Gear Buyers Guide

Know Everything About Gears Before Buying Them.

www.marshallgears.com

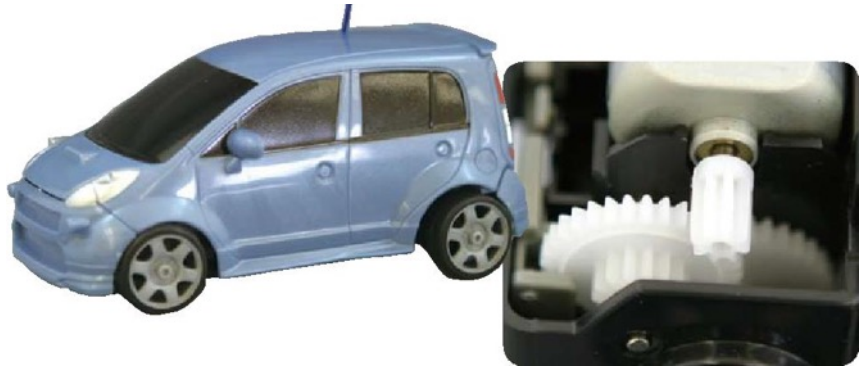
Table of Contents

What is a Gear ?

You must have seen one as they are everywhere.

I'm sure you once used to play with your toys. Toys usually contain a lot of gears.
Let's look at some of them.

■ Radio-controlled model car



Gears transmitting power and motion to the tires.

■ Play Top

A belt-shaped rack and a gear to spin the top

Look at these things in your kitchen, and you'll find some.

■ Coffee Mill

A pair of bevel gears to turn the mill

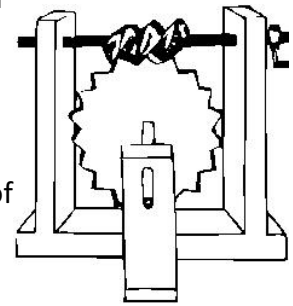
■ Hand-mixer

A gear to turn the mixer

History of Gears

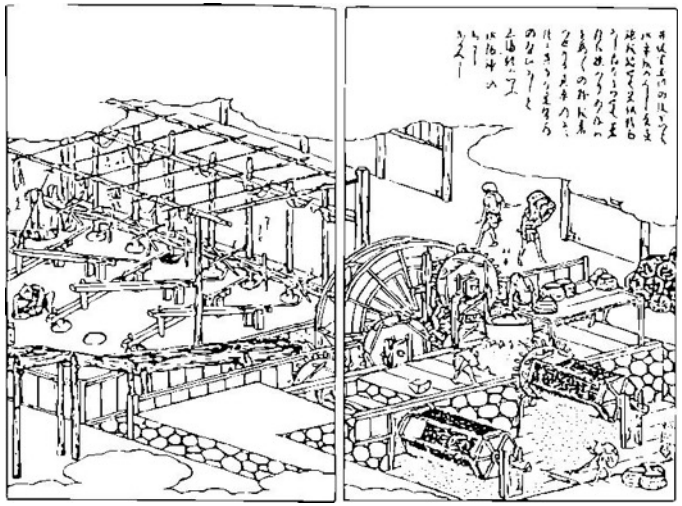
Maybe you want to know how far gears date back to.
Here's the answer.

Gears were already in use in 350 B.C. (about 2,300 years ago). You probably know about a Greek philosopher Aristotle (384~322 B.C.). One of Aristotle's writings includes a description about a gear. A hundred years later that day, a Hellenistic mathematician Archimedes (287~212 B.C.) drew a diagram of a hoist (See the diagram on the right) that was driven with a set of worm and worm wheel.

