## Bending Factor

Bending factor is defined as the ratio of depth of shed in front of shuttle ( s ) and the actual height of the shuttle ( h )

$$\text{So, Bending factor} = \frac{s}{h}$$

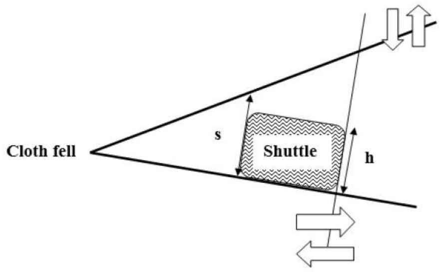


Figure 6.14: Bending factor

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## Bending Factor

If it is greater than 1, then there will not be any abrasion between warp sheets and the shuttle.

Conversely, if it is much lower than 1, then severe abrasion will take place between warp sheets and shuttle….high warp breakage rate

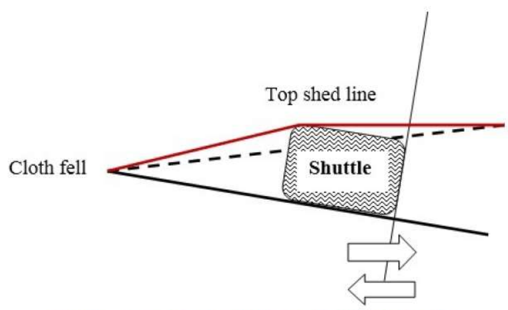


Figure 6.15: Situation with low bending factor

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## Bending Factor

The bending factor changes continuously as it is influenced by the following two factors.

- Movement of the healds
- Movement of the sley

The bending factor will reduce as the top shed line will move in the downward direction causing reduction in the value of s and vice versa.

Besides, as the reed moves towards the cloth fell, the bending factor reduces due to reduction in s.

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## Bending Factor

For late shedding (where the shed levels at 0), dwell occurs between 120°-240°. Therefore, during this period, the healds are stationary. So, the depth of shed in front of the shuttle varies only due to the sley movement.

After 240°, the shed starts to close and sley is still moving forward. Both the factors synergistically reduce the depth of shed at a faster rate.

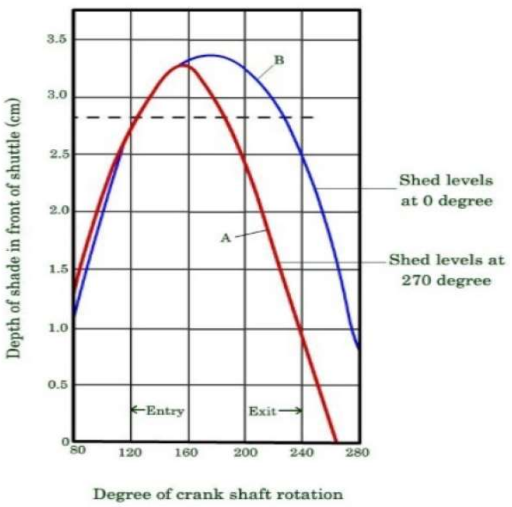

Figure 6.16: Bending factors for early and late shedding

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# Bending Factor

For early shedding (where the shed levels at 270°), dwell occurs between 30° -150°.

After 150°, shed starts to close. But, sley moves backwards till 180°. Therefore, between 150°-180°, two factors are countering each other in influencing bending factor.

After 180°, sley starts to move forward and shed is still closing (till 270°). Therefore, the shed depth reduces very fast after 180°.

