

# Design Analysis of Spring and Cam Follower Mechanism

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**Abstract** - When we think to convert rotary motion into linear or oscillatory, we think of many mechanisms like slider crank mechanism but the problem is we cannot use it everywhere and the world needs such mechanisms which is widely used and has an extensive application. Such one is cam follower. The Cam and follower mechanism are widely used for inlet and exhaust valves of internal combustion engines (IC engine). It is also used in wall clocks and the feed mechanism of automatic lathe machines. They are used in paper cutting machine and weaving textile machinery. Now the major question arises why we study cam follower and why we use springs in cam follower? This paper discusses about basic details of cam follower and its simulation in CATIA(V5) followed by finite element analysis of spring and its application in cam follower. After reading the paper, the reader will understand:

- Basics of cam follower
- Applications of cam follower in Industry
- Design of Spring & its application in cam follower
- Calculations and Analysis of spring

**Key Words:** CAM Shaft, Knife Edge, Ansys, Roller Follower, Spring

## 1. INTRODUCTION

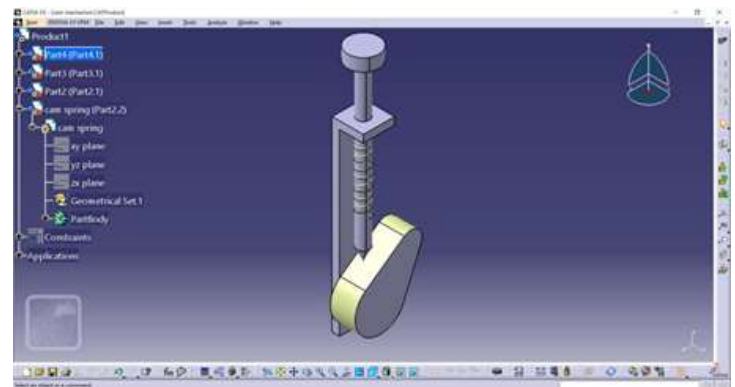
A Cam is a mechanical device used to transmit motion to a follower by direct contact. The driver is called the cam and the driven member is called the follower. In a cam follower pair, the cam normally rotates while follower may translate or oscillate. A familiar example is the crankshaft of an automobile engine, where the cams drive the push rods where push rods are followers to open and close the valves in synchronization with the motion of pistons. Design of cam is difficult and tough job for a design engineer as each and every competitor in industry market always looks for the better performance of mechanical system. So, a designer has to look for objective of mechanism, where it can be used, suitable material, suitable dimensions and its calculations and the most important is to how to apply the cam follower mechanism innovatively. This is all about the introduction of cam follower. Now let us look into application of spring in cam follower. Springs are flexible machine elements used to primarily to deflect under load with the ability to return to its original shape when unloaded. Springs are designed to provide a push, a pull or a torque. They are also designed to store energy, measure a force, or absorb shocks and

vibrations. Springs are used to apply force and control motion. Now the question arises who maintain the contact between cam and follower? Here the function of spring plays an important role. In cam follower mechanism, the spring is used to maintain contact between the cam and the follower. The springs are also used in places where the cam follower mechanism is used. During the impact loading of structural member, springs are connected with structural member to absorb some amount of energy so that the failure of structural member can be avoided. Since places where cam follower mechanism used are always associated with high stresses and fluctuating loads, the spring withstand external load and provide sufficient buckling strength. This is all about the introduction of spring.

## 2. BASICS OF MECHANISMS

### 2.1 Cam Follower

Fig-1



First of all, I would like to throw light on Catia model which is prepared for cam follower mechanism. Here this model is prepared keeping in mind the main objective. Here the main objective is to convert the rotary motion into translation motion. Here the main components which are first prepared individually and assembled later on are-

1. CAM, 2. CAM Shaft, 3. Support Base plate, 4. Spring

Here material used for CAM is fabric material. The honey comb pattern type fibre is given for aesthetic sense. The material which is used for Cam Shaft is steel which is a ductile material and base plate is also made up of same material. The mechanism here is again simple. The Cam is the driver which is undergoing rotary motion and the follower is the driven part which is undergoing translation motion. The spring is also connected to maintain the contact

between Cam and follower. I have tried to use closely coiled helical spring which is extensively used in many places and style of end as we can observe is plane and ground end.

i.e.  $N=N(t)-0.5$ ; where N denotes number of active coils and  $N(t)$  denotes total number of coils

The spring gets compressed and it is acting as compressed helical spring.