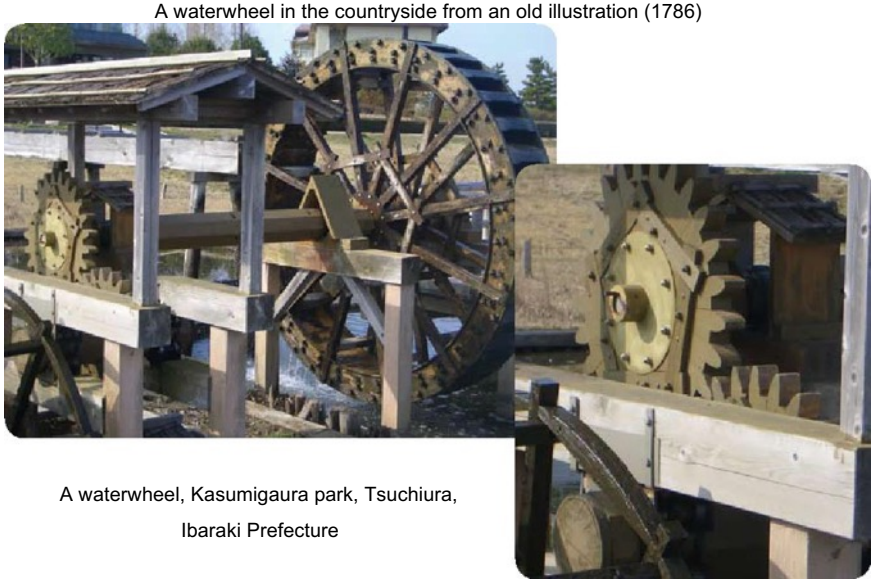


Ancient gears at the Ctesiphon archeological site in Iraq

Here in Japan, as seen from the picture below, gears were in use in the Edo period (1603~1867) as a power source for flour milling in waterwheels. The gear was as large as one meter in diameter, and zelkova and oak trees were used as the material.



A waterwheel in the countryside from an old illustration (1786)



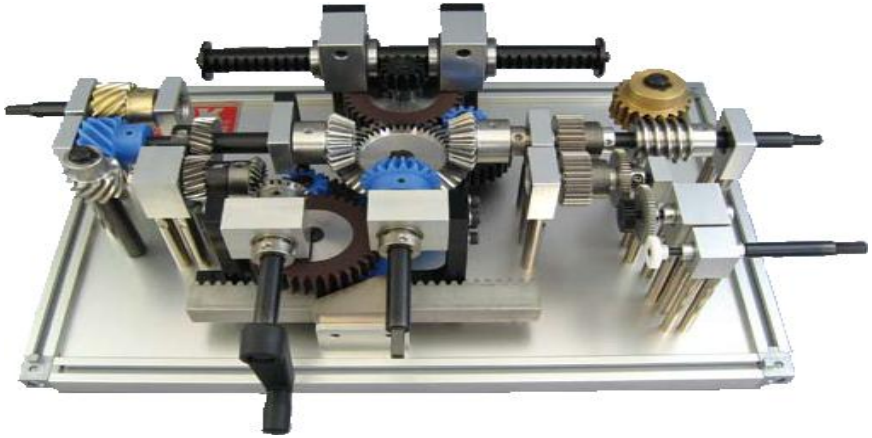
A waterwheel, Kasumigaura park, Tsuchiura, Ibaraki Prefecture

The Role of Gears

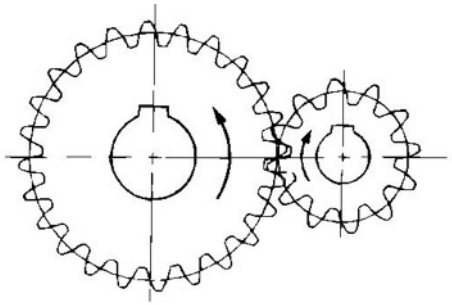
Let's see what gears can do. I'm sure you'll feel they are all-rounders.

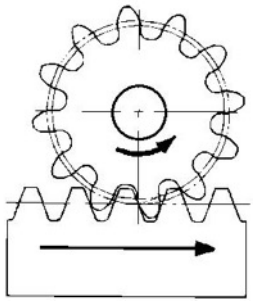
Gears work in pairs to do a job. They can:

- Transmit motion and power between rotating shafts.



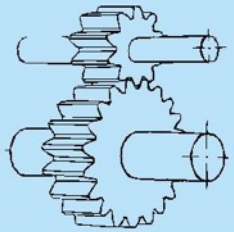
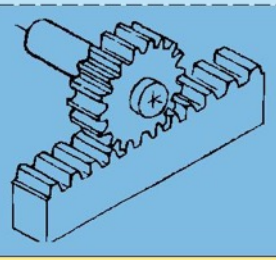
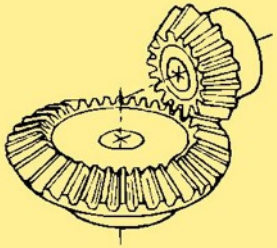
- Change the direction of rotation and speed





In any pair of gears, the larger gear will move more slowly than the smaller gear. Gears tend to change rotational directions.

- Configuration of Gears

Parallel axes 	Transmit power and motion between parallel shafts. Spur gears and helical gears are used.
	Change the rotary motion into the rectilinear motion and vice versa. A combination of spur gear and rack or a combination of helical gear and helical rack is needed to do work.
Intersecting axes 	Transmit power and motion between intersecting shafts at right (90˚) angles. Straight bevel gears or Spiral bevel gears are used.
Nonparallel, nonintersecting axes 	Transmit motion and power between nonparallel, nonintersecting shafts that are usually at right angles (90˚). Screw gears and worm gear pair are used.

What are the different types of Gears

Gears work in matching pairs, they have teeth which connect with the mating gear.

