

LECTURE 3

Springs

1. Introduction

Springs are defined as an elastic body, whose function is to distort when loaded and to recover its original shapes when the load is removed. For instance, in the safety valve shown in Fig. 1, the compressed spring holds the valve against the seat with a certain effort(force). If the steam pressure exceeds this effort, the valve will rise and compress the spring thus releasing the steam and preventing a pipeline breakdown.

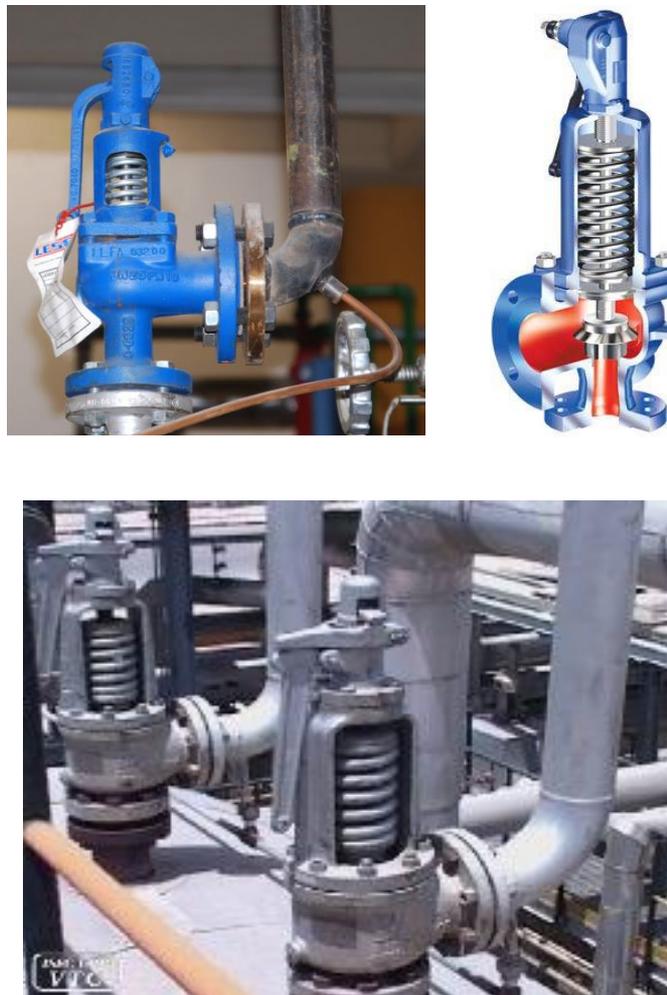


Fig. 1 Safety Valves.

Springs are widely used in machines, instruments, devices and installations for various purposes.

1.1 Application of springs

- Reduction of transmitted forces as a result of impact or shock loading as in car springs in car suspension system, railway buffers, aircraft landing gears.
- Control of motion in machines by maintaining contact between two elements as in cams and followers.
- Apply forces, as in breaks, clutches and spring-loaded valves.
- Storage of energy as in watches, toys.
- Measurement of force, as in engine indicator

1.2 Spring Shapes

According to their shape, springs are divided into

- Cylindrical (Fig. 2a)
- Conical (Fig. 2a) is used in special applications where a spring with a spring rate that increases with the load is desired.
- Laminated (Fig. 2c) is used in suspension systems.



Cylindrical



Conical



Leaf

Fig. 2 different Spring Shapes.

Cylindrical and conical springs are formed by winding wire into a helix which may be left- or right hand (Fig. 3).

2. Common Types of Springs

Though there are many types of springs, yet the following, according to principle of operations, are important from the subject point of view, as follows:

- a. Compression Spring
- b. Tension Spring
- c. Torsion Spring
- d. Leaf Spring

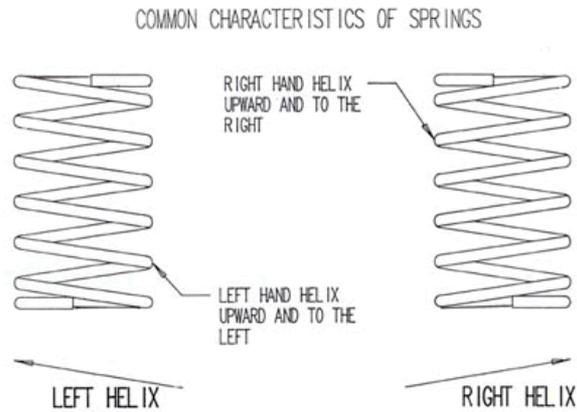


Fig. 3 Different Spring Shapes.