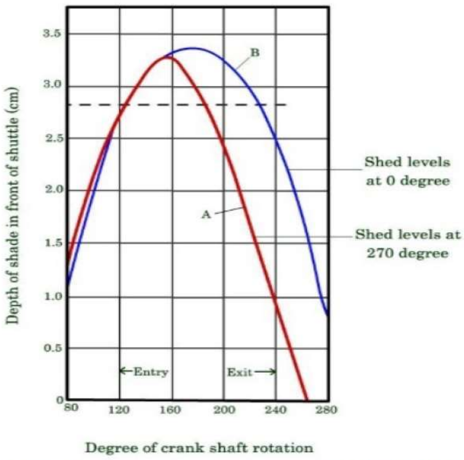


Figure 6.16: Bending factors for early and late shedding

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# Bending Factor

Table 6.3: Bending factors for early and late shedding

| Healds crossing time | Bending factors | |
|---|---|---|
| | Entering | Leaving |
| 270° Curve A(red): early shedding | 0.87 | 0.34 |
| 0° Curve B (blue): late shedding | 0.84 | 0.9 |

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## Heald Staggering

For weaving heavy density fabrics, when the healds are crossing each other, enormous amount of yarn to yarn friction will be created leading to end breakage.

This can be prevented by heald staggering which ensures that all the ends (or healds) are not crossing each other at the same time.

Heald staggering is done to reduce the abrasion between the warp yarns when the healds are crossing each other.

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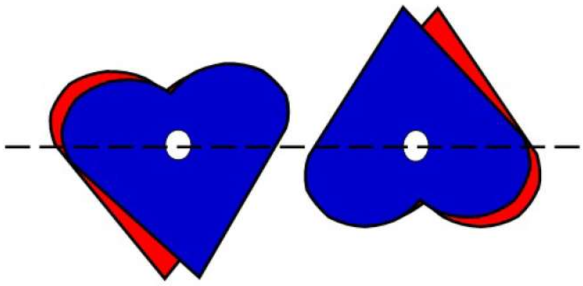
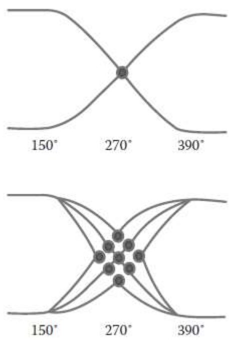
## Heald Staggering

The two cams of same group can be arranged in such a way that there is some phase difference (say 5-10°) between them

The other two cams, belonging to the other group, are at 180° phase difference with respect to the two cams of the first group



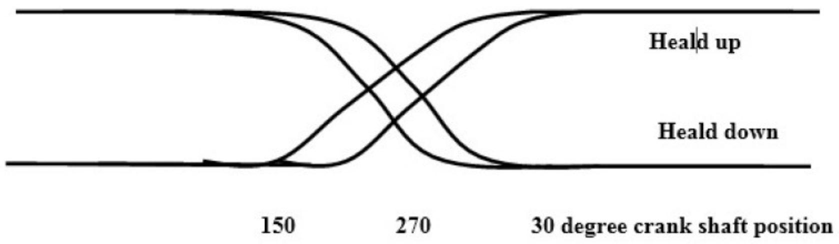



70

## Heald Staggering

This ensures that even when two healds are rising, they do not reach the middle of shed depth at the same time

Therefore, the number of ends which cross each other at a moment is reduced and thus the abrasion between the warp yarns is reduced considerably.

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## Design of Shedding Cams

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## Design of Shedding Cams

The following parameters decide the design of shedding cam.

✓Weave design of the fabric

✓Minimum distance between cam and follower

✓Lift of cam (difference between maximum and minimum radius of the cam)

✓Diameter of follower

✓Dwell of cam (duration of the two dwells)

✓Duration of the rise and fall

✓Character of movement (linear, SHM etc.)

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## Design of Shedding Cams

Number of shedding cams (with the exception of skip draft) is equal to the number of healds.

The number of healds is equal to the number of ends in the repeat of the design.

Therefore, the number of ends in the repeat of the design determines the number of shedding cams required

Eg. Plain weave requires 2 shedding cams, 3/1 twill weave requires 4 cams , and so on.

