Machine Design –II (MEC- 602)

- **L - T - P (4-0-0)**

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How to Fight COOVID - 19

- We all have be brave and courageous enough as scientist and technocrats to fight COVID 19.
- Psychologically, must have confidence to win war against this disease
- Follow adversaries issued by GOI HM and also we have to help to make our health system more strong and robust.
- Need of hour is to think creative to find solutions to fight this virus. (Innovative ideas can help us)
- In next disposal of used masks will be displayed (Safe Disposal of used masks is need of hour)


STEPS FOR SAFE DISPOSAL OF USED MASKS AT THE HOUSEHOLD LEVEL
Add 1-2 tablespoon of Detergent per litre of water
Add 1/2-1 teaspoon of salt per litre of water
1
On Entering home, first Wash hands in soap for 20 seconds
2
Take off masks with the help of ear thread only without touching any exposed part
3
Put/Dip masks in a non-plastic container like aluminium, steel, iron or earthen pre-filled with 1-2 tablespoon detergent and 1/2-1 teaspoon of salt, Do not touch anything
4
Wash hands in soap for 20 seconds
5
20 min
Soak for 20-30 minutes
6
20 min
Boil the contents
7
Sun dry the masks or hang outside home until fully dry for ensuring 100% drying
8
Cut or shred masks to prevent misuse
9
Discard masks for final disposal
This process is useful for treatment of 5-6 masks per boiling

- Now we will discuss course coverage , as you know this is 2^{nd} course of Machine Design.
- Do you know the Cos and POS
- CO is course outcomes (related to this subject) and PO is programme outcomes

Machine Design –II (MEC -602)

- **CO1: Analyze the stress and strain on mechanical components.**
- **CO2: Demonstrate knowledge of basic machine elements used in machine design.**
- **Design machine elements to perform functions in order to obtain desired objectives under various operating conditions.**

DESIGN by Definition

It is defined as the process of obtaining a optimal solution to problem within constraints i.e., solution through technological developments at minimum cost without compromising with quality and efficiency under specified constraints.

OPTIMAL Solution ????????

$f(z) = a1x1 + b2x2 \ldots\ldots bnxn$

$a = x1 + x2$ and $1 < x < 100, \ldots\ldots\ldots$

Z is cost or z is production or profit

Equations

Functional equation

$$\sigma = \frac{M}{Z} \qquad where\ z = \frac{I}{C} \qquad and\ I = \frac{1}{12} bh * 2$$

I and C are called parametric equations. (useful for fixing constraints)

Solution to obtain with in Local min. Or Global Min.

First Chapter of this course is Design of Belts, Chains, etc

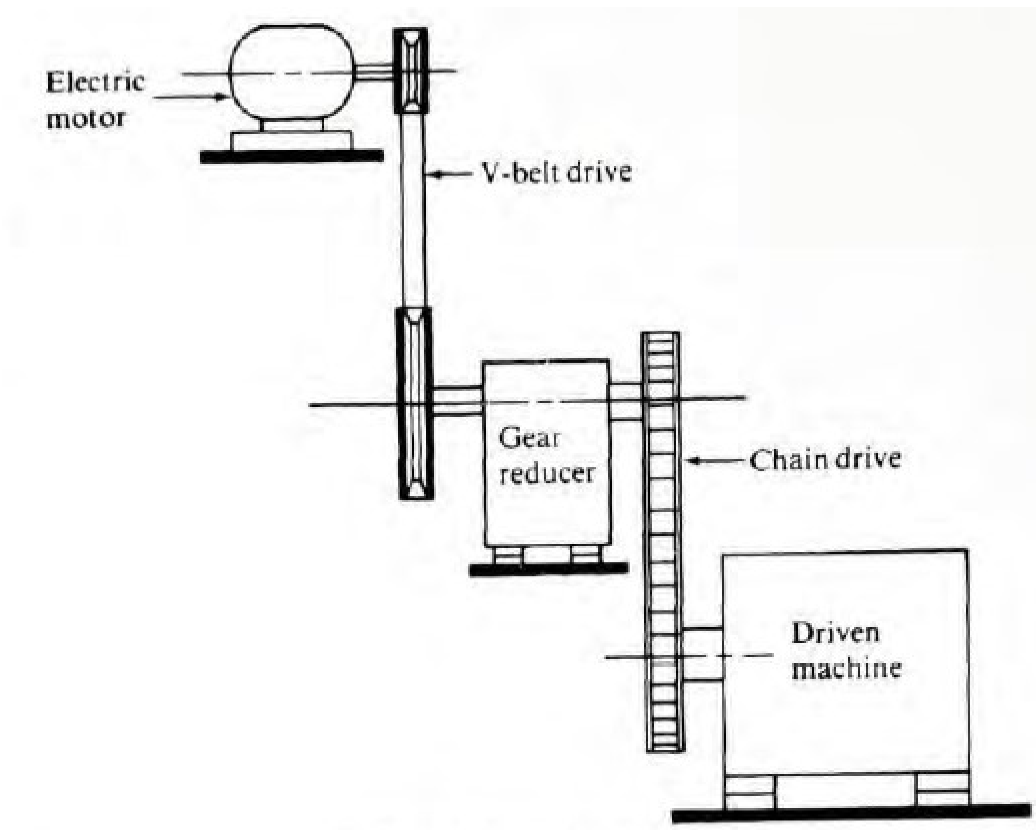
↓

Next few classes to be used to Discuss these

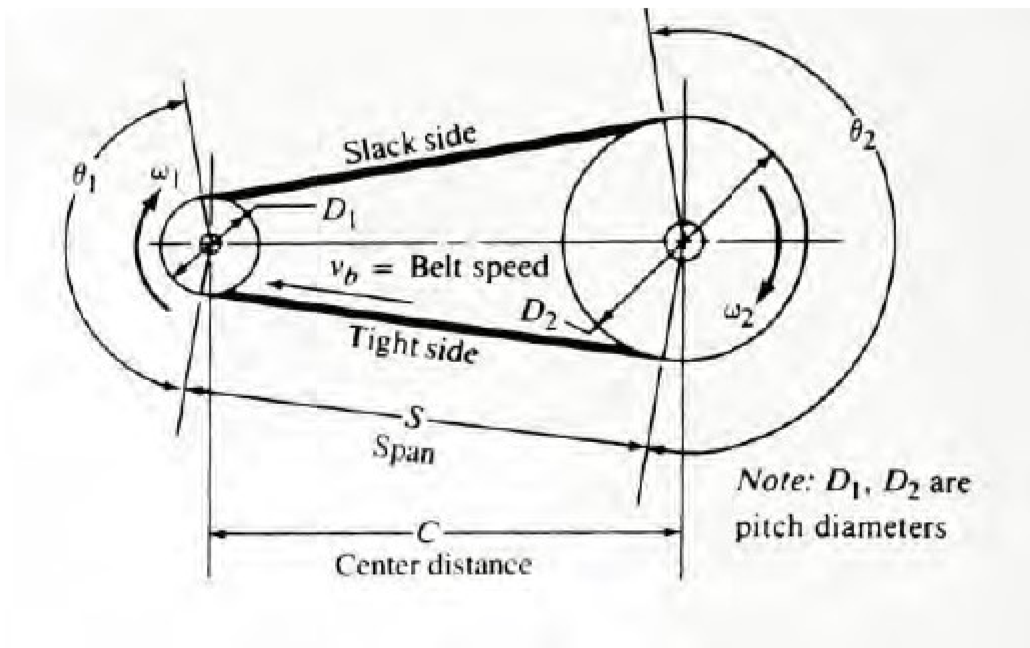
BELT DRIVES AND CHAIN DRIVES

Belts and chains are the major types of flexible power transmission elements. Belts operate on pulleys, whereas chains operate on toothed wheels called sprockets.

Combination drive employing V-belts, a gear reducer, and a chain drive



Basic belt drive geometry

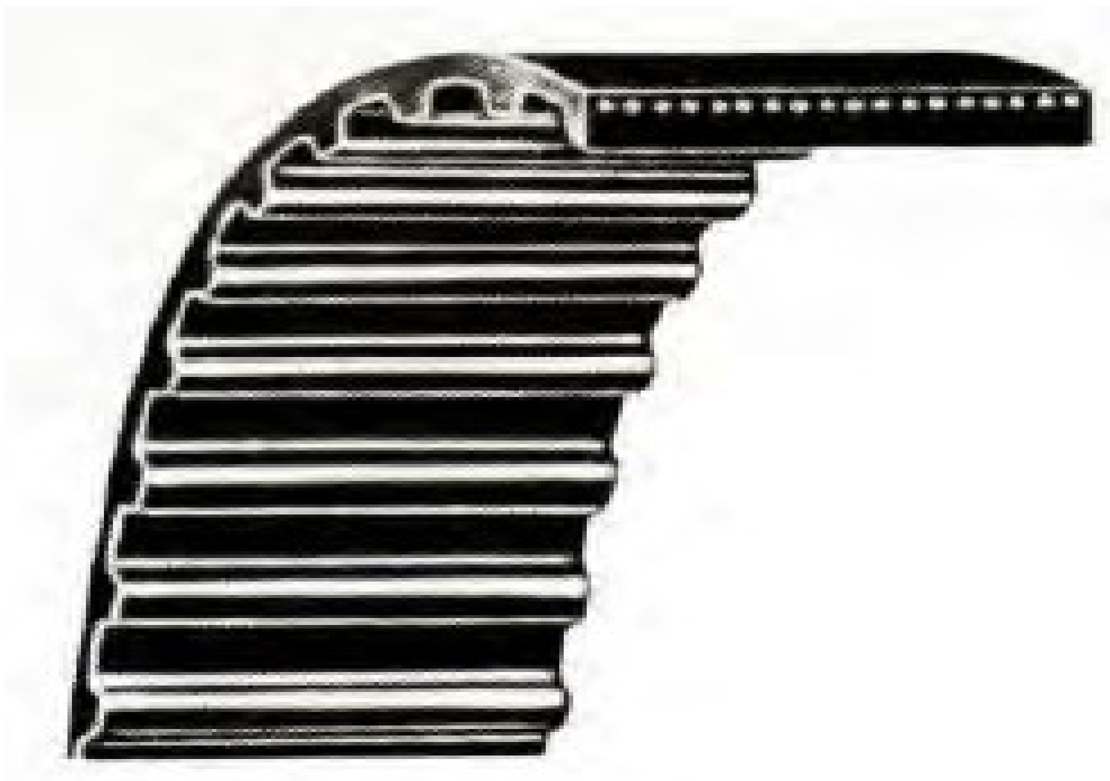


Types of belt drives

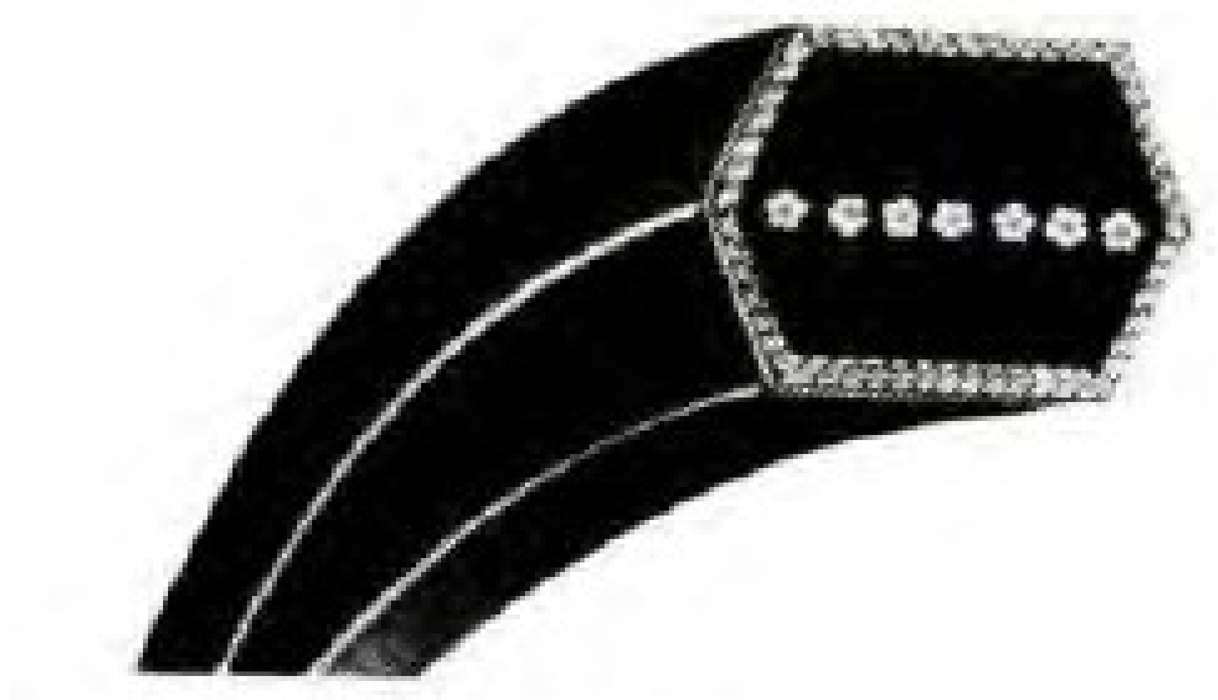
- *flat belts,*
- *synchronous belt,*
- *grooved or cogged belts,*
- *standard V-belts,*
- *double-angle V-belts.*

