UNIT-IV Design of Energy Storing Elements

Session -1

**Objective:** To understand what is energy.

 To introduce energy storing elements.

www.data4design.co.uk/PDF's/Springs%20text.pdf

**Recap**: Recall all the forms of energy and energy storing methods

**SPRING PPT and Board Explanation**

Spring is an elastic body whose function is to distort when loaded and to recover its original shape when the load is removed.

**APPLICATION OF SPRINGS**

* To apply forces as in brakes, clutches and spring loaded valves.
* To store energy as in watches, toys.
* To measure forces as in spring balance and engine indicators.
* To cushion, absorb or control energy due to either shock or vibration as in car.

**TYPES OF SPRINGS**

* Helical springs
* Conical and volute spring
* Torsion spring
* Laminated or leaf spring
* Disc or bellevile spring
* Special purpose spring

**HELICAL SPRINGS**

The helical springs are made up of a wire coiled in the form of helix and are primarily intended for tensile or compressive loads. The cross section of the wire from which the spring made may be circular, square or rectangular. The two forms of helical springs are compression spring and helical tension springs.



**TERMS USED IN COMPRESSION SPRING**

**SOLID LENGTH**

When the compression spring is compressed until the coils come in contact with each other the spring is said to be solid. The solid length of a spring is the product of total number of coils and the diameter of the wire.

LS=n’\*d

n’- total number of coils d- diameter of the wire **FREE LENGTH**

It is the length of the spring in the free or unloaded condition. It is equal to the solid length plus the maximum deflection or compression of the spring and the clearance between the adjacent coils.

LF=n’\*d+δmax+0.15 δmax

**SPRING INDEX**

It is defined as the ratio of the mean diameter of the coil to the diameter of the coil to the diameter of the wire.

C=D/d

D- mean diameter of coil d- diameter of wire SPRING RATE

It is defined as the load required per unit deflection of the spring. q=P/y

P- applied load

y- deflection of the spring

**PITCH**

The pitch of the coil is defined as the axial distance between adjacent coil in uncompressed state.

Pitch length=free length/(n’-1)

**Conclusion &Summary:** Recallthe energy storing elements(Springs) and its parameter.

Session -2

**Objective:** To understand stresses induced on spring wire.

‎ nptel.iitm.ac.in/courses/IIT-MADRAS/Machine\_Design\_II/.../4\_3.pdf

**Recap:** Recall the basics parameters of helical springs

**STRESSES IN HELICAL SPRING PPT and Board Explanation**

Consider a helical compression spring made of circular wire and subjected to an axial

load W

Maximum shear stress induced in the wire  *Ks*  8  *W*  *D*

 -----------

 *d* 3

Ks- Shear stress factor

When the springs are subjected to static loading the effect of wire curvature may be neglected because yielding of material will relive the stresses. In order to consider the effect ofboth direct shear as well as curvature of the wire wahl’s stress factor is introduced.

Maximum shear stress introduce in wire = *K*  8  *W*  *D*



*d* 3

Where

*K*  4*C*  1  0.615

4*C*  4 *C*

**DEFLECTION OF HELICAL SPRING OF CIRCULAR WIRE**

8  *W*  *D* 3  *n y* 

*Gd* 4

**STIFFNESS OF SPRING (or) SPRING RATE**

*q*  *W/*

 *Gd* 4

 8*D* 3 *n*

****

**Conclusion &Summary:** Conclude the session by recalling the stresses induced on wires

Session -3

**Objective:** To understand stresses induced on spring wire.

nptel.iitm.ac.in/courses/IIT-MADRAS/Machine\_Design\_II/.../4\_3.pdf

**Recap:** Recall the basics parameters of helical springs

**STRESSES IN HELICAL SPRING PPT and Board Explanation**

**Springs in series:** When two or more springs are arranged in series as shown. in fig, their equivalen

Stiffness is given by 

 

Where,

Q1 — Stiffness of first spring.

Q2 — Stiffness of second spring.

Qequ — Stiffness of the equivalent spring. Fig. Springs in series

Springs in parallel:

 

When two or more springs are arranged in parallel and subjected to load P. Their equivalent stiffness is given by

**Where,**

Fig Springs in parallel

Q and q - Stiffness of the spring.

Qeqv — Stiffness of the equivalent spring.

**Light service:**

It consists of operation under essentially static conditions and where the maximum load is carries infrequently i.e. a total of less than i000times. Examples are safety valves, slip coupling and bolted joints.