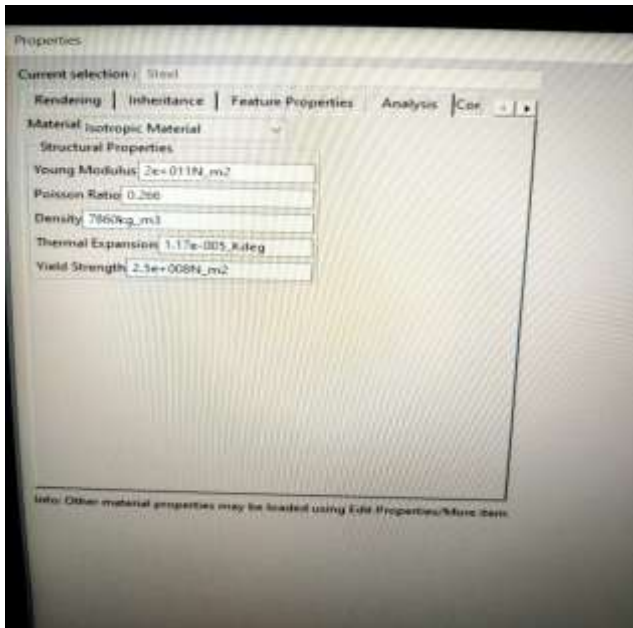


Fig-2: Material Properties of Mechanical Model

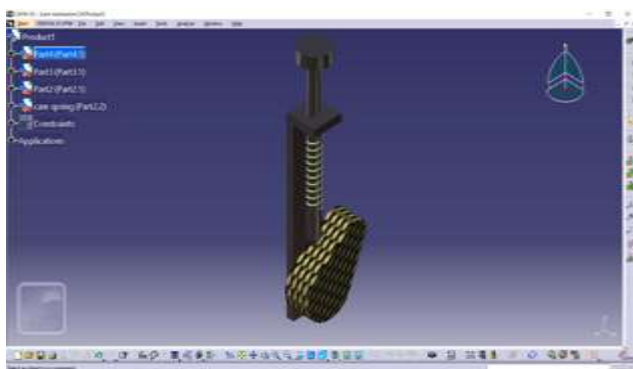


Fig-3: Model of CAM Follower Mechanism with Materials

Now It is important to know the different types of Cam:

**1.Disk Cam:** The disk cam has an irregular contour to impart a specific motion to the follower. The follower moves in a plane perpendicular to the axis of rotation of the camshaft and is held in contact with the cam by springs or gravity.

**2.Cylindrical Cam:** The cylindrical cam has a groove cut along its cylindrical surface. The roller follows the groove, and the follower moves in a plane parallel to the axis of rotation of the cylinder.

**3. Translating Cam:** The translating cam is a contoured or grooved plate sliding on a guiding surface. The follower may oscillate or reciprocate. The shape of the groove is determined by the specified motion of follower.

**Types of Followers:**

**1.Based on surface in contact:**

- (a)Knife edge follower(b) Roller follower
- (c) Flat faced follower(d) Spherical follower

**2.Based on type of motion:**

- (a) Oscillating follower(b) Translating follower

**Based on line of motion:**

- (a)Radial follower: The lines of movement of in-line cam followers pass through the centres of the camshafts.
- (b)Off-set follower: For this type, the lines of movement are offset from the centres of the camshafts

**2.2 Spring**

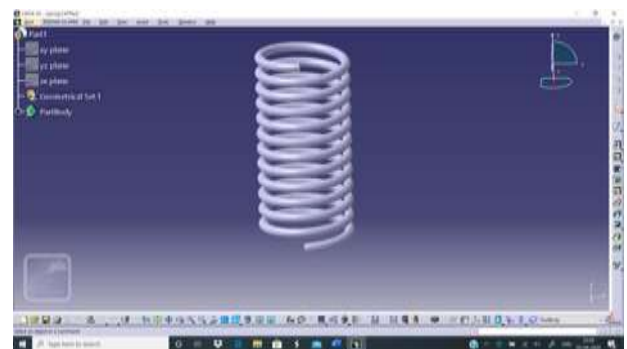


Fig-4: Spring model in CATIA V5

One of the most important job of the design engineer is to design a spring such that it can withstand fluctuating as well as constant load. The above one is the magnified image/model of spring that I have designed keeping in all the manufacturing considerations. The design is as follows: the material used for spring is structural steel and type of spring used is compressed helical spring. The style end of spring is plane and ground end. The spring is compressed and direct and torsional shear stress will be produced which is maximum at inner side of spring coil. The results are verified in Ansys software by doing FEA. Spring index is chosen such that it lies in between 4-12 from manufacturing consideration (i.e. the ratio of D/d). 50 N load is applied on spring during Cam mechanism and total number of turns of coils are taken as 12.

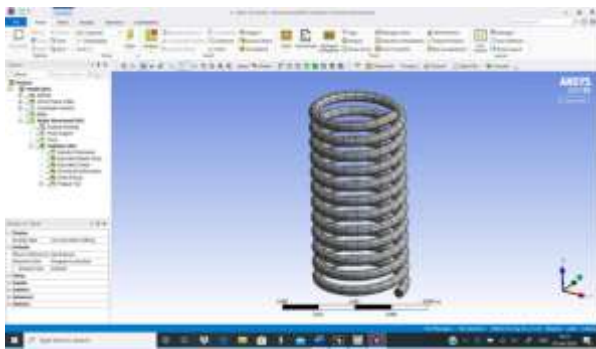


Fig -5: Analysis of Spring in ANSYS

Mesh is generated and then added the boundary conditions like fixed support and magnitude of force applied. Then Ansys results are generated.

