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DEPARTMENT OF AGRICULTURE ENGINEERING

19AGT202 – MACHINE DESIGN

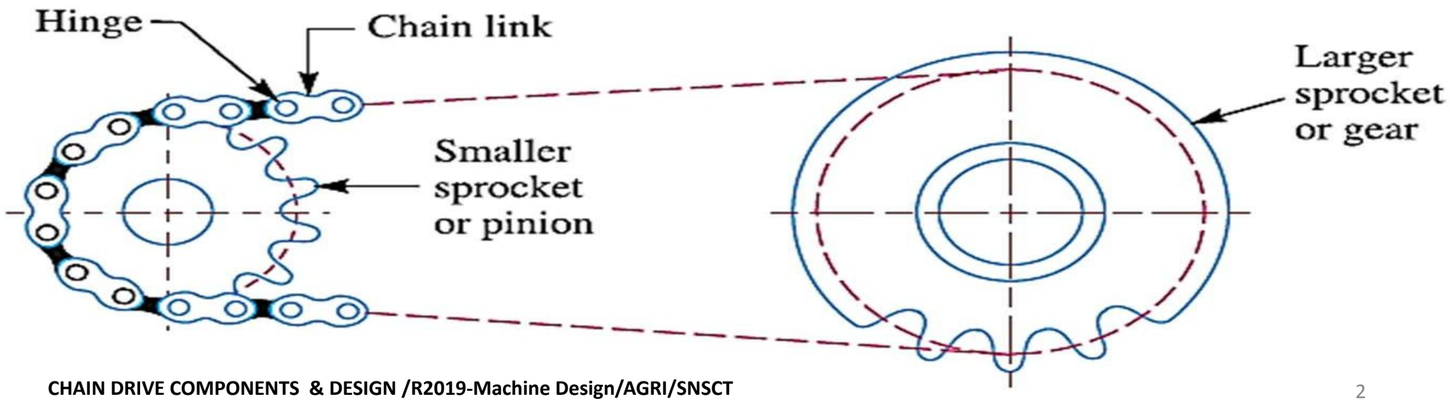
III YEAR V SEM

UNIT 5 – DESIGN OF TRANSMISSION SYSTEM COMPONENTS

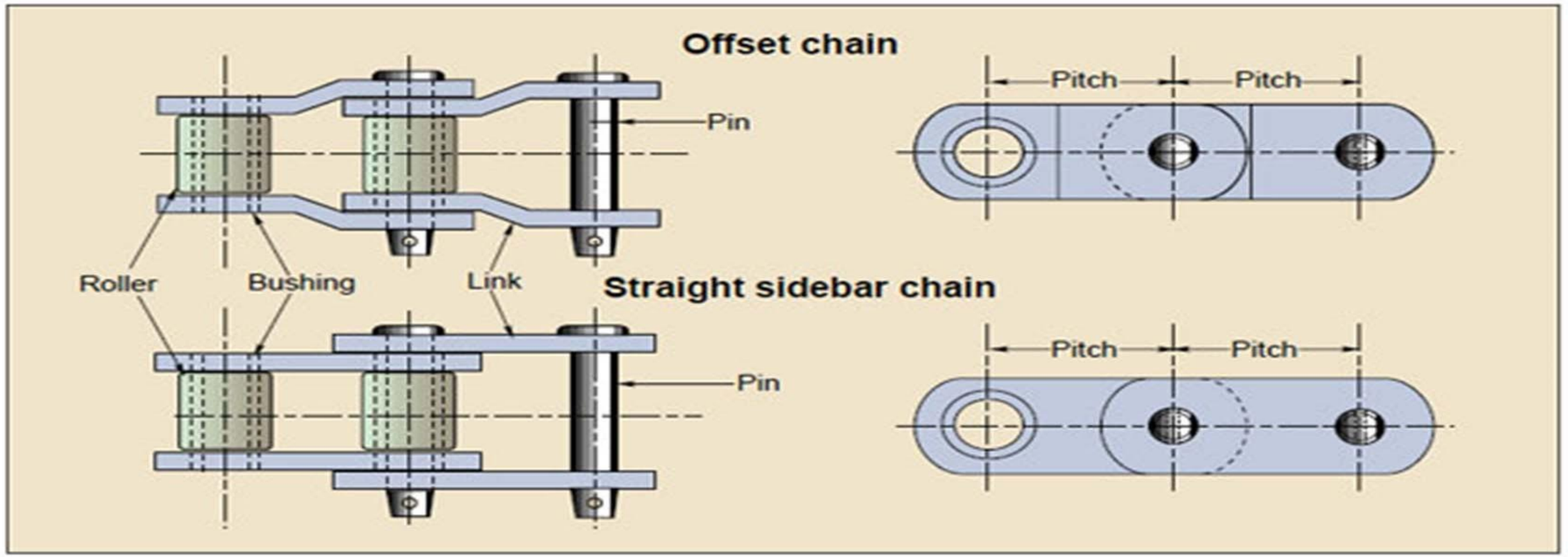
TOPIC – CHAIN DRIVE COMPONENTS & DESIGN

Chain Drives

- Roller chain is mostly used to transmit power.
- A chain is a power transmission element made as a series of pin-connected links.
- Load is applied by the driving sprocket on the chain, the load is transmitted to a bushing, pin, and pair of link plates, pins and link plates push the driven sprocket to run.