Helical Compression	Helical Tension	Helical Torsion	Leaf Spring

Fig. 4 Different Spring Types and their Symbols.

2. Helical Springs

The helical springs are made up of a wire coiled in the form of a helix. Depending on the kind of load helical springs are classified into compression (Fig. 4) and tension (Fig. 4) springs.

Spring turns may have round, square, or rectangular cross sections (Fig. 5).

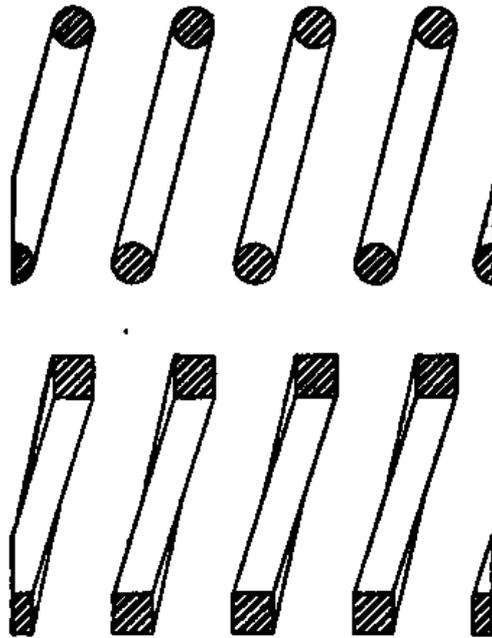


Fig. 5 Different Spring Wire Cross Sections.

The helical springs have the following advantages:

- Easy to manufacture
- Available in wide range.
- Reliable
- Constant Spring Rate
- Their characteristics can be varied by changing dimensions

2.1 Helical Compression Springs

Helical compression springs are used in several applications such as Safety valves, Car suspension system as shown in Fig. 6.

2.1.1 Helical compression Spring Ends

The end turns of a compression springs are modified to provide a supporting surface at the ends.

The spring ends types (Fig. 7) are

- Plain end: Least expensive - Tends to bow sideways under load
- Plain and ground end: Better mating conditions being flat - Likely to get entangled in storage
- Squared end
- Squared and ground end

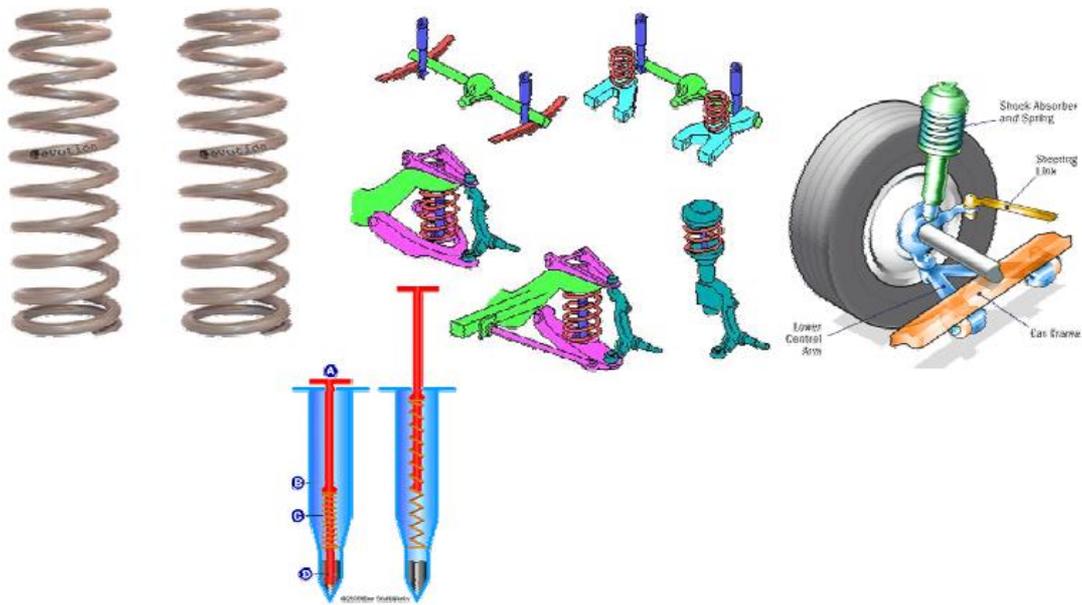


Fig. 6 Helical Compression Spring Application.