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## Design of Shedding Cams

Now, one revolution of shedding cam implies ‘n’ number of picks, where ‘n’ is the number of picks in the repeat of the design.

Because, after ‘n’ number of picks, a particular heald has to come back to the same position.

Therefore, the segment of the cam available for one pick is dependent on the number of picks in the repeat of the design.

Thus, the number of picks in the repeat of the design determines the design of the shedding cams .

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# Example 1

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## Design of Linear Shedding Cams

Example 1: Design a shedding cam for plain woven fabric using the following particulars:

Minimum distance between cam and follower centres (d): 4 units

Lift (l): 6 units

Diameter of follower (f): 2 units

Dwell period: 2/3 of a pick

Movement pattern during rise and fall: Linear

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## Design of Linear Shedding Cams

Generally the duration of dwell is considered to be 1/3 of a pick.

However, for weaving delicate yarns, larger dwell can be used to prevent the abrasion between the shuttle and the warp (2/3 in present situation)

The linear rise (or fall) implies that the movement of the follower in the vertical direction per unit time (per degree of cam rotation) is constant.

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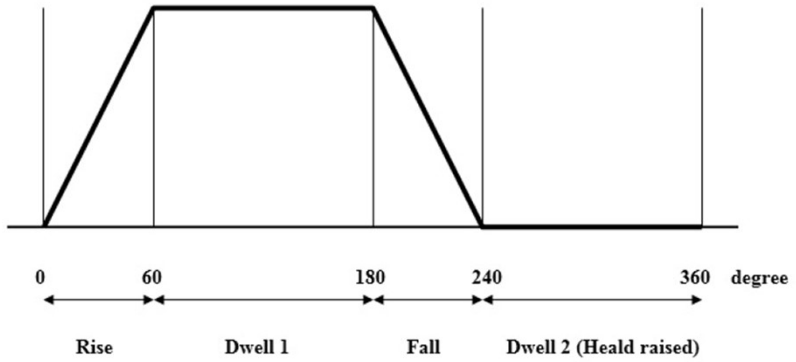
# Design of Linear Shedding Cams

As it is plain weave, the 360° rotation of bottom shaft or shedding cam will correspond to two picks. Therefore, one pick is equivalent to 180° rotation of the cam.

Each of the two dwells will be spanning over 2/3 ×180° =120°.

Therefore, the span for rise (and fall) will be 60°.

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# Steps for drawing Linear cam profile

<u>Step 1</u>

Draw a circle having its centre at O and radius OA of 4 units (cm or inch).

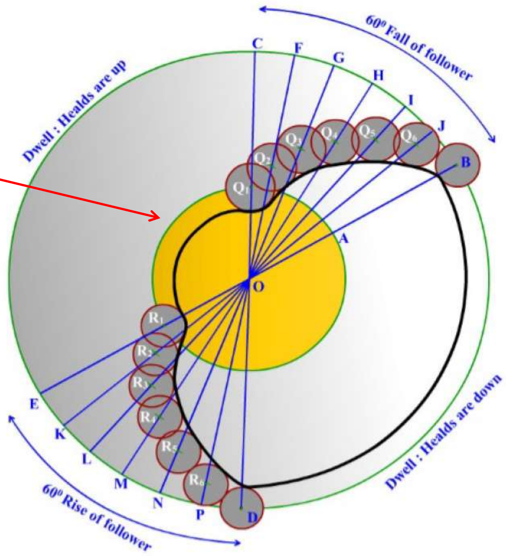


Figure 6.26: Linear cam for plain weave

80

## Steps for drawing Linear cam profile

Step 2

Add d and l (4 +6=10). Then draw another concentric circle having radius of OB (10 units).