V-belt Drive

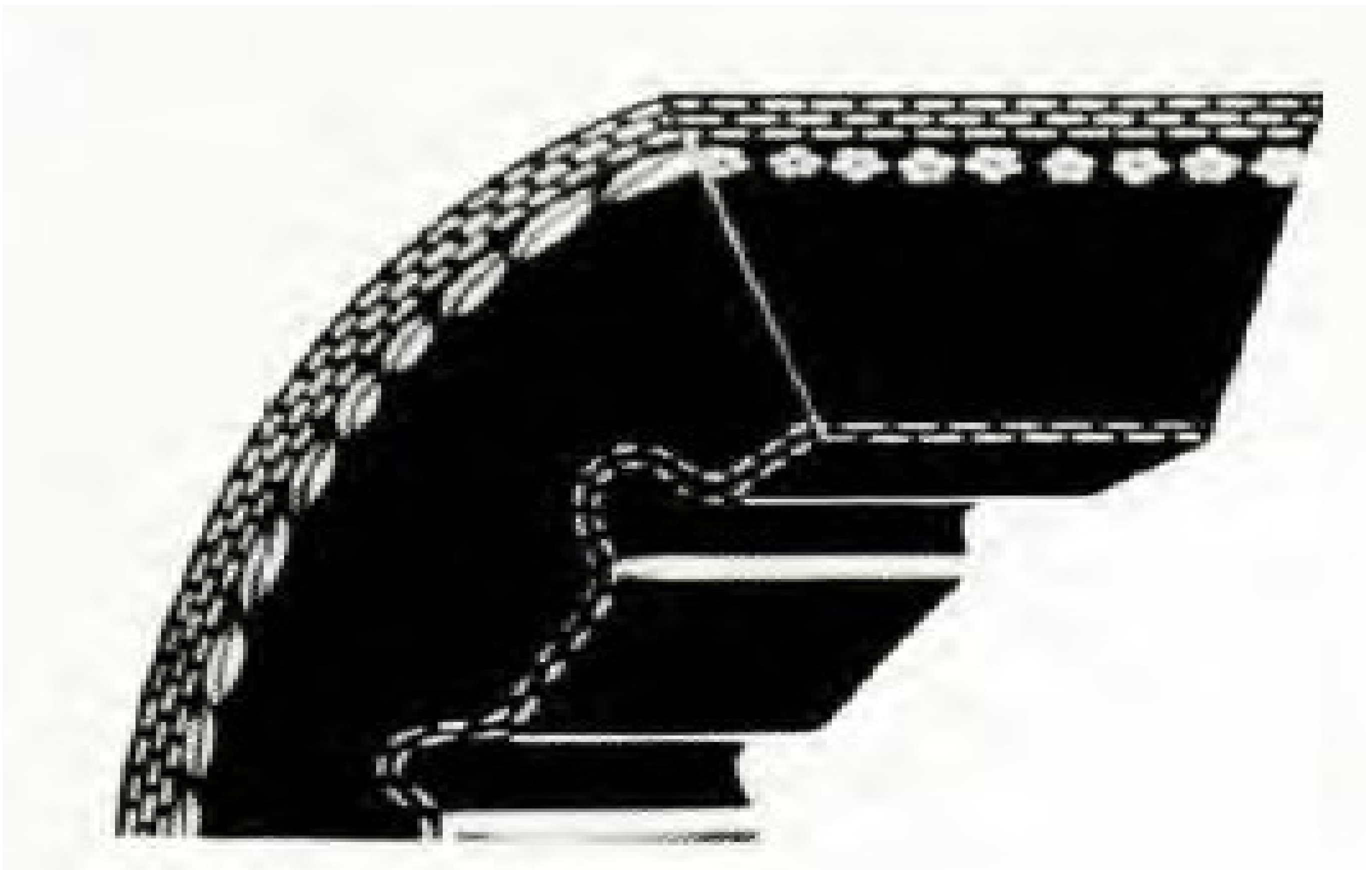
Synchronous Belt



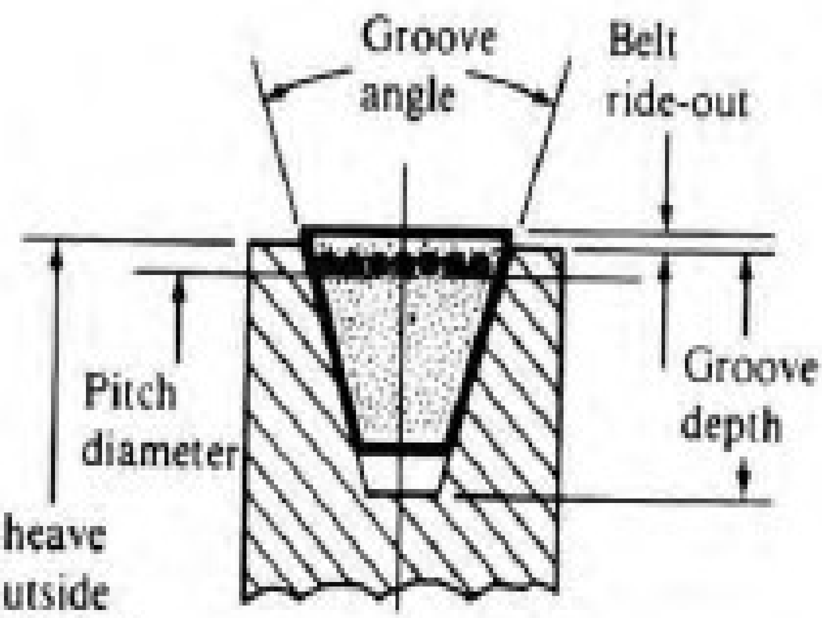
Double Angle V-Belt



Cogged belt



Cross section of V-belt and sheave groove



Some important formulae

1. The relationships between pitch length, *L,* center *C* distance, C, and the sheave diameters are

$$L = 2C + 1.57\,(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4C}$$

$$C = \frac{B + \sqrt{B^2 - 32\,(D_2 - D_1)^2}}{16}$$

where $B = 4L - 6.28(D_2 + D_1)$

2. The angular velocity ratio is

$$\frac{\omega_1}{\omega_2} = \frac{D_2}{D_1}$$

Formulae continued....

3. The angle of contact of the belt on each sheave is

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

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

4. The length of the span between the two sheaves, over which the belt is unsupported, is

$$S = \sqrt{C^2 - \left[\frac{D_2 - D_1}{2}\right]^2}$$

Design Procedure Cum Problem for V-belt drive

Design a V-belt drive that has the input sheave on the shaft of an electric motor (normal torque) rated at 50.0 hp at 1160-rpm, full-load speed. The drive is to a bucket elevator in a potash plant that is to be used 12 hours (h) daily at approximately 675 rpm.

Given:

•Power transmitted = 50 hp to bucket elevator

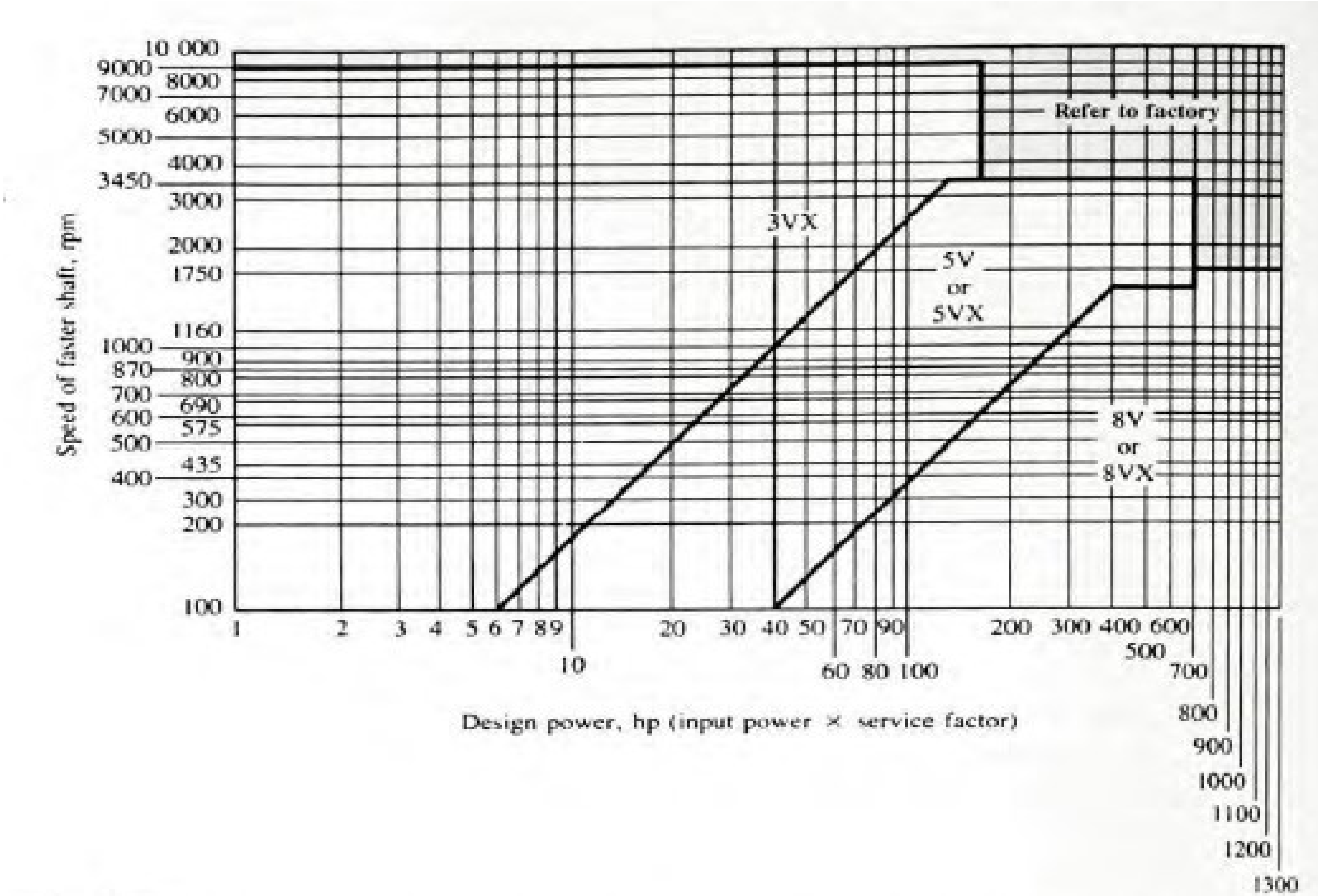
•Speed of motor = 1160 rpm; output speed = 675rpm

Step1: compute design power by obtaining the service factor from the following table:

For a normal torque electric motor running 12 h daily driving a bucket elevator the service factor is 1.3 from the table below. Then the design power is 1.30×50.0 hp = 65.0 hp.

