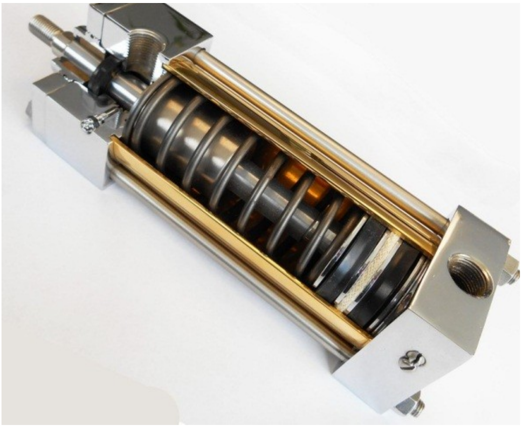
Spring (device)



By

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Introduction

- A spring is a device that changes its shape in response to an external force, returning to its original shape when the force is removed.

- In classical physics, a spring can be seen as a device that stores potential energy, specifically elastic potential energy, by straining the bonds between the atoms of an elastic material.

- Elasticity is the property of materials to return to their original size and shape after being deformed (that is, after the deforming force has been released).

- Common examples of current spring usage range from tiny coils that support keys on cellular phone touchpads to enormous coils that support entire buildings and protect them from earthquake vibration.

History

- Simple non-coiled springs were used throughout human history, e.g. the bow (and arrow).

- More sophisticated spring devices date to the Bronze Age, when eyebrow tweezers were common in several cultures.

- During the third century B.C., Greek engineer Ctesibius of Alexandria developed a process for making "springy bronze" by increasing the proportion of tin in the copper alloy, casting the part, and hardening it with hammer blows. He attempted to use a combination of leaf springs to operate a military catapult, but they were not powerful enough.

- During the second century B.C., Philo of Byzantium, another catapult engineer, built a similar device,

History

- Coiled springs appeared early in the 15th century, in door locks. The first spring powered-clocks appeared in that century and evolved into the first large watches by the 16th century.

- In 1676 British physicist Robert Hooke discovered Hooke's law which states that the force a spring exerts is proportional to its extension.

- In the eighteenth century, the Industrial Revolution spurred the development of mass-production techniques for making springs.

Classification

epending on the load force:

- **Tension/extension spring** – the spring is designed to operate with a tension load, so the spring stretches as the load is applied to it.
- **Compression spring** – is designed to operate with a compression load, so the spring gets shorter as the load is applied to it.
- **Torsion spring** – unlike the above types in which the load is an axial force, the load applied to a torsion spring is a torque or twisting force, and the end of the spring rotates through an angle as the load is applied.
- **Constant spring** - supported load will remain the same throughout deflection cycle..
- **Variable spring** - resistance of the coil to load varies during compression..

Classification

Depending on the shape:

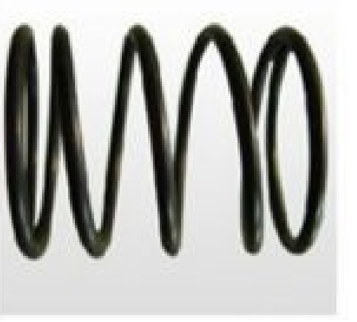
- **Coil spring** – this type is made of a coil or helix of wire.

- **Flat spring** – this type is made of a flat or conical shaped piece of metal.

- **Machined spring** – this type of spring is manufactured by machining bar stock with a lathe and/or milling operation rather than coiling wire. Since it is machined, the spring may incorporate features in addition to the elastic element. Machined springs can be made in the typical load cases of compression/extension, torsion, etc.

- **Serpentine spring** - a zigzag of thick wire - often used in modern furniture.

e examples of different types of springs:

Cylindrical Spiral Extension Spring	Cylindrical Spiral Compression Spring	Conical Spiral Compression Spring	Cylindrical Spiral Torsion Spring	Pressure Spring
				
Ring Spring	Belleville Spring	Volute Spring	Plate Spring	Mold Spring
				

Making

Raw materials:

- **Steel alloys** are the most commonly used spring materials. The most popular alloys include high-carbon (such as the music wire used for guitar strings), oil-tempered low-carbon, chrome silicon, chrome vanadium, and stainless steel.