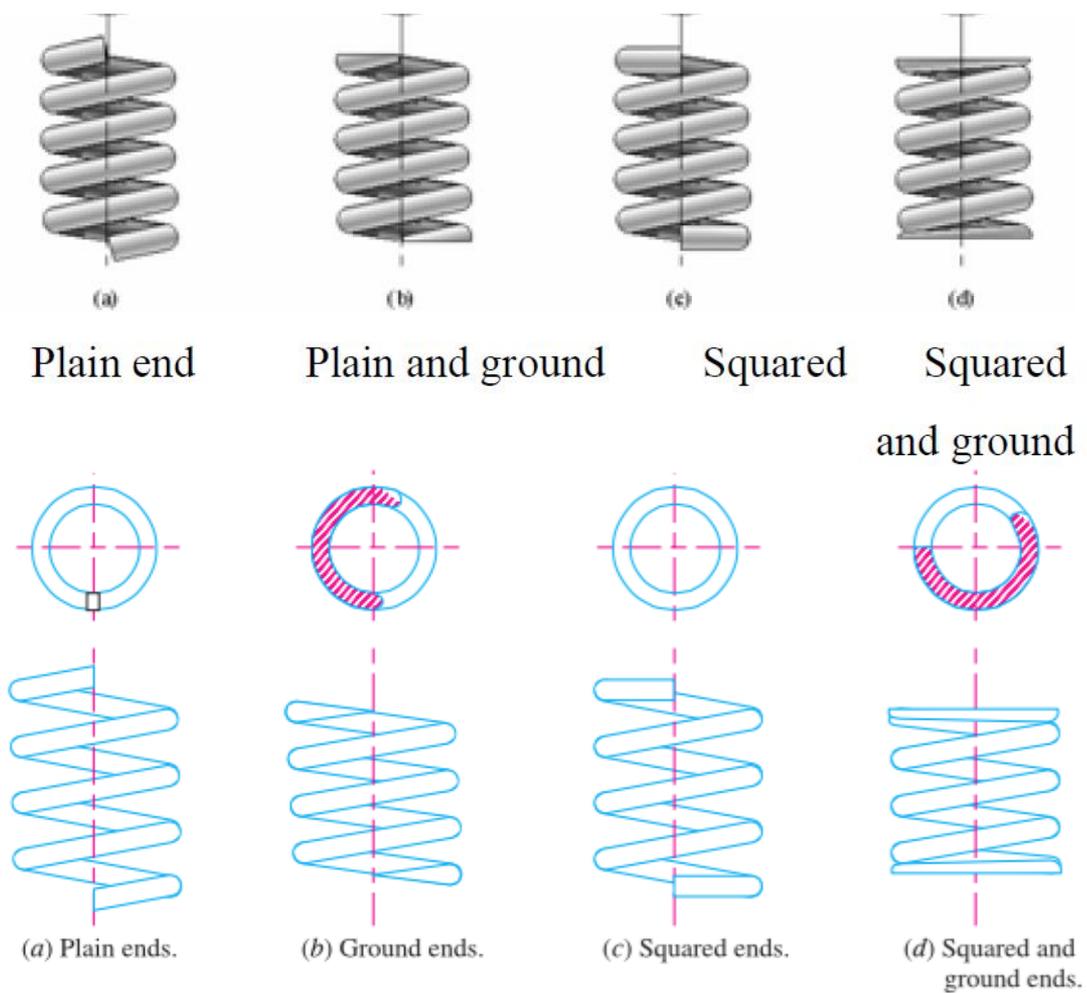


Fig. 7 Helical Compression Spring Ends

2.1.2 Helical Compression Spring Drawing

Although springs are not considered as fasteners, the method of representing them is closely related to the drawing of screw threads. The projection of the springs are conventionalized by using straight lines instead of helices (Fig. 7) or cross sections of coils (Fig. 8).

