1 DESIGN OF TRANSMISSION SYSTEM FOR FLEXIBLE ELEMENTS

1.1 BELT CLASSIFICATION:

1. Based on duty
   a. Light duty drives
      Power transmitted < 5 kW
      Belt speed <10 m/s
   b. Medium duty drives
      5kW<Power transmitted < 20 kW
      Belt speed upto 20 m/s
   c. Heavy duty drives
      Power transmitted > 20 kW
      Belt speed > 20 m/s

2. Based on centre distance
   a. Flat belts 5m to 20m
   b. V-belts < 5m
3. Based on structures
   a. Flat belts
   b. V-section belts
      i. Single V-belt
      ii. Multiple V-belt
      iii. Ribbed belt
   c. Toothed of timing belt
   d. Round belt

1.2 FACTORS INFLUENCING THE SELECTION OF BELT DRIVES

1. Power to be transmitted.
2. Space availability for installation of the drives.
3. Speed of machinery shafts.
4. Speed reduction ratio.
5. Distance between the axes of the rotating shafts.
6. Service conditions due to operating period and surroundings.

1.3 ADVANTAGES OF BELT DRIVES:-

1. They may be used to transmit power from one shaft to another when they are situated at a long distance.
2. They can operate smoothly without knocking.

3. They protect the other parts of the machine by making the belt to slip over the pulley when the load becomes higher than the rated value.
4. Belt drives are simple in design.
5. Their cost is also comparatively low.

1.4 DISADVANTAGES OF BELT DRIVES:-

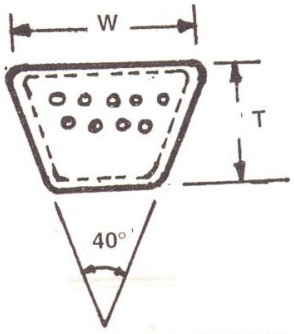
1. Large dimensions which need more space.
2. The velocity of the driven member sometimes may not be same as driving member because of slipping.
3. They exert heavy loads on shafts and bearings.
4. There may be loss of power due to friction.
5. Their life is comparatively shorter (1000 to 5000 hours).

1.5 MATERIALS USED FOR BELT DRIVES:-

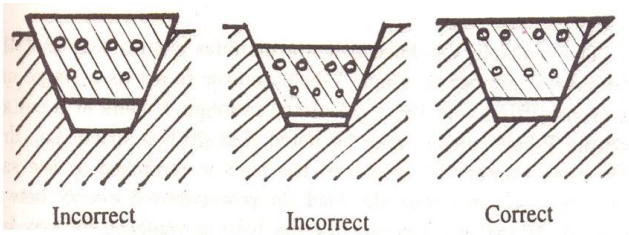
- Leather
- Cotton fabrics
- Rubber
- Some animal's hair
- Silk
- Rayon, woolen., etc.

1.6 SELECTION OF V-BELTS AND PULLEYS:

V-Belts are another types of flexible connectors for transmitting power from one pulley to another pulley whose centre distances are approximately 3 meters. Their cross section is trapezoid or similar to a wedge. The belts are operated on a grooved pulley, grooves being V-shaped or having two inclined sides and with flat bottom.



Cross-section of v-belt



Method of mounting v-belt in pulley.

1.7 MATERIALS USED:

Usually V-belts are made of cord and fabric, impregnated with rubber, the cord materials being cotton or rayon. Some of the companies where V-belts are made are Goodyear India ltd and fenner India ltd.

1.8 TYPES OF V-BELTS

Generally V-belts are classified into various grades based on their power transmitting capacity as A,B,C,D, and E.The cross sectional areas are in increasing order from A To E depending upon the places of applications-belts are manufactured into single V-belts, multiple V-belts and Ribbed V-belts.

1.9 ADVANTAGES OF V-BELTS:

1. It can be employed for high velocity ratio(up to 10m/s)
2. They are used to employ with small centre distance.
3. They can be operated at any position of the drive (i.e. Horizontal, vertical and inclined) and even with vertical shaft.
4. In this drive tight side of the drive need not compulsorily be at the bottom side of the pulley like in flat belt drive.
5. They can take shock especially at starting.
6. High smoothness of operation is obtained owing to absence of laced joints and other bolt fasteners which may produce noise as in the case of flat belts.
7. The space required for this drive is comparatively less.
8. During operation, the belt will not come out from the pulley at any cost which may sometimes happen in flat belt drive if shafts parallelism is slightly changed.

