Mechanical Equipment - Course 230.1

BELT DRIVES

A common method of transmitting power is a combination of belts and pulleys. There are many types of belts and pulleys used for the transmission of power but, in general, the same principles apply to all of them.

The effectiveness of a belt drive is dependent on the friction developed between the belt and the pulley. Factors which affect the friction are belt tension, length of contact between belt and pulley (arc of contact), cleanliness of belt and condition of belts and pulleys.

The arc of contact should be as large as possible to obtain maximum power of transmission. However, Figure 1 shows that the smaller pulley has an arc of contact less than 180°. Properly designed belt drives should have an arc of contact greater than 120° and therefore the pulleys should be selected accordingly.

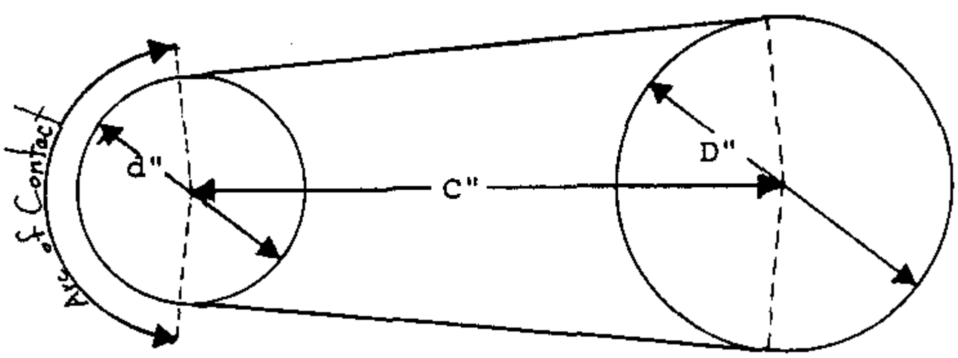


Figure 1

Some of the many types of belt and pulley combinations that will be encountered are:

- flat belts on flat, flanged pulleys or crowned pulleys,
- V belts on flat pulleys or V groove pulleys,
- toothed belts on gear type pulleys,
- round belts on half round grooved pulleys.

Flat Belts

At one time when all the machines in a machine shop were run from a single engine, the power was transmitted by flat belts, pulleys and shafts. The flat belt was probably the most popular form of belt drive. Today, however, flat belts are not used very much, particularly in Ontario Hydro's nuclear stations. Therefore only a few paragraphs will be devoted to discussing.

Flat belts are of various constructions. One type is leather belting made of several plies of leather bonded together. Figure 2 illustrates several other constructions. In Figure 2(a) the construction is plies of rubberized fabric; Figure 2(b) uses rubberized cord and Figure 2(c) is a combination of both (a) and (b). The belt illustrated in Figure 3 is used in instrumentation and is made of polyester film.

(a) (b) (c)

Figure 2

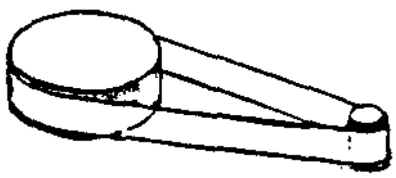


Figure 3

Flat belt pulleys are generally made of cast iron, but can also be made of wood, steel, or other suitable materials. The hub may be split or solid and there may be flanges on the sides of the face of the pulley. Figure 4 illustrates two typical pulleys; Figure 4(a) is split, steel pulley and 4(b) is a cast iron one. The pulleys' faces may be either flat or crowned.

(a) (b)

Figure 4

Crowned pulleys take advantage of the fact that a flat belt tends to move towards a larger diameter. Therefore making the centre of the face of larger diameter than the edges keeps the belt centred on the pulley. A cross section of one type of crowned pulley is shown in Figure 5.

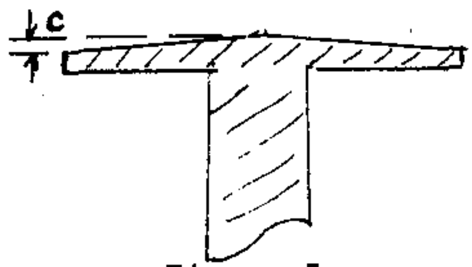


Figure 5

V-belts

Of all belt drives V-belts are probably the preferred drive for transmitted power. In contrast to the flat belt which depends only on the friction between the belt and the pulley to transmit power, the V-belt uses the wedging action of the belt in the grooves of the sheave to increase the frictional force.

