

Analysis Of Radial Cam With Roller Follower

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ABSTRACT:

A cam is a rotating or a reciprocating element of a mechanism which imparts rotating, reciprocating or oscillating motion to another element called follower. Cam mechanisms are used in many modern machines, including weaving looms, precision measurement instruments, automatic machine tools, automobile engines, and so on. The geometry of the cam profile is based on the type of motion of the cam and the type of the follower. MATLAB is the tool to optimize the motion and geometry of the cam mechanism and to evaluate the kinematic performance.

In this project a MATLAB code is written for designing of the cam profile for combination of motions, cycloidal, uniform velocity for radial cam with roller follower. MATLAB is used to get optimum values of displacement and velocity. A solid model of the cam is designed in Pro/ENGINEER Wildfire 4.0 and the Modal Analysis is done in ANSYS 13.0 Workbench to find out the natural frequencies at respective Mode shapes of the cam.

Key words : Cam Profile, Uniform Velocity, Modal Analysis, Natural Frequency, mode shape.

Cam Nomenclature :

Trace Point

Pitch Curve

Working Curve

Pitch Circle

Prime Circle

Base Circle

Stroke

Follower Displacement

Pressure Angle

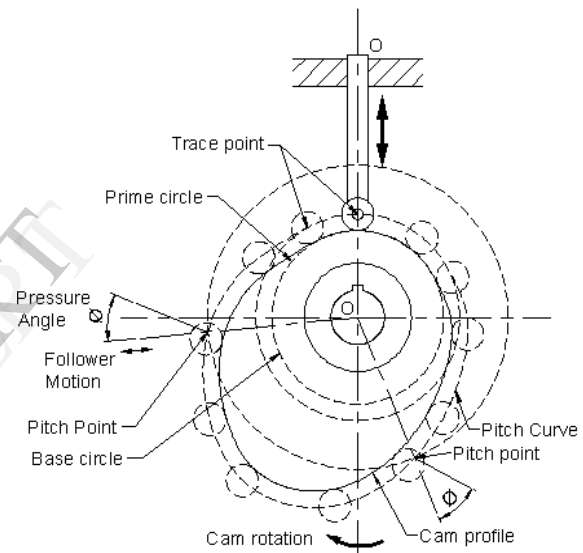


Fig 1 Cam Nomenclature

1. Introduction.

A cam may be defined as a rotating machine part designed to impart reciprocating and oscillating motion to another machine part, called a follower. Most cams operated by rotary motion, but this is not an essential condition and in special cases the motion may be semi-rotary, oscillatory or swinging. Even straight-line motion of the operating member is possible, though the term cam may not be considered properly applicable in such circumstances.

The majority of the cam movements may be described as devices for changing rotary motion into regular or intermittent reciprocating motion. Other forms of cams are utilized for changing the direction of reciprocating motions. The majority of cams used in machine construction are of the first type, as seen on shoe and textile machinery,

printing presses and other forms of automatic machinery.

A cam is an element of the cam-follower mechanical system that compels the movement of the Follower by direct contact. The motion of the follower is the result of the program. Just as a computer is programmed, so as a cam. Thus, the system can be thought of as a Mechanical information device. Accordingly, the goal of the designers is to build a program, established the locus of the contact points between the cam and follower, produce the cam profile coordinates system, and fabricate the cam within an acceptable accuracy. After all the parts are assembled the performance of the cam-follower system is observed. Cam –follower mechanisms are found in almost all mechanical devices and machines (i.e.; agricultural, transportation equipment, textiles, packaging, machine tools, printing presses, automobile internal combustion engines, food processing machines, switches, ejection molds, control systems, and more recently in micro machines such as micro electromechanical systems [MEMS]).

Automatic assembly machines have many cam-driven linkages that provide motion to tooling, the dynamic behavior of the components includes both the gross kinematic motion and self induced vibration motion developed by Khalil [10] used CAD software (Pro/engineering). In several dynamic models that are suitable for the determination of dynamic behavior and residual vibrations within cam-follower systems, as well as providing the means to predict follower jump, the follower motion were defined using 1-3-6 polynomial in rise and return using MATLAB to determine the cam profile as well as cam displacement, velocity diagrams.