Different types of gears are used based on the application type. The different types of gear are …
Gears are broadly classified between External Vs Internal Gears:

An external gear is one with teeth formed on the outer surface of a cylinder. Conversely, an internal gear is one with the teeth formed on the inner surface of a cylinder.

Spur Gears :

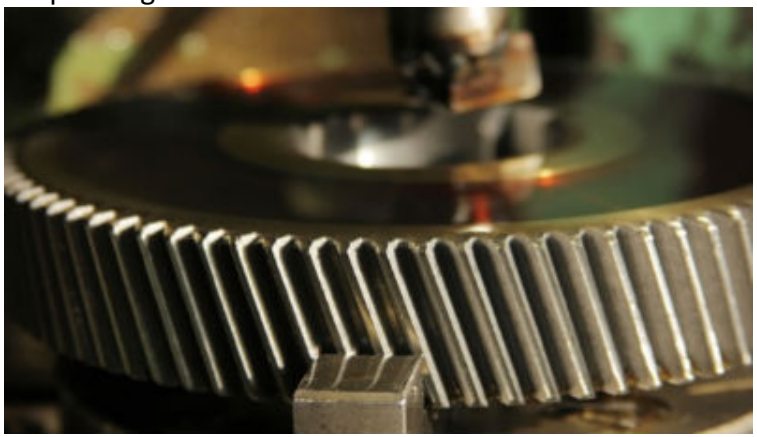
or straight-cut gears are the simplest type of gear. The teeth are straight and the teeth are parallel to the bore of the gear.

These gears mesh together correctly only if fitted to parallel shafts.

Spur gears are the most commonly used in the pretty much all industries and applications.

Helical Gears

They have teeth inclined at a certain angle to the bore. Since the gear is curved, this angling makes the tooth shape a segment of a ‘helix’.



Helical gears can be meshed in parallel or crossed layouts. The former refers to when the shafts are parallel to each other (commonly used) and the latter is when the shafts are non-parallel.
The angled teeth engage more gradually than do spur gear teeth causing them to run more smoothly and quietly.

With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face to a maximum, then recedes until the teeth break contact at a single point on the opposite side.
In spur gears, teeth suddenly meet at a line contact across their entire width, causing stress and noise.

Spur gears make a characteristic whine at high speeds. For this reason spur gears are used in low-speed applications and in situations where noise control is not a problem, and helical gears are used in high-speed applications, large power transmission, or where noise abatement is important.

The speed is considered high when the pitch line velocity exceeds 25 m/s.

These have more contact area and hence are used for higher power transmissions.
Single helical gears produce a slight sideward (axial) force and have to be used with thrust bearings to balance out the axial thrust.

Double Helical / Herringbone Gears:

These as the name suggests are having 2 helical angles and are used for maximum power transmission applications.

The double helical teeth cancel out the side thrust and hence these are self-balancing gears.

Worm gears & Shafts :

These are used to transmit power at 90 degrees apart shafts – they also offer large reduction ratios and have maximum power output.

Crown Gears

have a radius on their outer diameter.This radius keeps the gear aligned at the center of the face width.
Generally used in couplings and related applications.

Rack & Pinion:

These are used to generate linear motion and transmission of power at low speeds.

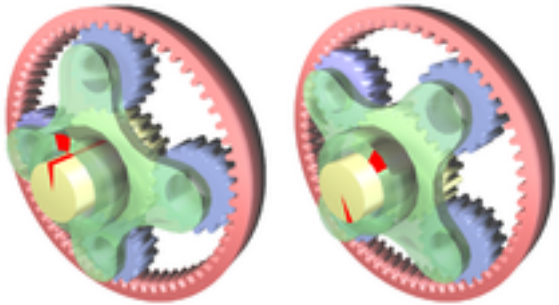
Bevel gears:

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point.

Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called miter gears.

Epicyclic Gears:

Epicyclic gearing or planetary gearing is a gear system consisting of one or more outer gears, or planet gears, revolving about a central, or sun gear.

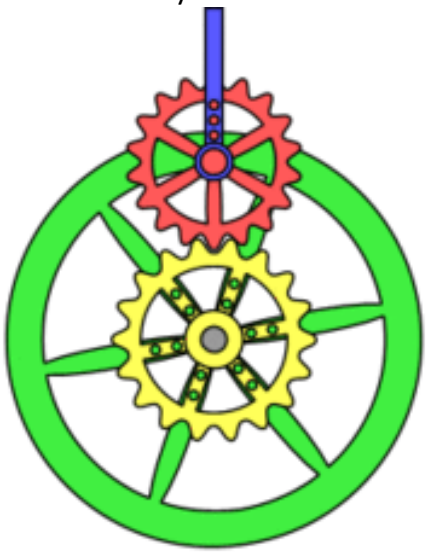


Examples are sun and planet gearing (see below), cycloidal drive, and mechanical differentials.

This design can produce large gear ratios in a small space and are used on a wide range of applications from marine gearboxes to electric screw drivers.