The wedging action is a result of the belt being bent around the sheave. In Figure 6(a) the cross-section of a straight portion of the belt shows that the sides are straight, however when the same belt is bent as if around a pulley the sides would be seen to be bulging out as in Figure 6(b).

(a) (b)

Figure 6

Figure 7 illustrates the typical method of constructing a V-belt. The load-carrying cords may be of a variety of materials such as rayon, nylon, glass-fibre or even steel, and there may even be several layers of cords. The cover can be one of several rubberized fabrics depending on the type of service for which the belt is intended. The main body of the belt is made of some kind of rubber, again chosen to suit the working environment. Some materials are good for oil resistance, others stand up better to heat or ozone attack.

V-belt cross-section dimensions conform to a standard and use a letter designation (A, B, C, D, or E) as illustrated in Figure 8. However the method of specifying length varies between manufacturers and therefore their catalogues will need to be consulted.

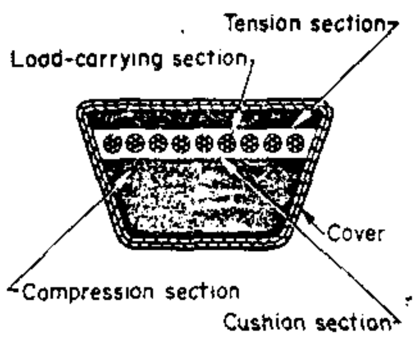


Figure 7

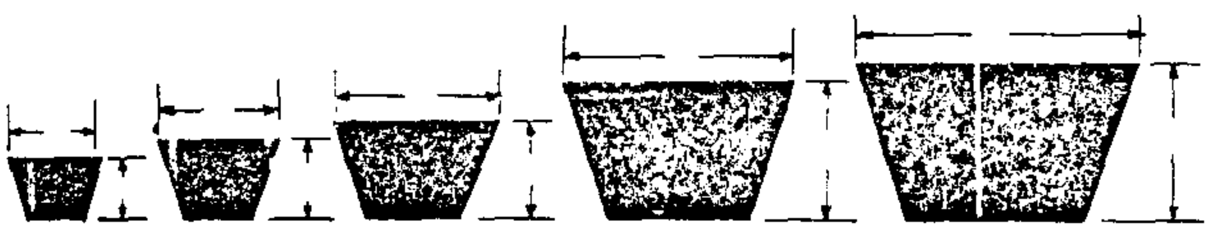


Figure 8

Different types of V-belt construction are shown in Figure 9. Two of these are worth highlighting.