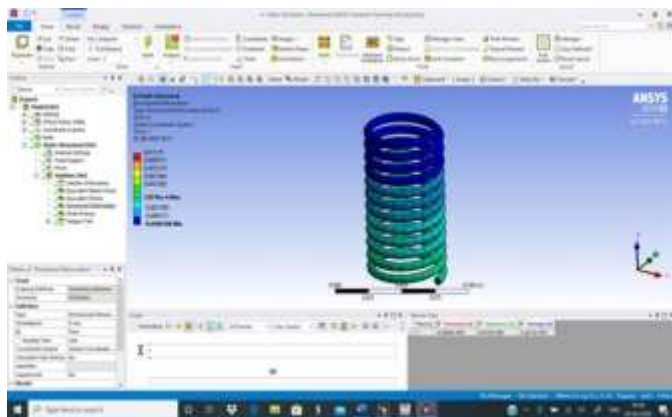


Fig-6: Deformation Simulation

Below one is the stress simulation which is carried out in ANSYS software:

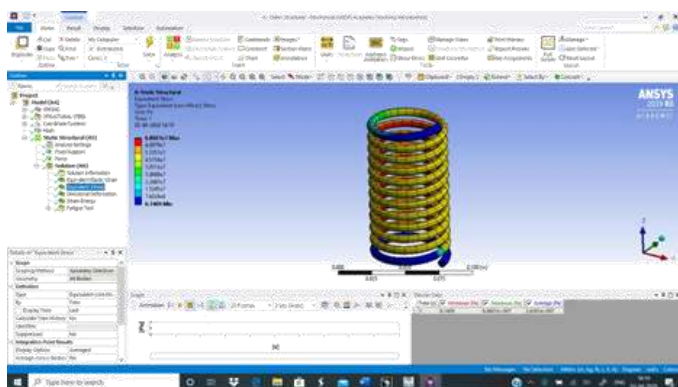


Fig-7: Stress Simulation

### 3. DESIGN CALCULATION OF SPRING KEEPING MANUFACTURING CONSIDERATION NORMS

**\*\*Here symbols have their usual meanings**

$P=50N$ ,  $G=7.6923e10$  Pascal,  $N= 11.5(12-0.5)$ ,  $D=54$  mm,  $d=6mm$

$\Delta$  (Deflection in Helical spring) =

$$\frac{(64.P* R^3*N)}{(G. d^4)} \dots\dots (1) \text{ (for closely coiled helical spring)}$$

$\Delta= 7.1$  mm..... (calculated result)

Ansys result = 6.83 mm

% error= 3.8%

T (Maximum stress developed in spring) =

$$[16.P.R/ (\pi. d^3)]. [(4C-1/4C-4) +0.615/C] \dots (2)$$

$C=D/d=9$ ..... (3)

Putting all above values, we will get,

$T= 73$  MPa.....(calculated)

Ansys result=69 MPa

% error =5.4%

E (strain energy) =  $0.5 \times P \times \Delta = 0.1775J$ .....(calculated)

Ansys result=0.1645J

% error=5.6%

There is a very small percentage of error that gives us idea that we always ignore some conditions while determining results but the software computes accurate result. Factor of safety is calculated by software and it is coming that **preferable FOS value should be 3.916 and its range is 1.2565 - 15.**

### 4. RESULTS

Following are some results based on structural analysis on spring on the application of force: 50N

Object Name	Equivalent Elastic Strain	Equivalent Stress	Directional Deformation	Strain Energy
Min	3.447e-010 m/m	6.1409 Pa	-6.8368e-003 m	7.8686e-016 J
Max	3.445e-	6.8601e+00	2.8516e-	1.2168e

	004 m/m	7 Pa	006 m	-004 J
Average /	1.8914e-004 m/m	3.6381e+007 Pa	-3.2675e-003 m	0.16545 J
Total strain energy				

**Table-1**

## 5. APPLICATIONS OF CAM FOLLOWER IN INDUSTRY

Although Cam follower is used in Automotive Industry mainly in IC engine, it is used to drive fuel pumps. It also helps in achieving even distribution of forces in a single machine component. By attaching a cylindrical roller in a machine component spontaneous movement can be achieved by an engineer. Cam Follower absorbs higher amount of shock that increases that increases mechanical efficiency of machine component. Central lock and ordinary lock system can also be developed by incorporating the mechanism of Cam and follower.

## 6. CONCLUSION

According to Cam Follower Mechanism the spring is designed with perfect dimensions and suitable factor of safety to avoid any failure due to impact load or fluctuating load. This paper discusses mainly about constant load acting on spring, how the Cam Follower mechanism is useful in Industry and also for small purposes and role of spring in the mechanism.

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## BIOGRAPHIES



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