Vol II Issue X

ISSN No : 2230-7850

Monthly Multidiciplinary
Research Journal

Indian Streams Research Journal

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RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

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Indian Streams Research Journal
Volume 2, Issue.10,Nov. 2012
ISSN:-2230-7850
Available online at www.isrj.net

ORIGINAL ARTICLE

"ESTIMATION OF VIBRATION RESPONSE OF CAM AND FOLLOWER MECHANISM"

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Abstract:

In several industries so many processing machines are used. These machines are the combinations of several mechanisms .A cam and follower is one such mechanism, which used in some of these machines. If the performance of cam and follower mechanism is affected by any failure, then the total performance of the machine will be hampered. The failure in the cam and follower mechanism is caused by so many factors. One of them is the induced vibration in the mechanism itself. Hence the objective of the present work is to estimate, the vibration response of a follower for cam and follower mechanism.

1.2 THE EFFECT OF VIBRATION ON CAM AND FOLLOWER MECHANISM

A cam and follower mechanism is generally used for various applications in an industry. Efficient working of this mechanism provides better performance of machine. One probable reason for the failure of this mechanism might be induced excessive vibration. The effect of excessive vibration in of this mechanism discussed below. (a)The vibration induced in a cam body provides additional fatigue load on bearing b1 and b2 (figure 1.1 B).(b) In worst case, the cam shaft will get bent. (c) The vibration follower provides additional cycling force to a spring K. If the action of force is continued for long time then the spring get fails. (d) In worst case the follower body will get bent.

1.3: GENERAL MECHANICS OF VIBRATION INDUCED IN FOLLOWER OF CAM AND FOLLOWER MECHANISM

A cam - follower mechanism is shown in Figure 1.1. In this mechanism F is a follower, while C is a cam which rotates with uniform speed. Spring K is attached at the other end of follower. As cam C rotates with dwell period, The displacement of follower does not take place. When cam approaches for it outstroke rotation, the equilibrium of follower is being disturbed. Hence follower F moves from point a to a'. When cam approaches from its return stroke, during a rotation of a cam, the follower F moves returns down from a' to a. Thus complete one cycle of rotation of a cam provides one cycle of oscillation for follower F. If this follower motion is used for some useful work, then a process resistance can be applied to the other side of a follower. This process resistance offers at the follower end which provides a force on a cam surface through an pressure angle Φ. This force changes at every moment. Indeed, the cam also provides equal and opposite force to the follower body. This force is also time variant. During the rocking operation of a follower the follower body experiences additional forces such as (a) Inertia Force (b) Spring Force (c) Process Resistance (d) Weight. These forces are mainly responsible to induce a vibration in a follower body.

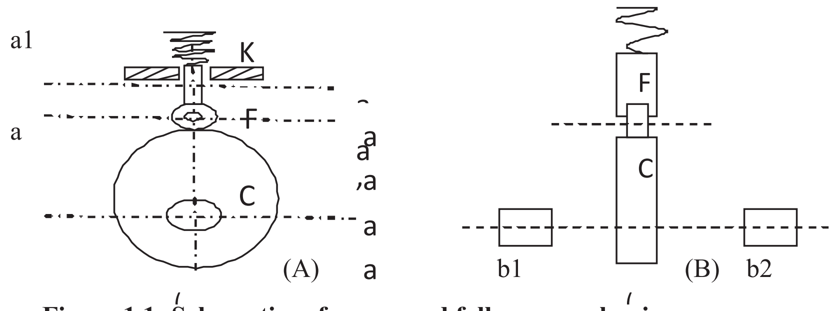


Figure 1.1: Schematics of a cam and follower mechanisms

1.4: AN APPROACH TO ESTIMATE OF VIBRATION RESPONSE OF A FOLLOWER IN CAM AND FOLLOWER MECHANISM

The estimation of vibration response of a follower is done like as under, For the pressing operation of rubber sheet a cam is designed by fixing the dwell period, outstroke period and return stroke period. Next to this a profile of a cam and displacement of a follower is constructed.The motion of cam is uniform acceleration and de-acceleration. The force pattern provided by cam on a follower is estimated during its outstroke and return stroke. The free body diagram (FBD) of a follower is considered for estimation of vibration of a follower. During the process of estimation, various forces has been taken into account such as (a) Inertia Force (b) Spring Force (c) Process Resistance (d) Weight. In addition to this, the load torque analysis is also done as matter of further interest.

1.6 A CASE STUDY OF PRESENT WORK

In this case study, the operation of pressing a rubber sheet is taken. For this case, a roller follower is considered. The specifications of follower and cam is detailed as under, (a)The roller diameter is 25 cm and the length of stem is 14 cm,(b)The stem diameter is 1 cm. (c) Diameter of disc 3 cm and length 3 cm.(d)The cylinder is 5 cm. In this cylinder the rubber material is placed, which is as shown in figure 1.2

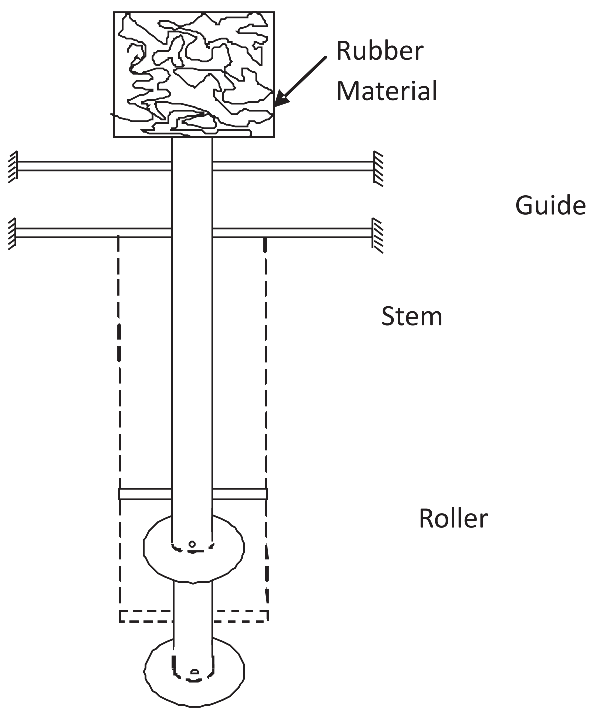


Figure 1.2: Schematic diagram of roller cam follower

The displacement diagram and cam profile for the present study are constructed. These diagrams are shown in figure 1.3 and figure 1.4