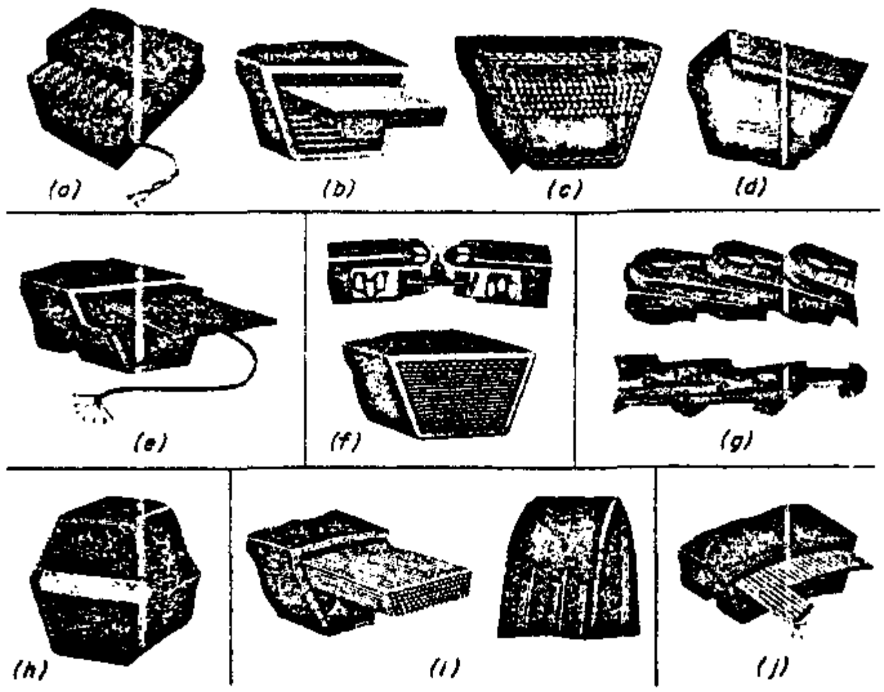


Figure 9

The belt in 9(d) is toothed or serrated on the underside. This is to help it to run cooler in high temperature applications. In "variomatic" or variable speed drive applications a belt like that in 9(j) would be used.

The pulleys or sheaves for V-belt drives are generally made from cast iron but any suitable material would serve. The grooves should have flat sides and should be deep enough so that the belt does not ride on the bottom. Figure 10 is a cross-section of a typical grooved sheave.

For proper running of a V-belt drive several things should be observed. All of the belts should be in good physical condition, not frayed, cracked or giving evidence of local wear. The belts should be riding in the grooves correctly as illustrated in Figure 11(a). No belts in the set should be appreciably longer than the others since this means that some belts are being overloaded. The belts should be tensioned properly.

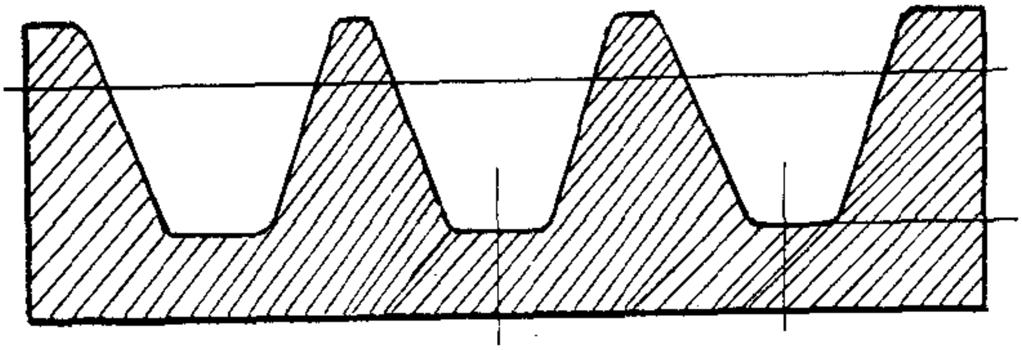
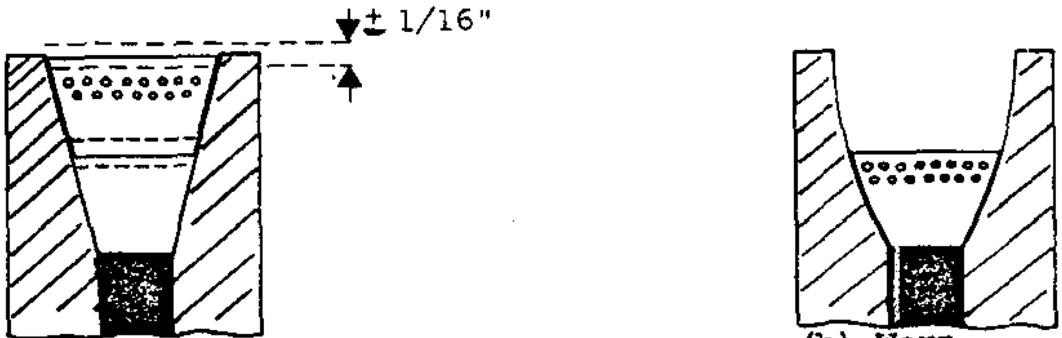


Figure 10



(a) Correct

(b) Worn

Figure 11

Problems with V-belt Drives

Some of the problems with V-belt drives can be detected early in their development by simple inspection. Preventive action can then be taken at the first appropriate time instead of waiting for a complete breakdown of the drive.

The following conditions can be observed while the drive is running. Under no circumstances should any component of the drive be touched.

If the belts are slipping, either the tension needs to be increased or the load is too great.

Check the tight side of the drive to see whether any belts appear slack. If so, then the groove may be worn, the belt may be stretched or the set was mismatched at the outset.