	Driver type					
	AC motors: Normal torque[a] DC motors: Shunt-wound Engines: Multiple-cylinder			AC motors: High torque[b] DC motors: Series-wound, compound-wound Engines: 4-cylinder or less		
Driven machine type	<6 h per day	6–15 h per day	>15 h per day	<6 h per day	6–15 h per day	>15 h per day
Agitators, blowers, fans, centrifugal pumps, light conveyors	1.0	1.1	1.2	1.1	1.2	1.3
Generators, machine tools, mixers, gravel conveyors	1.1	1.2	1.3	1.2	1.3	1.4
Bucket elevators, textile machines, hammer mills, heavy conveyors	1.2	1.3	1.4	1.4	1.5	1.6
Crushers, ball mills, hoists, rubber extruders	1.3	1.4	1.5	1.5	1.6	1.8
Any machine that can choke	2.0	2.0	2.0	2.0	2.0	2.0

***Step 2.* Select the belt section.** **From Figure below, a 5V belt is recommended for 70.0 hp at 1160-rpm input speed.**



Step 3. Compute the nominal speed ratio:

Ratio = 1160/675 = 1.72

Step 4. Compute the driving sheave size that would produce a belt speed of 4000 ft/min, as a guide to selecting a standard sheave

Belt speed $V_b = \pi D_1 n_1/12$ ft/min

- Then the required diameter to give V_b = 4000 ft/min is $D_1 = 12V_b/\pi n_1$

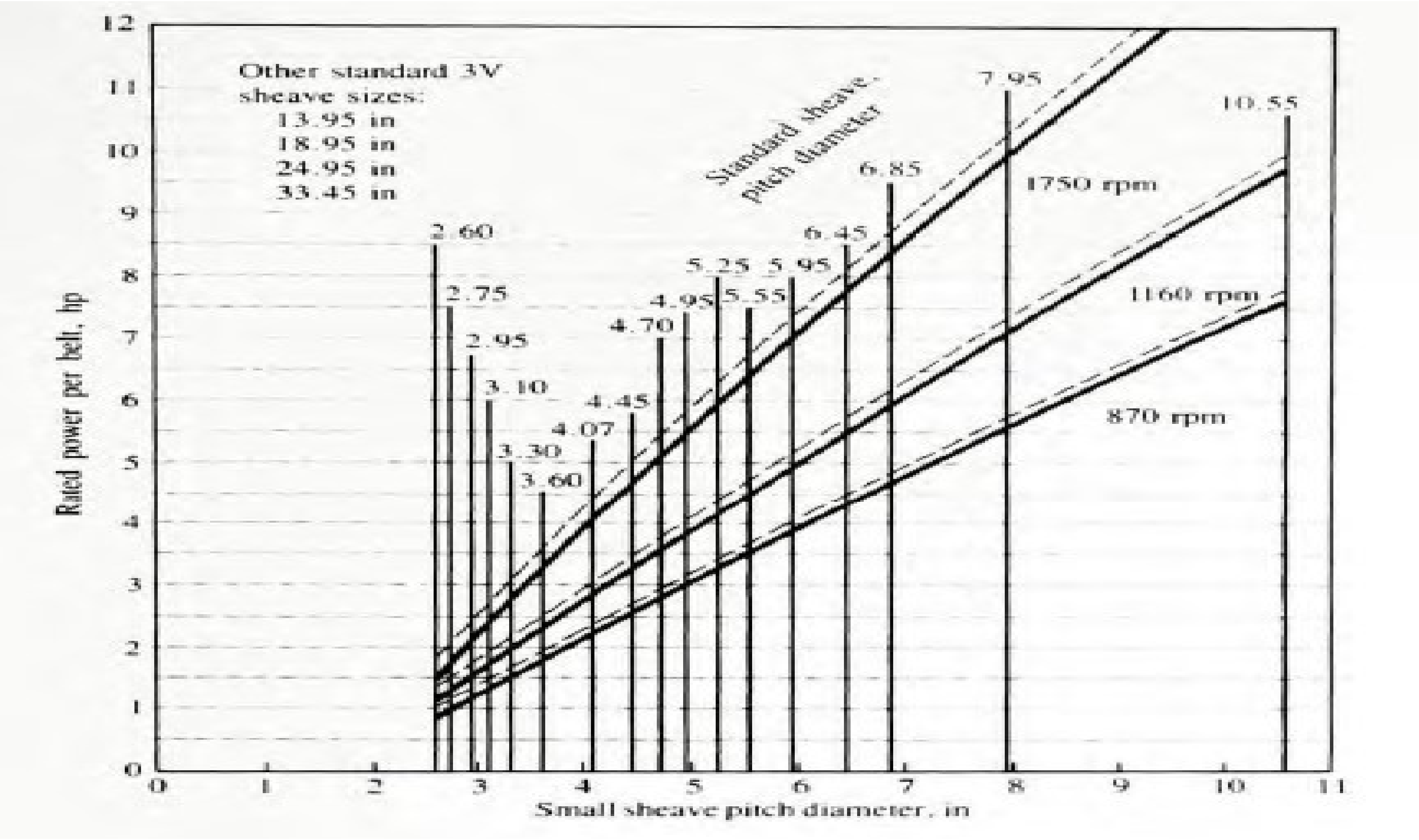
D_1 = 13.17 in

- *Step 5.* Select trial sizes for the input sheave, and compute the desired size of the output sheave. Select a standard size for the output sheave, and compute the actual ratio and output speed.

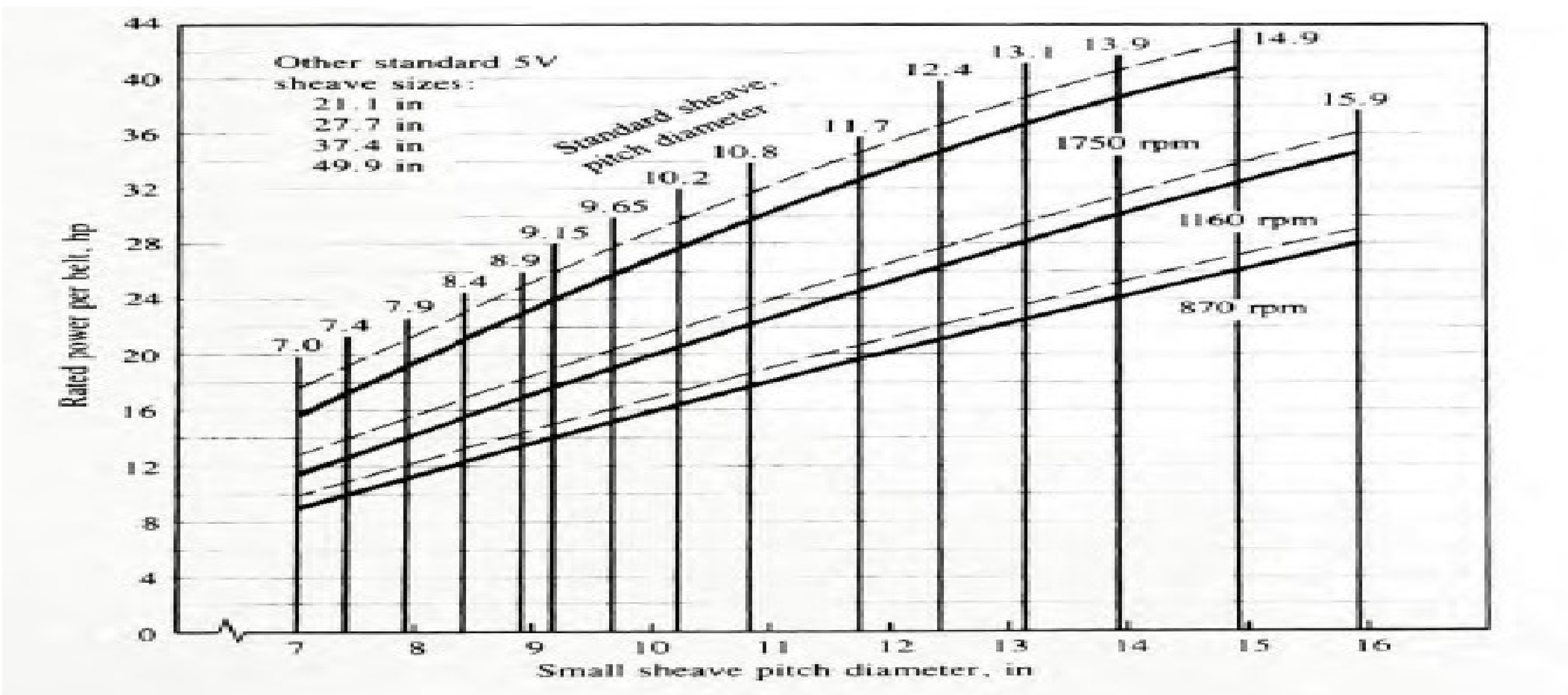
The two trials in boldface in Table below give only about 1 % variation from the desired output speed of 675 rpm, and the speed of a bucket elevator is not critical. Because no space limitations were given, let's choose the larger size.

Standard driving sheave size, D_1	Approximate driven sheave size ($1.72D_1$)	Nearest standard sheave, D_2	Actual output speed (rpm)
13.10	22.5	21.1	720
12.4	**21.3**	**21.1**	**682**
11.7	20.1	21.1	643
10.8	18.6	21.1	594
10.2	17.5	15.9	744
9.65	16.6	15.9	704
9.15	**15.7**	**15.9**	**668**
8.9	15.3	14.9	693

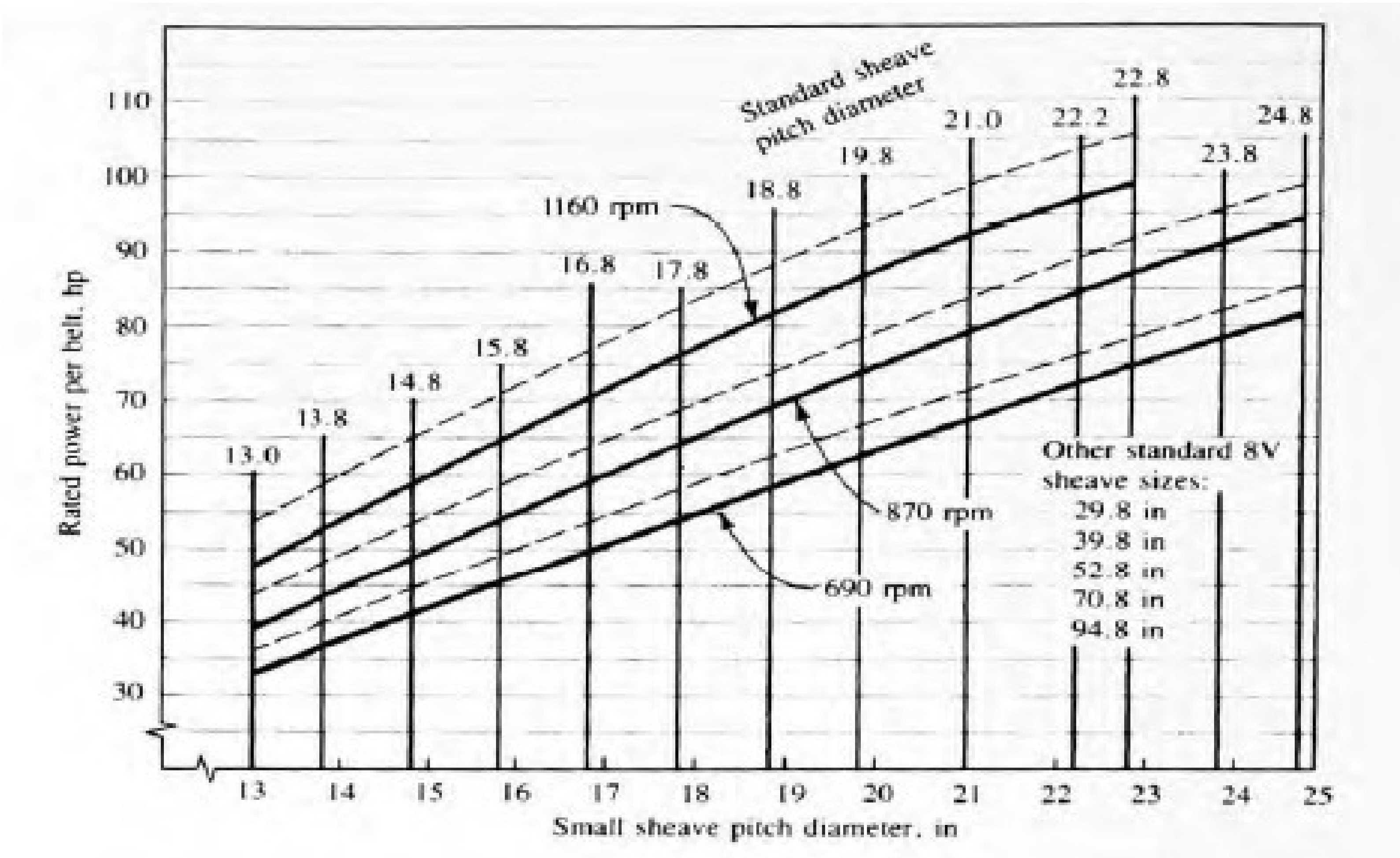
Step 6: Determine the rated power from following figures: Power rating 3v