Cam shaft diameter 40 mm. least Radius of Cam 25 mm, Diameter of Roller 25 mm, Angle of Lift or Rise 1200, Angle of Follower fall 900, Lift of Follower 40 mm and Dwell 100 and 1400, during the lift motion is uniform acceleration and de- acceleration .

First draw the Displacement diagram

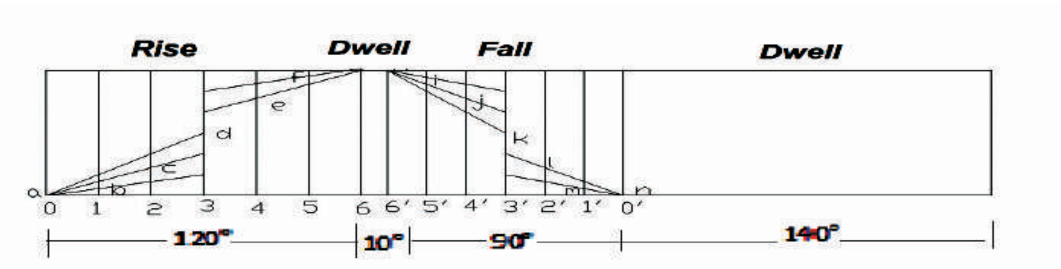


Figure 1.3: Schematic diagram the displacement of cam

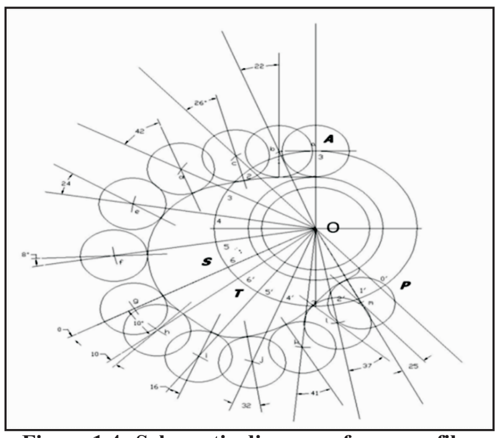


Figure 1.4: Schematic diagram of cam profile.

Figure 1.4: Schematic diagram of cam profile.

1.5: ESTIMATION OF PROCESS RESISTANCE

Procedure to calculate the process resistance is as follows,

First select the material of minimum elasticity which can easily compressed, when the follower displaces upward direction kindly see in Figure 4.1.In this case a rubber as a material for compressing is chosen.

For rubber material elasticity (E)= 110kgf/mm² .
:.E = 11,000 Kgf / cm² (From data book)

From figure 4.1 using following parameter and calculate the process resistance is thus estimated as, the strain induced in material can be calculated by following formula.

Strain=change in length / original length=4/5=0.8;
The original length =5cm, Final length=1/4 cm;
The corresponding stress by using following formula.
:. Stress=E*strain = 11000*0.8 =880 Kgf / cm²

One can estimate maximum force expressed by a stem on a rubber material by following formula

:. Maximum force =Stresses *Area =880*0.785*9 =6217.2 kgf =6200kgf
Now ,process resistance is divided into 12 equal parts which is shown Figure 4.4

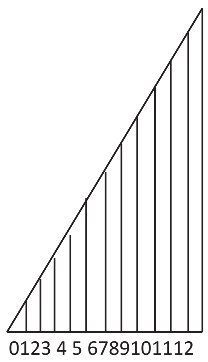


Figure1.5: Schematic diagrams for Process Resistance

SR. NO.	Forces(kgf)
0	0
1	516.66
2	1033.32
3	1530
4	*2066.66*
5	2583.32
6	3100
7	3616.66
8	4133.32
9	4650
10	5166.66
11	5683.32
12	6200

Table 1.1 For Process Resistance

1.6: ESTIMATION OF VOLUME, WHIGHT OF FOLLWER,ACCLERATION AND INERTIA FORCE

With the reference to Figure 4.1, one can estimate the following parameter.(a) volume of follower.(b)Mass of follower.(c)Inertia force on a follower.(d)Acceleration of follower
Volume of follower Equation can be estimated by using below stated formula.
Volume of stem $V1=\pi/4(d)^2*l=3.14/4*(1)^2*0.3=2.12$ cubic cm
Where d is diameter, l is length of stem
Volume of Disc $V2=\pi/4(d)^2*l=3.14/4*(3)^2*14=10.99$ cubic cm
Volume of Hemispherical $V3=4/3\ \pi(r)3=4/3\ \pi*(1)3=4.18$ cubic cm
Where r is radius of stem
:.Total Volume of follower =V1+V2+V3 = 2.12+10.99+4.18 =17.29 cubic cm.=20 cubic cm.
Weight of follower calculated by following formula.
Weight of follower=20*8 gm/cc=160 gms=0.16 kgf = 1.6 N
Acceleration of a follower can be calculated as follow

$S = ut \times (1/2) at^2$

Where S is a distance travel by follower, t is a time, a is acceleration of a follower
In present case rpm of cam is a running at 300 rpm
Therefore, 300 revolution = 60 second.
:. 1 revolution = 0.2 second = 200 millisecond.
We know that, 1 sec = 1000 millisecond.
:.For 360°revolution =200 millisecond.
:.For 60°revolution=33 millisecond.
Assume S=2 cm
:. T=0.03 sec.
One knows that $S = Ut * (1/2) at^2$

$0.02 = 0 * (1/2)(a)*(0.03)^2$

:. Acceleration (a)of follower=44.44 m/s²
Inertia force calculated by following formula

Inertia Force = (W/g) X a
= (0.16/9.81)X 44.44
:. Inertia force= 0.72 kgf

1.7: CONSIDER THE FREE BODY DIAGRAM (FBD) OF FOLLOWER FOR OUTSTROKE

The follower is a converted into a free body diagram in which various forces act. When a follower moves a distance of 0-20mm during outstroke in this phase acceleration act in upward direction. While the weight of follower, inertia force, process resistance, spring force and initial act in downward direction which is shown in figure 1.6.