**Average service**:

It includes springs subjected to the maximum load 1000 to 100000 times during service life. Example: engine governor springs. Automobile suspension springs used in circuit breaker mechanism.

**Severe service:**

It consists of a large number of cycles i.e. Greater than one million of varying load where the maximum load is one-half or less of the maximum load. Example: automotive valve springs.

**Conclusion &Summary:** Conclude the session by analyzing springs position in series and parallel with the help of formule.

Session -4

**Objective:** To improve problem solving skill spring

**Recap**: Recall all the parameters and formulae with help of data book.

Tutorial Problem: **Board Presentation**

From university question bank solve simple problems on open coil and closed coil springs

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in springs

Session -5

**Objective:** To understand stresses induced on concentric springs.

elearning.vtu.ac.in/12/enotes/Des\_Mac-Ele2/Unit3-RK.pdf‎

**Recap:** Recall the basics parameters of helical springs

**CONCENTRIC SPRINGS PPT and Board Explanation**

Concentric helical springs are used to obtain a greater spring force in a given space and to ensure the operation of a mechanism in the event that one spring will break. To obtain the above conditions, either a two- spring nest or a three-spring nest may be used. Fig. Shows the two concentric springs have the same free length and arc compressed equally. Such springs are used for automobile clutches and railway clutches. To obtain a spring force which does not increase in a direct relation to the deflection, but it increases faster; concentric springs are made of different lengths as shown in fig.

 

 

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in concentric springs.

Session -6

**Objective:** To understand what is leaf spring.

 To know the function of leaf springs

elearning.vtu.ac.in/12/enotes/Des\_Mac-Ele2/Unit3-RK.pdf‎

**Recap**: Recall all the forms of energy and energy storing methods

**LEAF SPRING PPT and Board Explanation**

The laminated or leaf spring consists of a number of flat plates of varying lengths held together by means of clamps and bolts. These are mostly used in automobiles.



2L1- length of span (or) overall length of spring

l-width of band (or) distance between centers of U bolt, ineffective length of springh effective length of spring 2L=2L1-L

Length of smallest l*eaf= Effectivel ength  ineffectiv elength n  1*

*Length of next leaf= Effectivel ength  2  ineffectiv elength n  1*

Length of master leaf=2L1+π(d+t)\*2

Bending stress in the spring

  6*WL*

*b nbt* 2

Deflection in the leaves

6*WL*3

 

*nEbt* 3

**Conclusion &Summary:** Recallthe leaf spring elements

 and its parameter.

Session -7

**Objective:** To design disc springs.

www.data4**design**.co.uk/PDF's/**Springs**%20text.pdf

**Recap:** Recall the concepts energy storing elements and introduce disc springs

**DESIGN OF BELLE VILLE SPRINGS Board Presentation**

Belleville springs or Disc springs arc used where space limitations require high capacity units i.e. Applications requiring high spring stiffness and compact spring units. This is obtained at the expense of thickly non-uniform stress distribution across the section. High Stresses are used in the design of Belleville springs. Each spring consists of several annular discs that arc dished to a conical shape as in fig (a). There are staked up one on top of another as in fig. (b) In order to increase the deflection. 

The unit may be held in alignment by a central bolt or a tube. The springs placed in series as shown in fig. (c) and the deflection is proportional to the number of discs. The springs are placed in parallel as shown in fig. (b) and has the high load capacity, which is depend on number of discs. When the load is applied uniformly around the edge, the relation between applied load P and axial deflection is given by equation.



Where, P Applied load

Y Deflection of each disc

1 Thickness of disc

D —outside diameter of disc

V Poison’ s ratio

H -Free height of truncated cone

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in disc springs

Session -8

**Objective:** To improve the problem solving skill leaf spring

**Recap**: Recall all the parameters and formulae with help of data book.

Tutorial Problem: **Board Presentation**

From university question bank solve simple problems on Leaf springs

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in

 Leaf springs

Session -9

**Objective:** To analyse concentric springs

elearning.vtu.ac.in/12/enotes/Des\_Mac-Ele2/Unit3-RK.pdf‎

**Recap**: Recall all the parameters and formulae of coil spring with help of data book.

**CONCENTRIC SPRINGS** **Board Presentation**

Concentric helical springs are used to obtain a greater spring force in a given space and to ensure the operation of a mechanism in the event that one spring will break. To obtain the above conditions, either a two- spring nest or a three-spring nest may be used. Fig. Shows the two concentric springs have the same free length and arc compressed equally. Such springs are used for automobile clutches and railway clutches.