Chain Drives



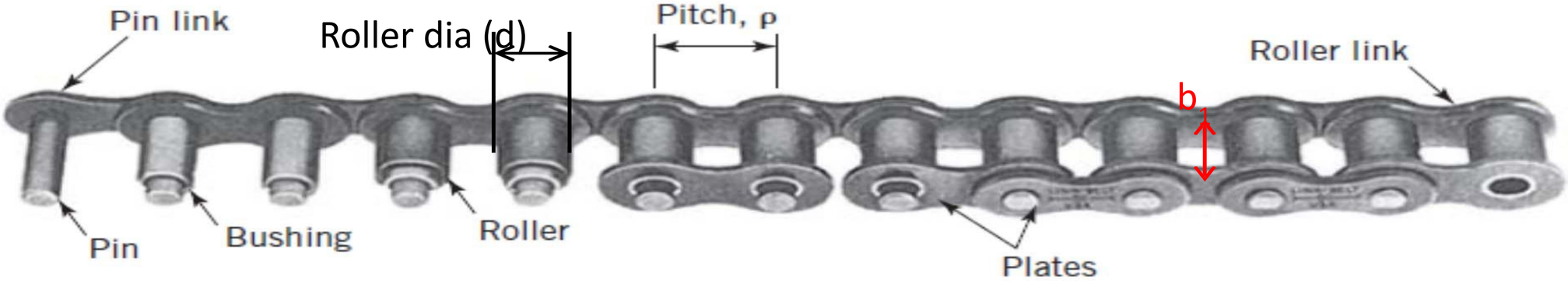
Chain Drives - Advantages

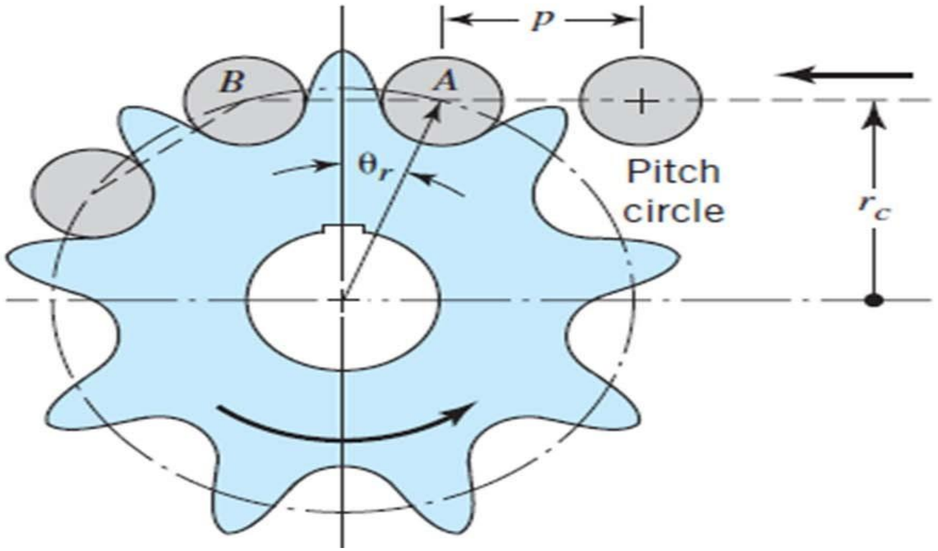
- Due to no slippage, constant velocity is obtained.
- Less width is occupied, due to metal strength.
- Can be used for short as well as long center distances.
- High transmission efficiency (97-99%).
- One chain can transfer power to multiple shafts.
- Can be operated at high temperature.
- Permits high speed ratio of 8 to 10.
- Multiple reduction stages are made, for high reduction ratio.