(a)When follower approaches during outstroke from 0-20 mm.

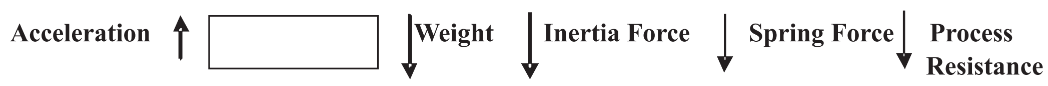


Figure 1.6: Free body diagram for follower which is approaches during outstroke from 0- 20mm
From the representation of FBD one can balance the force system by following way,
Total upward force by cam on follower during the direction of travel

=Weight + Inertia force + spring force + process resistance

F2 (3) = 0.16+0.72+K*0.5*2+3100

Where F_2(3) is a force is given by link 2 to link 3 i,e by cam on follower, k is a spring constant and x is displacement

When follower approaches during outstroke from 20-40 mm.

When a follower approaches for a distance 20-40mm,during outstroke .The inertia force act upward direction. While weight, spring force, acceleration act on a downward direction. In this case process resistance is negligible

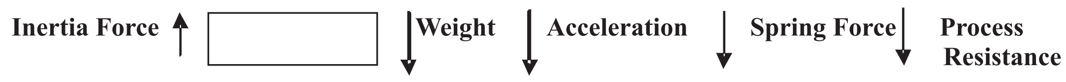


Figure 1.7: Free body diagram for follower which is approaches during outstroke from 20-40mm.
From the representation of FBD on can balance the force system by following way,
Total upward force by cam on follower during the direction of travel =
-Weight + Inertia force- spring force - process resistance
F2 (3) = 0.72-0.16+ (-K*X*0.5) – 6200/40
Where F_2(3) is a force is given by link 2 to link 3 i,e by cam on follower.

1.8: WHEN THE FOLLOWER APPROCHES DURING RETURN STROKE FROM 40-20 MM.(?)

Figure 1.8 : Schematic of FBD for follower during return stroke

From the representation of FBD one can balance the force system by following way,
Now calculate value of spring constant (K):-
Total upward force by cam on follower during the direction of travel=
-Weight + Inertia force- spring force - process resistance
F_2(3) =-0.16+0.72+ (-K*X*0.5)
In this condition assume, F_2 (3) = 0

– 0.16 – K (2)*0.5 + 0.72 = 0
- K (2)*0.5 – 0.56 = 0
:. Spring constant K=0.56 kgf/cm

1.9: Estimation of F_2 (3) for different angles of cam rotation during outstroke.
Cam rotation during outstroke(cam angle at 0°):-

When a cam is at 0°during outstroke, in this phase acceleration act upward direction. While the weight of follower, inertia force act downward in direction which is shown in figure 4.5(a).In this case spring force and resistance force is negligible

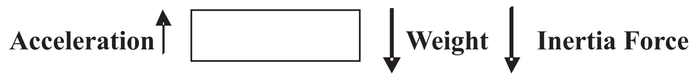


Figure 1.9: Cam rotation during outstroke(cam angle at 0°).

From the representation of FBD on can balance the force system by following way,
Total upward force by cam on follower during the direction of travel =
Weight + Inertia force + spring force + process resistance+ acceleration
:.F2 (3) = 0.72+0.16 = 0.88 Kgf.
Thus the further calculation is same as above whose answers given in table as shown for 20°,40°,60°,80°,100° and120°.

2.0: FORCE EXERTED BY CAM ON FOLLOWER ALONG LINE OF STROKE .

Thus the different force exerted at the variation of cam angle by cam on follower is in table 1.2.

ANGLE(θ)	FORCE F_2 (3)(KGF)	PRESSURE ANGLE(Φ)	FORCE ALONG COMMON NORMAL F_2 (3) X 1 / COSΦ
0°	0.88	0°	0.88
20°	1034.76	22°	1116.02
40°	2067.79	26°	2300.62
60°	3101.44	42°	4173.39
80°	4133.712	24°	4524.911
100°	5168.536	8.0°	5219.33
120°	6202	0°	6202

Table 1 .2.Force exerted by cam on follower along line of stroke.

2.1: ESTIMATION OF LOAD TORQUE FOR CAM ROTATION DURING OUTSTROKE.

The load torque is calculated by multiplying the F2 (3) force with the length of link arm moment. Refer Figure 2.1.The values of different load torque is given in the table 2.0.

SR. NO.	ANGLE(θ)	FORCE F_2 (3) (KGF)	LINK OF MOMENT(cm)	LOAD TORQUE(kgf - cm)
1	0°	0.88	L1=0.0	0
2	20°	1116.02	L2=1.6	1785.632
3	40°	2300.62	L3=2.0	4601.24
4	60°	4173.39	L4=3.8	15858.882
5	80°	4524.911	L5=2.8	12669.75
6	100°	5219.33	L6=0.8	4175.464
7	120°	6202	L7=0.0	0

Table 2.0 : Estimation of Load Torque for cam rotation during outstroke.

