Belt drive performance hinges on choosing the right material and design for the job.

Belt drives are used in many pieces of equipment we come in contact with daily. They are in the cars we drive, the computer printers we use, and the lawn mowers we hate. Belt-drive designers must carefully consider the material and design of the sheaves, sprockets, and bushings that make up the drive to insure maximum service life and performance.

When selecting a material for a sheave or sprocket, designers should consider the number of parts needed and application, including any special requirements such as corrosion resistance, heat conduction, static conductivity, wear resistance, and low operating noise.

**Material selection**
Industrial sheaves and sprockets -- collectively called pulleys -- are typically made of gray or ductile iron. These materials offer excellent wear resistance, machinability, heat dissipation, and damping. Machining cast bar stock is the most economical method for producing prototype or small quantities.

As a general rule, stock sheaves and sprockets made of gray iron are statistically balanced and can be used for rim speeds up to 6,500 fpm. Exceeding recommended speeds is dangerous because it can result in serious structural problems as well as noise, vibration, and reduced bearing life. High speed applications require special design analysis and hardware.

Both ductile iron and steel, including sintered steel, are used for higher rim speeds because they have a higher tensile strength than gray iron. Class 65 ductile iron, for example, has a tensile strength of 65,000 psi and can be used for rim speeds up to 8,000 fpm or higher depending on the configuration of the pulley. The tensile strength of sintered
Steel varies, with allowable rim speeds averaging 8,000 fpm. Steel is usually the preferred material for rim speeds over 10,000 fpm.

An important characteristic of both ductile iron and steel is their ability to withstand heavy shock loads. This property, known as elongation, gives these materials much better shock resistance than gray iron, which is more brittle and likely to break when over-stressed.

**Special materials**

Pulleys can be made from a variety of nonferrous materials and plastic. Aluminum offers a number of advantages including light weight, excellent machinability, high strength-to-weight ratio, resistance to oxidation in air, excellent heat dissipation, and high electrical conductivity. Aluminum can be cast by all common methods, and some alloys are heat treatable for higher strength and hardness.

Aluminum components provide excellent service when used in office equipment, household appliances, and light-duty machine tools. However, aluminum sheaves and sprockets are unlikely to meet performance requirements of heavily loaded drives that operate in dirty environments and require full industrial service.

The same applies to plastic sheaves and sprockets commonly found in business machines, appliances, lawn-and-garden equipment, power tools, and computer peripherals. One additional concern with plastic is its poor heat dissipation when used on V-belt drives. This can significantly reduce drive performance.

Nylon, Nylatron, and polycarbonate, with or without fiberglass reinforcement, are commonly used materials for power transmission components. In addition to being lightweight these materials are rustproof and can be molded around a metal insert. They come in a wide variety of filled and non-filled grades and can be made to conduct electricity.

Injection-molded plastic pulleys usually cost much less in high volumes than machined metal. This is because most plastic parts are ready for use after molding. However, when selecting either aluminum or plastic, it is important to carefully evaluate the service life of the drive along with the performance characteristics of the application.
Corrosion resistance

Ferrous materials are not corrosion resistant, so they typically receive a surface treatment or coating during manufacture. Pulley manufacturers surface treat most parts with rust-preventive coatings, paint, or both. One manufacturer uses a clear rust-preventative dip to provide both outdoor and humid, indoor protection. This water-based, nonflammable product is preferable to solvent or oil-based products used by some manufacturers. Other manufacturers use painting or plating. Special chrome, nickel, and zinc platings can be used to improve both corrosion and abrasion resistance.

For most drive applications, however, corrosion is not a major concern because the equipment is sheltered during storage and while in service. Severe rusting also does not occur in sheave grooves on equipment in continuous operation.

When equipment is idle for long periods of time, extensive rusting can lead to pitting of the groove area. This is a problem because rust is abrasive enough to destroy a belt in a relatively short time. The pulley bore can also rust when unused or exposed to the elements and other corrosive conditions. If this happens, the shaft may also rust, resulting in a blemish that could lead to fatigue failure of the drive. Enclosing the drive or operating it at more-frequent intervals can help maintain groove condition.
Wear resistance

Because of their low cost and wear resistance, both gray and ductile iron are suited to industrial applications that require long-term operation. Typically, drives in machine tools, lawn-and-garden implements, and agricultural and construction equipment are made of gray or ductile iron.
When long service life is not a factor or higher tensile strength is required, steel or steel alloys can be a cost-effective alternative to cast iron. Alloy steels can also be heat treated or surface coated to increase hardness and wear resistance. Steel pulleys are used in lawn-and-garden equipment and the majority of automotive drives.

**Types of construction**

Standard industrial sheaves and pulleys come in three basic designs. Web pulleys have a substantial thinning between hub and rim, while block pulleys do not. Arm, or spoked, pulleys have a thinning of material plus sizable holes between hub and rim. Web and arm pulleys are generally used in larger-diameter applications.

The proper pulley diameter is critical to drive performance. Using a diameter that is too small produces excessive bending stresses in the belt undercord and higher belt tensions that can lead to increased belt temperatures. It also results in torque loss and belt creep and slippage.

Bearing loads on electric motors can also be a problem with small diameter pulleys. The National Electrical Manufacturers Assn. recommends minimum diameters used on standard electrical motors.

**Bushings**

Bushings fit within a hub to mate a sheave or sprocket to a shaft. The most common industrial type is a tapered bushing, which relies on a wedging action to connect pulley to shaft. Most standard, heavy-duty industrial pulleys have a hub machined for a tapered bushing. Differences in taper angles and mounting-bolt patterns prevent the different types of tapered bushings from being interchanged. The same bushing size, however, may be used with several pulley diameters, sheaves with different numbers of grooves, and pulleys grooved for different belt cross sections.

The power-transmission industry rates bushings for torque capacity. Bushings are usually keyed to the shaft. Keyless shaft-hub locking devices are available from several manufacturers and are primarily used with custom-designed pulleys.

For safety and performance, a shaft must extend fully through the bushing. Bushings also must be used with the proper size shaft. A bushing cannot be properly tightened on an undersized shaft. To insure correct mating, regardless of what type of tapered bushing is used, these guidelines should be followed:

- Keep pulley and hub mating surfaces free of dirt, grease, and paint. Contamination can cause a pulley to ride off-center, resulting in vibration or wobble.
- Never lubricate mating surfaces. This can result in excessive radial pressure between the tapers and cause the pulley hub or bushing to split.
- Torque setscrew to recommended value. Excessive or unequal torque may damage the bushing or misalign the pulley.
- Avoid uneven pressure on jack-out screws, which are used to back out the bushing. Follow recommended torque value to prevent damage to the bushing flange for removal without damage to the product.

Recommendations on pulley diameters and bushings are available from full-line belt, sheave, sprocket, and bushing manufacturers and the Rubber Manufacturers’ Assn. Belt and sheave power transmission standards also are available from the Mechanical Power Transmission Assn., Society of Automotive Engineers, and the American Society of Agricultural Engineers.
Styles of tapered bushings include the QD (left), which uses a mounting flange and is frequently found on belt drives, and the Taper-Lock, which is a flangeless or flush-mounted design and often used in chain drives. Both are products of The Gates Rubber Co./Dodge Manufacturing Strategic Alliance, Denver, Colo.