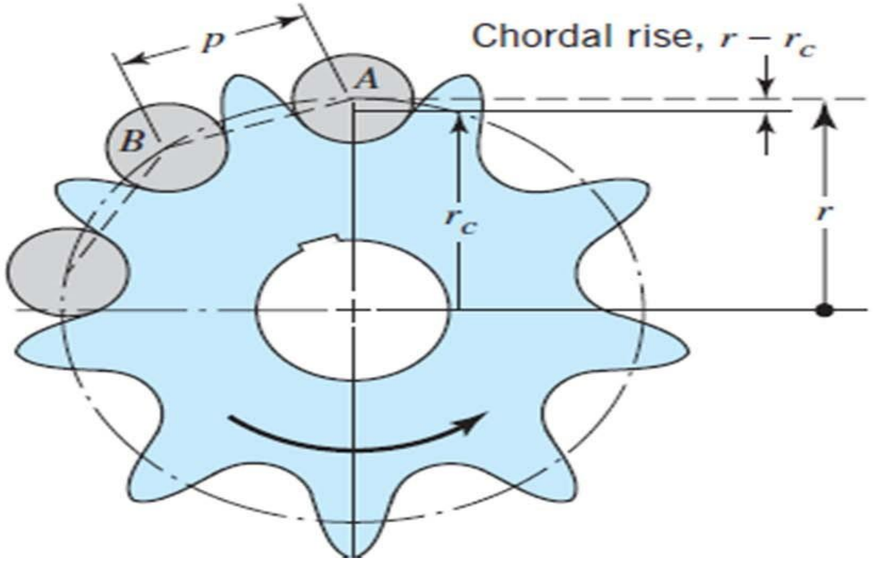
Chain Drives - Limitations

- Installation and component cost is higher.
- Require maintenance and lubrication.
- Velocity fluctuation occurs, when mounted inaccurately.

Chain Drives – Roller chains





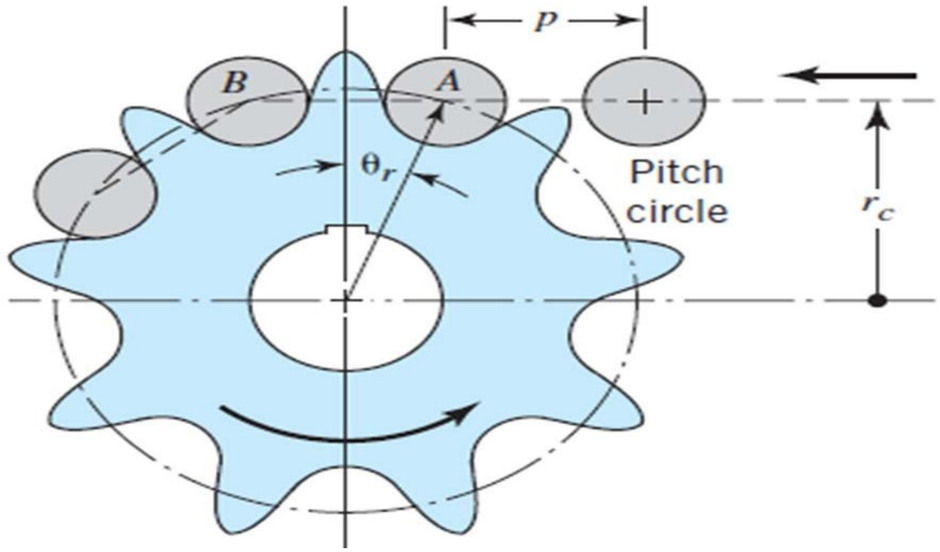


Chain Drives - Nomenclature

Pitch

Is the distance between the centers of two adjacent pins.

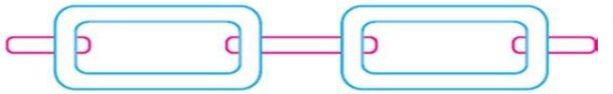
Pitch circle radius (r_c) Distance between the pin center and the center of sprocket, when the hinge is meshed with that sprocket.