Look for wobble on the pulleys as this could mean a bent shaft which would require straightening.

Serious misalignment could probably be spotted by sighting along the belts, but alignment is better checked with the drive stopped. Other conditions can be seen best while drive is stopped and isolated.

Examine the belts for wear, fraying, cracking, broken cords or oil damage. Some of these things can be due to normal wear, however, they can be symptoms of other trouble particularly if they occur prematurely.

Examine the sheaves to see that they are not worn excessively nor cracked and chipped.

Immediately after stopping check the bearing temperatures. High temperatures can be due to lack of lubrication, or too tight belts.

Determine whether or not the belts are correctly tensioned. If a belt has flipped over it is generally an indication that one or more of the cords on one side are broken and therefore the belt should be replaced.

Wipe off any oil or grease on the belts using a cloth moistened with a suitable solvent. Oil or grease attack the belt material and soften it.

Handling Advice

Be careful. When turning the drive by hand remember that the inertia of the motor and driven equipment may keep the belts moving after the turning force is removed. If the drive is being rotated by pulling on the belts then hands and fingers can be pulled into the sheave accidentally. Apply the turning force by means of a lever on a sheave where possible.

Diagnosis of V-belt Failures

Condition:	Belt material soft, spongy and tacky. Some peeling.
Cause:	Oil or grease.
Prevention:	Splash guards where possible; otherwise oil resistant belts.

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Condition:	Cover fabric ruptured at one location.
Cause:	Belt pried on or some object falling into sheave groove.
Prevention:	Install by moving motor.

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Condition:	Cracked or checked belts particularly on underside.
Cause:	Backbending or high operating temperature.
Prevention:	Check for cause of high temperature (eg, slippage) and rectify if possible to keep ambient temperature below 150°F.

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Condition:	Snapped belt.
Cause:	Belt too loose causing it to snap tight on start-up.
Prevention:	Maintain correct tension.

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Condition:	Worn or abraded belt sides.
Cause:	Abrasive material on sheave, or misalignment.
Prevention:	Keep Drive clean. Align properly.

Variable Speed Pulleys and Belts

When it is necessary to change the speed ratio between the driver and driven pulleys while the drive is in motion then a variable speed belt drive can be used.

These drives utilize a belt similar to that shown in Figure 12. A cross-section of the belt would show that it is arched. It also has ribs running across the belt which give it rigidity in that direction but still permitting flexibility in the lengthwise direction.

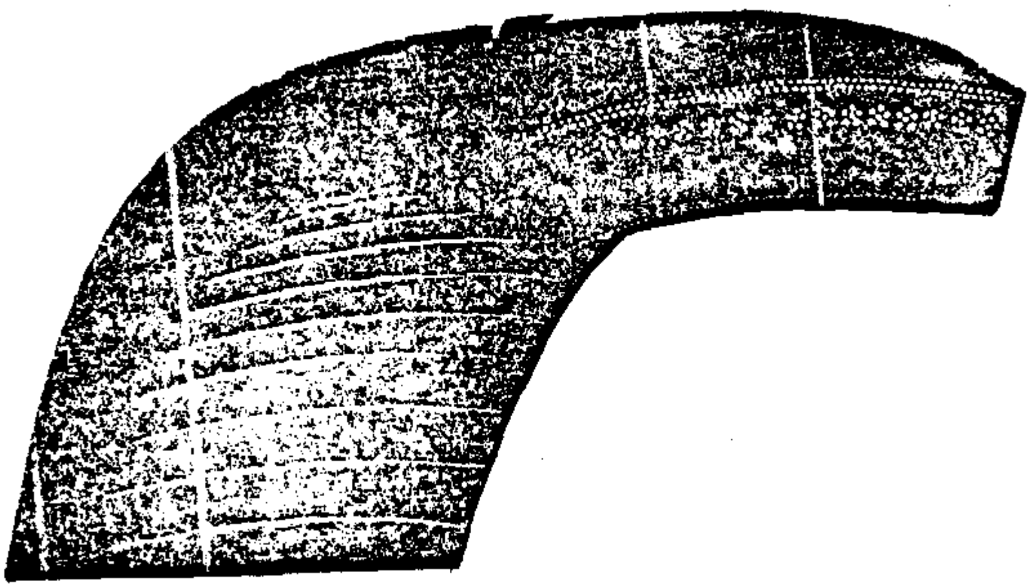

Figure 12

There are two methods of operating a variable speed drive. One is to use a pulley on which one flange can move against a spring while the other is fixed to the shaft as illustrated in Figure 13. As th centre distance between the pulleys is varied by moving the motor back and forth the speed ratio of the drive is varied. The other method is to use two pulleys on one of which the flanges open at the same rate as they close on the other. The movement of the flanges would be controlled by both the speed and the load.