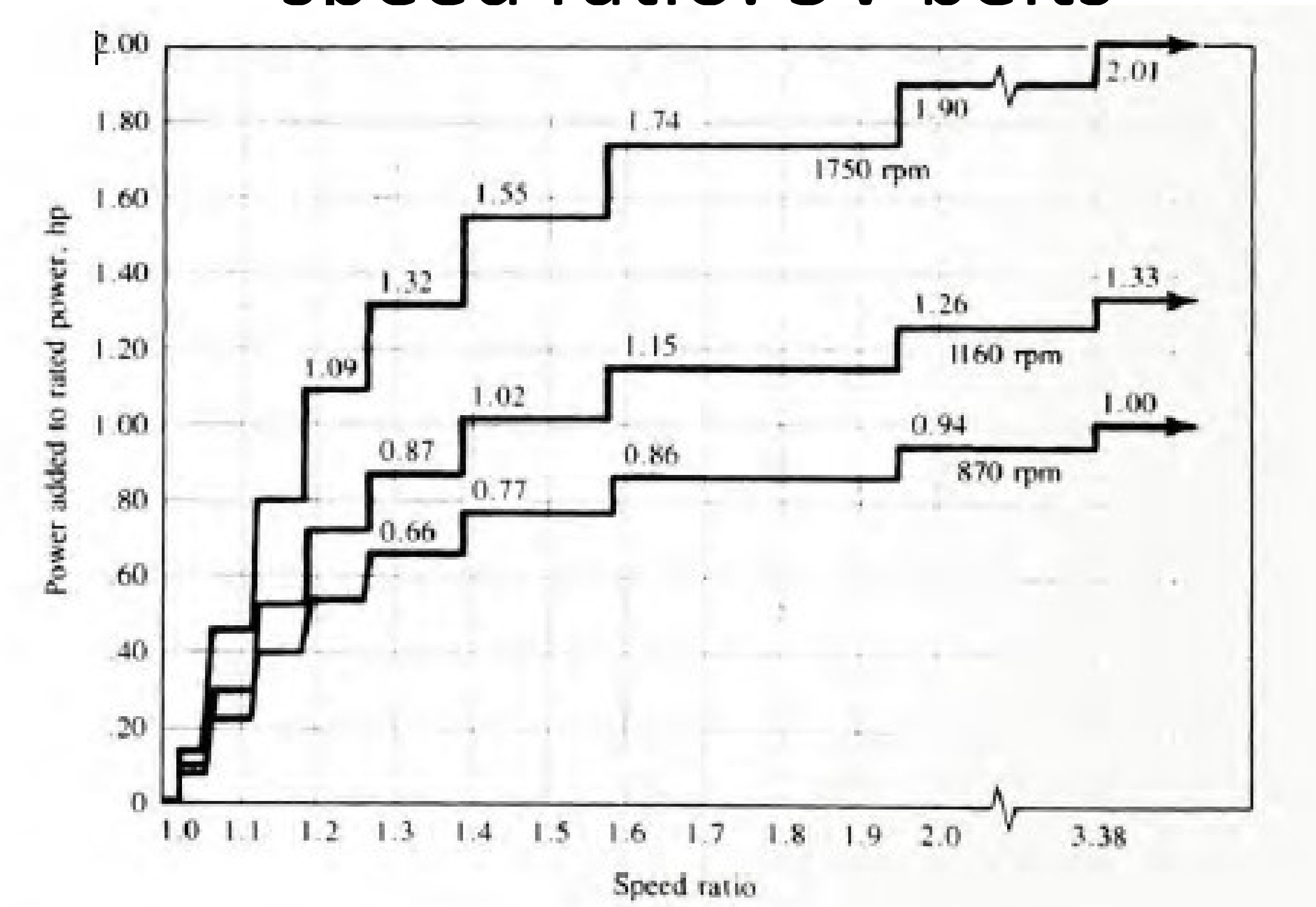
Power rating: 5V belts



Power rating: 8V belts



Power added versus speed ratio: 5V belts



- For a 12.4-in sheave at 1160 rpm, the basic rated power is 26.4 hp. Multiple belts will be required. The ratio is relatively high, indicating that some added power rating can be usedPower added is 1.15 hp. Then the actual rated power is 26.4 + 1.15 = 27.55 hp.

- *Step 7.* Specify a trial center distance. We can use following Equation to determine a nominal acceptable range for C:

$$D_2 < C < 3(D_2 + D_1)$$
$$21.1 < C < 3(21.1 + 12.4)$$
$$21.1 < C < 100.5 \text{ in}$$

- In the interest of conserving space, let's try C = 24.0 in.

***Step** 8.* Compute the required belt length

$$L = 2C + 1.57(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4C}$$

$$L = 2(24.0) + 1.57(21.1 + 12.4) + \frac{(21.1 - 12.4)^2}{4(24.0)} = 101.4 \text{ in}$$

Step 9. Select a standard belt length from the following table:

Standard belt lengths for 3V, 5V, and 8V belts (in)

3V only	3V and 5V	3V, 5V, and 8V	5V and 8V	8V only
25	50	100	150	375
26.5	53	106	160	400
28	56	112	170	425
30	60	118	180	450
31.5	63	125	190	475
33.5	67	132	200	500
35.5	71	140	212	
37.5	75		224	
40	80		236	
42.5	85		250	
45	90		265	
47.5	95		280	
			300	
165			315	
			335	
			355	

Compute the resulting actual center distance. In this problem, the nearest standard length is 100.0 in. Then,

$$B = 4L - 6.28(D_2 + D_1) = 4(100) - 6.28\,(21.1 + 12.4) = 189.6$$

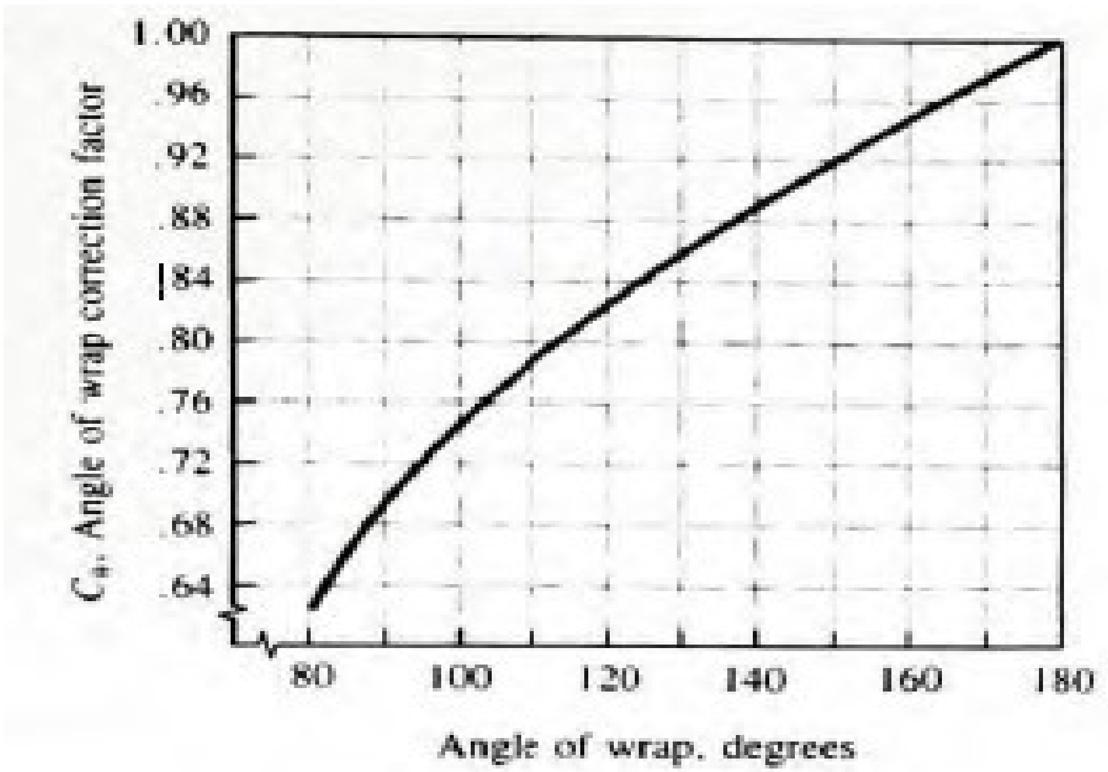
$$C = \frac{189.6 + \sqrt{(189.6)^2 - 32(21.1 - 12.4)^2}}{16} = 23.30 \text{ in}$$

Step *10.* Compute the angle of wrap of the belt on the small sheave

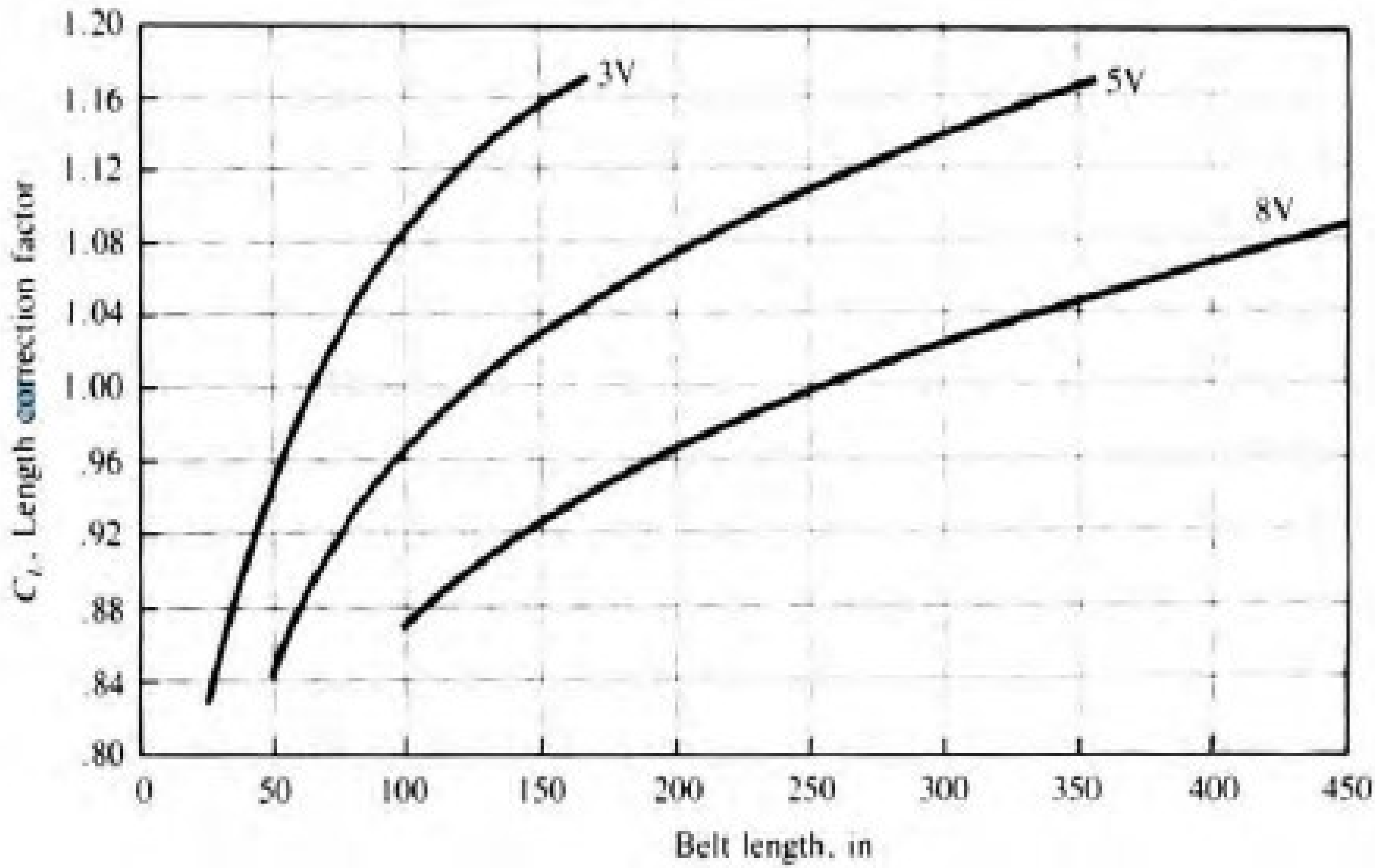
$$\theta_1 = 180^\circ - 2\sin^{-1}\left[\frac{D_2 - D_1}{2C}\right] = 180^\circ - 2\sin^{-1}\left[\frac{21.1 - 12.4}{2(23.30)}\right] = 158^\circ$$