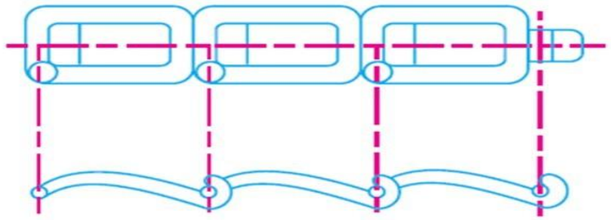


Chain Drives - Classification

- **Hoisting and hauling (or crane) chains**

- Can be used up to 0.25m/s
- Two types : Oval and square links





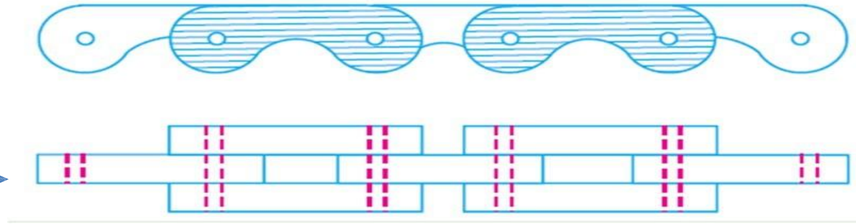
- **Conveyor Chains**

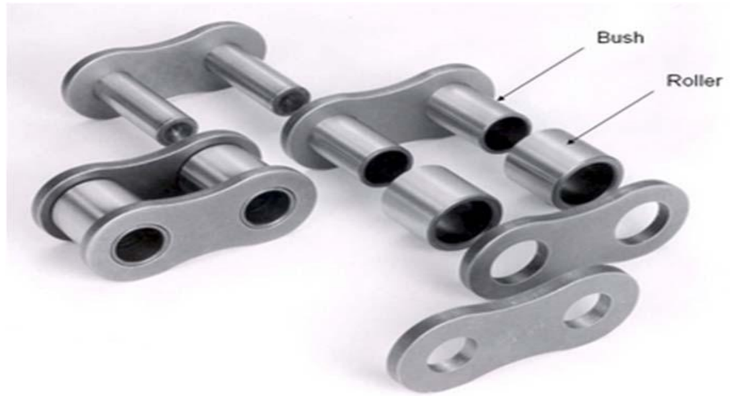
- Used for elevating and conveying within 0.8 to 3m/s.
- Two types : Detachable or hook joint, closed joint type.

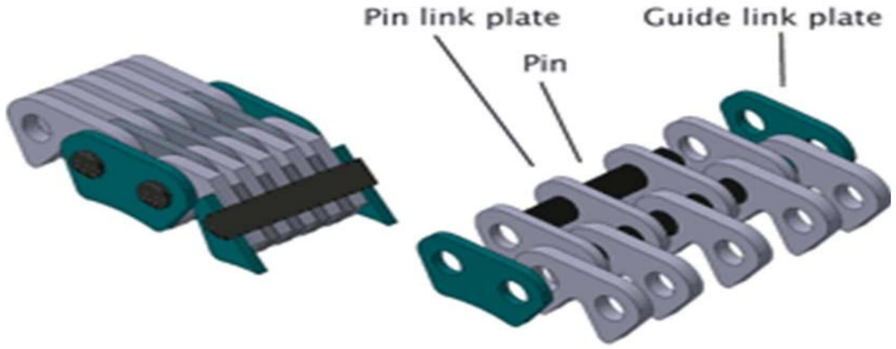
Chain Drives - Classification

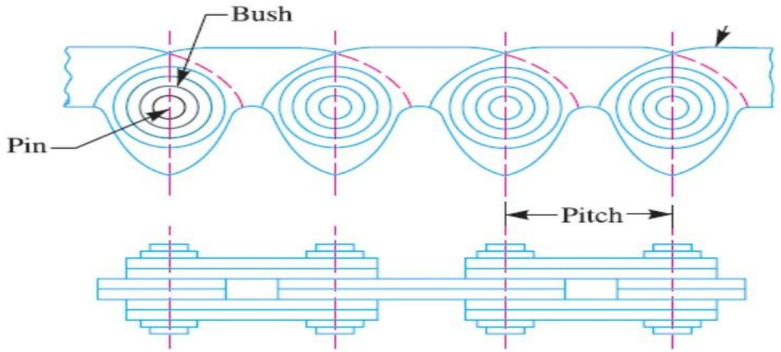
- **Power Transmitting Chains**

- Used for short center distance.
- Three types :
- Block or bush chain
- Bush roller chain
- Silent chain