Sun and Planet Gears

Sun and planet gearing is a method of converting reciprocating motion into rotary motion that was used in steam engines.



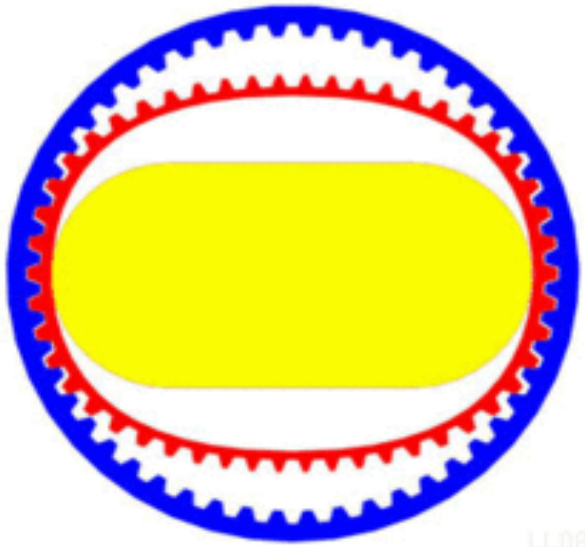
James Watt used it on his early steam engines to get around the patent on the crank, but it also provided the advantage of increasing the flywheel speed so Watt could use a lighter flywheel.

The sun and planetary gear is used in most of the automatic transmission system. In automatic transmission compound sun and planetary gear is used.

In the illustration, the sun is yellow, the planet red, the reciprocating arm is blue, the flywheel is green and the driveshaft is gray.

Harmonic Gears

A harmonic gear is a specialized gearing mechanism often used in industrial motion control, robotics and aerospace for its advantages over traditional gearing systems, including lack of backlash, compactness and high gear ratios.



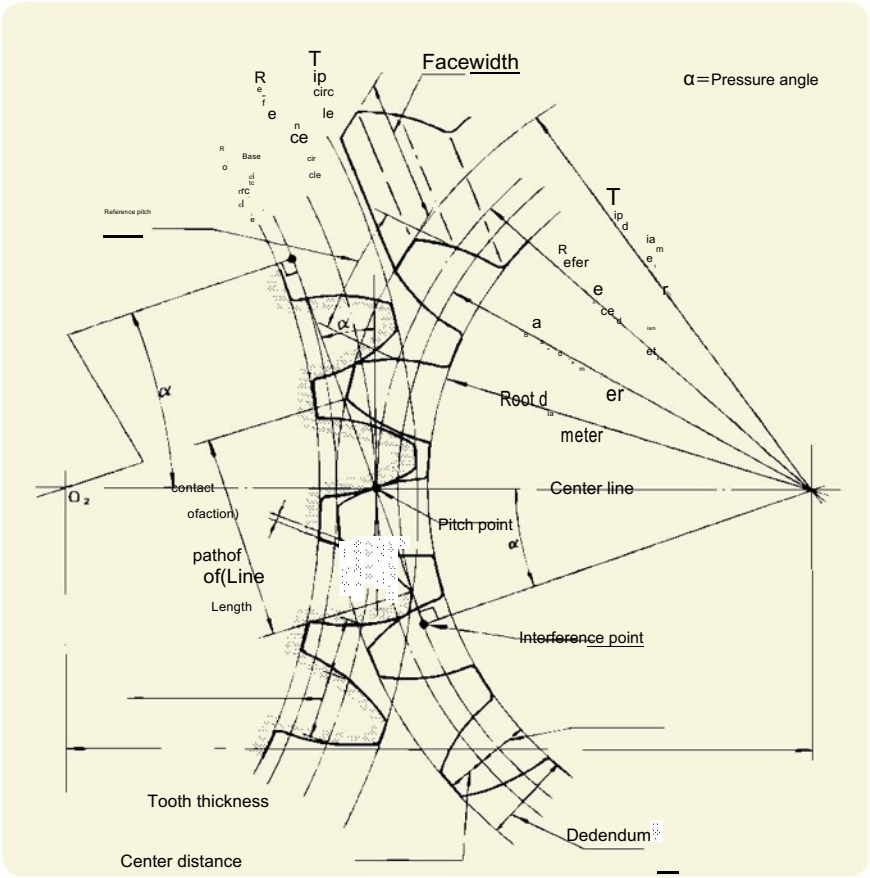
It is very commonly implemented in robotics today and used in aerospace as well, for gear reduction but may also be used to increase rotational speed, or for differential gearing.

Fundamental Gear terms

Module? Reference diameter? - What do they mean?

Cited here are technical terms used with reference to gears. Though these terms are used on an infrequent basis, the knowledge of these terms will help you better understanding gears.