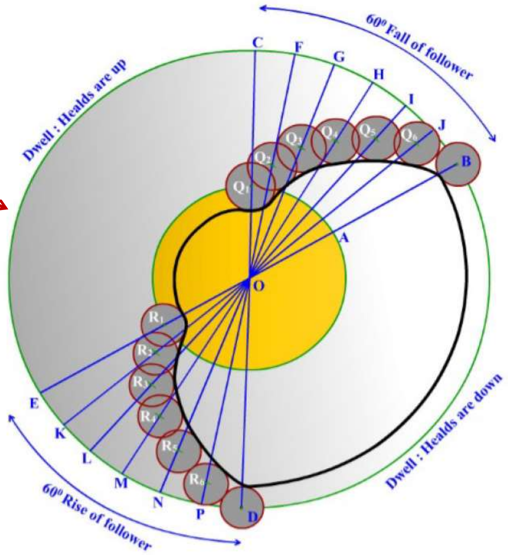


Figure 6.26: Linear cam for plain weave

81

## Steps for drawing Linear cam profile

Step 3

Divide the circle in four segments of 60°, 120°, 60° and 120°, for rise, dwell 1, fall and dwell 2 respectively. Here ∠COB = ∠DOE = 60°.

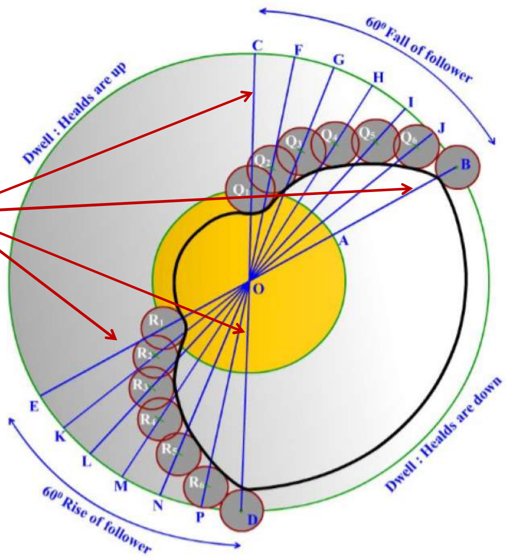


Figure 6.26: Linear cam for plain weave

82

## Steps for drawing Linear cam profile

Step 4

Divide ∠COB in six equal parts by the radii OF, OG, OH, OI and OJ. Similarly, ∠DOE is divided in six equal parts by radii OK, OL, OM, ON and OP. Therefore angles COF, FOG, GOH, HOI, IOJ and JOB are all equal to 10° each. Similarly angles EOK, KOL, LOM, MON, NOP and POD are all equal to 10° each.

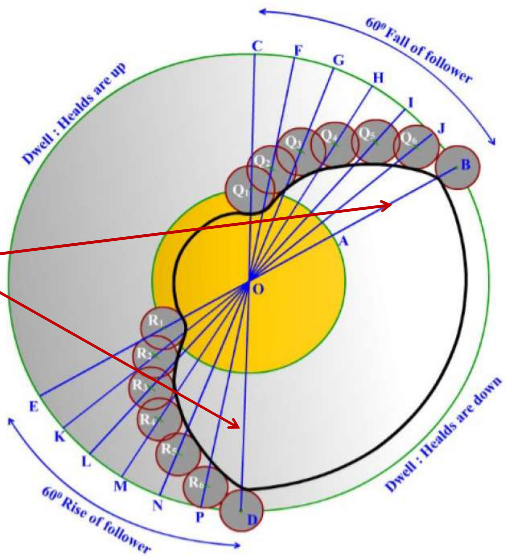


Figure 6.26: Linear cam for plain weave

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## Steps for drawing Linear cam profile

As the span of the rise and fall (60° for each) has been divided into six equal parts i.e. 10° each, the distance between the centres of cam and follower would increase by 1/6 × 6 unit = 1 unit after each 10° rotation of the cam during the rise.