- ***Step*** *11.* Determine the correction factors from following Figures For 0 - 158°, C_θ = 0.94. For L = 100 in, C_L = 0.96.

Angle of wrap correction factor, Cθ



Belt length correction factor C_L

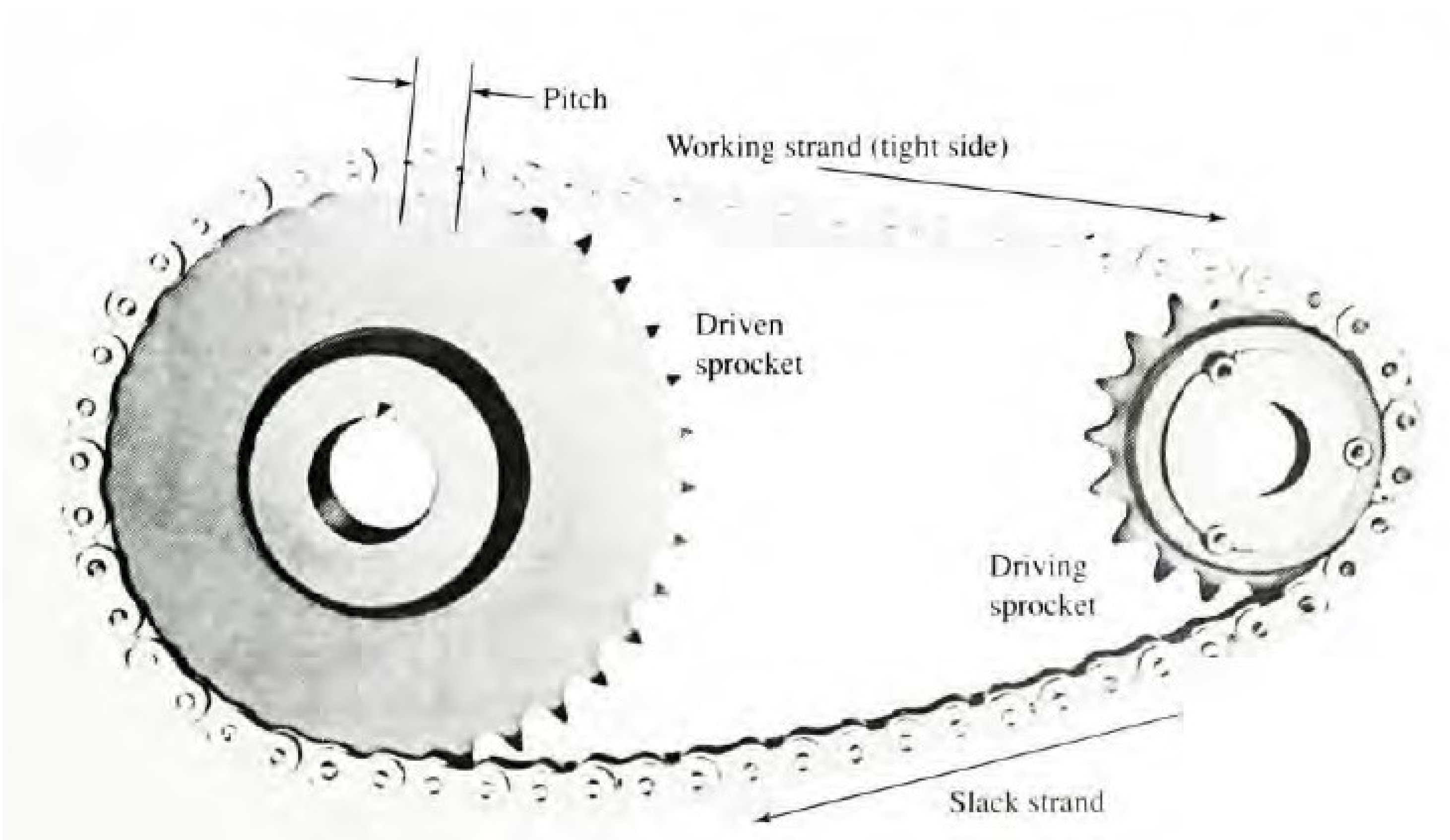


- *Step 12.* Compute the corrected rated power per belt and the number of belts required to carry the design power:

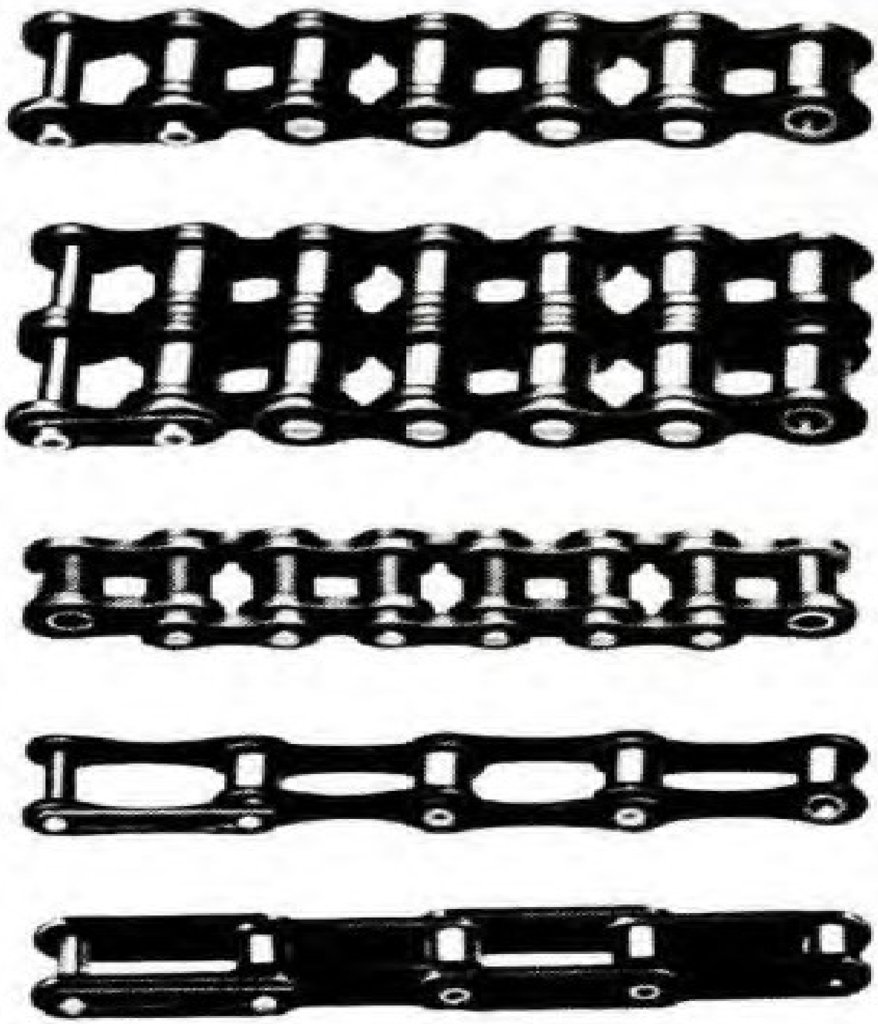
Corrected power = $C_\theta C_L P$ = (0.94)(0.96)(27.55 hp) = 24.86 hp

Number of belts = 65.0/24.86 = 2.61 belts (Use 3 belts.)

CHAIN DRIVES



Rolling Chain styles



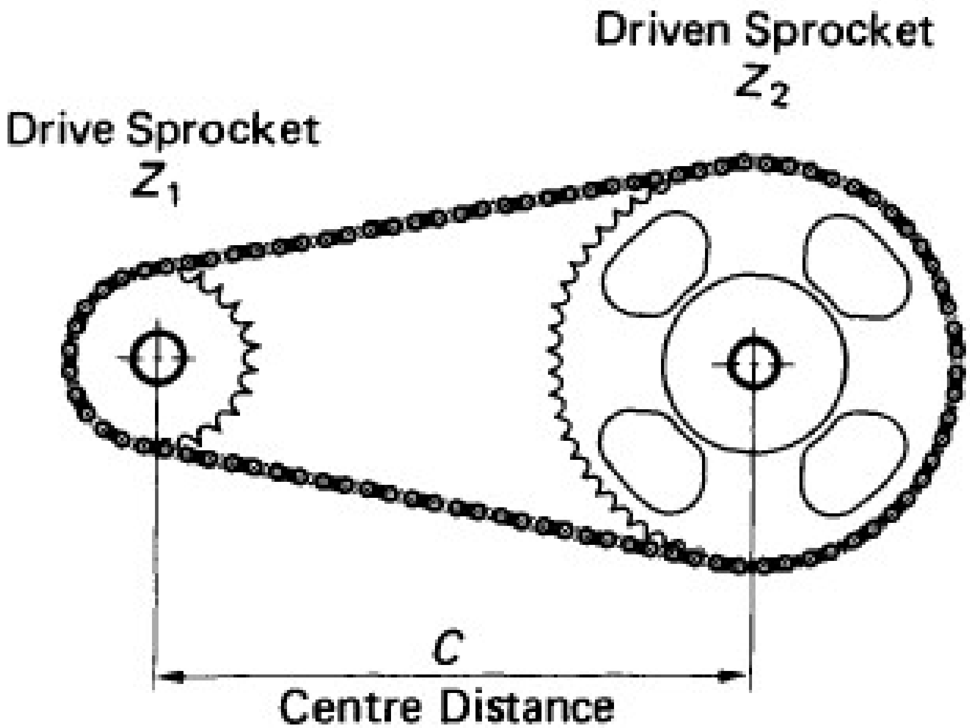
(a) Standard roller chain, single strand

(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



Z1 - No of teeth on drive sprocket
Z2 - No of teeth on driven sprocket
C - Centre Distance in mm
***P* - Chain Pitch in mm**
***i* = Z_2/Z_1 = Drive Ratio**
***L* = Chain Length in Pitches**

Selection of a chain drive

In order to select a chain drive the following essential information must be known:

(a) The power, in kilowatts, to be transmitted.

