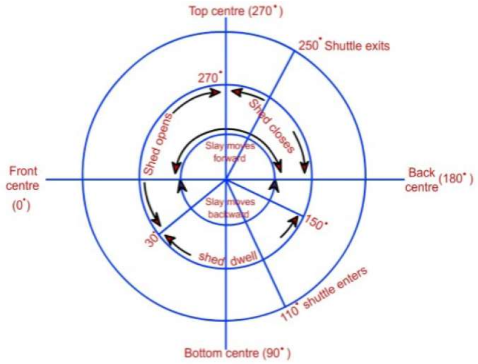


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

Loom Timing

Sley Motion

0°: Beat-up takes place and sley occupies its forward most position

180°: Sley occupies its backward most position

0°-180°: Sley moves backward

180°-360°: Sley moves forward

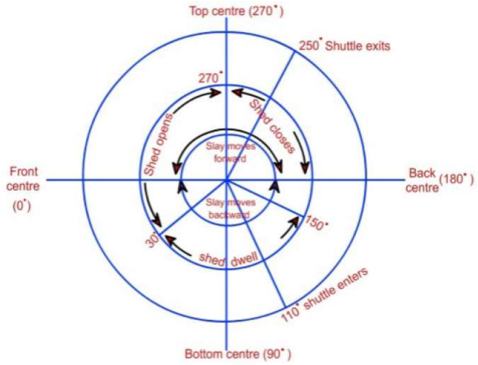


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

Loom Timing

Take-Up

0° -10° : Take-up (intermittent type)

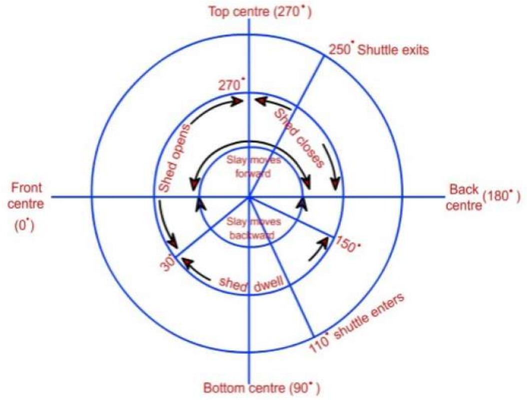


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

Early Shedding

- The shuttle enters and leaves the shed at around 110° and 240° respectively. The shed is levelled (closed) at 270° .

- Then it starts to open as the two healds starts to move in opposite directions. The shed is fully open at 30°.

- From 30° to 150° , the healds are stationary. Therefore, the shed is fully open and at dwell during this period.

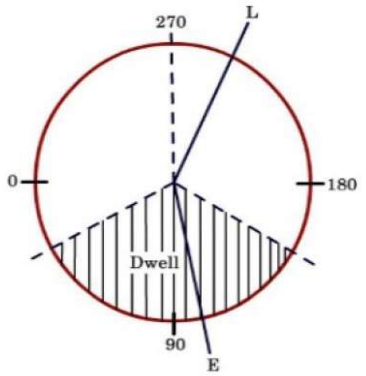


Figure 6.10: Timing for early shedding

Early Shedding

➢When the shuttle enters the shed (110°), more than half of the dwell period is over. When the shuttle leaves the shed (240°), the shed is about to close.

➢Therefore, there is high probability that the shuttle will abrade the warp sheet which is not desirable specially for the delicate warp yarns.

➢However, this type of timing is advantageous for weaving heavy cloth. Because, during beat up (0°), the shed is crossed.

➢Therefore, the newly inserted pick will be trapped by the crossed warp yarns. As a result, the pick will not be able to move away from the cloth fell ever after the reed recedes.

➢This facilitates attaining higher picks per inch which is required for heavy fabric.

Late Shedding

➢Timing of shedding is delayed

➢The shed is levelled (closed) at 0°.

➢Then it starts to open as the two healds move in opposite directions. The shed is fully open at 120° .

➢From 120° to 240°, the healds are stationary. Therefore, the shed is fully open and at dwell during this period.

➢The timing of shuttle flight (110-240°) almost coincides with the dwell time.

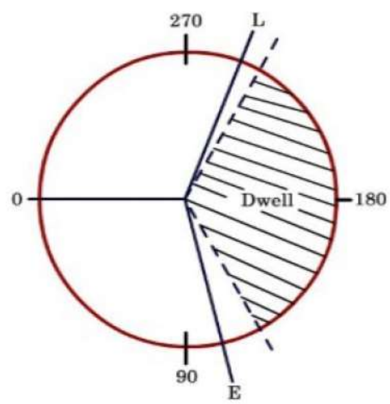


Figure 6.11: Timing for late shedding

Late Shedding

- The problem of abrasion between warp and shuttle can be minimised by adopting late shedding
- The beat up occurs when the shed is levelled and healds are yet to cross each other.
- Therefore, this timing is not favourable for weaving heavy fabrics.
- However, this kind of timing is favourable for weaving delicate warp yarns and the possibility of abrasion with the shuttle is very low.

