

Applications Note – Gears

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Executive Summary

The general purpose of a gear is to transfer motion from one object to another in a mechanism. The important design considerations for the design of gears in a mechanism are the gear ratio, which determines the proper number of teeth to use, and also the type of gear to use, which depends on the application. An example of gears being designed for a mechanism is in the design of the PI Engineering Ship Simulator. In this project, gears were used to transfer the rotational motion of the steering wheel to a hydraulic motor. The methods outlined in this applications note were utilized in the design process.

Keywords

1. **Gear** - a component within a transmission device that transmits rotational force to another gear or device.
2. **Teeth** – linkages on a gear that mesh with other gear teeth, allowing force to be fully transferred without slippage.
3. **Gear Ratio** - the relationship between the number of teeth on two gears that are meshed.

Introduction

Gears have many uses in mechanics; a gear's most general purpose is to transfer rotational motion from one shaft to another. Linear motion can also be obtained through a rack and pinion system. There are many different types of gears, including spur gears, bevel gears, crown gears, and worm gears. The type and size of gear chosen for a given application depends on the desired output specifications. For example, if more torque is required on the output shaft, then a larger gear would need to be placed on the output shaft relative to the input shaft, thus producing mechanical advantage. The following is an aide in the use of gears in the design of a mechanism.

Steps

1. The first step in the design of any mechanism is to define the problem. In other words, determine the desired output of the system. Examples of desired outputs would be shaft speed, torque, or rotation direction.
2. Determine the proper gear ratio to use. This is calculated using the following equation:

$$\frac{V_A}{V_B} = \frac{N_B}{N_A} \quad (1)$$

where V_A and V_B are the velocities of gears A and B respectively, and N_A and N_B are the number of teeth in gears A and B respectively. Note that as the gear ratio increases, the output velocity decreases and the output torque increases.

3. Choose specific gears for the application. This includes finding gears that have the required number of teeth, outer diameter that can fit within size constraints, materials that can accommodate the forces involved, and compatible teeth. A labeled diagram of a gear is shown in Figure 1.

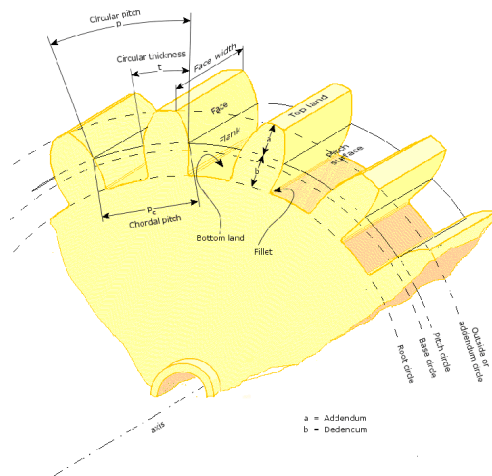


Figure 1. Labeled Diagram of a Gear

4. Assemble the gear train. It is very important to line the gears up properly so that the gears function correctly. This will make the gears less likely to jump or for the teeth to fail due to fatigue. It is generally easier to use a chain to transfer motion between sprockets, as opposed to spur gears that directly drive each other. This is because it is less critical that the gears are perfectly lined up since there is some “wobble-room” in the chain. Also because it is easier to wrap a chain around sprockets than it is to perfectly align spur gears.

Example

In the PI Engineering Ship Simulator application, gears were used to transfer motion from the steering wheel to a hydraulic motor. It was a design specification to use a 1:6 gear ratio to maximize the number of turns of the hydraulic motor to minimize leakage. This allowed the shaft of the hydraulic motor to turn approximately 17.5 times for every 3 turns of the steering wheel. There were also size constraints limiting the outer diameters of the gears. The final design was an 84 tooth sprocket on the wheel shaft attached by a #35 chain to a 14 tooth sprocket mounted on the hydraulic motor shaft. This gave the desired gear ratio of 1:6. Some of the relevant calculations are shown below.

$$\frac{14\text{teeth}}{84\text{teeth}} = \frac{2.9\text{turns}}{17.4\text{turns}} = \frac{1}{6} \quad (2)$$

Conclusions

Gears are used to transfer motion from one object to another in a mechanism; usually this motion is rotational, but linear motion can be obtained as well through the use of a rack and pinion system. There are many important design considerations with respect to gears. The most fundamental calculation for gears is the gear ratio. This ratio describes the relative motion of the gears involved. A high gear ratio corresponds to a high torque output and a low gear velocity, and vice versa. The gear ratio can be used to determine the proper number of teeth for the gears. Another important design consideration is the outer diameter of the gears, since size is usually a constraint. A large number of teeth will generally correspond to a larger outer diameter. Also, it is important to consider that it can be difficult to align spur gears correctly, and therefore it is generally easier to use sprockets connected by a chain.

References

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