HANDBOOK OF TIMING BELTS AND PULLEYS

SECTION 1 INTRODUCTION

Timing belts are parts of synchronous drives which represent an important category of drives. Characteristically, these drives employ the positive engagement of two sets of meshing teeth. Hence, they do not slip and there is no relative motion between the two elements in mesh.

Due to this feature, different parts of the drive will maintain a constant speed ratio or even a permanent relative position. This is extremely important in applications such as automatic machinery in which a definite motion sequence and/or indexing is involved.

The positive nature of these drives makes them capable of transmitting large torques and withstanding large accelerations.

Belt drives are particularly useful in applications where layout flexibility is important. They enable the designer to place components in more advantageous locations at larger distances without paying a price penalty. Motors, which are usually the largest heat source, can be placed away from the rest of the mechanism. Achieving this with a gear train would represent an expensive solution.

Timing belts are basically flat belts with a series of evenly spaced teeth on the inside circumference, thereby combining the advantages of the flat belt with the positive grip features of chains and gears.

There is no slippage or creep as with plain flat belts. Required belt tension is low, therefore producing very small bearing loads. Synchronous belts will not stretch and do not require lubrication. Speed is transmitted uniformly because there is no chordal rise and fall of the pitch line as in the case of roller chains.

The tooth profile of most commonly known synchronous belts is of trapezoidal shape with sides being straight lines which generate an involute, similar to that of a spur gear tooth. As a result, the profile of the pulley teeth is involute. Unlike the spur gear, however, the outside diameter of a timing pulley is smaller than its pitch diameter, thus creating an imaginary pitch diameter which is larger than the pulley itself. This is illustrated in **Figure 1**. Backlash between pulley and belt teeth is negligible.

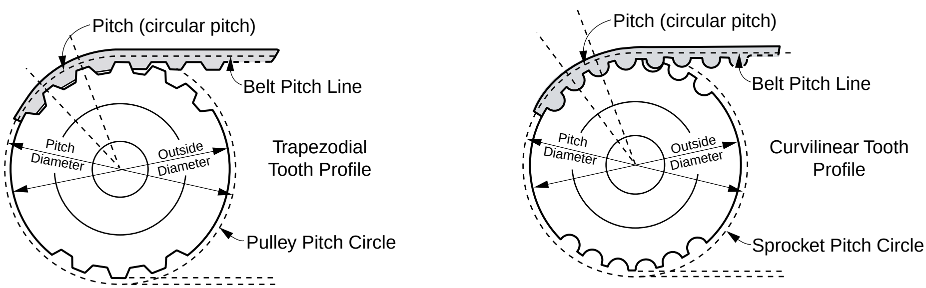


Fig. 1 Pulley and Belt Geometry

The trapezoidal shape timing belt was superseded by a curvilinear tooth profile which exhibited some desirable and superior qualities. Advantages of this type of drive are as follows:

- Proportionally deeper tooth; hence tooth jumping or loss of relative position is less probable.
- Lighter construction, with correspondingly smaller centrifugal loss.
- Smaller unit pressure on the tooth since area of contact is larger.

NOTE: Credit for portions of this technical section are given to: Gates Rubber Co., Sales Engineering Dept., Rubber Manufacturers Association (RMA), International Organization for Standardization (ISO).

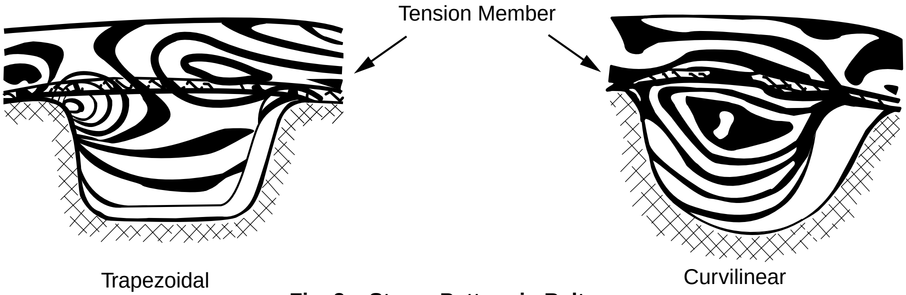


Fig. 2   Stress Pattern in Belts

- Greater shear strength due to larger tooth cross section.
- Lower cost since a narrower belt will handle larger load.
- Energy efficient, particularly if replacing a "V" belt drive which incurs energy losses due to slippage.
- Installation tension is small, therefore, light bearing loads.

In **Figure 2**, the photoelastic pattern shows the stress distribution within teeth of different geometry. There is a definite stress concentration near the root of the trapezoidal belt tooth, with very low strains elsewhere. For the curvilinear tooth, there is a uniform, nearly constant, strain distribution across the belt. The load is largest in the direction of the tension member to which it is transferred.