1.10 DISADVANTAGES:

1. V-Belts are not as advisable as flat ones, because of formation of high bending stresses in v-belts due to higher ratio of belt section height to the pulley diameter comparing to the flat belts.
2. Designs of pulleys are more complicated than design of flat belt pulleys.
3. The power transmitting capacity of v-belts is in lower range than flat belts.
4. V-belts cannot be used with large center distances.
5. They cannot be used for cross belt drives.

1.11 DESIGNATION OF V-BELTS:

As per Indian standards (IS 2494-1964) v-belt is recognized by a letter which represents the size of the cross section followed by nominal inside length (i.e. inner circumferential length) of the belt. For example a V-belt cross section D and of nominal inside length 3047 mm shall be designated as D3048-IS2494:1964 or simply D3048

1.12 DESIGN OF V-BELTS:

V-belts are designed based on

(i) Fundamental formulas.
(ii) Manufacturer's catalogues.

NOTE:

1. Ratio of driving tensions

$$\frac{T_1}{T_2} = e^{\mu\theta/\sin\left(\frac{\alpha}{2}\right)}$$

T_1 and $T_2$are Tensions at tight and slack side respectively.

θ = Angle of contact in radians

α = Angle subtended by sides of V-belts.

2. Power transmitted by a belt
   P= (T_1-T_2) x V - N-m/s
   P= $((T_1-T_2)$ x V) / 75 –Hp

1.12.1 DESIGN OF BELTS USING MANUFACTURER'S TABLE:

Design of V-belts depends on two concepts:

1. Design power (i.e. Total power after considering safety factors or correction factors)

2. Belt Rating(i.e. Power transmitting capacity of one belt)

Consider a V-belt, required to transmit the power 'P' from one pulley of diameter'd' to another pulley 'D'. The pulleys being situated at a distance of 'C'

Steps to be followed:-

1. At first based on the amount of power to be transmitted, select the type of belt from A to E grades **(PSG7.58)**
2. Calculate the design power using the relation

$$\text{Design power} = \frac{\text{Rated power x service fator}}{\text{Arc of contact factor x Belt's pitch length factor}}$$

$$\text{The pitch length } L = 2C + \frac{\pi}{2}(D+d) + (D-d)^2/4C \quad \textbf{(PSG7.61)}$$

$$\text{The arc of contact } \theta = 180° - \frac{(D-d)}{C} x\ 60° \quad \textbf{(PSG7.54)}$$

3. Note the inside length corresponding to the pitch length from **(PSG7.58)**
4. Determine the belt rating from (i.e. power transmitting capacity of one belt) **(PSG7.62)**
5. Obtain the No of belts required using the following relation

$$\text{No of belts} = \frac{\text{Desing power}}{\text{Belt rating}}$$

6. Correct the centre distance according to the selected pitch length **(PSG7.61)**
7. Determine the parameters of V-groove pulleys.

Example 1.1. Design a V-belt drive to the following specification

Power to be transmitted =75kW

Speed of the driving wheel = 1440 Rpm

Speed of the driven wheel = 400Rpm

Diameter of the driving wheel = 300mm

Centre distance = 2500mm

Service =16 hour / day

Given Data:-

P = 75 kW

d = 300 mm

n_1 = 1440 Rpm

n_2 = 400 Rpm

SOLUTION:

STEP 1-TYPE OF BELT

For the given power of 75 kW D type or E type belts are suited, let us select D type belt from

(PSG7.61)

STEP 2-DESIGN POWER

Design power $= \frac{\text{Rated power x service fator}}{\text{Arc of contact factor x Belt's pitch length factor}}$

Service factor = 1.5 (For heavy duty and 16 hrs/day with A.C.Motor high torque) **(PSG7.69)**