2.About Matlab.

MATLAB (MATrix LABoratory) is an interactive system for matrix-based computation, designed for scientific and engineering use. MATLAB is a high performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notations. Typically uses include: Math and computation Algorithm development Modeling, simulation, and prototyping Data analyzing, exploration and visualization Scientific and engineering graphics Application development including graphical user interface building MATLAB is a software package for high-

performance numerical computation and visualization. It provides an interactive environment with hundreds of built-in functions for technical computation, graphics, and animation. Best of all, it also provides easy extensibility with its own high-level programming language. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows solving many technical computing problems especially those with matrix and vectoring foundation.

2.Matrix Operators

MATLAB has several operators for our use.

+ addition
 - subtraction
 * matrix multiplication
 / division
 ^ exponentiation
 .* term-by-term multiplication
 ./ term-by-term division
 .^ term-by-term exponentiation
 >> MATLAB prompt

3.Kinematic Analysis of Cam using MATLAB.

3.1.Displacement and velocity of the cam follower.

r_b = radius of the base circle = 0.4m

r_f = follower radius = 0.01 905/2m

c = degrees to radians multiplier = $\pi / 180$

h = height of the follower

X_c = displacement from the roller center to the center of the cam in x direction.

Y_c = displacement from the roller center to the center of the cam in y direction.

S = displacement of the follower.

dS = velocity of the follower.

$X_c = -(r_b + r_f) * \sin(\theta_1) - s_1 * \sin(\theta_1)$

$y_c = (r_b + r_f) * \cos(\theta_1) + s_1 * \cos(\theta_1)$

$dx_c = -(r_b + r_f) * \cos(\theta_1) - s_1 * \cos(\theta_1) - ds_1 * \sin(\theta_1)$

$dyc = -(r_b + r_f) * \sin(\theta_1) - s_1 * \sin(\theta_1) + ds_1 * \cos(\theta_1)$

Cycloidal Rise:

b is the radius of the base circle

h is the rise of the follower

θ_0 is the starting angle of the rise

$\beta = \theta_1 - \theta_0$ is the angular range of the rise

Rise :

$$S = rb + \frac{h}{2\pi} \left(\frac{2\pi}{\beta} (\theta - \theta_0) - \sin \left(\frac{2\pi}{\beta} (\theta - \theta_0) \right) \right),$$

$$\theta_0 < \theta < \theta_1,$$

$$s' = \frac{h}{2\pi} \left(\frac{2\pi}{\beta} - \frac{2\pi}{\beta} \cos \frac{2\pi}{\beta} (\theta - \theta_0) \right), s'(\theta_0) = 0,$$

Cycloidal Return:

h_0 is the radius at the start of the return,

h is the amount of return,

θ_1 is the starting angle of the return,

$\beta = \theta_1 - \theta_2$ is the angular range of the return

Return:

$$S = h_0 - \frac{h}{2\pi} \left(\frac{2\pi}{\beta} (\theta - \theta_1) - \sin \left(\frac{2\pi}{\beta} (\theta - \theta_1) \right) \right), \quad \theta_1 <$$

$$\theta < \theta_2,$$

$$s' = -\frac{h}{2\pi} \left(\frac{2\pi}{\beta} - \frac{2\pi}{\beta} \cos \frac{2\pi}{\beta} (\theta - \theta_1) \right), \quad s'(\theta_1) = 0,$$

Uniform Velocity:

$\beta = \theta_1 - \theta_0$ is the angular range of the rise.

$$\text{Displacement} = \frac{h}{\beta} (\theta - \theta_0)$$

$$\text{Velocity} = \frac{h}{\beta}$$

h is the rise of the follower

θ_0 is the starting angle of the rise.

3.2. Matlab output For Displacement And Velocity.

a. Matlab Output For Constant Velocity for 210 Degrees.

Displacements are:

Displacement for follower: 0.0359695 m.
 Displacement for follower: 0.035771 m.
 Displacement for follower: 0.035848 m.
 Displacement for follower: 0.035924 m.
 Displacement for follower: 0.036000 m.

Velocities are:

Velocity for follower: 0.004265 m/sec.