- Other metals that are sometimes used to make springs are **beryllium copper alloy**, **phosphor bronze**, and **titanium**.

- **Rubber** or **urethane** may be used for cylindrical, non-coil springs.

- **Ceramic material** has been developed for coiled springs in very high-temperature environments. **One-directional glass fibre composite** materials are being tested for possible use in springs.

Making

teps involved in manufacturing process:

Coiling

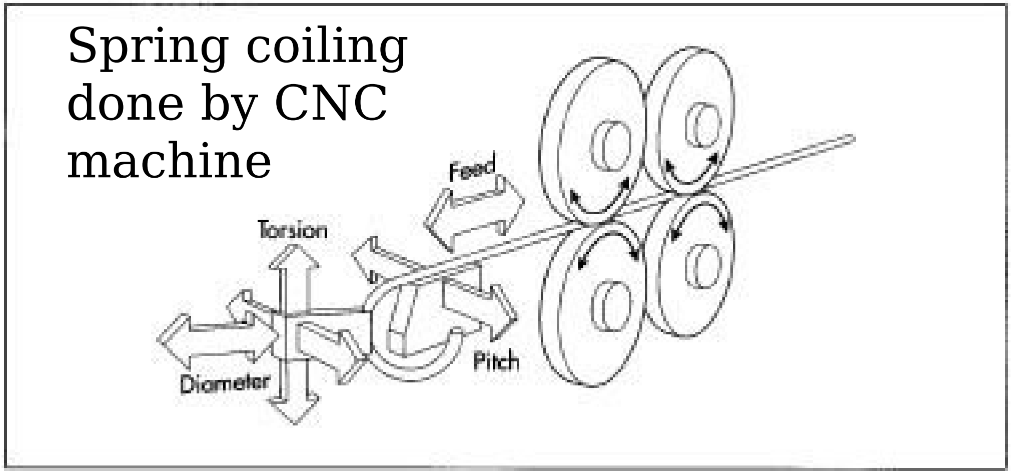
1. **Cold winding**
2. **Hot winding**

Hardening

3. **Heat treatment**

Finishing

4. **Grinding**
5. **Shot peening**
6. **Setting**
7. **Coating**



Spring coiling done by CNC machine


Hot wound coil spring

Hooke's law:

As long as they are not stretched or compressed beyond their elastic limit, most springs obey Hooke's law, which states that the force with which the spring pushes back is linearly proportional to the distance from its equilibrium length.

$$\mathbf{F = -k\,x}$$

where

x is the displacement vector – the distance and direction the spring is deformed from its equilibrium length.

F is the resulting force vector – the magnitude and direction of the restoring force the spring exerts.

k is the rate, spring constant or force constant of the spring, a constant that depends on the spring's material and construction.

The negative sign indicates that the force the spring exerts is in the opposite direction from its displacement

imple harmonic motion :

Since force is equal to mass, *m*, times acceleration, *a*, the force equation for a spring obeying Hooke's law looks like:

$$F = m\,a \;\rightarrow\; -k\,x = m\,a$$

Since acceleration is the second derivative of x with respect to time:

$$-k\,x = m\,(d^2x/dt^2)$$

This is a second order linear differential equation for the displacement as a function of time:

$$(d^2x/dt^2) + (k/m)\,x = 0$$

Solutions are:

$$x(t) = A \sin\left(t\sqrt{(k/m)}\right) + B \cos\left(t\sqrt{(k/m)}\right)$$

A and B are arbitrary constants

imitations of Hooke’s law:

- This law actually holds only approximately, and only when the deformation (extension or contraction) is small compared to the rod's overall length. For deformations beyond the elastic limit, atomic bonds get broken or rearranged, and a spring may snap, buckle, or permanently deform.

- Many materials have no clearly defined elastic limit, and Hooke's law can not be meaningfully applied to these materials.

- Moreover, for the super elastic materials, the linear relationship between force and displacement is appropriate only in the low-strain region.

Reference

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THANK YOU

Leaf spring on a truck

Volute spring

A heavy-duty helical spring designed for compression and tension