Shown in Fig. 7 is a non sectioned view of a helical compression spring. Fig. 8 and 9 show a section and a half section of the elevation of a helical compression spring; respectively. Fig. 10 shows a plan of a helical compression spring.

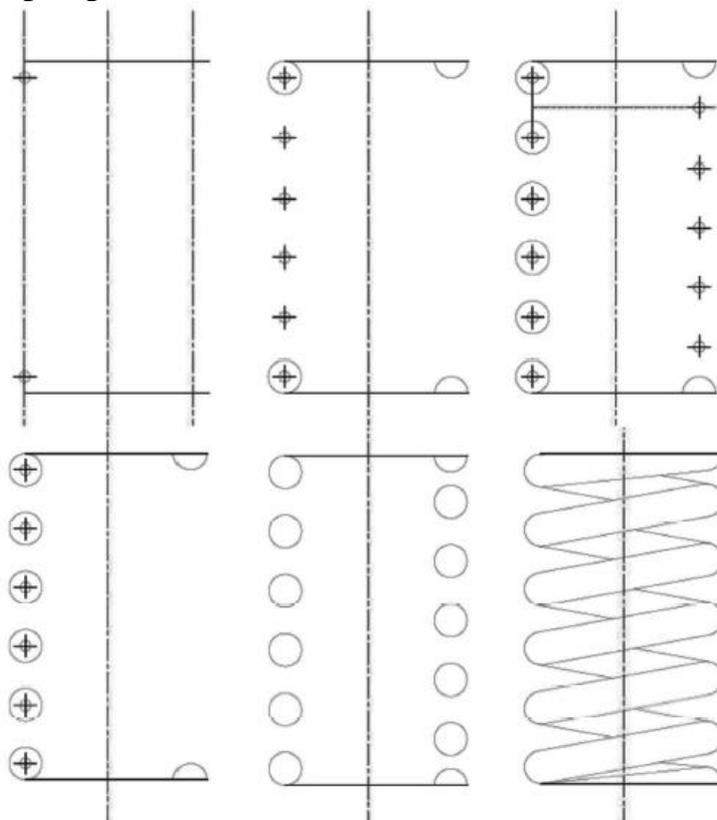


Fig. 7 Helical Compression Spring Drawing.

Section view

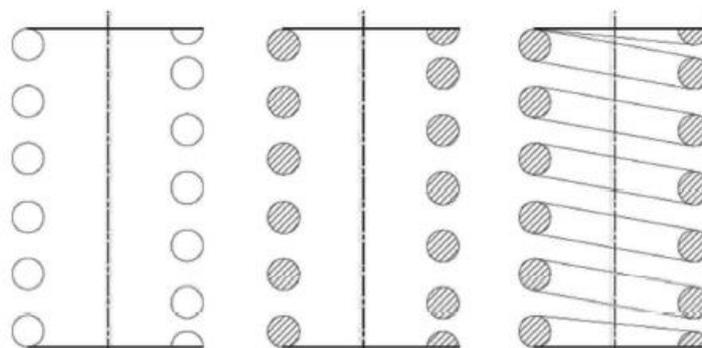


Fig. 8 Helical Compression Spring Drawing.

Half section

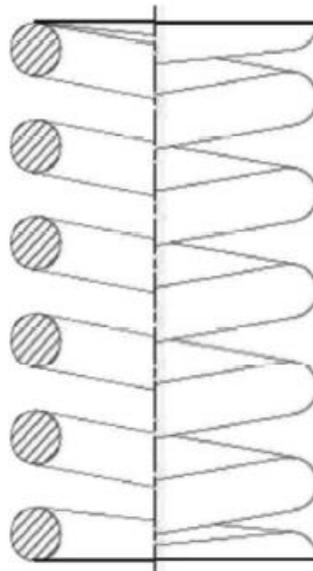


Fig. 9 Helical Compression Spring Drawing.