(b) The speed of the driving and driven shafts in rev/min.

(c) The characteristics of the drive.

(d) Centre Distance.

From this basic information, the driver sprocket speed and selection power to be applied to the ratings charts, are derived.

Horse Power Ratings… chain no. 40 (table 5)

No. of teeth	0.500 inch pitch				Rotational speed of small sprocket, rev/min																				
	10	25	50	100	180	200	300	500	700	900	1000	1200	1400	1600	1800	2100	2500	3000	3500	4000	5000	6000	7000	8000	9000
11	0.06	0.14	0.27	0.52	0.91	1.00	1.48	2.42	3.34	4.25	4.70	5.60	6.49	5.57	4.66	3.70	2.85	2.17	1.72	1.41	1.01	0.77	0.6	0.50	0.00
12	0.06	0.15	0.29	0.56	0.99	1.09	1.61	2.64	3.64	4.64	5.13	6.11	7.09	6.34	5.31	4.22	3.25	2.47	1.96	1.60	1.15	0.87	0.69	0.57	0.00
13	0.07	0.16	0.31	0.61	1.07	1.19	1.75	2.86	3.95	5.02	5.56	6.62	7.68	7.15	5.99	4.76	3.66	2.79	2.21	1.81	1.29	0.98	0.78	0.00	
14	0.07	0.17	0.34	0.66	1.15	1.28	1.88	3.08	4.25	5.41	5.98	7.13	8.27	7.99	6.70	5.31	4.09	3.11	2.47	2.02	1.45	1.10	0.87	0.00	
15	0.08	0.19	0.36	0.70	1.24	1.37	2.02	3.30	4.55	5.80	6.41	7.64	8.86	8.85	7.43	5.89	4.54	3.45	2.74	2.24	1.60	1.22	0.97	0.00	
16	0.08	0.20	0.39	0.75	1.32	1.46	2.15	3.52	4.86	6.18	6.84	8.15	9.45	9.75	8.18	6.49	5.00	3.80	3.02	2.47	1.77	1.34	0.00		
17	0.09	0.21	0.41	0.80	1.40	1.55	2.29	3.74	5.16	6.57	7.27	8.66	10.04	10.61	8.96	7.11	5.48	4.17	3.31	2.71	1.94	1.47	0.00		
18	0.09	0.22	0.43	0.84	1.48	1.64	2.42	3.96	5.46	6.95	7.69	9.17	10.63	11.65	9.76	7.75	5.97	4.54	3.60	2.95	2.11	1.60	0.00		
19	0.10	0.24	0.46	0.89	1.57	1.73	2.56	4.18	5.77	7.34	8.12	9.66	11.22	12.64	10.59	8.40	6.47	4.92	3.91	3.20	2.29	0.09	0.00		
20	0.10	0.25	0.48	0.94	1.65	1.82	2.69	4.39	6.07	7.73	8.55	10.18	11.81	13.42	11.44	9.07	6.99	5.31	4.22	3.45	2.47	0.00			
21	0.11	0.26	0.51	0.98	1.73	1.91	2.83	4.61	6.37	8.11	8.98	10.69	12.40	14.10	12.30	9.76	7.52	5.72	4.54	3.71	2.65	0.00			
22	0.11	0.27	0.53	1.03	1.81	2.01	2.96	4.83	6.68	8.50	9.40	11.20	12.99	14.77	13.19	10.47	8.06	6.13	4.87	3.98	2.85	0.00			
23	0.12	0.28	0.56	1.08	1.90	2.10	3.10	5.05	6.98	8.89	9.83	11.71	13.58	15.44	14.10	11.19	8.62	6.55	5.20	4.26	3.05	0.00			
24	0.12	0.30	0.58	1.12	1.98	2.19	3.23	5.27	7.28	9.27	10.26	12.22	14.17	16.11	15.03	11.93	9.18	6.99	5.54	4.54	0.87	0.00			
25	0.13	0.31	0.60	1.17	2.06	2.28	3.36	5.49	7.59	9.66	10.69	12.73	14.76	16.78	15.98	12.68	9.76	7.43	5.89	4.82	0.00				
26	0.13	0.32	0.63	1.22	2.14	2.37	3.50	5.71	7.89	10.04	11.11	13.24	15.35	17.46	16.95	13.45	10.36	7.88	5.25	5.12	0.00				
28	0.14	0.35	0.67	1.31	2.31	2.55	3.77	6.15	8.50	10.82	11.97	14.26	16.53	18.79	18.94	15.03	11.57	8.80	5.99	5.72	0.00				
30	0.15	0.37	0.72	1.41	2.47	2.74	4.04	6.59	9.11	11.59	12.82	15.28	17.71	20.14	21.01	16.67	12.84	9.76	7.75	6.34	0.00				
32	0.16	0.40	0.77	1.50	2.64	2.92	4.31	7.03	9.71	12.38	13.68	16.30	18.89	21.48	23.14	18.37	14.14	10.76	3.54	1.41					
35	0.18	0.43	0.84	1.64	2.88	3.19	4.71	7.69	10.62	13.52	14.96	17.82	20.67	23.49	26.30	21.01	16.17	12.30	9.76	0.00					
40	0.21	0.50	0.96	1.87	3.30	3.65	5.38	8.79	12.14	15.45	17.10	20.37	23.62	26.85	30.06	25.67	19.76	15.03	0.00						
45	0.23	0.56	1.08	2.11	3.71	4.10	6.08	9.89	13.66	17.39	19.24	22.92	26.57	30.20	33.82	30.63	23.58	5.53	0.00						

Type A Type B Type C

Type A: Manual or drip lubrication ,Type B: Bath or disc lubrication,Type C: Oil stream lubrication

Horse Power Ratings… chain no. 60 (table 6)

No. of teeth	0.750 inch pitch				Rotational speed of small sprocket, rev/min																				
	10	25	50	100	120	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000	5500	6000
11	0.19	0.46	0.89	1.72	2.05	3.35	4.95	6.52	8.08	9.63	12.69	15.58	11.85	9.41	7.70	6.45	5.51	3.94	3.00	2.38	1.95	1.63	1.39	1.21	0.00
12	0.21	0.50	0.97	1.88	2.24	3.66	5.40	7.12	8.82	10.51	13.85	17.15	13.51	10.72	8.77	7.35	6.28	4.49	3.42	2.71	2.22	1.86	1.59	1.38	0.00
13	0.22	0.54	1.05	2.04	2.43	3.96	5.85	7.71	9.55	11.38	15.00	18.58	15.23	12.08	9.89	8.29	7.08	5.06	3.85	3.06	2.50	2.10	1.79	0.00	
14	0.24	0.58	1.13	2.19	2.61	4.27	6.30	8.30	10.29	12.26	16.15	20.01	17.02	13.51	11.05	9.26	7.91	5.66	4.31	3.42	2.80	2.34	0.41	0.00	
15	0.26	0.62	1.21	2.35	2.80	4.57	6.75	8.90	11.02	13.13	17.31	21.44	18.87	14.98	12.26	10.27	8.77	6.28	4.77	3.79	3.10	2.60	0.00		
16	0.27	0.66	1.29	2.51	2.99	4.88	7.20	9.49	11.76	14.01	18.46	22.87	20.79	16.50	13.51	11.32	9.66	6.91	5.26	4.17	3.42	1.78	0.00		
17	0.29	0.70	1.37	2.66	3.17	5.18	7.65	10.08	12.49	14.88	19.62	24.30	22.77	18.07	14.79	12.40	10.58	7.57	5.76	4.57	3.74	0.00			
18	0.31	0.75	1.45	2.82	3.36	5.49	8.10	10.68	13.23	15.76	20.77	25.73	24.81	19.69	16.11	13.51	11.53	8.25	6.29	4.98	4.08	0.00			
19	0.33	0.79	1.53	2.98	3.55	5.79	8.55	11.27	13.96	16.63	21.92	27.16	26.91	21.35	17.48	14.65	12.50	8.95	6.81	5.40	0.20	0.00			
20	0.34	0.83	1.61	3.13	3.73	6.10	9.00	11.86	14.70	17.51	23.08	28.99	29.06	23.06	18.87	15.82	13.51	9.66	7.35	5.83	0.00				
21	0.36	0.87	1.69	3.29	3.92	6.40	9.45	12.46	15.43	18.38	24.23	30.02	31.26	24.81	20.31	17.02	14.53	10.40	7.91	6.28	0.00				
22	0.38	0.91	1.77	3.45	4.11	6.71	9.90	13.05	16.17	19.26	25.39	31.45	33.52	26.60	21.77	18.25	15.58	11.15	8.48	0.00					
23	0.40	0.95	1.85	3.61	4.29	7.01	10.35	13.64	16.90	20.13	26.54	32.88	35.84	28.44	23.28	19.51	16.66	11.92	9.07	0.00					
24	0.41	0.99	1.93	3.76	4.48	7.32	10.80	14.24	17.64	21.01	27.69	34.31	38.20	30.31	24.81	20.79	17.75	12.70	9.66	0.00					
25	0.43	1.04	2.01	3.92	4.67	7.62	11.25	14.83	18.37	21.89	28.85	35.74	40.61	32.23	26.38	22.11	18.87	13.51	10.27	0.00					
26	0.45	1.08	2.09	4.08	4.85	7.93	11.70	15.42	19.11	22.76	30.00	37.17	43.07	34.18	27.98	23.44	20.02	14.32	10.90	0.00					
28	0.48	1.16	2.26	4.39	5.23	8.54	12.60	16.61	20.58	24.51	32.31	40.03	47.68	38.20	31.26	26.20	22.37	16.01	0.00						
30	0.52	1.24	2.42	4.70	5.60	9.15	13.50	17.79	22.05	26.26	34.62	42.89	51.09	42.36	34.67	29.06	24.81	17.75	0.00						
32	0.55	1.33	2.58	5.02	5.98	9.76	14.40	18.98	23.52	28.01	36.92	45.75	54.50	46.67	38.20	32.01	27.33	19.56	0.00						
35	0.60	1.45	2.82	5.49	6.54	10.67	15.75	20.76	25.72	30.64	40.39	50.03	59.60	53.38	43.69	35.62	31.26	1.35	0.00						
40	0.69	1.66	3.22	6.27	7.47	12.20	18.00	23.73	29.39	35.02	46.16	57.18	68.12	65.22	53.38	44.74	38.20	0.00							
45	0.77	1.86	3.63	7.05	8.40	13.72	20.25	26.69	33.07	38.39	51.92	64.33	76.63	77.83	63.70	53.38	12.45	0.00							
	Type A				Type B							Type C													

Type A: Manual or drip lubrication ,Type B: Bath or disc lubrication, Type C: Oil stream lubrication