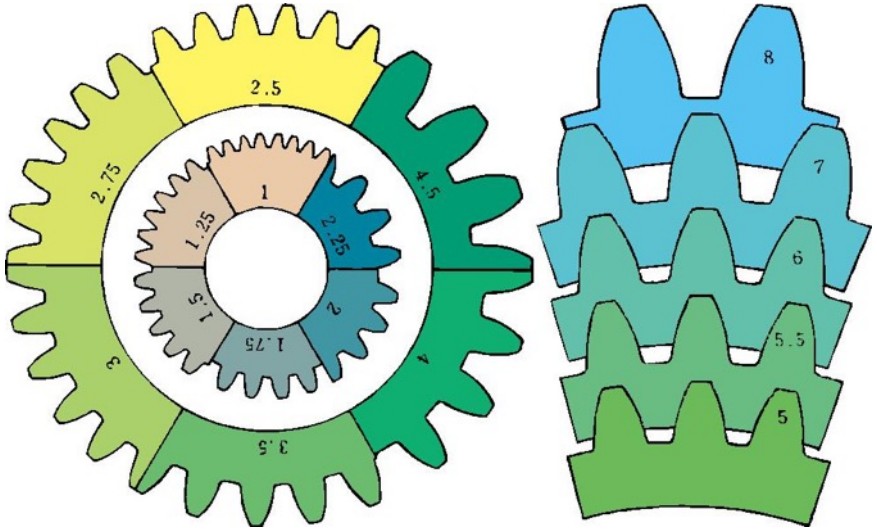
■ Technical terms for gears



■ Comparative Size of Gear-Tooth

M１, M３, m８, ・・・

The "M" represents "module" and the system of unit used is the metric system. These m l, m 3, m 8 are called Module One, Module Three, Module Eight, respectively. This is the global vocabulary to express the size of gear-tooth. The bigger the number, the larger the tooth size.

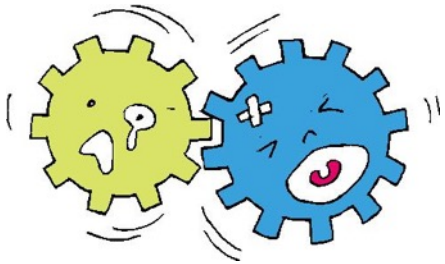


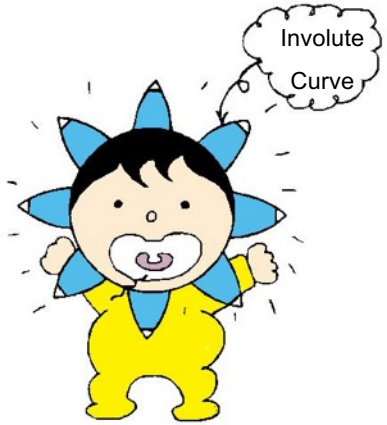
In the United States and other countries where the unit of length in common use is "inch", "Diametral pitch" is widely used to represent the tooth size. For example, DP24, DP8, ... (DP - the ratio of the number of teeth to the diameter of the pitch circle measured in inches.)

"Circular pitch" is also used to represent the tooth size. In that case, the sizes of tooth are designated as CP5, CP10 ...

■ Tooth profile and pressure angle

Involute gear teeth and cycloidal gear teeth are typical of the tooth profile.
Modern gearing is based on involute teeth.
Satisfactory gears must transmit power and motion smoothly by rolling action. The involute gear form provides constant velocity ratios between mating gear teeth.





[Features of the involute teeth]

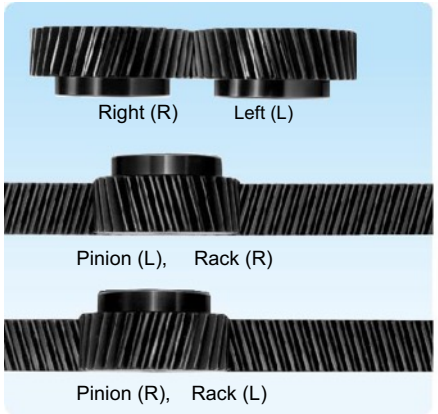
- Conjugate action is relatively independent of small errors in center distance.
- Can be manufactured at low cost since the tooth profile is relatively simple.
- Allow the contact point to move smoothly, transmitting the motion.
- Can save time and labor to change hobs since a single hob can process gears of di erent numbers of teeth if the size (module) of teeth is the same.
- The teeth are strong because of their root thickness.

The pressure angle will be dealt with in the subsequent course, but it is usually 20˚. In some cases, however, it is 14.5˚,15˚or 17.5˚, 22.5˚, or 27˚.