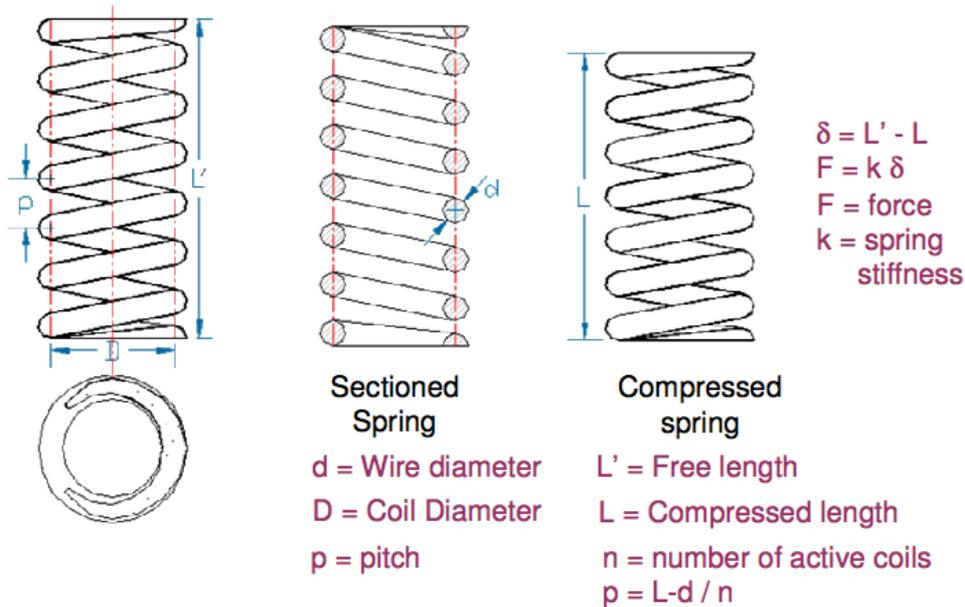


Fig. 10 Helical Compression Spring Drawing.

2.1.3 Helical Compression Spring Design

The most important parameters (Fig. 11 and 12) in the helical compression spring design and selections are

- Outside diameter, OD
- Inside diameter, ID
- Mean diameter, D_m

- Wire diameter, D_w
- Pitch, P : The distance from center to center of the wire in adjacent active coils in uncompressed state
- Spring Rate: (k) is the load required per unit deflection of the spring.

$$\text{Spring Rate} = \frac{\text{Load}}{\text{Deflection}}$$

- Free length, L_f : is the length of the spring in the free or unloaded condition.
- Solid length, L_s : When the compression spring is compressed until the coils come in contact with each other, the the spring is said to be solid.

