Belt Drives

MET 201W
E. Evans

Methods of Power Transmission

• There are three methods of transmitting power mechanically from shaft to shaft:
  – Flexible Belts
  – Chain Drives
  – Gears

Belt Drive Speeds

• 2500 to 7000 ft/min
• Ideal speed is around 4000 ft/min

Belts flap a bit at high speeds.
The slower you go, the lower the torque transmission capacity.

Flexible Belt Advantages

• Almost any drive application can be made using stock items – availability & fast delivery
• Highly efficient
• Clean – no lubrication needed
• Smooth starting and running
• Silent operation
• Long life
• Extremely wide horsepower range
• Wide range of driven speeds from standard motors
**More Flexible Belt Advantages**

- Capable of transmitting power around corners or out of plane.
- Dampen vibration between driver and driven machines.
- Easy installation.
- Can be used as an effective means of clutching.
- They act as a “safety fuse” refusing to transmit severe power overload, except for a very brief period.

**Industrial Narrow Section V-belts**

<table>
<thead>
<tr>
<th>Belt Size</th>
<th>Power Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>P_max ≈ 10 HP</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>P_max ≈ 40 HP</td>
</tr>
<tr>
<td>1&quot;</td>
<td>P_max ≈ 100 HP</td>
</tr>
</tbody>
</table>

Power transmission is determined by:

- belt size,
- the smaller diameter sheave pitch diameter
- the rotational speed of the driving shaft

**How to Make Belts More Flexible**

- **THIN BELT**
  - The thin belt is shallow and more flexible.

- **CIG BELT** (3VX, 5VX, 8VX)
  - Belts fail when cords pull away from the rest of the belt.
  - The rubber takes up space
  - Belts flex when they enter small pulleys.
  - Bending stress is 3x – 4x tensile stress
  - Smaller pulley → bigger bending stress

- **CORDS**

- **Flanks transmit torsion thru FRICTION**

- **Rubber**

- **Cords are in TENSION**
Fixed Bore Pulley or Sheave

**Sheave** (pronounced “shiv”) a grooved wheel designed to accommodate one or more V-belts. Also called grooved pulley, or pulley.

- Cast Iron
- Standard size bores
- Efficient, lightweight & economical
- 1 or 2 belt configurations

Lightweight, Bushed Type Sheave

- 1/2” to 1-1/2” bore
- Pitch Diameter 2.4 to 18.4 in
- Power capacity to 15 HP
Wedge Pulley

Multiple belt configuration

Synchronous Sprockets

High torque capacity
Use with synchronous belts

Belt Dynamics

GEOMETRY:
\[ C = \frac{B + \sqrt{B^2 - 32(D_2 - D_1)^2}}{16} \]
\[ B = 4L - 6.28(D_2 + D_1) \]
\[ L = 2C + 1.57(D_1 + D_2) + \frac{(D_2 - D_1)^2}{4C} \]

DYNAMICS:
\[ \omega_1 = \frac{D_2}{D_1} \]
\[ \theta_1 = 180^\circ - 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right) \]

The smaller \( \theta_1 \), the smaller the friction.

High torque capacity
Use with synchronous belts

Belt Dynamics

GEOMETRY:
\[ S = \sqrt{C^2 - \left(\frac{D_2 - D_1}{2}\right)^2} \]

DYNAMICS:
\[ \omega_1 = \frac{D_2}{D_1} \]
\[ \theta_2 = 180^\circ + 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right) \]

The smaller \( \theta_2 \), the smaller the friction.
**Power – Speed – Torque Relationships**

<table>
<thead>
<tr>
<th>Horsepower / Speed / Torque Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HP</strong></td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>Increases</td>
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<tr>
<td>Decreases</td>
</tr>
<tr>
<td>Decreases</td>
</tr>
</tbody>
</table>

\[
T = \frac{63000(HP)}{RPM}
\]

**Limits of Belt Drives**

- Belts are limited by:
  - Maximum Tension in the Belt
  - Maximum Friction between belt and sheave

**Multiple Belts**

When specifying multiple belts, they have to be matched so the one belt doesn’t take all the load.

“Matched” belts – all are compared and are actually all the same length

**driver**: the sprocket or pulley located on the motor or prime mover.

**driven**: the sprocket or pulley located on equipment being driven by the power source or prime mover.
Slipage

- Belts tend to slip during startup and shutdown.
- Don’t count on slippage for safety
- Don’t depend on belts to slip
- Don’t depend on belts to not slop

Idler Drives

**Use of Idlers**

Idlers are grooved sheaves or flat pulleys that do not transmit power. The purpose of idlers in V-belt drives are to:
- provide take-up for fixed center drives
- clear obstructions
- direct belts to run centers (in an angle pulley drives)
- break-up long spans where belt whip and vibration may occur
- increase area of contact on critically loaded sections
- check certain types of drives
- to maintain tension, when idler is spring-loaded or weighted

Idlers usually “penalize” V-belt drive performance (due to the additional bending stresses they impose) so they are avoided when possible, by other drive designs. However, when idlers cannot be avoided, there are several factors that require consideration when designing the drive. These considerations most important are:
- e.m.m. and belt length
- corrections for HP rating
- idler diameters
- use of flat or grooved idlers
- installation and take-up
- alignment on drive

Power Added - 8V Belts

**DAYCO Industrial V-Belt Drives Design Guide**