Figure 2.1

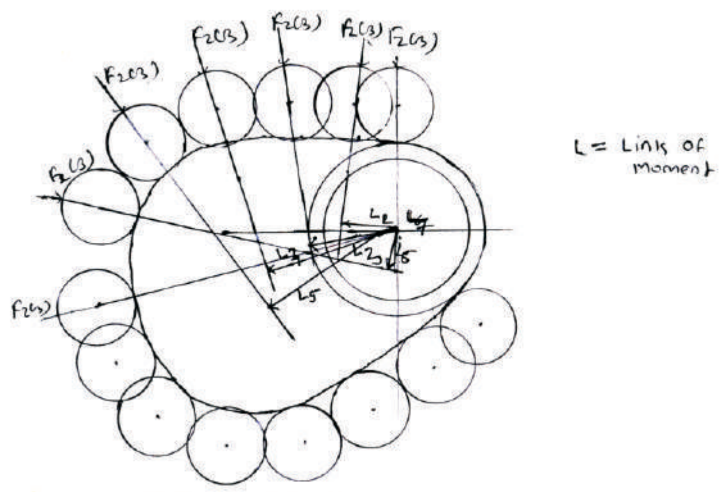


figure2.1: Schematics of a load applied by a follower on a cam during outstroke.

2.2: ESTIMATION OF $F_3(2)$ FOR DIFFERENT ANGLES OF CAM ROTATION DURING RETURN STROKE.

In this case cam rotation during return stroke $F_3(2)$ is a force is given by link 3 to link 2 i,e by follower on cam therefore the process resistance is negligible.

(A) Cam rotation during return- stroke.(cam angle at 130°):-

When a cam is at 130° during return stroke, in this phase inertia force act upward direction while the weight of follower,spring force act downward in direction and in this case process resistance is negligible which is shown in figure 2.2.

Inertia Force $\uparrow$ $\boxed{\quad}$ $\downarrow$ Weight $\downarrow$ Spring Force $\downarrow$ Process Resistance $\uparrow$

Figure 2.2:Cam rotation during return- stroke.(cam angle at 130°).

From the representation of FBD one can balance the force system by following way,
Total upward force by cam on follower during the direction of travel =
Weight + Inertia force + spring force + process resistance+ acceleration
:. $F_3(2)$ = Weight - Inertia force + spring force
$F_3(2) = 0.16-0.726+0.56*4 = 0.56$ kgf
Where, $F_3(3)$ is a force is given by link 2 to link 3 i,e by cam on follower, k is a spring constant and x is a displacement

Thus the further calculation is same as above whose answers given in table as shown for 145°,160°,175°,190°,205° and220°.

2.3: FORCE EXERTED BY CAM ON FOLLOWER ALONG LINE OF STROKE.

Thus the different force exerted at the variation of cam angle by cam on follower is in table 1.4

ANGLE(θ)	FORCE F_2 (3)(KGF)	PRESSURE ANGLE(Φ)	FORCE ALONG COMMON NORMALF_2 (3) X 1 / COSΦ
130°	0.56	10°	0.56
145°	0.504	16°	0.5243
160°	0.308	32°	0.3631
175°	0.0	41°	0.0
190°	-0.308	37°	-0.3856
205°	-0.504	25°	-0.5561
220°	0.16	0°	0.16

Table 1.4 : Force exerted by cam on follower along line of stroke.

2.4: ESTIMATION OF LOAD TORQUE FOR CAM ROTATION DURING RETURN STROKE.

The load torque is calculated by multiplying the f3(2) force with the length of link arm moment. The values of different load torque is given in the table 1.5

SR. NO.	ANGLE(θ)	FORCE F2(3) (KGF)	LINK OF MOMENT(cm)	LOAD TORQUE(kgf-cm)
1	130°	0.56	1.13	0.63
2	145°	0.5243	2.0	1.0486
3	160°	0.3631	3.8	1.379
4	175°	0.0	3.7	0.0
5	190°	-0.3856	2.7	-1.04112
6	205°	-0.5561	1.7	-0.945
7	220°	0.16	0	0.0

Table 1.5: Estimation of Load Torque for cam rotation during return stroke.

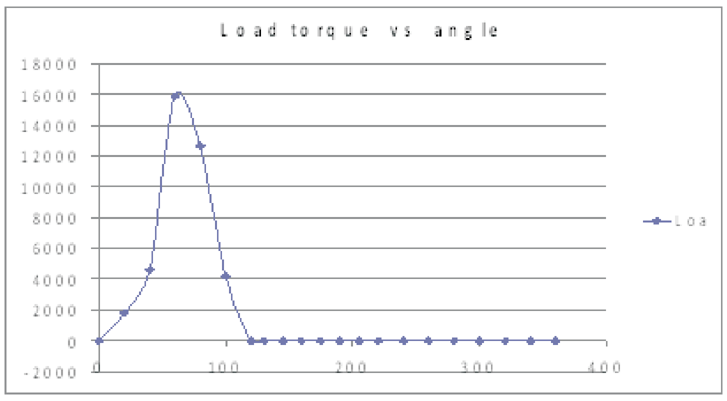
2.5: ESTIMATION OF POWER REQUIRTMENT:-

With the reference to Figure 2.3 one can estimate the power required to
drive the cam shaft.
Consider Triangle A1. Portion from the graph(figure 4.12)

A1=1/2*b*h = 0.5*20*π/180*1784.768 = 311.44 kgf –cm²
Trapezoidal A2=1/2*b*h+b*h =0.5*20*π/180*(4601.24-2816.42)+ π/180*20*(2816.22-0)
= 294.310 kgf –cm²
Same calculation for A3, A4,A5,A6,A7,A8,A9,A10,A11&A12 As above