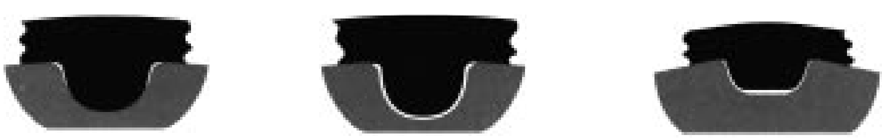
Because of their superior load carrying capabilities, the curvilinear belts are marketed under the name of Gates' HTD drives. This is an abbreviation of High Torque Drives.

As a result of continuous research, a newer version of the curvilinear technology was developed by Gates, which was designated as Gates' PowerGrip® GT®2 belt drives.

SECTION 2   GATES POWERGRIP® GT®2 BELT DRIVES

The PowerGrip GT2 Belt Drive System is an advance in product design over the Gates' older, standard HTD system. The PowerGrip GT2 System, featuring a modified curvilinear belt tooth profile, provides timing and indexing accuracy superior to the conventional PowerGrip Trapezoidal Belt System. Plus, PowerGrip GT2 Belts have a higher capacity and longer belt life than trapezoidal belts.

It's difficult to make a true quantitative comparison between the backlash of a trapezoidal tooth drive and PowerGrip GT2 drive due to the difference in "pulley to belt tooth" fit (see **Figure 3**). Trapezoidal belts contact the pulley in the root radius-upper flank area only, while the PowerGrip GT2 system permits full flank contact.



PowerGrip® GT®2 Belt Tooth/Groove Contact   **PowerGrip® HTD® Belt Tooth/Groove Contact**   **PowerGrip® Trapezoidal Belt Tooth/Groove Contact**

Fig. 3   Comparison of Different Tooth Profiles

The main stress line in a trapezoidal tooth timing belt is at the base of the teeth. During operation, this stress greatly reduces belt life. The PowerGrip GT2 system overcomes this condition with its complete tooth flank contact which eliminates the tooth stress line area. This greatly increases belt life and prevents tooth distortion caused by drive torque. In addition, the conventional timing belt has a chordal effect as it wraps small pulleys. This is significantly reduced in the PowerGrip GT2 system because there is full tooth support along the pulley. Full support improves meshing, reduces vibration and minimizes tooth deformation.

On drives using a low installation tension, small pulleys, and light loads, the backlash of the PowerGrip GT2 system will be slightly better than the trapezoidal timing belt system. However, with increased tension and/or loads and/or pulley sizes, the performance of the PowerGrip GT2 system becomes significantly better than the trapezoidal timing belt system.

The PowerGrip GT2 system is an extension of the HTD system with greater load-carrying capacity. HTD was developed for high torque drive applications, but is not acceptable for most precision indexing or registration applications. The HTD design requires substantial belt tooth to pulley groove clearance (backlash) to perform.

As smaller diameter pulleys are used, the clearance required to operate properly is increased. HTD drive clearance, using small diameter pulleys, is approximately four times greater than an equivalent GT2 timing belt drive.

The PowerGrip GT2 system's deep tooth design increases the contact area which provides improved resistance to ratcheting. The modified curvilinear teeth enter and exit the pulley grooves cleanly, resulting in reduced vibration. This tooth profile design results in parallel contact with the groove and eliminates stress concentrations and tooth deformation under load. The PowerGrip GT2 design improves registration characteristics and maintains high torque carrying capability.

PowerGrip GT2 belts are currently available in 2 mm, 3 mm, 5 mm, 8 mm and 14 mm pitches. Specific advantages of the PowerGrip GT2 system can be summarized as follows:

- **Longer belt life**
  The strong fiberglass tensile cords wrapped in a durable neoprene body provide the flexibility needed for increased service life. The deep tooth profile provides superior load-carrying strength and greatly reduces ratcheting when used with pulleys provided by a licensed supplier.
- **Precision registration**
  PowerGrip GT2 belts provide timing and synchronization accuracy that make for flawless registration, with no loss of torque carrying capacity.
- **Increased load-carrying capacity**
  Load capacities far exceed HTD and trapezoidal belt capabilities making PowerGrip GT2 belts the choice for accurate registration, heavy loads and small pulleys.
- **Quieter operation**
  The PowerGrip GT2 belt's specially engineered teeth mesh cleanly with pulley grooves to reduce noise and vibration. Clean meshing and reduced belt width result in significant noise reduction when compared to Trapezoidal and HTD belts.
- **Precise positioning**
  PowerGrip GT2 belts are specifically designed for applications where precision is critical, such as computer printers and plotters, laboratory equipment and machine tools.

Some of the many applications of PowerGrip GT2 belts are:

- data storage equipment
- machine tools
- hand power tools
- postage handling equipment
- DC stepper/servo applications
- food processors
- centrifuges
- printers
- floor care equipment
- money handling equipment
- medical diagnostic equipment
- sewing machines
- automated teller machines
- ticket dispensers
- plotters
- copiers
- robotics equipment
- vending equipment
- vacuum cleaners
- office equipment