To obtain a spring force which does not increase in a direct relation to the deflection, but it increases faster; concentric springs are made of different lengths as shown in fig



Let

P — Axis load

D — Mean coil diameter of outer spring

D — Wire diameter of outer spring

N — Number of active coils in outer spring.

—Length of outer spring



**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in Leaf springs

Session -10

**Objective:** To design Belleville springs.

www.**bellevillesprings**.com/‎

**Recap:** Recall the concepts energy storing elements and introduce disc springs

**DESIGN OF BELLE VILLE SPRINGS Board Presentation**

Belleville springs or Disc springs arc used where space limitations require high capacity units i.e. Applications requiring high spring stiffness and compact spring units. This is obtained at the expense of thickly non-uniform stress distribution across the section. High Stresses are used in the design of Belleville springs. Each spring consists of several annular discs that arc dished to a conical shape as in fig (a). There are staked up one on top of another as in fig. (b) In order to increase the deflection 

The unit may be held in alignment by a central bolt or a tube. The springs placed in series as shown in fig. (c) and the deflection is proportional to the number of discs. The springs are placed in parallel as shown in fig. (b) and has the high load capacity, which is depend on number of discs. When the load is applied uniformly around the edge, the relation between applied load P and axial deflection is given by equation.



Where, P Applied load

Y Deflection of each disc

1 Thickness of disc

D —outside diameter of disc

V Poison’ s ratio

H -Free height of truncated cone

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in disc springs

Session -11

**Objective:** To know the flywheel.

 To design the flywheel

my.safaribooksonline.com/book/.../19-**flywheel**/ch19\_sub19\_4\_xhtml

**Recap:** Recall the concepts energy storing elements and introduce the elements flywheel

**DESIGN OF FLYWHEEL PPT and Board Explanation**

A flywheel used in machines serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement and release it during the period when the requirement of energy is more than supply.



Figure 4.3 Turning moment diagram for single cylinder double acting steam engine

The fluctuation of energy may be determined by the turning moment diagram for one complete cycle of operation. Consider a turning moment diagram for a single cylinder double acting steam engine. The vertical ordinate represents the turning moment and the horizontal ordinate represents the crank angle. a little consideration will show that the turning moment is zero when the crank angle is zero. It rises to maximum value when crank angle reaches 90° and it again zero when crank angle reaches 180°. This is shown by curve abc in figure and it represents the turning moment for outstroke. The curve cde is turning moment diagram for in stroke and is somewhat similar to the curve abc. The work done is the product of turning moment and angle turned, therefore the area of the turning moment diagram represents the work done per revolution.

The difference between the maximum and minimum speeds during a cycle is called the maximum fluctuation of speed. The ratio of the maximum fluctuation of speed to the mean speed is called coefficient of fluctuation of speed.

*N*1  *N* 2

1

2*N*1  *N* 2 

Coefficient of fluctuation of speed

*CS* 

*N*

 *N*

 *N* 2 

  

*C*  1 2

*S* 

 21  2 

1  2 

in terms of angular speeds

*C*  *v*1  *v*2

*S v*

 2*v*1  *v*2 

*v*1  *v*2 

in terms of angular velocity

Maximum fluctuation of energyΔE= maximum energy-minimum energy

coefficent of fluctuation of energy CE 

work done per cycle=Tmean\*θ

max *imumfluctuationofene rgy workdonepercycle*

θ =angle turned in radians per revolution

=2π in case of stream engine and two stroke I.C engine

=4π in case of four stroke I.C engines energy stored in flywheel rim

    

Maximum fluctuation of energyΔE=*I* 2  1 2  = *I* 2 *C*

 *mk* 2 2 *C*

 2*EC*

   *S S S*

k may be equal to mean radius of rim(R) because the thickness of rim is very small as compared to the diameter of rim substituting k=R

ΔE= *mR*2 *C*

2

*S*

2

 *mv CS*

Mass of the flywheel rim *m*  2*RA*

A=b\*t

b-width of rim , t- thickness of rim

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps

solving in flywheel

Session -12

**Objective:** To improve the problem solving skill flywheel

**Recap**: Recall all the parameters and formulae with help of data book.

Tutorial Problem: **Board Presentation**

From university question bank solve simple problems on flywheel

**Conclusion &Summary**: Recall the session by summarizing the formulae and steps solving in flywheel