A3=3570.28 kgf –cm² A4=4968.71 kgf –cm² A5=2944.71 kgf –cm²
A6=728.61 kgf –cm² A7=0.2744 kgf –cm² A8=0.3610 kgf –cm²
A9=0.1804 kgf –cm² A10=-0.1362 kgf –cm² A11=-0.247 kgf –cm²
A12=-0.1236 kgf –cm²
Total Area=18549.49 kgf –cm²

:. T mean=Total area/angle = 18549.49/ (π/180*360˚) = 2952.24 kgf-cm = 268.89 N-m
Power =T mean*ш
Assume speed N=120 r.p.m
power= T mean*2π*N = 3639kw
Now calculate Horse power
H.P.=3639/786 =4.87hp
Estimate H.P. motor requirement
85%mechanical efficiency and



2.6: ESTIMATION OF FLY WHEEL REQUIRTMENT

Now calculate fluctuation of energy ?E
From T-θ graph(Figure 4.11) calculate the total Area:-
Triangle ?1 = ½*(h*b)=1/2*(4601.24-2952.24)*(40-28)*Π/180
=172.68 kgf-cm
Triangle ?2=1964.44 kgf-cm
Triangle ?3=1112.99 kgf-cm
Triangle ?4=1407.95 kgf-cm
Triangle ?5= 64.04 kgf-cm

Rectangle□1=(12699.75-4601.24)*(80-60)Π/180=2826.37 kgf-cm

Rectangle□2=1751.51kgf-cm

:.Fluctuation of energy ?E= ?1+ ?2+ ?3+ ?4+?5+□1+□2
:. ?E= 9299.98 kgf-cm = 9.299*9.81 = 91.223 N-m
We know that ,
Fluctuation of energy ?E=I w2Cs
91.223=I*(2π*120/60)* 0.0225
:. Moment of inertia I= 322.64 kg-m2
Now estimate size of flywheel:-
Assuming mean diameter of flywheel(Dm)=0.9m
:.Radius of gyration= Dm/2 =0.9/2 = 450 mm
We know that,I=mk2 = 322.64 = m (0.45) 2
:.Weight of flywheel(m)= 1593.28 kg
Assuming cast iron of gravity 7.2(from data book p,n. 36).
:.Density (ρ)=7.2*103 kg/m3
Rim cross section of flywheel:-
Weight of flywheel(m)=Area*Length*Density = A*π*Dm*ρ
1593.28=A*3.14*0.45*7.2*1000
: Area A= 0.1566 m2 A=2h2 :.h=0.279 m2
If b=2h :.b=0.5596m
:.Flywheel diameter Do = Dm + h = 1.45m
Since the value of Do = 1.45m.
2.7: ESTIMATION OF VIBRATION RESPONSE OF A FOLLOWER OF CAM AND FOLLOWER MECHANISM.

The estimated force F2 (3) which is exerted by cam and follower is shown in figure 4.12

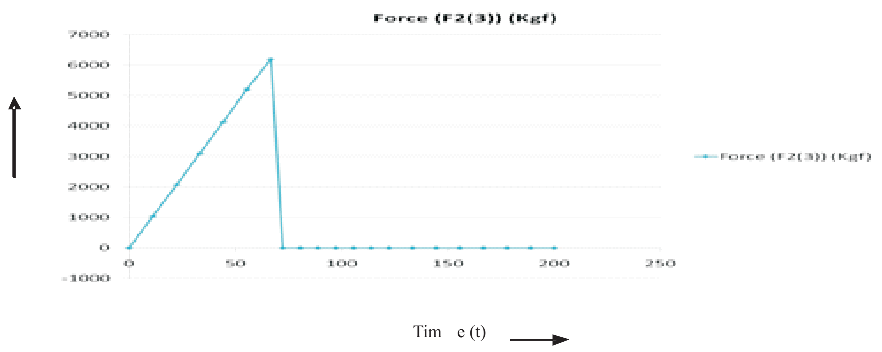
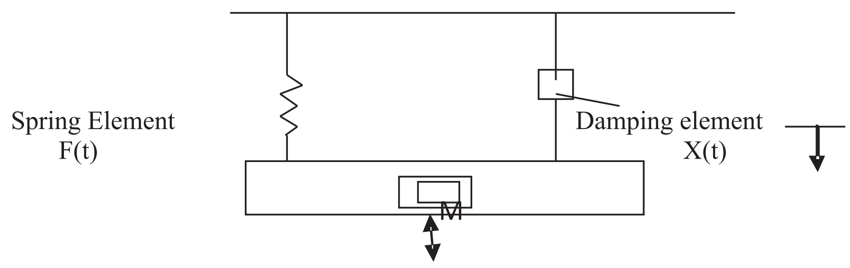


Figure 2.4: G raph between force F3(2) Vs tim e (t).

This force pattern is now useful for estimation of vibration response of a follower. Hence in view of this the total follower structure is considered as single mass single stiffness and single damper unit (Refer Figure 2.5). The mass of follower designated as m, while stiffness is designated as K, and damper is designated as C.

The derivation of governing equations for such a system is detailed under, If the system is subjected to vertical force, say f (t), then Newton's law of motion leads to the differential equation of motion in terms of the displacement as a function of time, x (t)



Figure(2.5): Schematic of representation of a column as a single mass degree of freedom.

$$m\frac{d^2x}{dt^2} \int c\frac{dx}{dt} \int kx(t) \int f(t) \quad ....(1.1)$$

m=mass k=spring stiffness C=damper element

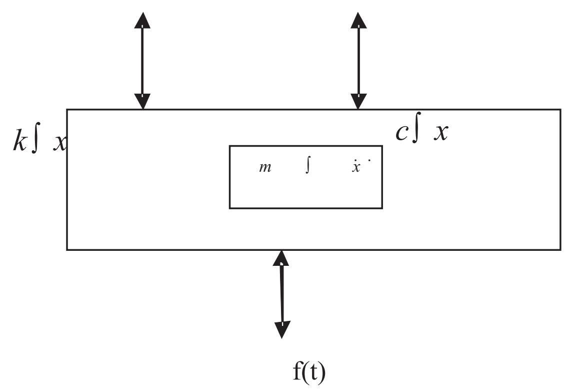


Figure 2.6: schematic of a Free body diagram.