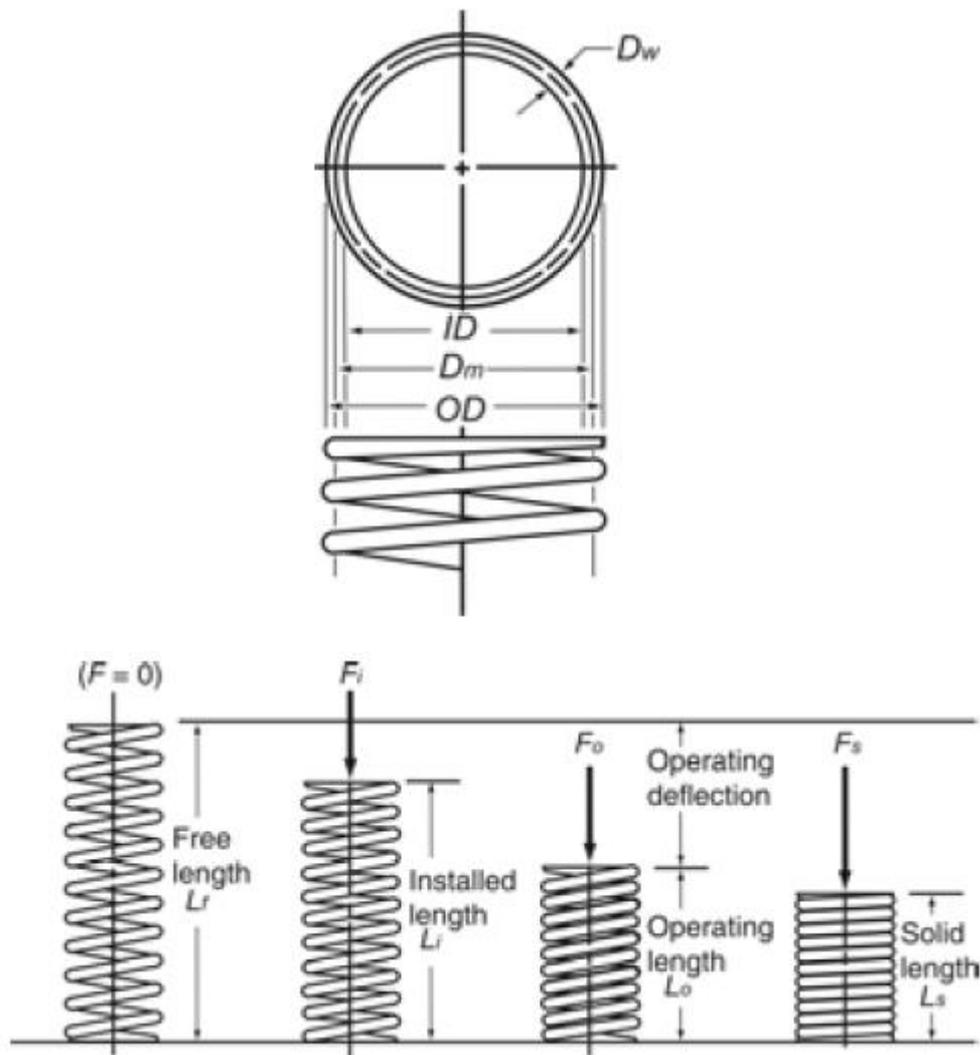


Fig. 11 Helical Compression Spring Terminologies.

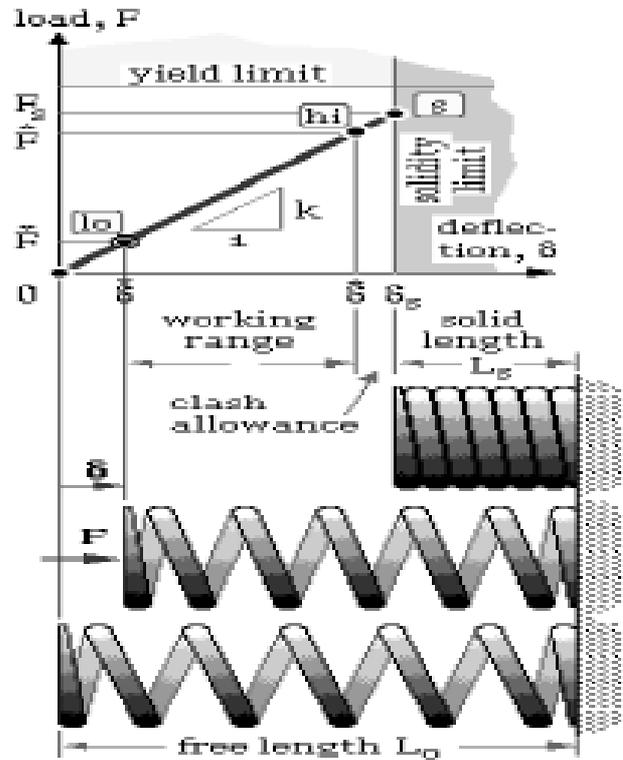


Fig. 12 Helical Compression Spring Terminologies.

2.2 Helical Tension Springs

Helical tension springs are similar to compression springs and manufactured with each winding touching the adjacent winding with a preset residual load (Fig. 13).

The tension spring are provided with hooks or loops as shown in Fig. 14 and 15. These loops may be made by turning a whole coil or half of the coil.



Fig. 13 Helical Tension Spring.