The pitch length $L=2C+\frac{\pi}{2}(D+d) + (D-d)^2/4C$ **(PSG7.61)**

$D= \frac{n_1}{n_2} x\, d = \frac{1440}{400} x300 =$ 1080 mm

$L= 2X2500 + \frac{\pi}{2}(1080 + 300) + \frac{(1080-300)^2}{4X2500}$ = 7229 mm

The next standard pitch length = 7648 mm **(PSG7.60)**

STEP 3-INSIDE LENGTH

Corresponding inside length = 7569 mm **(PSG7.60)**

Length factor = 1.05

The arc of contact θ = $180° - \frac{(D-d)}{C} x\ 60°$ **(PSG7.54)**

$= 180° - \frac{(1080-300)}{2500} x\ 60° = 161.3°$

Arc of contact factor = 0.955 **(PSG7.68)**

Design power = $\frac{75x1.5}{1.05x0.955}$ = 112.0 kW.

STEP 4-BELT RATING

Power transmitting capacity of one belt

$= \left(3.22\ S^{-0.09} - \frac{506.7}{d_e} - 4.78x10^{-4}S^2\right)$S **(PSG7.62)**

$d_e = d_p x F_b$ = 300x1.4 = 342 < d_e(max)(=425mm)

S=$\frac{\pi dn}{60x1000}$ = $\frac{\pi x300x1440}{60x1000}$ = 22.6 m/s

Belt capacity = $\left(3.22\ (22.6)^{-0.09} - \frac{506.7}{342} - 4.78x10^{-4}(22.6)^2\right) 22.6$

= 15.96 kW at 180° arc of contact

Required belt capacity for 161.3° arc of contact = 15.96x161.3/180

= 14.3 kW

STEP 5-NO OF BELTS REQUIRED

No of belts required = $\frac{\text{Design power}}{\text{Belt Rating}} = \frac{112}{14.3}$ = 7.82 belts = 8 belts

STEP 6-CORRECT THE CENTRE DISTANCE

Since the pitch length is changed from 7229mm to 7648mm, the centre distance should also be increased to place the belt properly over the pulley.

New centre distance C'= $A + \sqrt{A^2 - B}$ **(PSG7.61)**

A = $\frac{L}{4} - \frac{\pi}{8}(D + d)$ = $\frac{7648}{4} - \frac{\pi}{8}(1080 + 300)$= 1370

B= $\frac{(D-d)^2}{8}$ =$\frac{(1080-300)^2}{8}$ = 76050

C'= $A + \sqrt{A^2 - B}$ = $1370 + \sqrt{1370^2 - 76050}$ =2712 mm

Initial tension = 0.75 to 1 % of L **(PSG7.61)**

Take 1 % of L =7648 X $\frac{1}{100}$ =76 mm

Final centre distance = 2712+76 = 2788 mm

Width of the pulley = (n-1)e+2f = (8-1)37+2x24=307mm **(PSG7.70)**

SPECIFICATION:-

Type of belt = D7569 50 IS2494

No of belts = 8

Pitch dia of smaller pulley = 300mm

Pitch dia of bigger pulley = 1080mm

Centre distance = 2788mm

Ex 1.1 A motor driven blower is to run at 650 rpm driven by an electric motor of 7.5kW at 1800 rpm. Design V-belt drive.

Ex 1.2 Select a suitable V-belt and design the drive for a wet grinder. Power is available from a 0.5 kW motor running at 750 rpm. Drum speed is to be about 100 rom. Drive is to be compact.

Example.1.2. Select a suitable V-belt and design the drive for a wet grinder. Power is available from a 0.5 kW motor running at 750 Rpm. Drum sped is to be about 100 Rpm. Drive is to be compact.