One solution of governing equation can be obtained by following way
In many cases the vibrations are periodic like the case we are considering i.e. is the vibrations caused by

periodic excitation of follower. Here oversimplifying assumptions considered that follower experiences a periodic excitation. Any periodic function of time can be represented as an infinite sum of sine and cosine terms

If f(t) is periodic function with a period t its Fourier series representation is given by

$$f(t) = \frac{a_0}{2} + a_1 \cos\omega t + a_2 \cos 2\omega t + ... + b_1 \cos\omega t + b_2 \cos 2\omega t .....$$

$$= \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos n\omega t + b_n \sin n\omega t) \quad ....(1.2)$$

When $\omega = 2\pi/\tau$ is the fundamental frequency and $a_0, a_1, a_2, a_3, ...\ b_1, b_2, b_3...$, are constant coefficient. To determine the coefficients an and bn , we multiply Equation(4.1) by $\sin n\omega t$ and $\cos n\omega t$ respectively, and integrate over one period $\tau = 2\pi/\omega$ Then one notices that all terms except one on the right hand side of the equation will be zero and one obtain

$$a_0 = \frac{w}{\pi} \int_0^{2\pi/w} f(t)\,dt = \frac{2}{\tau} \int_0^{\tau} f(t)\,dt \quad ....(1.3)$$

$$an = \frac{w}{\pi} \int_0^{2\pi/w} f(t) \cos nwtdt = \frac{2}{\tau} \int_0^{\tau} f(t) \cos nwtdt \quad ....(1.4)$$

$$bn = \frac{w}{\pi} \int_0^{2\pi/w} f(t) \sin nwtdt = \frac{2}{\tau} \int_0^{\tau} f(t) \sin nwtdt \quad ....(1.5)$$

The physical interpretation of Equation (1.1) is that any periodic function can be represented as sum of harmonic functions. Though the series in an infinite sum one can approximate most periodic functions with the help of only a few harmonic function

```
%===============================================================
%
%Program4.m
%Main program which calls PERIOD
%
%===============================================================
%Run "Program4" in MATLAB command window. Program4.m and period.m
%should be in the same folder,and set the path to this folder
%following seven lines contain problem-dependent data
clc
clear all
xm=100.0;
xk=100000.0;
xai=0.1;
n=21;
m=20;
time=0.12;
f=[0.880000     1034.760000     2067.790000     3101.440000     4133.712000
5219.330000     6202.000000     0.560000...
   0.504000     0.308000        0.000000        -0.308000       -0.504000
0.000000        0.000000        0.000000...
   0.000000     0.000000        0.000000        0.000000        0.000000]';
t=[0.000000     11.110000       22.220000       33.330000       44.330000       55.550000...
   66.660000    72.215000       80.540000       88.880000       97.210000       105.545000...
   113.870000   122.210000      133.320000      144.430000      155.540000      166.650000...
   177.760000   188.870000      200.000000 ];
%end of problem-dependent data
```

```
[phi,fzero,x,xpc,xps]= period(xm,xk,xai,n,m,time,f,t);
fprintf('Response of a single D.O.F. system under periodic force\n\n');
fprintf('xm   = %10.8e\n',xm);
fprintf('xk   = %10.8e\n',xk);
fprintf('xai  = %10.8e\n',xai);
fprintf('n    = %2.0f\n',n);
fprintf('m    = %2.0f\n',m);
fprintf('time = %10.8e\n\n',time);
fprintf('Applied force and response: \n\n');
fprintf('   i          t(i)                    f(i)               x(i)');
fprintf('\n\n');
for i=1:21
   fprintf('  %2.0f       %10.8e           %10.8e      %10.8e\n',i,t(i),f(i),x(i));
end
figure(1)
subplot(121);
plot(t,f);
xlabel('t');
ylabel('F(t)');
title('Program 4: F(t)');
subplot(122);
plot(t,x);
title('Program 4: x(t)');
xlabel('t');
ylabel('x(t)');
```

ANGLE(θ)	FORCE F2 (3)	TIME
0°	0.88	0
20°	1034.76	11.11
40°	2067.79	22.22
60°	3101.44	33.33
80°	4133.712	44.44
100°	5168.536	55.55
120°	6202	66.66
130°	0.56	72.215
145°	0.5243	80.54
160°	0.3631	88.88
175°	0.0	97.21
190°	-0.3856	105.545
205°	-0.5561	113.87
220°	0.16	122.21
240°	0	133.32
260°	0	144.43
280°	0	155.54
300°	0	166.65
320°	0	177.76
340°	0	188.87
360°	0	200

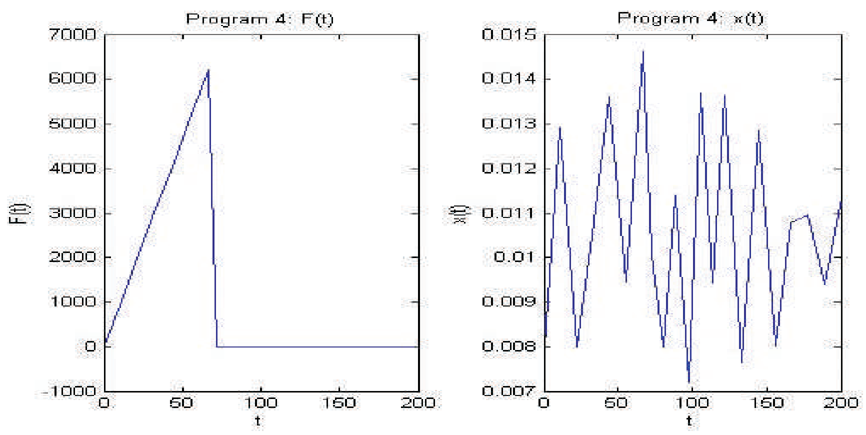


figure 2.2: Schematics of force pattern and corresponding vibration response of follower.