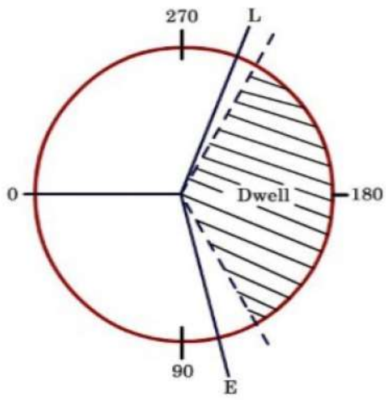
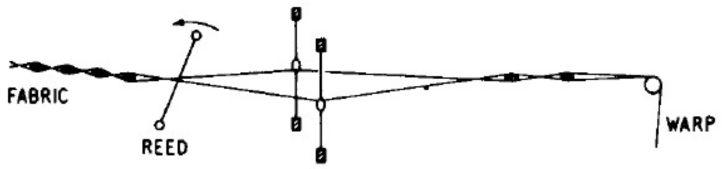
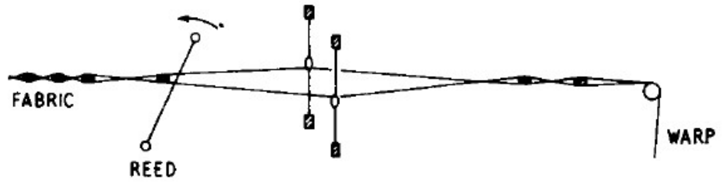


Figure 6.11: Timing for late shedding



(a) BEATING ON CLOSED SHED



(b) BEATING ON OPEN SHED

Effect of Shed Timing and Backrest Position

- The early shedding coupled with raised position of the backrest results higher pick density in the woven fabric.

- Figure shows the normal and raised position of the backrest.

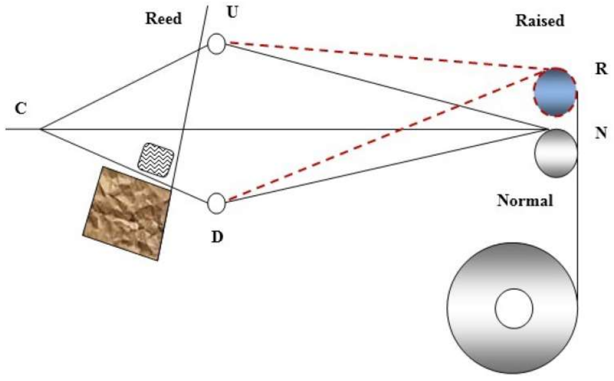


Figure 6.12: Warp line with normal and raised backrest positions

Effect of Shed Timing and Backrest Position

- When the backrest is at normal position, the top and bottom sheds are symmetrical with respect to the line CN which represents the warp line when the shed is levelled.

- In this case, the length of two shed lines CUN and CDN are equal which signifies that the tension in both the sheds (top and bottom) is equal.

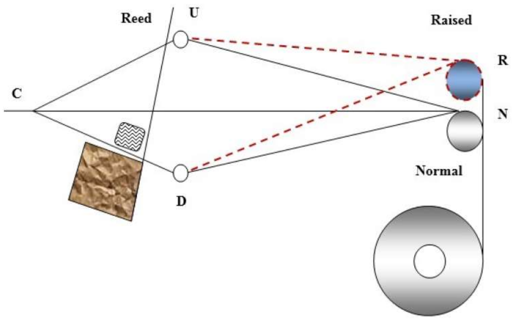


Figure 6.12: Warp line with normal and raised backrest positions

Effect of Shed Timing and Backrest Position

➢However, when the backrest is raised from its normal position, the length of shed lines become unequal.

➢This is clearly visible from the fact that length of the top shed line CUR is smaller than the bottom shed line CDR. Thus the tension in the top shed line will be lower than that of bottom shed line.

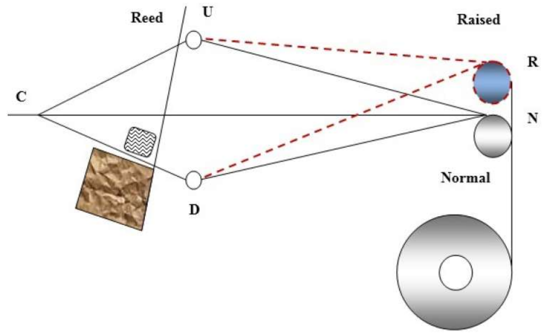


Figure 6.12: Warp line with normal and raised backrest positions

Effect of Shed Timing and Backrest Position

➢In case of early shedding, the shed will be levelled at 270°.

➢At beat up (360°), the shed is fully crossed i.e. the top shed line of the last pick has now formed bottom shed line and vice versa.

➢Thus the higher tension prevailing in the bottom shed ends will force the newly inserted weft (circle) in the downward direction from the cloth plane as shown in Figure.

Effect of Shed Timing and Backrest Position

- This will be facilitated by the greater curvature attained by the top shed ends which are now under low tension.
- The previous pick (the second circle from the right) will be forced in the upward direction with respect to cloth plane but by a lesser magnitude.
- This process will repeat after the insertion of each and every pick and as a consequence higher pick density in the fabric will result.

Effect of Shed Timing and Backrest Position

- As the beat up is performed at crossed shed, the newly inserted weft remains tightly meshed between the ends as the reed pushes the former towards the cloth fell against the yarn to yarn frictional and bending resistances (Figure).
- Once the beating is completed and sley starts its movement towards the back centre of the loom, newly inserted pick cannot spring back away from the cloth fell as it is trapped in the crossed shed.

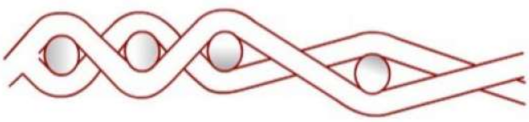


Figure 6.13. (a) Vertical displacement of newly inserted weft (b) Beat up at crossed shed