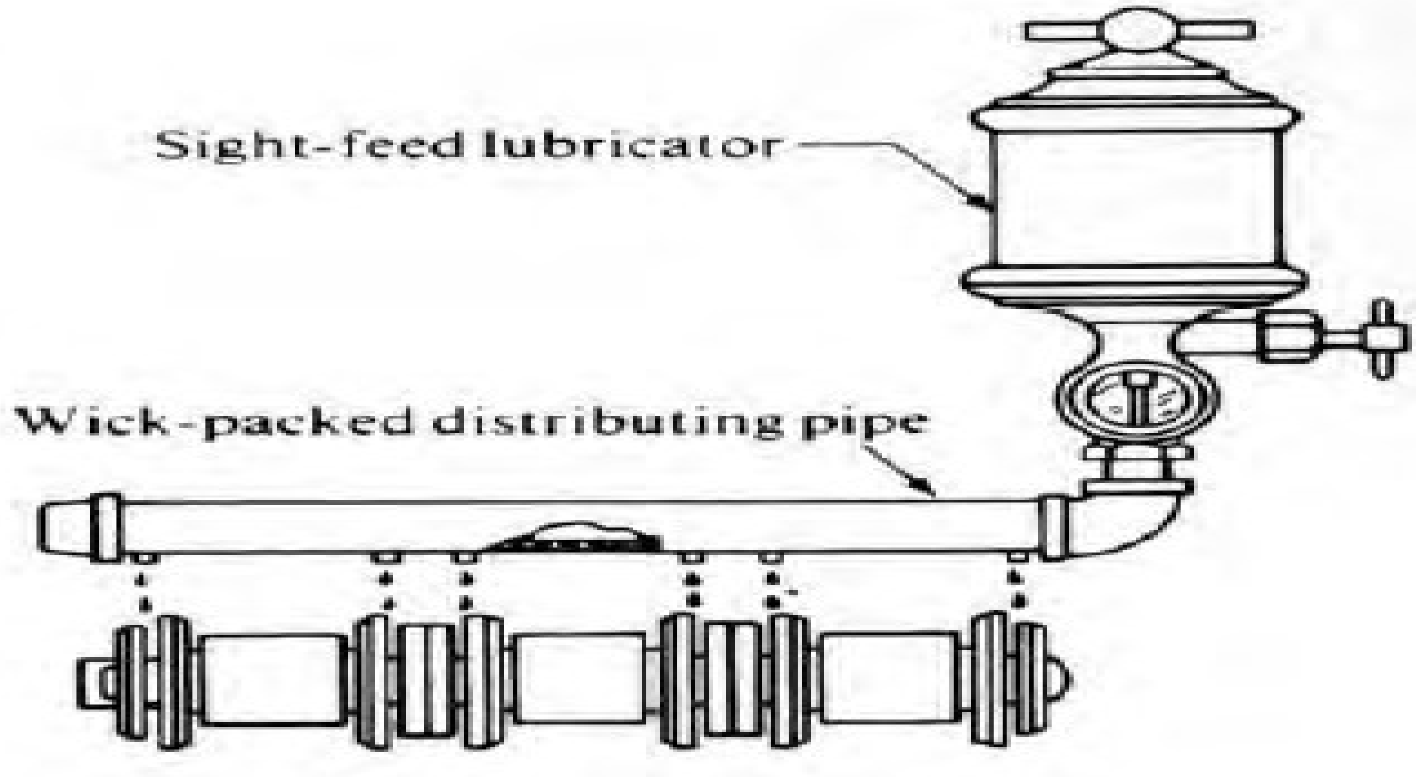
Horse Power Ratings… chain no. 80 (table 7)

No. of teeth	1.000 inch pitch				Rotational speed of small sprocket, rev/min																				
	10	25	50	75	88	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500
11	0.44	1.06	2.07	3.05	3.56	4.03	7.83	11.56	15.23	18.87	22.48	26.07	27.41	22.97	19.61	14.92	11.84	9.69	8.12	6.83	4.96	3.77	3.00	2.45	0.00
12	0.48	1.16	2.26	3.33	3.88	4.39	8.54	12.61	16.82	20.59	24.53	28.44	31.23	26.17	22.35	17.00	13.49	11.04	9.25	7.90	5.65	4.30	3.41	2.79	0.00
13	0.52	1.26	2.45	3.61	4.21	4.76	9.26	13.66	18.00	22.31	26.57	30.81	35.02	29.51	25.20	19.17	15.21	12.45	10.43	8.91	6.37	4.85	3.85	3.15	
14	0.56	1.35	2.63	3.89	4.53	5.12	9.97	14.71	19.39	24.02	28.62	33.18	37.72	32.98	28.16	21.42	17.00	13.91	11.66	9.96	7.12	5.42	4.30	3.52	
15	0.60	1.45	2.82	4.16	4.86	5.49	10.68	15.76	20.77	25.74	30.66	35.55	40.41	36.38	31.23	23.76	18.85	15.45	12.93	11.04	7.90	6.01	4.77	0.00	
16	0.64	1.55	3.01	4.44	5.18	5.86	11.39	16.81	22.16	27.45	32.70	37.92	43.11	40.30	34.41	26.17	20.77	17.00	14.25	12.16	8.70	6.62	5.25	0.00	
17	0.68	1.64	3.20	4.72	5.50	6.22	12.10	17.86	23.54	29.17	34.75	40.29	45.80	44.13	37.68	28.66	22.75	18.62	15.60	13.32	9.53	7.25	0.00		
18	0.72	1.74	3.39	5.00	5.83	6.59	12.81	18.91	24.93	30.88	36.79	42.66	48.49	48.08	41.05	31.23	24.78	20.29	17.00	14.51	10.39	7.90	0.00		
19	0.76	1.84	3.57	5.28	6.15	6.95	13.53	19.96	26.31	32.60	38.84	45.03	51.19	52.15	44.52	33.87	26.88	22.10	18.44	15.74	11.26	0.36	0.00		
20	0.80	1.93	3.76	5.55	6.47	7.32	14.24	21.01	27.70	34.32	40.88	47.40	53.88	56.12	48.08	36.58	29.03	23.76	19.91	17.00	12.16	0.00			
21	0.84	2.03	3.95	5.83	6.80	7.69	14.95	22.07	29.08	36.03	42.92	49.77	56.58	60.39	51.73	39.36	31.23	25.56	21.42	18.29	13.09	0.00			
22	0.88	2.13	4.14	6.11	7.12	8.05	15.66	23.12	30.47	37.75	44.97	52.14	59.27	64.97	55.47	42.20	33.49	27.41	22.97	19.61	14.03				
23	0.92	2.22	4.33	6.50	7.45	8.42	16.37	24.17	31.85	39.46	47.01	54.51	61.97	69.38	59.30	45.11	35.80	29.30	24.55	20.97	15.00				
24	0.96	2.32	4.52	6.66	7.77	8.78	17.09	25.22	33.24	41.18	49.06	56.88	64.66	72.40	63.21	48.08	38.16	31.23	26.17	22.35	15.99				
25	1.00	2.42	4.70	6.94	8.09	9.15	17.80	26.27	34.62	42.89	51.10	59.25	67.35	75.42	67.20	51.12	40.57	33.20	27.83	23.76	8.16				
26	1.04	2.51	4.89	7.22	8.42	9.52	18.51	27.32	36.01	44.61	53.14	61.62	70.05	78.43	71.27	54.22	43.02	36.22	29.51	25.20	0.00				
28	1.12	2.71	5.27	7.77	9.06	10.25	19.93	29.42	38.78	48.04	57.23	66.36	75.44	84.47	79.65	60.59	48.08	39.36	32.98	28.16	0.00				
30	1.20	2.90	5.64	8.33	9.71	10.98	21.36	31.52	41.55	51.47	61.32	71.10	80.82	90.50	88.33	67.20	53.33	43.65	36.58	31.23					
32	1.28	3.09	6.02	8.89	10.36	11.71	22.78	33.62	44.32	54.91	65.41	75.84	86.21	96.53	97.31	74.03	58.75	48.08	40.30	5.65					
35	1.40	3.38	6.58	9.72	11.33	12.81	24.92	36.78	48.47	60.05	71.54	82.95	94.29	105.38	111.31	84.68	67.20	55.00	28.15	0.00					
40	1.61	3.87	7.53	11.11	12.95	14.64	28.48	42.03	55.40	68.63	81.76	94.80	107.77	120.67	133.51	103.46	82.10	40.16	0.00						
45	1.81	4.35	8.47	12.49	14.57	16.47	32.04	47.28	62.32	77.21	91.98	106.65	121.24	135.75	150.20	123.45	72.28	0.00							

Type A | Type B | Type C

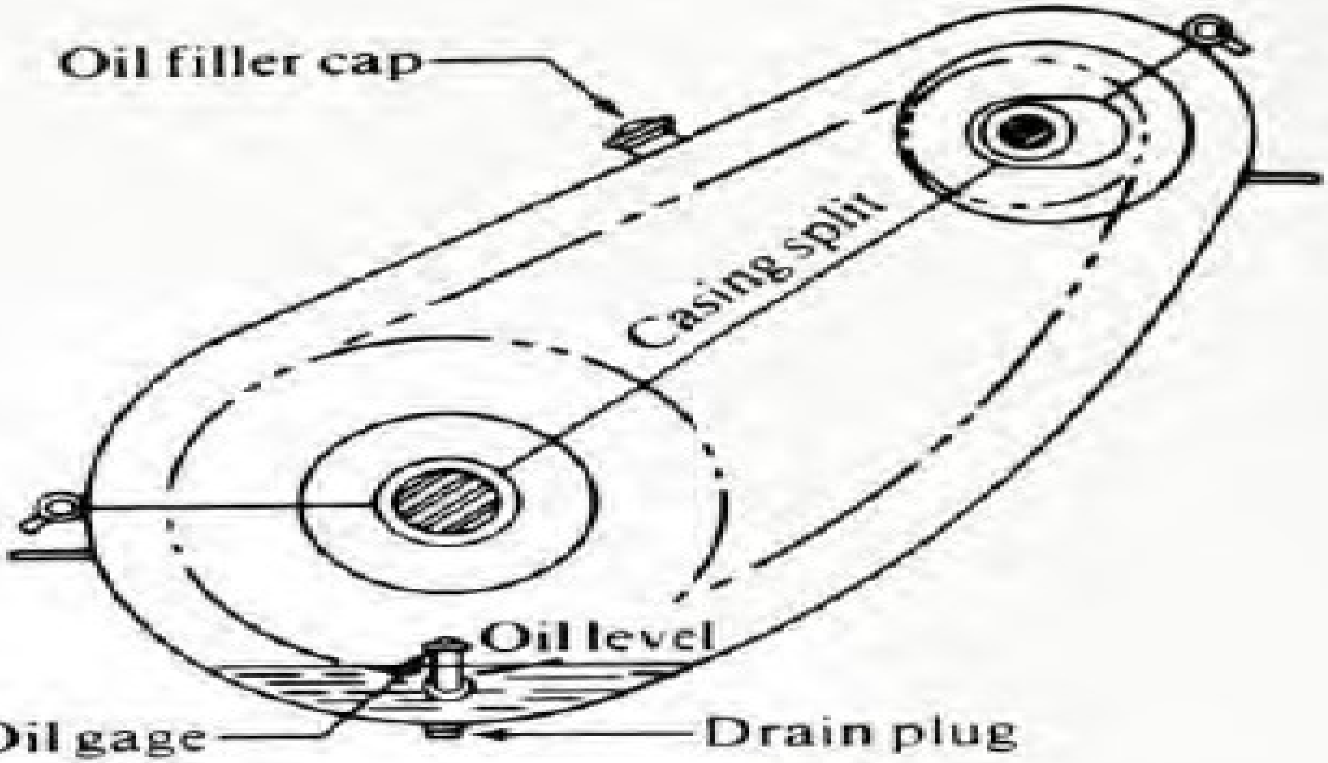
Type A: Manual or drip lubrication ,Type B: Bath or disc lubrication, Type C: Oil stream lubrication