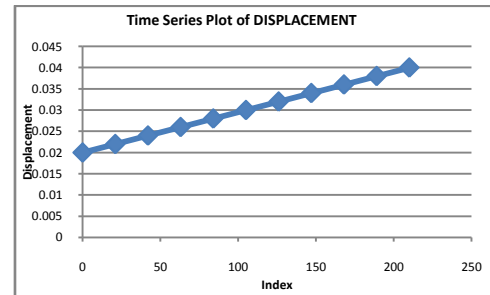


Fig 2 Output of Displacement

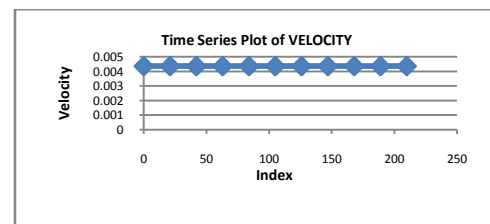


Fig 3 Output of Velocity

b. Matlab Output For Return Cycloidal For 140 Degrees.

Displacements are:

Displacement for follower: 0.043000 m.
 Displacement for follower: 0.043000 m.
 Displacement for follower: 0.042999 m.
 Displacement for follower: 0.042997 m.
 Displacement for follower: 0.042993 m.

Velocities are:

Velocity for follower: 0.000000 m/sec.
 Velocity for follower: -0.000018 m/sec.
 Velocity for follower: -0.000072 m/sec.
 Velocity for follower: -0.000163 m/sec.
 Velocity for follower: -0.000289 m/sec.

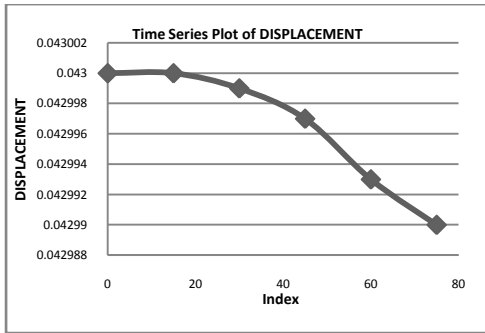


Fig 4 Output of Displacement

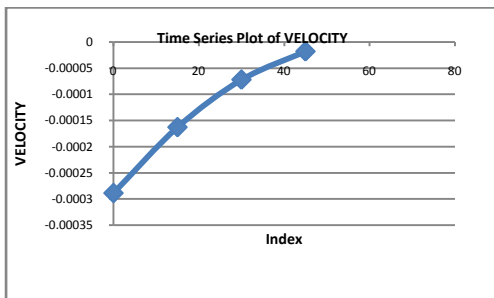


Fig 5 Output of Velocity

4. Design of Cam Profile Using Matlab.

In this present work a Matlab code is written for the designing of a cam profile.

The generated cam profile using Matlab is as shown below.

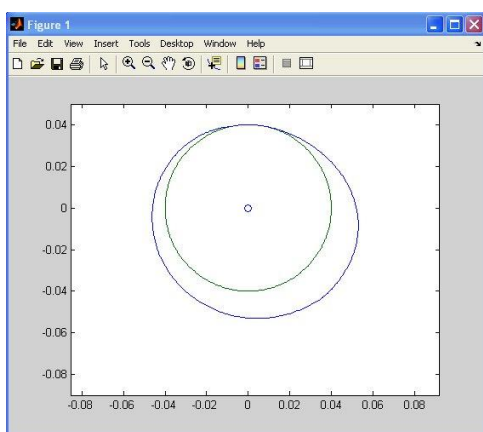


Fig 6 Output of Cam Profile in Matlab

5.Modal Analysis of Cam using ANSYS.

Modal Analysis is the study of dynamic properties of structure under Vibrational excitation. Modal Analysis is the field of measuring and analysing the dynamic response of structure or fluids when excited by an input.

Modal Analysis is used to calculate the natural frequencies and mode shapes of the model.

A solid model of a cam is modeled in Pro/ENGINEER Wildfire 4.0.This model is imported into ANSYS 13.0 Workbench. Here we took Steel as the material for Cam and finally Modal analysis is done.

The obtained natural frequencies of a model at different modes are shown in table 2.