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## Steps for drawing Linear cam profile

Step 5

Five arcs are drawn having centre at O and radius of 5 (4+1), 6 (5+1), 7 (6+1), 8 (7+1), 9 (8+1) units. The arc having radius of 5 units will cut radii OF and OK at points Q2 and R2 respectively. The arc having radius of 6 units will cut radii OG and OL at points Q3 and R3 respectively.

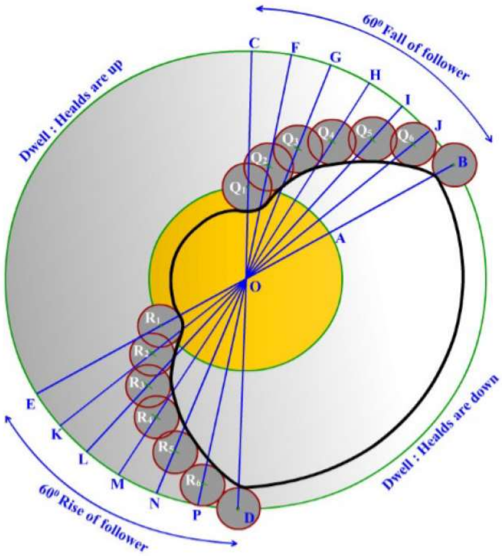


Figure 6.26: Linear cam for plain weave

85

## Steps for drawing Linear cam profile

Step 6

Draw small circles having diameter of 2 units, representing the follower, considering Q1, Q2, …., Q6 and B as centres. Also draw small circles, having diameter of 2 units, considering R1, R2, …, R6 and D as centres.

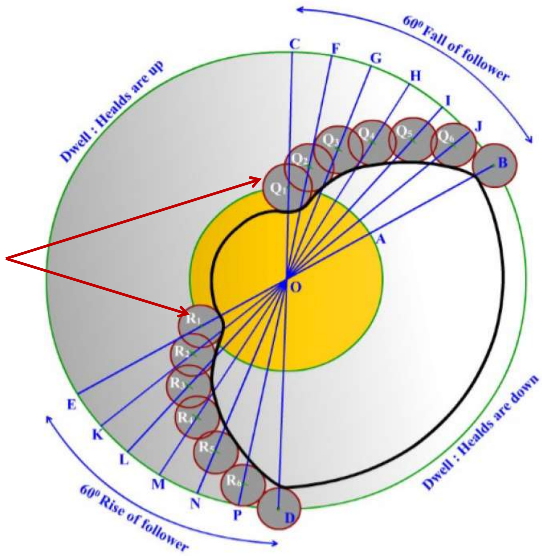


Figure 6.26: Linear cam for plain weave

86

## Steps for drawing Linear cam profile

Step 7

Join the inner surfaces of these 14 circles with smooth curved line to get the profile of the cam.

Segment DOB (120°) causes dwell 1 of the heald at lower position. The segment EOC (120°) causes the dwell 2 of the heald at the raised position.

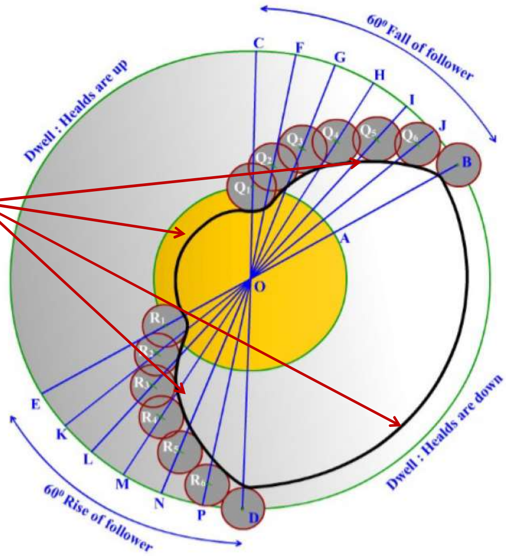


Figure 6.26: Linear cam for plain weave

87

## Example 2

88

Example 2: Design a shedding cam for 2/1 twill fabric using the following particulars:

Minimum distance between cam and follower centres (*d*) : *4 units*
Lift (*l*): *6 units*
Diameter of follower (*f*): *2 units*
Dwell period: 1/3 of a pick
Movement pattern during rise and fall: Linear

89

## Steps for drawing Linear cam profile

As it is 2/1 twill weave, the 360° rotation of the cam shaft or cam will correspond to three picks. Therefore, one pick is equivalent to 120° rotation of the cam.