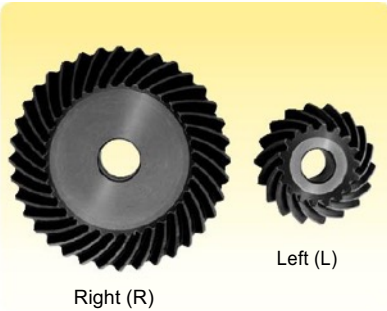
■ Direction of hand, and mating

A pair of helical gears connecting parallel shafts is made up of opposite hand gears, that is, one will be a left-hand gear; the other a right-hand gear. The same applies to spiral bevel gears. As for screw and worm gears connecting non-parallel shafts, if the shaft angle is 90 degrees, the gears will be of the same hand. The teeth of a left-hand gear lean to the left and the teeth of a right-hand gear lean to the right when the gear is placed on a flat surface.

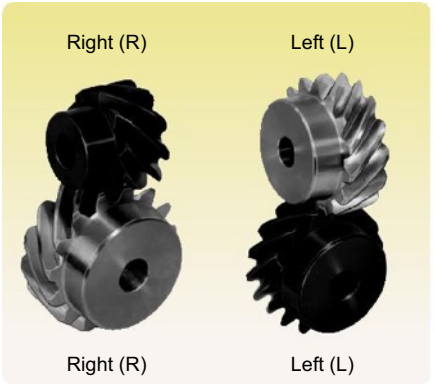
● Helical gear



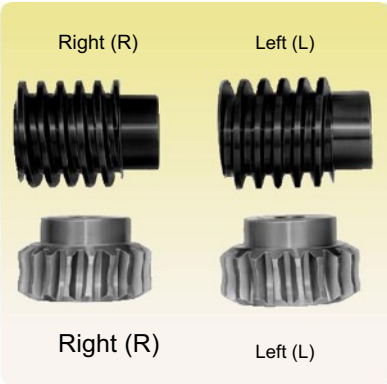
● Spiral bevel gear



● Screw gear



● Worm gear pair



Gear Materials and Heat Treatment

Let's see what sort of materials are used to produce gears, and why?

Choosing the proper material is vitally important. As the applications of gears are so diverse, various materials are used. Dealt with here are gear materials and heat treatment.

■ Gear materials and their features.

● Ferrous metals

S45C (Carbon steel for machine structural use), and SCM415 (Case-hardening alloy steel) are most commonly used. Both are good materials for making gears. Steel castings such as IS 1030, 2708, 2707 and 2644 are good materials. Alloy steels like En 8, EN 9, EN 19 and EN 24 are used widely.

Steel and Alloy Steel round and rectangular bars

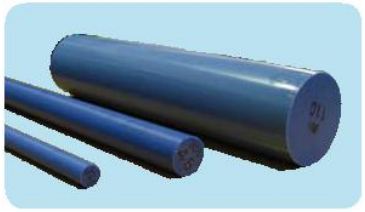
● Nonferrous metals

Aluminium bronze castings are wear-resistant. The gears made out of these nonferrous metals are used for worm wheels and screw gears, etc. because of their wear-resistance. As they are castings, they are somewhat costly and their procurement is more di cult.

Aluminum bronze casting
(The core portion - grey iron casting)

● Plastics

Plastics are used as the gear material for the applications that require the operation with minimum or no lubrication, such as food processing machines and toys, etc. Plastic gears made by the injection molding process are very cost effective and are used in such applications as light duty o ce machines etc.



Plastic round bars

■ Heat treatment

Steels get stable in their structure when heat treated and become harder and stronger. The illustration here depicts forge scenes of a Japanese blade KATANA.

More powerful

● Thermal Refining

This is the heat treatment to refine crystal structure of steels to improve the strength.

●Gas Nitriding

● Volume Hardening

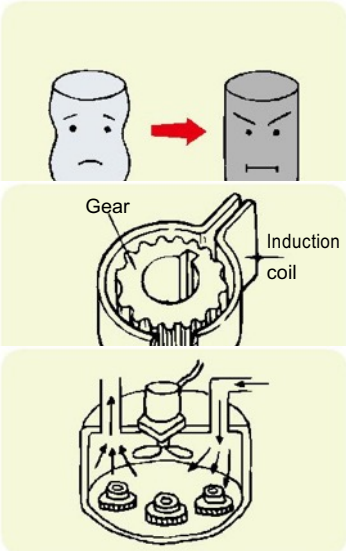
● Flame Hardening

● High-Frequency Induction Hardening

This is the process where steels are hardened by means of induction heating (approx.800℃) and subsequent quenching.

●Case / Gas Carburizing and Quenching

After di using carbon molecules into the surface of steel at high temperature, steels are case hardened to produce a hard and wear-resistant surface with progressively softer core which retains ductility.



Gear Accuracy and Strength

No wonder gears with high precision are durable and quiet.