DISCUSSION OF RESULTS

This chapter deals with the result and discussion of the present work. The vibration response obtained by applying a time variant force is discussed phase wise in forthcoming article.

Phase A1-A2:
In this phase ,the force on follower changes from 0.88 kgf to 1034.76 kgf . While the displacement value at point A1 is 0.0088 mm and the displacement value at point A2 is 0.0129 mm. during this section the increment in displacement is seen.

Phase A2-A3:
In this phase ,the force on follower changes from 1034.76 kgf to 2067.79 kgf . While the displacement value at point A2 is 0.0129 mm and the displacement value at point A3 is 0.008 mm during this section the decrement in displacement is seen.

Phase A3-A4:
In this phase ,the force on follower changes from 2067.79 kgf to 3101.44 kgf . While the displacement value at point A3 is 0.008 mm and the displacement value at point A4 is 0.0135 mm during this section the increment in displacement is seen.

Phase A4-A5
In this phase ,the force on follower changes from 3101.44 kgf to 4133.712 kgf . While the displacement value at point A4 is 0.0135 mm and the displacement value at point A5 is 0.0095 mm during this section the decrement in displacement is seen.

Phase A5-A6
In this phase ,the force on follower changes from 4133.712 kgf to 5219.33 kgf . While the displacement value at point A5 is 0.0095 mm and the displacement value at point A6 is 0.0147 mm during this section the increment in displacement is seen.

Phase A6-A7
In this phase ,the force on follower changes from 5219.33 kgf to 6202 kgf . While the displacement value at point A6 is 0.0147 mm and the displacement value at point A7 is 0.008 mm during this section the decrement in displacement is seen.

Phase A7-A8
In this phase the force on a cam and follower changes from 6202 kgf to 0.56 kgf . While the displacement value at point A7 is 0.008 mm and the displacement value at point A8 is 0.0114 mm during this section the increment in displacement is seen.

Phase A8-A9

In this phase ,the force on follower changes from 0.56 kgf to 0.504 kgf . While the displacement value at point A8 is 0.0114 mm and the displacement value at point A9 is 0.0072 mm during this section the decrement in displacement is seen.

Phase A9-A10
In this phase ,the force on follower changes from 0.504 kgf to 0.308 kgf . While the displacement value at point A9 is 0.0072 mm and the displacement value at point A10 is 0.0135 mm during this section the increment in displacement is seen.

Phase A10-A11
In this phase ,the force on follower changes from 0.308 kgf to 0.0 kgf . While the displacement value at point A10 is 0.0135 mm and the displacement value at point A11 is 0.0095 mm during this section the decrement in displacement is seen.

Phase A11-A12
In this phase ,the force on follower changes from 0.0 kgf to -0.308 kgf . While the displacement value at point A11 is 0.0095 mm and the displacement value at point A12 is 0.00134 mm during this section the increment in displacement is seen.

Phase A12-A13
In this phase ,the force on follower changes from -0.308 kgf to -0.504 kgf . While the displacement value at point A12 is 0.0134 mm and the displacement value at point A13 is 0.0076 mm during this section the decrement in displacement is seen.

Phase A13-A14
In this phase ,the force on follower changes from -0.504 kgf to -0.0 kgf . While the displacement value at point A13 is 0.0076 mm and the displacement value at point A14 is 0.0128 mm during this section the increment in displacement is seen.

Phase A14-A15
In this phase ,the force on follower changes from -0.0 kgf to 0.0 kgf . While the displacement value at point A14 is 0.0128 mm and the displacement value at point A15 is 0.0081 mm during this section the decrement in displacement is seen.

Phase A15-A16
In this phase ,the force on follower changes from 0.0 kgf to 0.0 kgf .While the displacement value at point A15 is 0.0081 mm and the displacement value at point A16 is 0.0106 mm during this section the increment in displacement is seen.

Phase A16-A17
In this phase ,the force on follower changes from 0.0 kgf to 0.0 kgf .While the displacement value at point A16 is 0.0106 mm and the displacement value at point A17 is 0.0108 mm during this section the decrement in displacement is seen.

Phase A17-A18
In this phase ,the force on follower changes from 0.0 kgf to 0.0 kgf .While the displacement value at point A17 is 0.0108 mm and the displacement value at point A18 is 0.0094 mm during this section the decrement in displacement is seen.

Phase A18-A19
In this phase ,the force on follower changes from 0.0 kgf to 0.0 kgf .While the displacement value at point A18 is 0.0094 mm and the displacement value at point A19 is 0.011 mm during this section the increment in displacement is seen.

Phase A19-A20
In this phase ,the force on follower changes from 0.0 kgf to 0.0 kgf .While the displacement value at point A19 is 0.011 mm and the displacement value at point A20 is 0.012mm during this section the increment in displacement is seen.