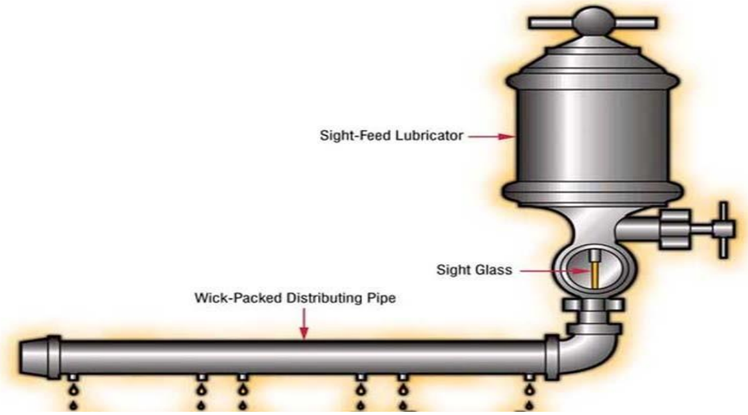


Chain Drives – Lubrication

- The performance of chain assembly is improved by proper lubrication. It reduces the friction and act as a coolant.
- Improper lubrication produces premature chain failure.
- Lubrication types depend upon the speed and environment.

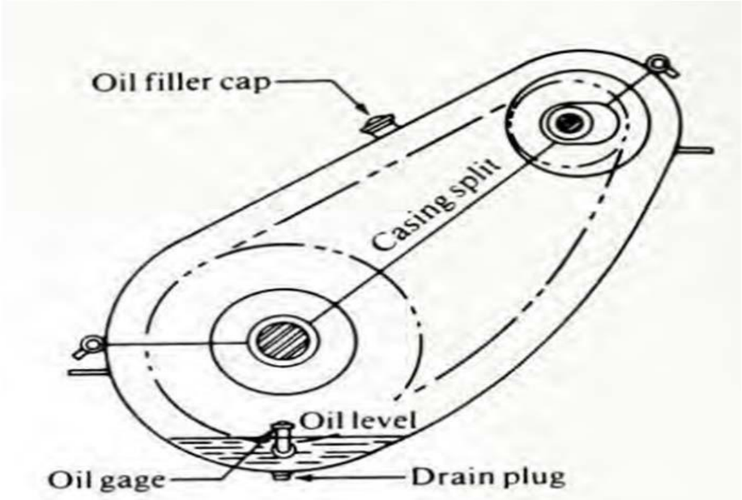
Chain Drives – Lubrication

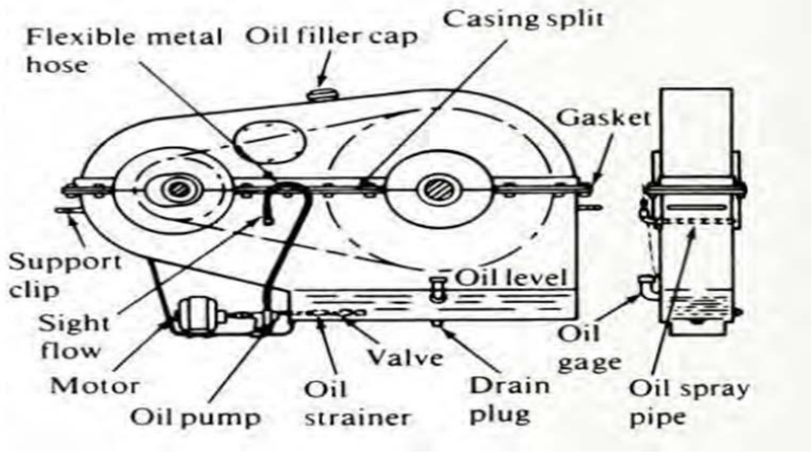
- **Manual lubrication** : Lube is applied periodically using brush or oil can. e.g. cycle or bike chain.
- **Drip lubrication** : oil drips with sufficient flow is directed on the chain. e.g. Conveyor chains, engine.



Chain Drives – Lubrication

- **Bath or Disc lubrication** : chain runs through an oil sump or bath in the drive housing. In disc lubrication, a disc picks up the oil and deposit on chain. Oil level is to be maintained in these cases.
- **Stream lubrication** : Some nozzles attached with supply of oil, are set on chain to spray the oil on chain near sprocket engagement.