The two dwells, in this case, will not be equal. When the heald remains at the raised position, two picks are inserted. When the heald remains at the bottom position, one pick is inserted.

Therefore, the dwell of heald at raised position will be longer than the dwell of heald at lowered position.

90

## Steps for drawing Linear cam profile

The shorter dwell (in lowered position) will be spanning over 1/3 ×120° = 40°.

Therefore, the duration of dwell of the heald in raised position will be = duration for one pick + duration of short dwell = 120°+ 40°= 160°.

Two dwells have now consumed 200° and the remaining 160° will be equally shared between rise and fall. Therefore, the span for rise and fall will be 80° for each.

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## Steps for drawing Linear cam profile

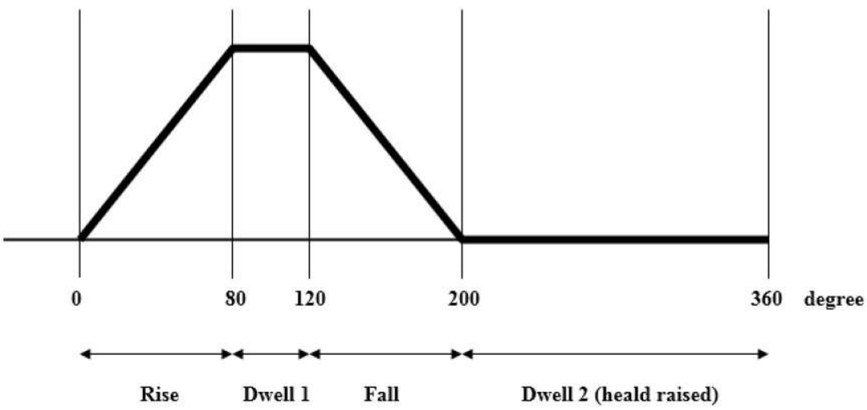


Figure 6.27: Linear movement pattern for 2/1 twill weave

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## Steps for drawing Linear cam profile

Step 1

Draw a circle having its centre at O and radius OA of 4 units (cm or inch).

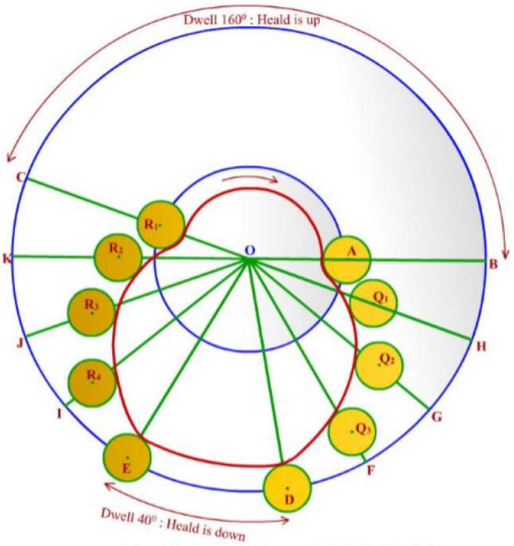


Figure 6.28: Linear cam for plain weave

93

## Steps for drawing Linear cam profile

Step 2

Add d and l (4 + 6 = 10). Then draw another concentric circle having radius of OB (10 units).