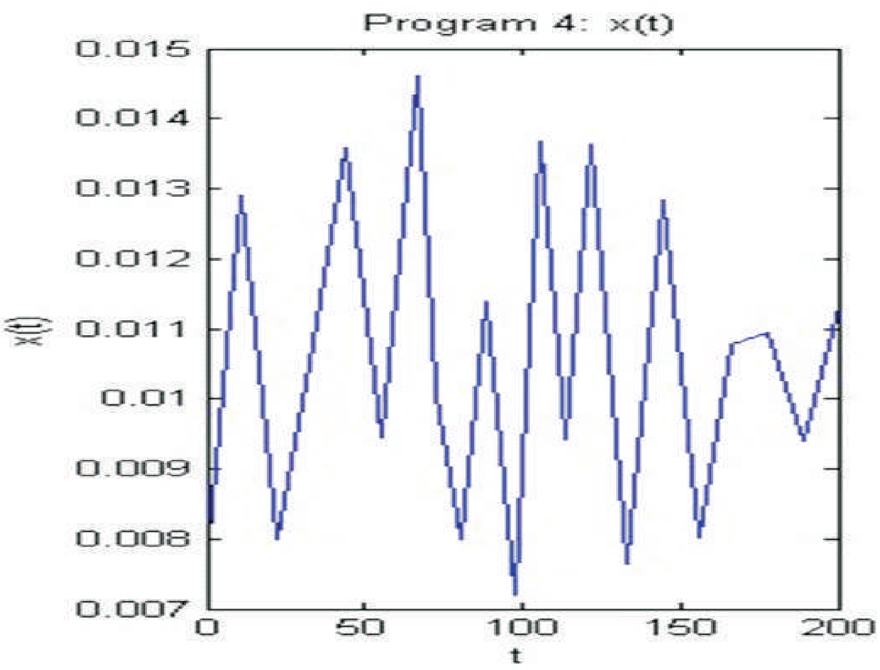


Figure 5.1: Schematic of a vibration response of a follower

CONCLUSION

Through the present investigation following are some important conclusions are made, which are discussed below.

1)Considering the present case study, the force pattern is estimated. Which shows linearity for outstroke phase and suddenly falls in return stroke phase.
2)The pattern of vibration response of follower shows a periodic vibrations.
3)The vibration response of follower shows maximum amplitude is obtained at 0.0147 mm, which occurs at a time 66.66 milisec. The corresponding force is obtained as 6202 kgf. for this maximum amplitude.
4) The vibration response of follower shows minimum amplitude is obtained at 0.0072 mm, which occurs at a time 80.54 milisec. The corresponding force is obtained as 0.504 kgf. for this minimum amplitude.

REFERENCES

(1)Ahn K.Y and Kim S.H. (2001), *"Influence of spring dynamics and friction on a spring-actuated cam system," Archive of Applied Mechanics, 2001, Volume 71, Number 8, Pages 497-508.*
(2)Ahn K.Y and Kim S.H. (2001), *"Modelling and analysis of a high-speed circuit breaker mechanism with a spring-actuated cam", Volume 215, Number 6 / 2001 663-672.*
(3)Andresen ulf and singhose William(2004),*"Simple Procedure for Modifying High - Speed Cam Profiles for Vibration Reduction," November 2004 -- Volume 126, Issue 6, 1105 (4 pages) .*
(4) Ardayfio D. D (1976).*," Dynamic of high-speed cam mechanisms with damped flexible followers driven by flexible camshafts" (1976): ASME paper 76-DET-63.*
(5)Ambardekar M. N., Gupta K. N.,, *Stochastic optimal control of vibrations of a high-speed driven mechanism Mech. Mach. Theory 25 (1990): 59–68.*
(6) Cveticanim livija, *"Vibrations of cam-follower system", University of Novi Sad,2000, Novi Sad, Trg D., Obradovica, 6, Serbia, September 1, 2002; vol. 216, 9: pp. 875-883.*
(7)Desh mech j.(2004) ,*Dynamic Responses of a Globoidal Cam System, September 2004 -- Volume 126, Issue 5, 909 (7 pages) .*
(8)Hammami L., Fenina S., Abdennadher M.,Haddar M., *Vibro-Acoustic" Analysis of a Double Sandwich Panels System," International Journal of engineering simulation, Volume 6,Numéro1,2005,ISSN1468-1137.*
(9)Karle Hanfried and Klaus Mauersberber (2009) *",A Contribution to the History of Cam Mechanisms ",*

International Symposium on History of Machines and Mechanisms, Pages 133-150.
(10)Karle Hanfried and Klaus Mauersberber,*"Archimedean Spirals to Screw Mechanisms ",History of Mechanism and Machine Science, 1, Volume 11, The Genius of Archimedes -- 23 Centuries of Influence on Mathematics, Science and Engineering, Part 2, Pages 163-176.*
(11)Karle Hanfried, *"On the Power Transmission and Running Quality of Micro-Mechanisms," 2009, Proceedings of EUCOMES 08, Pages 377-385.*
(12)Karle Hanfried(2004), *"On the Development of the Constraint Motion Theory of Franz reufiauk,2004, International Symposium on History of Machines and Mechanisms, 5, Pages 201-215.*
(13)Malekzadeh K., Khalili M.R., Mittal R.K., *Response of composite sandwich panels with transversely flexible core to low-velocity transverse impact: International Journal of Impact Engineering,34, 2007, 522-543.*
(14) Meunier M., Shenoi R.A.,*" Dynamic analysis of composite sandwich plates with damping modelled using high-order shear deformation theory," Composite Structures, 54, 2001, 243-254.*
(15)Mills J.K(1991), Notas L.,Fenton R.G., *"Optimal design and sensitivity analysis of flexible cam mechanisms," Mechanism and Machine Theory,Volume 28, Issue 4, July 1993, Pages 563-581.*
(16) Wang, Yiming Wu, Shuqin Peng, Ming Bai, Jianjun, *" Vibration and noise measurement synchronous and analysis on paper transmitting system for sheet-fed offset press."Technology and Innovation Conference 2009 (ITIC 2009), International12-14 Oct. 2009.*
(17) Khurmi R.S. and Gupta *Text book of Thory of machine. Volume I.*
(18)Rao J.s. and Dukkipati *Text book of Mechanism and Machine. Volume II.*
(19)Rothbert Harnold A. *Text book of Cam dynamics.*

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