Now, let's think about gear accuracy and strength. Good gears are considered to be:

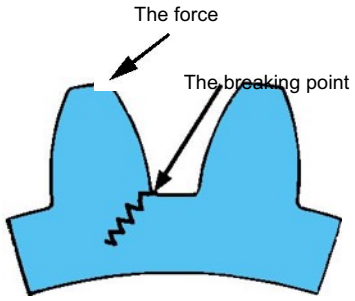
① Small and light
② Able to transmit high power and forces
③ Quiet
④ Durable

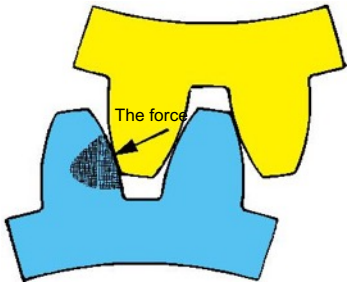
■ Strength and durability

The strength of gears is expressed in terms of bending strength and surface durability. If the force beyond the limits is put on the teeth,

- the teeth will be broken, or
- the surface of the teeth will be worn.

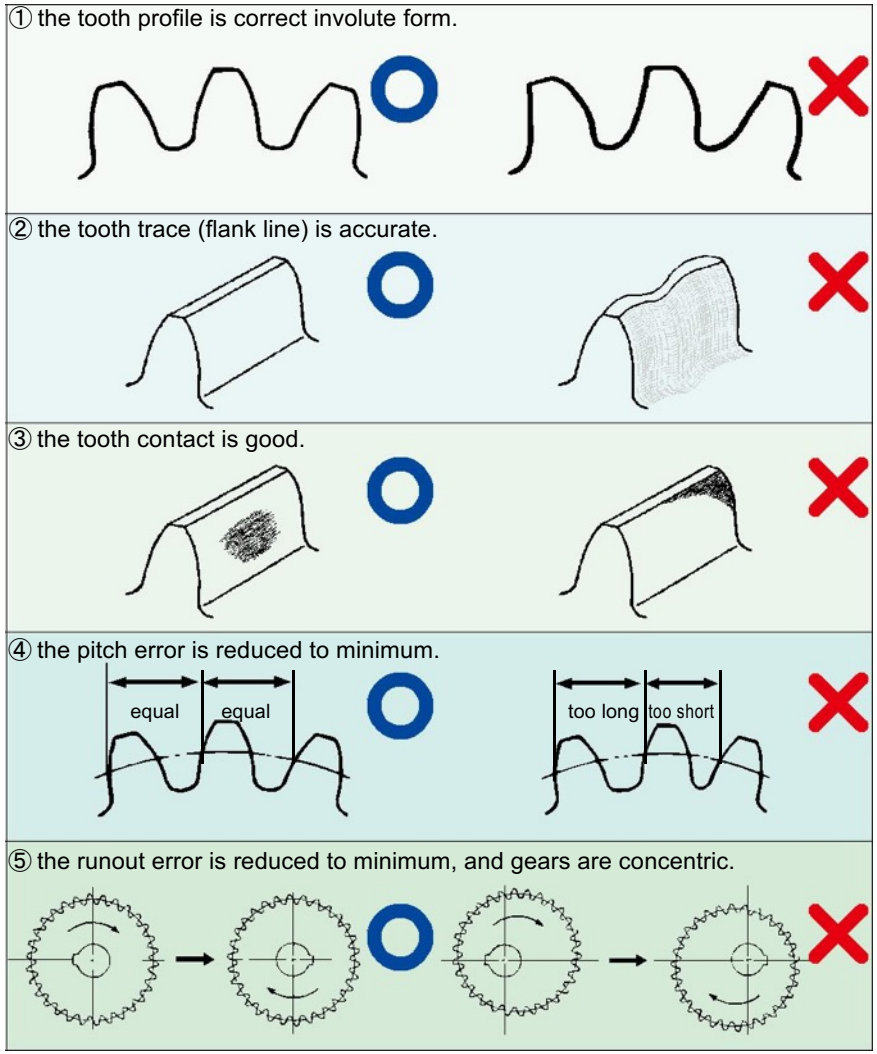
In making gears it is important to establish tolerance requirements appropriate for the application. So if gears with much higher strength are required, a suitable material must be chosen, and, if necessary, the material must be hardened. Also, the gears must be produced with higher accuracy. The material to be used and the accuracy are very important factors contributing to gear strength and quietness.





■ Accuracy

Quality gears must transmit power smoothly, with a minimum of vibration and noise. To make gears as quiet as possible, it is necessary that:



How to Make Gears

Let's get familiar with the way gears are made. Are you with me?

■ Gear cutting of helical gears with gear hobs

Gear hobs are shaped like a screw. This photo shows that the teeth of a helical gear are being generated with the hobbing machine when the gear blank and the gear hob are meshed. In this same manner the gear cutting of spur gears and worm wheels is carried out.