Chain Drives – Roller chains

(a) Standard roller chain, single strand

(b) Standard roller chain, two-strand (also available with three and four strands)

(c) Heavy series roller chain

(d) Double-pitch drive chain

(e) Double-pitch conveyor chain

Roller chains - Recommendations

- $T_1 \leq 17, T_2 \leq 120$

  T_1, T_2 = No. of teeth on small, large sprocket

- Velocity Ratio (V.R.) = $\frac{n_1}{n_2} \leq 7$

- 30 pitches≤center distance (C) ≤ 50 pitches

- Pitch (p) should be even.
- Chain length (L)=2C + $\frac{T_1+T_2}{2} + \left(\frac{T_2-T_1}{2\pi}\right)^2 \cdot \frac{1}{C}$

Roller chains – problem solving steps

1. Specify a service factor and compute the design power.

$$K_s = K_1 . K_2 . K_3 \; ; \; P_t = K_s \times P$$

Load factor (K_1)	= 1, for constant load
	= 1.25, for variable load with mild shock
	= 1.5, for heavy shock loads
Lubrication factor (K_2)	= 0.8, for continuous lubrication
	= 1, for drop lubrication
	= 1.5, for periodic lubrication
Rating factor (K_3)	= 1, for 8 hours per day
	= 1.25, for 16 hours per day
	= 1.5, for continuous service

Multiple strand factor (1,2,3) - K_m=1.7, 2.5, 3.3 – P_t/K_m

Roller chains - Calculation

2. Compute the velocity ratio. V.R. = n_1/n_2
3. Select the chain pitch, and rpm of smaller sprocket.

Table 21.4. Power rating (in kW) of simple roller chain.

Speed of smaller sprocket or pinion (r.p.m.)	*Power (kW)*				
	06 B	08 B	10 B	12 B	16 B
100	0.25	0.64	1.18	2.01	4.83
200	0.47	1.18	2.19	3.75	8.94
300	0.61	1.70	3.15	5.43	13.06
500	1.09	2.72	5.01	8.53	20.57
700	1.48	3.66	6.71	11.63	27.73
1000	2.03	5.09	8.97	15.65	34.89
1400	2.73	6.81	11.67	18.15	38.47
1800	3.44	8.10	13.03	19.85	–
2000	3.80	8.67	13.49	20.57	–

Roller chains - Calculation

Table 17–20

Rated Horsepower Capacity of Single-Strand Single-Pitch Roller Chain for a 17-Tooth Sprocket

Source: Compiled from ANSI B29.1-1975 information only section, and from B29.9-1958.

Sprocket Speed, rev/min	ANSI Chain Number					
	25	35	40	41	50	60
50	0.05	0.16	0.37	0.20	0.72	1.24
100	0.09	0.29	0.69	0.38	1.34	2.31
150	0.13*	0.41*	0.99*	0.55*	1.92*	3.32
200	0.16*	0.54*	1.29	0.71	2.50	4.30
300	0.23	0.78	1.85	1.02	3.61	6.20
400	0.30*	1.01*	2.40	1.32	4.67	8.03
500	0.37	1.24	2.93	1.61	5.71	9.81
600	0.44*	1.46*	3.45*	1.90*	6.72*	11.6
700	0.50	1.68	3.97	2.18	7.73	13.3
800	0.56*	1.89*	4.48*	2.46*	8.71*	15.0
900	0.62	2.10	4.98	2.74	9.69	16.7
1000	0.68*	2.31*	5.48	3.01	10.7	18.3
1200	0.81	2.73	6.45	3.29	12.6	21.6
1400	0.93*	3.13*	7.41	2.61	14.4	18.1
1600	1.05*	3.53*	8.36	2.14	12.8	14.8
1800	1.16	3.93	8.96	1.79	10.7	12.4
2000	1.27*	4.32*	7.72*	1.52*	9.23*	10.6
2500	1.56	5.28	5.51*	1.10*	6.58*	7.57
3000	1.84	5.64	4.17	0.83	4.98	5.76
	Type A		Type B			Type C

Roller chains - Calculation

4. Number of teeth of small sprocket.

Table 21.5. Number of teeth on the smaller sprocket.

Type of chain	*Number of teeth at velocity ratio*					
	1	2	3	4	5	6
Roller	31	27	25	23	21	17
Silent	40	35	31	27	23	19

5. Pitch of the chain

Table 21.1. Characteristics of roller chains according to IS: 2403 — 1991.