GIVEN:-

Power 'P' = 0.5 kW

Motor speed 'n' = 750 Rpm

Drum speed 'N' =100 Rpm

SOLUTION:

STEP 1 SELECTION OF BELT

For power 0.5kW 'A' type belt may be selected **(PSG7.58)**

For this belt the minimum pulley pitch diameter is d_{min} =75 mm

D_{max} can be calculated as $d_{e\,max} = d_{p\,max} \times F_{b\,max}$ **(PSG7.62)**

$d_{e\,max}$ =125 **(PSG7.62)**

$125 = d_{p\,max} \times 1.14$ $d_{p\,max}$=110mm

Hence we should select the diameter of the smaller pulley (d) between 75 mm and 110 mm

Diameter of the drum 'D'= $\frac{n}{N}\eta . d = \frac{750}{100} 0.98x100$ =735mm **(PSG7.61)**

STEP 2 CENTRE DISTANCE

$\frac{C}{D} = 0.85\ for\ \frac{D}{d} = 7.35$ **(PSG7.61)**

C=0.85Xd=0.85x735=625mm

C_{min}=0.55(D+d)+T=0.55(735+100)+8=467mm

C_{max}=2(D+d)=2(735+100)=1670mm

Since C value is in between C_{min} and C_{max} our selection is correct.

STEP 3 DESIGN POWER

Design power = $\frac{\text{Rated power x service fator}}{\text{Arc of contact factor x Belt's pitch length factor}}$

Rated power =0.5 kW

Service factor =1.2(for light duty) **(PSG7.69)**

The arc of contact θ $= 180° - \frac{(D-d)}{C} x\ 60°$ **(PSG7.68)**

$$= 180° - \frac{(735-100)}{625} x\ 60° = 119°$$

Arc of contact factor=0.82 **(PSG7.68)**

The pitch length L=2C+ $\frac{\pi}{2}$(D+d) + (D-d)^2/4C **(PSG7.61)**

=2x625+ $\frac{\pi}{2}$ (735+100)+(735-100)^2/4x625= 2723mm

Next standard pitch length =2880mm **(PSG7.60)**

Length factor =1.11 **(PSG7.60)**

Design power = $\frac{0.5x1.2}{0.82 \text{ x } 1.11}$ =0.659 kW=0.7Kw

STEP 4-INSIDE LENGTH

Inside length =2845mm **(PSG7.60)**

STEP 5-BELT RATING

Belt speed $=\frac{\pi dn}{60x1000}$ = $\frac{\pi x100x750}{60x1000}$ = 3.93 m/s

Equivalent pitch diameter $d_e=d_p x F_b$ =100x1.14 =114mm **(PSG7.63)**

For 3.93 m/s and d_e =114 mm ,

Belt capacity =0.9 kW **(PSG7.63)**

STEP 6-TOTAL NO OF BELTS

No of belts required = $\frac{\text{Design power}}{\text{Belt Rating}} = \frac{0.7}{0.9}$ = 0.8 belts = 1belts

STEP 7-CENTRE DISTANCE

New centre distance C'= $A + \sqrt{A^2 - B}$ **(PSG7.61)**

A = $\frac{L}{4} - \frac{\pi}{8}(D + d)$ = $\frac{2880}{4} - \frac{\pi}{8}(735 + 100)$= 392

B= $\frac{(D-d)^2}{8}$ =$\frac{(735-100)^2}{8}$ = 50403

C'= $A + \sqrt{A^2 - B}$ = 392+ $\sqrt{392^2 - 50403}$ =713 mm

Distance of initial tension =0.5 % of L **(PSG7.61)**

Actual centre distance =713+ (0.5/100) x2880 = 727.4 mm = 730 mm

STEP 8-WIDTH OF THE PULLEY

Width of the pulley = (n-1) e+2f=2x10 (e=0)

= 20mm

SPECIFICATION:

Type of belt =A2845-IS2494

Diameter of motor pulley =100mm

Diameter of drum pulley =735mm

Centre distance =730mm

Width of pulley =20mm

No of belts =1

Questions from Anna University Exam

A motor of power 2 kW running at a speed of 1400 rpm transmits power to an air blower running at560 rpm. The motor pulley diameter is 200 mm. The center distance may be 1000 mm. Design asuitable V-belt drive. [AU, N/D 2012]

Design a V-belt drive to the following specifications: Power to be transmitted = 75 kW; Speed ofdriving wheel = 1440 rpm; Speed of driven wheel = 400 rpm; Diameter of driving wheel = 300 mm;Center distance = 2500 mm; Service = 16 hours/day. [AU, M/J 2013]

1.13 FLAT BELT DRIVES:

1.13.1 TYPES OF FLAT BELTS

1. **Open belt drive.**