Gear hob

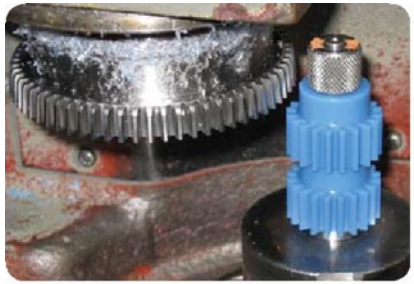
■ Gear cutting of racks with rack cutters

This photo shows that the gear cutting of racks is in progress with the rack cutter. Many teeth are cut at a time. Rack cutters, in the same way, handle gear cutting of helical racks.

Rack cutter

■Gear cutting of spur gears with pinion type cutters

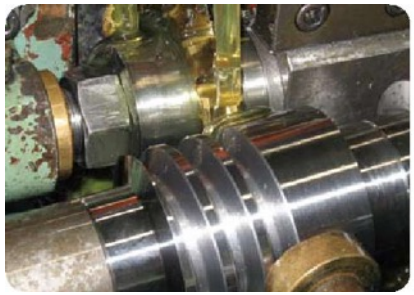
Pinion type cutters are shaped like a spur gear. These photos here show that the pinion type cutters are in operation. The pinion type cutters can also cut gear teeth of internal gears.



Pinion type cutter

■ Gear cutting of worms with worm cutters

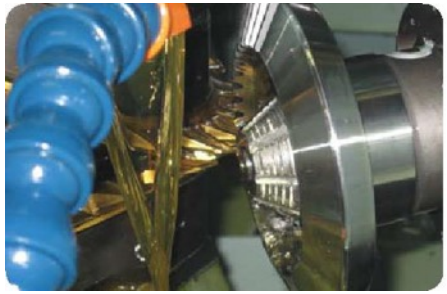
This photo shows that gear teeth of a worm are being generated with the worm cutter. The gear cutting is rather time-consuming. Worm cutters are common to milling cutters.



Worm cutter

■Gear cutting of straight bevel gears with Coniflex cutters

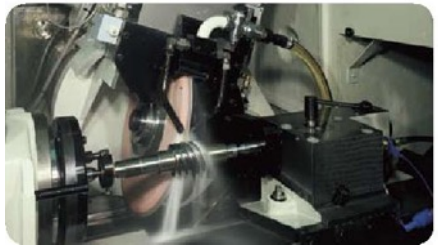
The gear cutting is being done with a set (the upper cutter and the lower cutter)of Coniflex cutters. Coniflex cutters produce gear teeth of accurate tooth contact. So the gears made with Coniflex cutters operate quietly.



Coniflex cutter (the lower cutter)

■ The grinding of worms with single-rib grinding wheels

A single-rib grinding wheel, rotating at a very high speed, is smoothing the gear teeth of a worm to increase their accuracy.



Single-rib grinding wheel

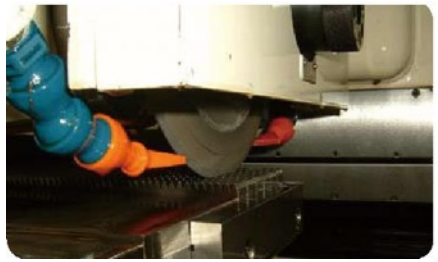
■ The grinding of helical gears with threaded grinding wheels

The gear teeth of a helical gear are being ground with a threaded grinding wheel. The grinding e ciencies are good because of its multiple threads. Spur gears can be ground in the same way with the threaded grinding wheels.

Threaded grinding wheel

■ The grinding of racks with single-rib grinding wheel

The grinding of a rack is being carried out in the room where temperature is kept at 20℃. Grinding wheels are shaped like a discus. The grinding of high quality racks requires a special technique and know-how.



Single-rib grinding wheel

Marshall Engg works is a custom gear manufacturer that specializes in all types of industrial gear cutting. Our factory is one of the largest Gear Hobbing machine setup of its kind in India consisting of 45 Gear hobbers and machine tools - so all your machining, gear cutting and related operations can be done under one roof.

If you have a gear and have no information on it, we can help. Marshall has the knowledge and equipment to help you with any of your gear manufacturing needs.

Gear Cutting Capabilities

Gear Type	Diameter / Length	Face Width	Module / D.P
Spur	3600 mm	1250 mm	50 M / 1 D.P
Helical Gears	3600 mm	1250 mm	32 M
Double Helical	3600 mm	1250 mm	32 M
Worm Gear Wheel	3600 mm	1250 mm	32 M
Sprockets	3600 mm	1250 mm	2.5 CP
Crown Gears	1600 mm All Types of Crowning.	1250 mm	20 M
Splines & Spline Shafts	3600 mm / 3000 length	1250 mm	2.5 " Pitch
Internal Gears	Less than 10 M – 1600 mm More than 10 M 3000 mm	800 mm	20 M

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