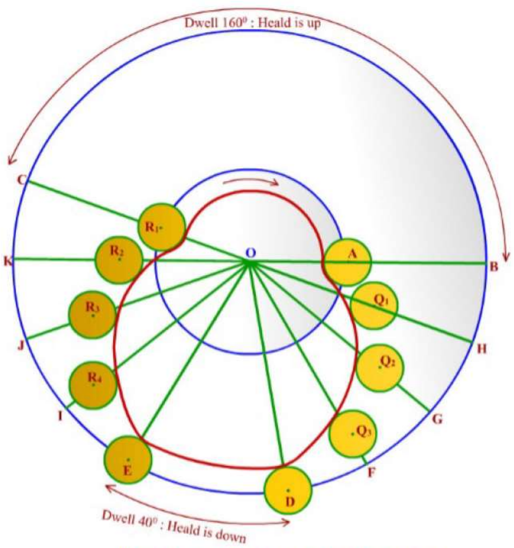


Figure 6.28: Linear cam for plain weave

94

# Steps for drawing Linear cam profile

Step 3

Divide the circle in four segments of 80°, 40°, 80° and 160° for rise, dwell 1, fall and dwell 2 respectively.

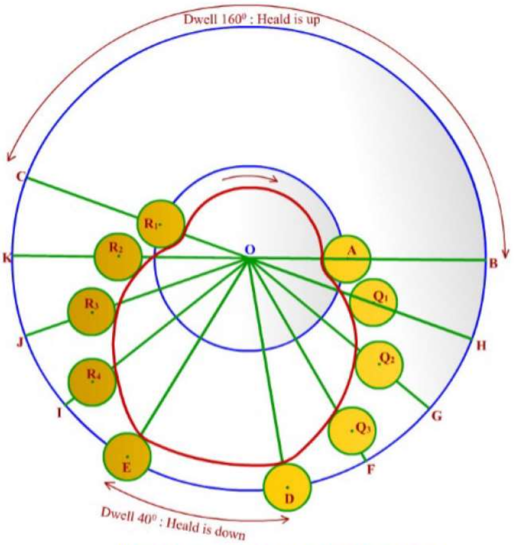


Figure 6.28: Linear cam for plain weave

95

# Steps for drawing Linear cam profile

Step 4

Segment COE is divided into four equal parts by the radii OK, OJ and OI. Similarly, segment BOD is divided into four equal parts by radii OF, OG and OH.

Therefore angles EOI, IOJ, JOK and COK are all equal to 20°. Similarly angles BOH, HOG, GOF and DOF are all equal to 20°.

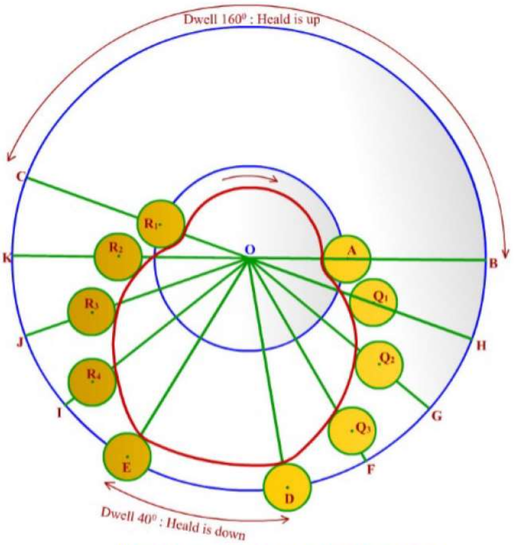


Figure 6.28: Linear cam for plain weave

96

## Steps for drawing Linear cam profile

Total lift of the follower is 6 units.

As the span of the rise and fall (80° each) has been divided into four equal parts i.e. 20° each, the distance between the centres of cam and follower would increase by ¼ × 6 unit = 1.5 unit after each 20° rotation of the cam during the rise.

During the fall it will be just opposite.