For good efficient operation of these types of drives the pulleys need to be maintained in good condition with the working faces smooth. The belts will require inspection for defects as described for conventional V-belts. If the drive is working correctly the tension on the belt should be maintained automatically.

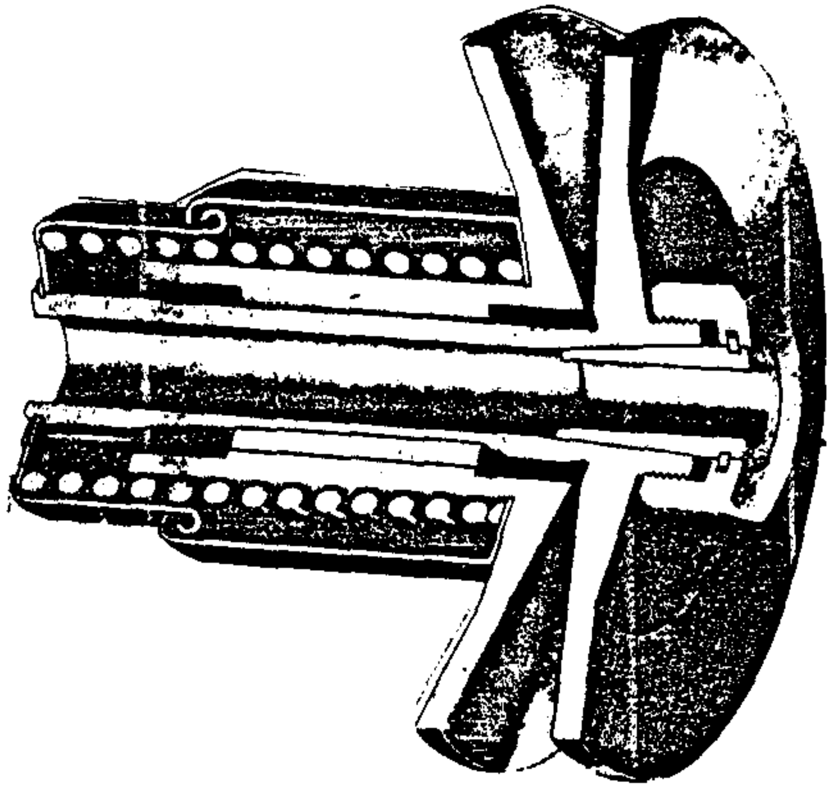

Figure 13

Toothed Belt Drives

There exist applications where the drive must be positive with no slippage, such as timing of valve operations. In these instances it is possible to use gear or chain drives, however, there exists a range of toothed belts which run in pulleys, resembling gears. For relatively low load situations these drives provide an inexpensive and quiet solution with adequate precision.

The construction of the belts is similar to that of V-belts except that the cords should resist stretching to maintain the rotational relationship betweent he two pulleys and the teeth should be able to withstand wear. For example, one timing belt for an overhead camshaft drive has glass fibre cords and nylon teeth. For lighter service other cords would be suitable as would rubber or neoprene cover and teeth.

The belts are available in several widths and lengths and with a range of pitches of the teeth. The pulleys must have teeth of the same pitch as the belt and one or both pulleys should be flanged to locate the belt and prevent it travelling off the edges.

Figure 14 illustrates a typical toothed belt drive.