Material Data for Steel:

Table 1 Material properties of steel

Density kg/m ³	7850
Young's Modulus Mpa	2.e ⁺⁰⁰⁵
Poisson's Ratio	0.3
Bulk Modulus Mpa	1.6667 e ⁺⁰⁰⁵
Shear Modulus Mpa	76923

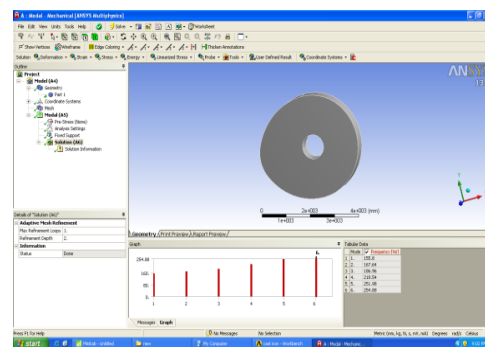


Fig 7 Modal Analysis of Cam

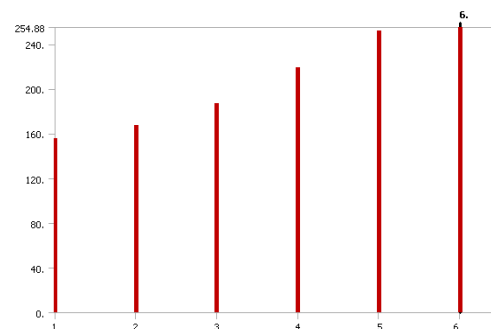
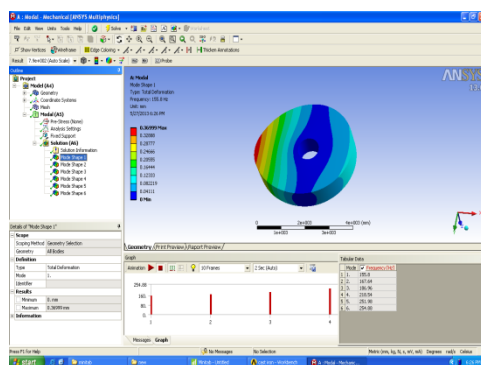


Fig 8 Natural Frequencies at each mode

Table 2 Frequency values at the respective modes

MODE	FREQUENCY (Hz)
1	155.80
2	167.64
3	186.96
4	218.54
5	251.98
6	254.88

A mode shape is a specific pattern of vibration executed by a mechanical system at a specific frequency. Different mode shapes will be associated with different frequencies. Natural frequency at Mode shape 1 is shown in fig 9.

**Fig 9 Natural Frequency at mode shape 1**

6.Conclusion.

In this paper we Generated the cam profile with roller follower using MATLAB, obtaining the relations between angle, displacement and velocity. We got the maximum displacement as 0.04300 m, and maximum velocity as 0.004265 m/sec.

Natural Frequencies for the respective Mode shapes of the model were calculated by using modal analysis in ANSYS 13.0 Workbench.

7.References .

- [1] H.D.Desai,V.K.Patel computer aided kinematic and dynamic Analysis of cam & follower. Proceedings of the world congress on engineering 2010 vol. 2 WCE 2010,june 30-july 2,2010,London,U.K.
- [2]J. Michael McCarty , Cam & follower systems , july 2009.
- [3] Edward B. Magrab , Shapour Azarm(2000)'An engineer's guide to MATLAB.
- [4] S.S.Rattan (2009) 'Theory of Machines'

[5] Doina Pisla (2010) ' New Trends in Mechanism and science: Analysis and Design'

[6] Mohd Hanaffin Bin Othman(2009) 'Analysis & Vibration in cam follower System'

[7] Kwakernaak,H,Smith .J,(1968) 'Minimum Vibration Cam Profile' , Journal of Mechanical Engineering Science,vol.10 No.3,june,PP219-227.

[8] Norton,R.L,2002 "Cam Design Manufacturing Handbook Industrial Press Inc SBN 0831131225.

[9] R.S.Kurmi, J.K.Gupta(2005) 'Theory of Machines'.

[10] Khalil Sherafatnia "Vibration in Cam-Follower Systems" July 2007.

[11] Modal Analysis, by Jimin He & Zhi-Fang Fu, Butterworth-Heinemann publications.