Drip feed lubrication



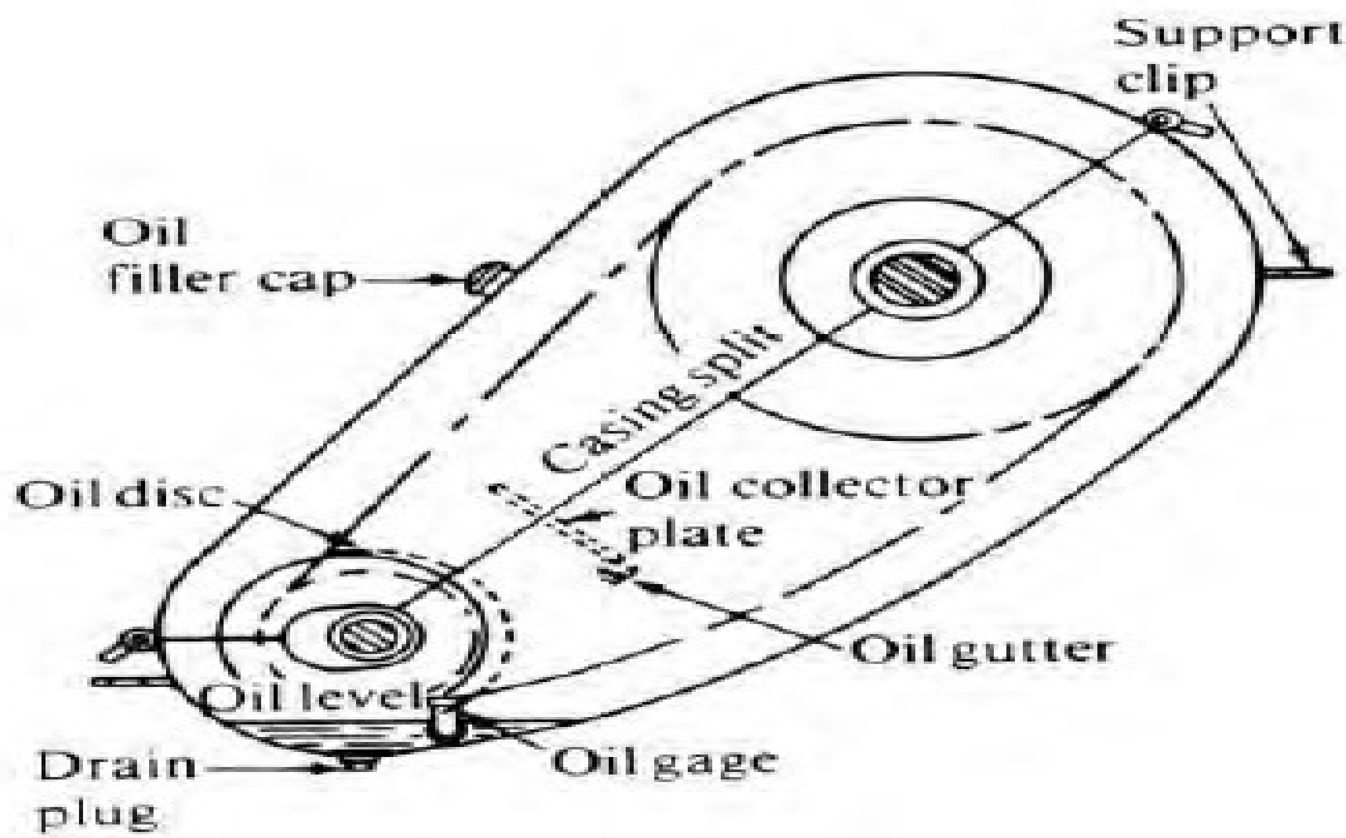
(a) Drip feed lubrication (Type A)

Shallow Bath lubrication



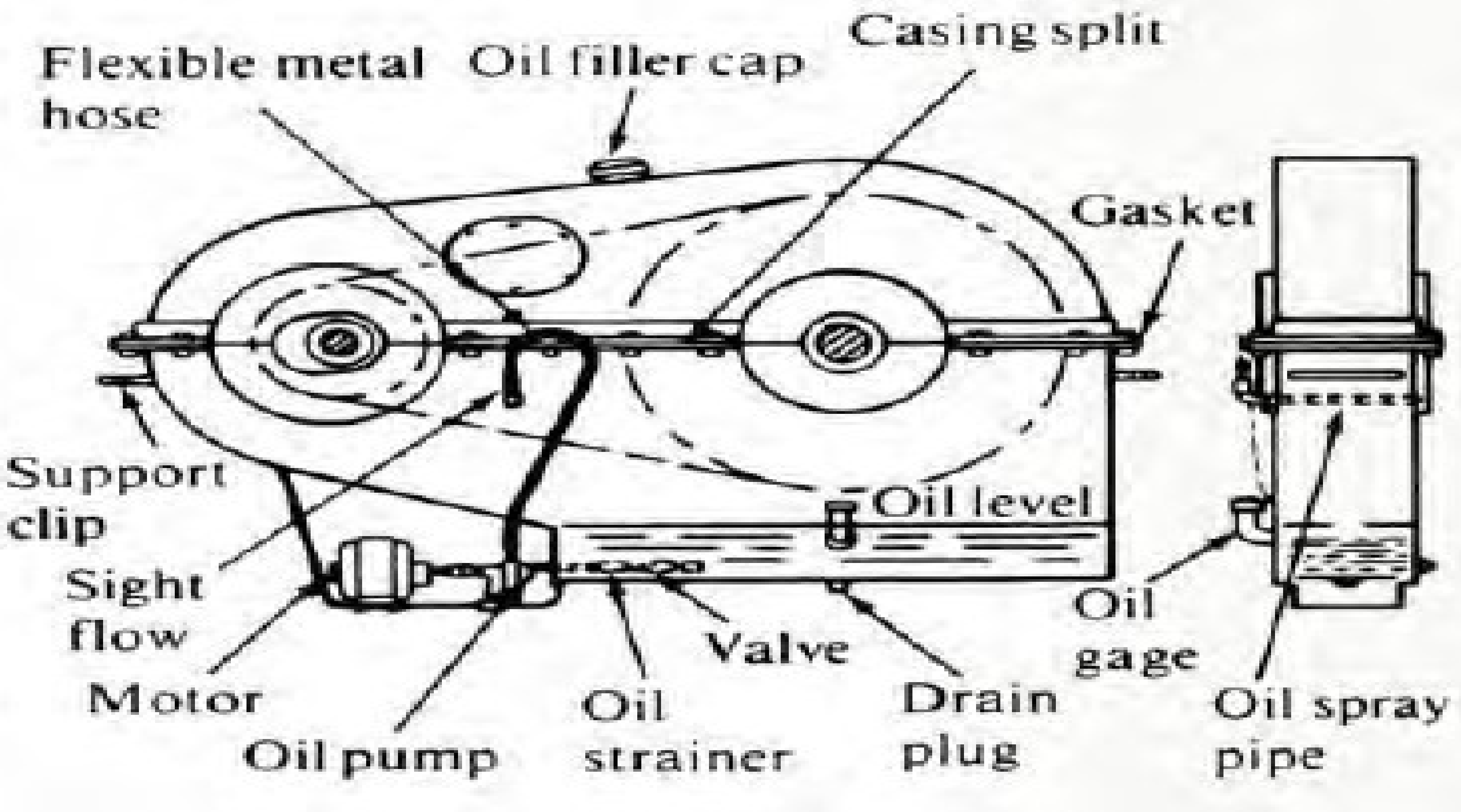
(*b*) Shallow bath lubrication (Type B)

Disc lubrication



(c) Disc or slinger lubrication (Type B)

Oil Stream lubrication



(d) Oil stream lubrication (Type C)

The ratings in table 5, 6 & 7 are for a single strand of chain. Multiply the capacity in the tables by the following factors.

- **Two strands: Factor =1.7**
- **Three strands: Factor = 2.5**
- **Four strands: Factor = 3.3**

The ratings are for a service factor of 1.0. Specify a service factor for a given application according to Table 8(following)

Service factors for Chain drives(table 8)

Load type	Type of driver: Hydraulic drive	Electric motor or turbine	Internal combustion engine with mechanical drive
Smooth (agitators; fans; light, uniformly loaded conveyors)	1.0	1.0	1.2
Moderate shock (machine tools, cranes, heavy conveyors, food mixers and grinders)	1.2	1.3	1.4
Heavy shock (punch presses, hammer mills, reciprocating conveyors, rolling mill drive)	1.4	1.5	1.7

General Recommendation for designing chain drives

1.The minimum number of teeth in a sprocket should be 17 unless the drive is operating at a very low speed, under 100 rpm.

2. The maximum speed ratio should be 7.0, although higher ratios are feasible. Two or more stages of reduction can be used to achieve higher ratios.

3. The center distance between the sprocket axes should be approximately 30 to 50 pitches (30 to 50 times the pitch of the chain).

Recommendations continued…..

4. The larger sprocket should normally have no more than 120 teeth.

5. The preferred arrangement for a chain drive is with the centerline of the sprockets horizontal and with the tight side on top.

6.The chain length must be an integral multiple of the pitch, and an even number of pitches is recommended. The center distance should be made adjustable to accommodate the chain length and to take up for tolerances and wear.

A convenient relation between center distance (C), chain length (L), number of teeth in the small sprocket (N1), and number of teeth in the large sprocket *(N2),* expressed in pitches, is

$$L = 2C + \frac{N_2 + N_1}{2} + \frac{(N_2 - N_1)^2}{4\pi^2 C}$$

The center distance for a given chain length, again in pitches, is

$$C = \frac{1}{4}\left[L - \frac{N_2 + N_1}{2} + \sqrt{\left[L - \frac{N_2 + N_1}{2}\right]^2 - \frac{8\,(N_2 - N_1)^2}{4\pi^2}}\right]$$

7. The pitch diameter of a sprocket with *N* teeth for a chain with a pitch *of p* is

$$D = \frac{p}{\sin(180°/N)}$$

8. The minimum sprocket diameter and therefore the minimum number of teeth in a sprocket are often limited by the size of the shaft on which it is mounted.

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

9. The arc of contact, θ1, of the chain on the smaller sprocket should be greater than 120°.

For reference, the arc of contact, θ2 , on the larger sprocket is,

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

Problem: 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.

Given:

- Power transmitted = 15 hp to a coal conveyor
- Speed of motor = 900 rpm
- output speed range = 230 to 240 rpm

Step 1. **Specify a service factor and compute the design power. From Table 8, for moderate shock and a gasoline engine drive through a mechanical drive *SF* = 1.4.**

Design power = 1.4(15.0) = 21.0 hp

Step 2. Compute the desired ratio. Using the middle of the required range of output speeds, we have

$$\text{Ratio} = (900 \text{ rpm})/(235 \text{ rpm}) = 3.83$$

Step 3. Refer to the tables for power capacity (Tables 5, 6, and 7), and select the chain pitch. For a single strand, the no. 60 chain with p= 3/4 in seems best.

A I7-tooth sprocket is rated at 21.96 hp at 900 rpm by interpolation. At this speed, type B lubrication (oil bath) is required.

Step 4. Compute the required number of teeth on the large sprocket:

$$N2 = N1 \times \text{ratio} = 17(3.83) = 65.11$$

Let's use the integer: 65 teeth.

Step 5. Compute the actual expected output speed:

$$n_2 = n_1(N_1/N_2) = 900\ \text{rpm}(17/65) = 235.3\ \text{rpm}$$

Step 6. Compute the pitch diameters of the sprockets

$$D_1 = \frac{p}{\sin(180°/N_1)} = \frac{0.75\ \text{in}}{\sin(180°/17)} = 4.082\ \text{in}$$

$$D_2 = \frac{p}{\sin(180°/N_2)} = \frac{0.75\ \text{in}}{\sin(180°/65)} = 15.524\ \text{in}$$

Step 8. Compute the required chain length in pitches

$$L = 2C + \frac{N_2 + N_1}{2} + \frac{(N_2 - N_1)^2}{4\pi^2 C}$$

$$L = 2(40) + \frac{65 + 17}{2} + \frac{(65 - 17)^2}{4\pi^2 (40)} = 122.5 \text{ pitches}$$

Step 9. **Specify an integral number of pitches for the chain length, and compute the actual theoretical center distance. Let's use 122 pitches, an even number.**

$$C = \frac{1}{4}\left[L - \frac{N_2 + N_1}{2} + \sqrt{\left[L - \frac{N_2 + N_1}{2}\right]^2 - \frac{8\,(N_2 - N_1)^2}{4\pi^2}}\right]$$

$$C = \frac{1}{4}\left[122 - \frac{65 + 17}{2} + \sqrt{\left[122 - \frac{65 + 17}{2}\right]^2 - \frac{8(65 - 17)^2}{4\pi^2}}\right]$$

$$C = 39.766 \text{ pitches} = 39.766(0.75 \text{ in}) = 29.825 \text{ in}$$

Step 10. **Compute the angle of wrap of the chain for each sprocket. Note that the minimum angle of wrap should be 120 degrees.**

For

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

$$\theta_1 = 180° - 2\sin^{-1}[(15.524 - 4.082)/(2(29.825))] = 158°$$

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

$$\theta_2 = 180° + 2\sin^{-1}[(15.524 - 4.082)/(2(29.825))] = 202°$$

Because this is greater than 120°, it is acceptable.

- **For the larger sprocket,**