ISO Chain number	*Pitch (p) mm*	*Roller diameter* (d_1) *mm Maximum*	*Width between inner plates* (b_1) *mm Maximum*	*Transverse pitch* (p_1) mm	*Breaking load (kN) Minimum*		
					Simple	*Duplex*	*Triplex*
05 B	8.00	5.00	3.00	5.64	4.4	7.8	11.1
06 B	9.525	6.35	5.72	10.24	8.9	16.9	24.9
08 B	12.70	8.51	7.75	13.92	17.8	31.1	44.5
10 B	15.875	10.16	9.65	16.59	22.2	44.5	66.7
12 B	19.05	12.07	11.68	19.46	28.9	57.8	86.7
16 B	25.4	15.88	17.02	31.88	42.3	84.5	126.8
20 B	31.75	19.05	19.56	36.45	64.5	129	193.5

Roller chains - Calculation

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10 B	15.875	10.16	9.65	16.59	22.2	44.5	66.7
12 B	19.05	12.07	11.68	19.46	28.9	57.8	86.7
16 B	25.4	15.88	17.02	31.88	42.3	84.5	126.8
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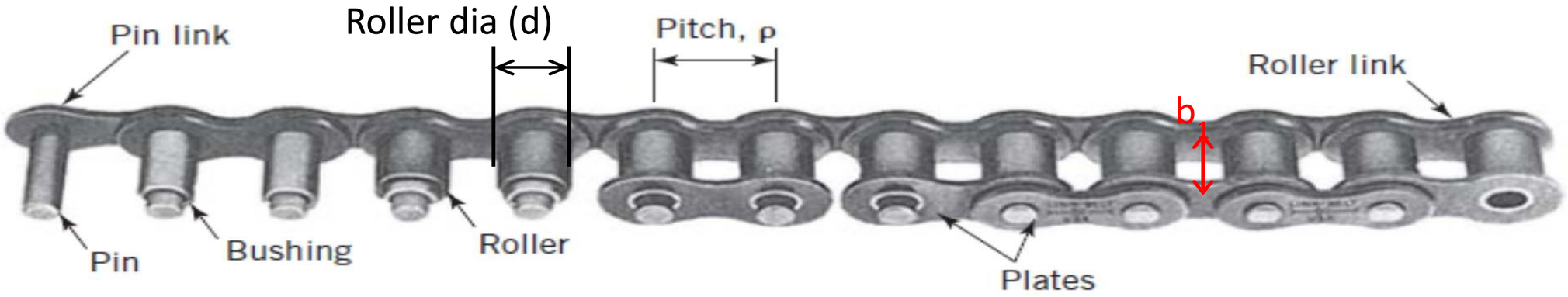

Roller chains - Calculation

6. Compute number of teeth of larger sprocket.

$T_2 = T_1$ V.R (check in catalogue)

7. Compute the actual expected output speed

$$n_2 = n_1 \quad (T_1/T_2)$$

8. Compute the pitch diameters of the sprockets.

$$D_1 \; 2 = \frac{}{\sin(180^{\circ}/T_1)\sin(180^{\circ}/T_2)} \qquad D = \frac{p \; p}{}$$

9. Compute the length of the chain (L).

Roller chains - Calculation

10. Corrected center distance.

$$C = \frac{1}{4}\cdot\left[L - \frac{T_1 + T_2}{2} + \sqrt{\left(L - \frac{T_1 + T_2}{2}\right)^2 - 8\cdot\left(\frac{T_2 - T_1}{2n}\right)^2}\right]$$

11. Compute the angle of wrap of the chain for each sprocket

$$\theta_1 = 180^\circ - 2.\sin^{-1}\left[(D_2 - D_1)/2C\right]$$

$$\theta_2 = 180^\circ + 2.\sin^{-1}\left[(D_2 - D_1)/2C\right]$$

Roller chains - Calculation

Design a chain drive for a heavily loaded coal conveyor to be driven by a gasoline engine through a mechanical drive. The input speed will be **900** rpm, and the desired output speed is 230 to 240 rpm. The conveyor requires 15.0 hp. (variable load with mild shock, 20 hr)

1. K_s=1.25(.8)(1.4)=1.4; P_t=K_s x P = 1.4 x 15 = 21hp

2. V.R. = n_1/n_2 = 900/235 = 3.83

3. P_t = 15hp = 21hp x 0.7456 kW/hp = 15.6576kW

Roller chains - Calculation

3. Select the chain pitch, and rpm of smaller sprocket.

Table 21.4. Power rating (in kW) of simple roller chain.

Speed of smaller sprocket or pinion (r.p.m.)	*Power (kW)*				
	06 B	08 B	10 B	12 B	16 B
100	0.25	0.64	1.18	2.01	4.83
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2000	3.80	8.67	13.49	20.57	–

Roller chains - Calculation

4. Number of teeth on sprockets.

Table 21.5. Number of teeth on the smaller sprocket.