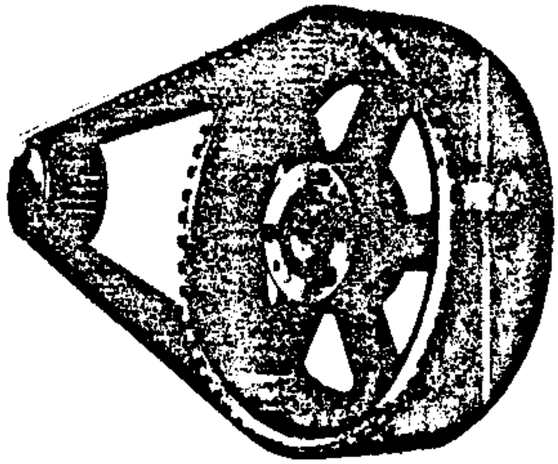

Figure 14

Idlers

Without a means for moving one of the components to create tension in the belt it may be necessary to use another pulley called an idler to act as a tensioning device. It is called an idler because it drives nothing.

The idler pulley may be placed on the outside of the belt or the inside and may be on the tight or slack sides.

An outside idler has the advantage of increasing the arc of contact but there is a limit to the amount of take-up possible since it would not be good to have the belts touching. It can be seen in Figure 15(a) and (b) that this possibility exists. Another disadvantage of the outside idler is the reverse bend which it puts on the belt. This reduces the life of the belt since it is generally not designed to take the tension created at the inside surface by a reverse bend.

The arc of contact is decreased by an inside idler but the amount of take-up virtually unlimited as shown in Figure 15(c) and (d).

The best location for an idler is on the slack side of the drive, however it must be on the tight side it should be close to the driven pully.

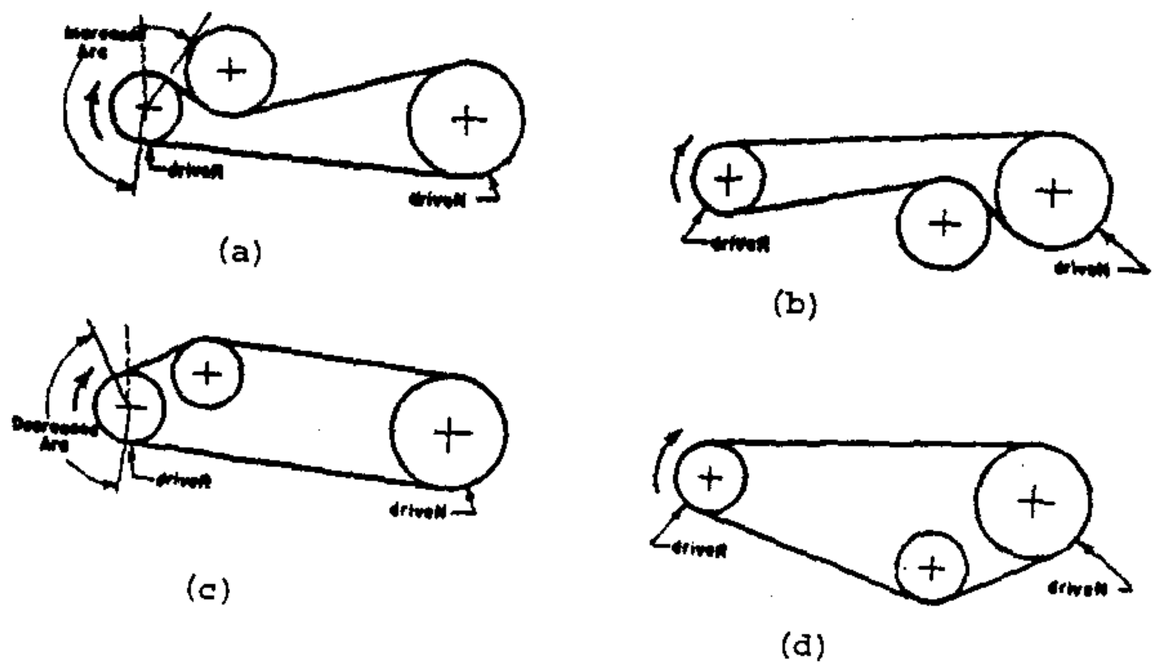

Figure 15

H. Timmins
L. Laplante

ASSIGNMENT

1. Why are crowned pulleys used for flat belts?

2. List four items that should be checked on a belt drive for proper operations.

3. Describe one type of variable speed drive pulley.

4. What is the purpose of an idler on a belt system?