97

## Steps for drawing Linear cam profile

Step 5

Three arcs were drawn having centre at O and radius of 5.5 (4+1.5), 7.0 (5.5 +1.5) and 8.5 (7.0+1.5) units. The arc having radius 5.5 units will cut radii OH and OK at points Q1 and R2 respectively. The arc having radius 7.0 units will cut radii OG and OJ at points Q2 and R3 respectively.

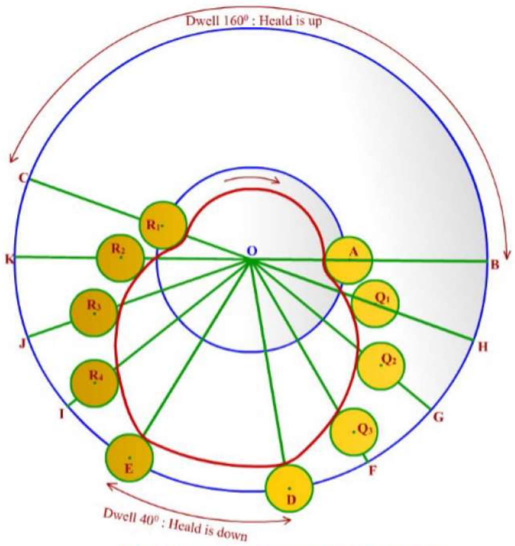


Figure 6.28: Linear cam for plain weave

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## Steps for drawing Linear cam profile

Step 6

Small circles having diameter of 2 units, representing the follower, are drawn considering R1, R2, R3, R4 and E as centres. Small circles, having diameter of 2 units, are also drawn considering A, Q1, Q2, Q3 and D as centres.

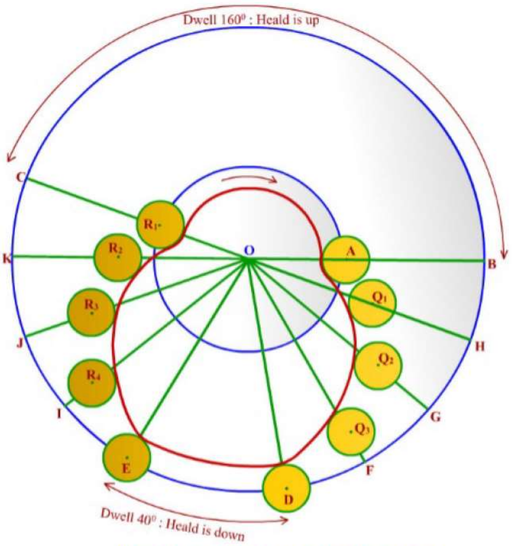


Figure 6.28: Linear cam for plain weave

99

## Steps for drawing Linear cam profile

Step 7

The inner surfaces of these 10 circles are joined with smooth curved line to get the profile of the cam.

The segment DOE (40°) causes dwell 1 of the heald at lower position of the shed.

The segment BOC (160°) causes the dwell 2 of the heald at the raised position.

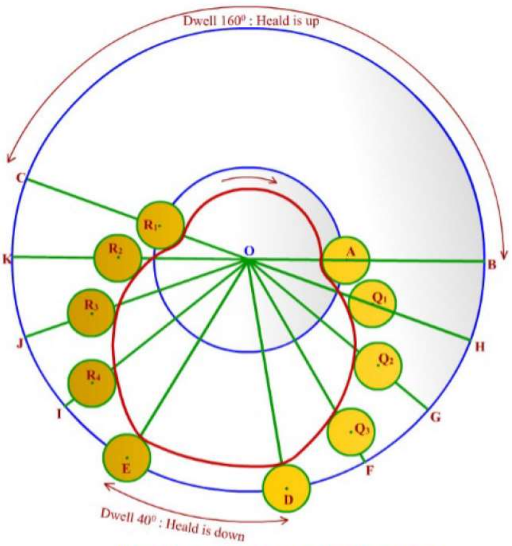


Figure 6.28: Linear cam for plain weave

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