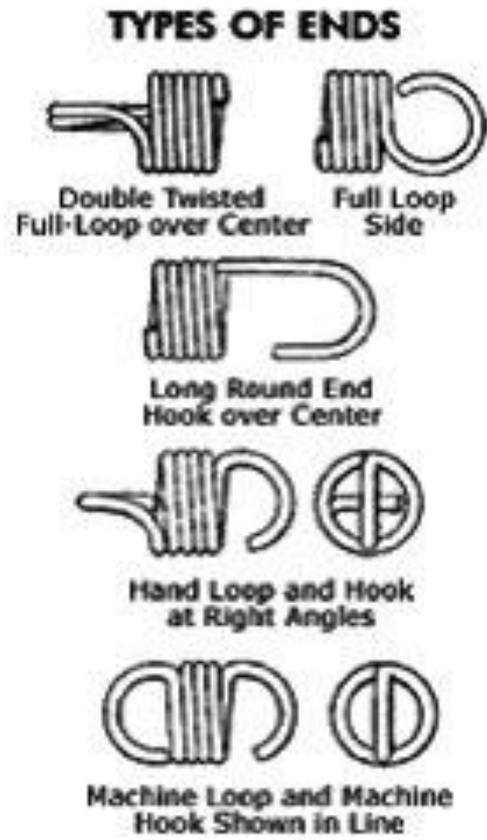


Fig. 14 Helical Tension Spring Ends.

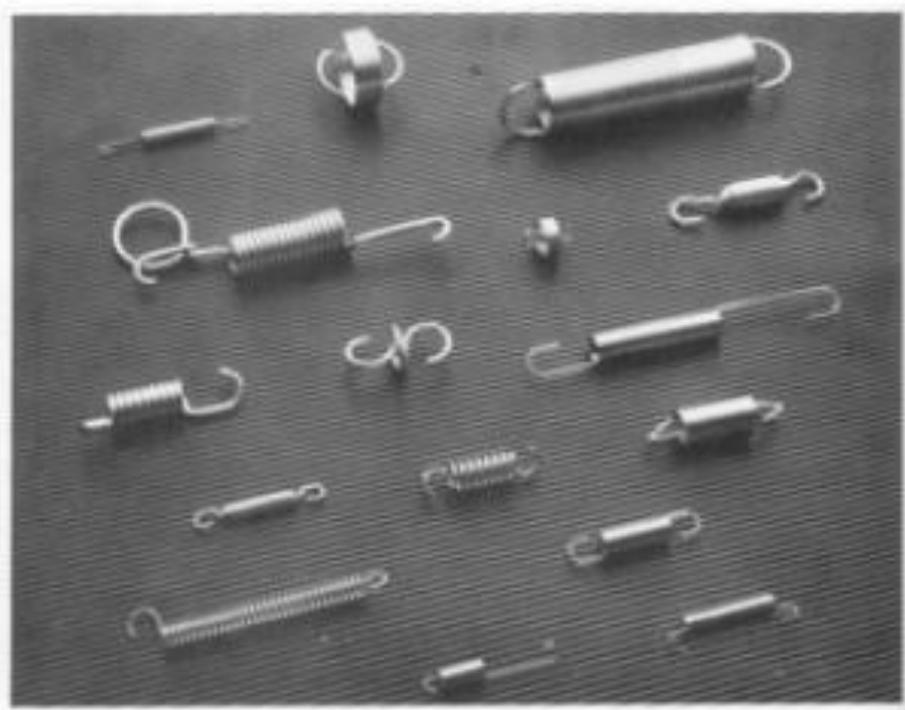


Fig. 15 Helical Tension Spring Ends.

3. Torsion Springs

The torsion spring function is to resist turning motion. The spring might be of helical or spiral type as shown in Fig.16. The spiral type is made from flat strips and used in watches and clocks.



(a) Helical torsion spring.

(b) Spiral torsion spring.

Fig. 16 Torsion Spring Types.

4. Helical and Torsion Spring Materials

The material of the spring should have high fatigue strength (should be able to be subjected to as many load cycles), high ductility.

- Carbon Steel
- Music Wire Steel
- Stainless Steel
- Phosphor bronze
- Copper or nickel based alloys - Light-duty springs

5. Helical Spring Manufacturing

Springs with wire diameter up to approx. 0.4 mm to 25 mm are usually cold wound. Hot forming shall be used for the production of heavily loaded springs of greater sizes with a wire diameter from 18mm to 56 mm. Compression springs are usually made of wires and rods of round section. Springs of rectangular wire are most often used in applications where low constructional height of the spring is required together with relatively high load.

6. Leaf Springs

The leaf spring consists of a number of flat plates of varying lengths held together by means of clamps and bolts, as shown in Fig.15. These are mostly used in truck suspension system. The material used for leaf springs is usually plain carbon steel



Fig. 15 Leaf Spring.