Type of chain	Number of teeth at velocity ratio					
	1	2	3	4	5	6
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5.Pitch

Table 21.1. Characteristics of roller chains according to IS: 2403 — 1991.

ISO Chain number	Pitch (p) mm	Roller diameter (d_1) mm Maximum	Width between inner plates (b_1) mm Maximum	Transverse pitch (p_1) mm	Breaking load (kN) Minimum		
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10 B	15.875	10.16	9.65	16.59	22.2	44.5	66.7
12 B	p = 19.05	12.07	11.68	19.46	28.9	57.8	86.7
16 B	25.4	15.88	17.02	31.88	42.3	84.5	126.8
20 B	31.75	19.05	19.56	36.45	64.5	129	193.5

Roller chains - Calculation

6. $T_2 = T_1 \times V.R = 23 \times 3.83 = 88.09 = 89$

7. $n_2 = n_1 x(T_1/T_2) = 900(23/89) = 232.58$ rpm

Range given 230-240 – OK

8. $D_1 = \frac{p}{\sin(180^\circ/T_1)} = \frac{19.05}{\sin(180^\circ/23)} = 139.902$mm

$D_2 = \frac{p1\ 19.05}{\sin(180^\circ/T_2)} = \frac{}{\sin(180^\circ/89)} = 539.790$mm

Roller chains - Calculation

9. Length of the chain

C = 40pitch (30 to 50 is recommended)

$$L = 2C + \frac{T_1+T_2}{2} + \left(\frac{T_2-T_1}{2\pi}\right)^2 \cdot \frac{1}{C}$$

L = 138.757pitch = 140 pitches (even recommended)

L = 140(19.05) = 2667 mm

Corrected center distance

$$C = \frac{1}{4} \cdot \left[L - \frac{T_1+T_2}{2} + \sqrt{\left(L - \frac{T_1+T_2}{2}\right)^2 - 8 \cdot \left(\frac{T_2-T_1}{2\pi}\right)^2}\right]$$

C = 40.64 pitch

C = 40.64(19.05) = 774.248mm

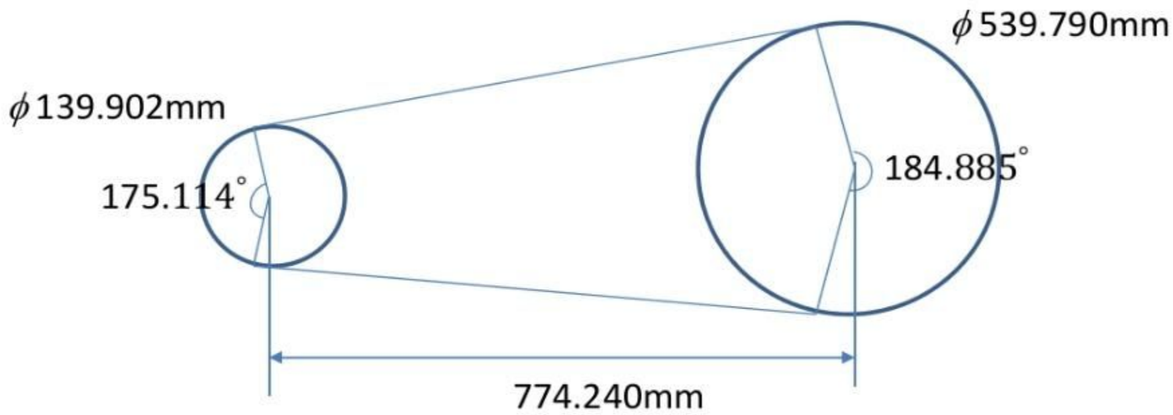
Roller chains - Calculation

10. Angle of wrap

$$\theta_1 = 180^\circ - 2.sin^{-1}[(D_2 - D_1)/2C] = 175.114^\circ$$

$$\theta_2 = 180^\circ + 2.sin^{-1}[(D_2 - D_1)/2C] = 184.885^\circ$$

Design summary



Chain

Pitch	: No. 12B, 19.05mm
Length	: 140pitches = 2667mm
Center distance	: 774.24mm maximum
Sprockets	: Single strand, No. 12B, 19.05mm pitch
Small	: 23 teeth, D = 139.902mm
Large	: 89 teeth, D = 539.790mm

Lubrication

Bath lubrication is recommended due to 1000 rpm, large sprocket dip in bath.

REFERENCES

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