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Computer Aided Modeling and Analysis of CAM Follower

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***Abstract*— The current cam and follower mechanism in four stroke engines employs a flat follower. In this work an attempt is made to study the static and dynamic analysis of cam at low speed. In static analysis to study the deflection of cam and follower with respect to angular velocity and in dynamic analysis to calculate natural frequency with respect to given loading condition. The modeling of Cam and follower is done on CATIA V5 Software and analysis of Cam and Follower is done by using ANSYS 11.0 Software.**

Keywords: **Follower & Cam; Static Analysis; Vibration Analysis; Finite Element Approach [FEA].**

I. INTRODUCTION

Cam and follower mechanism is preferred over a wide variety of internal combustion engines because due to the cam and follower it is possible to obtain an unlimited variety of motions. Again the cam and follower has a very important function in the operation of many classes of machines, especially those of the automatic type, such as printing presses, shoe machinery, textile machinery, gear-cutting machines, screw machines etc. The cam may be defined as a machine element having a curved outline or a curved groove, which, by its oscillation or rotation motion, gives a predetermined specified motion to an-other element called the follower. In other word, cam mechanism transforms a rotational or oscillating motion to a translating or linear motion. In fact, cam can be used to obtain unusual or irregular motion that would be dif-ficult to obtain from other linkage. The variety of differ-ent types of cam and follower systems that one can choose from is quite broad which depends on the shape of contacting surface of the cam and the profile of the follower. In this work an attempt is made to study the static and dynamic analysis of cam at low speed. In static analysis to study the deflection of cam and follower with respect to angular velocity and in dynamic analysis to calculate natural frequency with respect to given loading condition. The modeling of Cam and follower is done ion CATIA V5 Software and analysis of Cam and Follower is done by using ANSYS 11.0 Software.[1][2]

II. PROBLEM IDENTIFICATION AND OBJECTIVE

Most of the internal combustion engines used in various applications such as automotive to power generation have disk cam and follower mechanisms, having a line contact between the cam and follower. In order to improve the mechanical efficiency of the mechanism in this work an attempt is made to study the static and dynamic analysis of cam at low speed. In static analysis to study the deflection of cam and follower with respect to angular velocity and in dynamic analysis to calculate natural frequency with respect to given loading condition.[3]

III. MODAL ANALYSIS

Modal analysis of Cam and follower is performed by Ansys software to determine the vibrations characteristics such as natural frequencies and mode shapes. And from static analysis check out the deflection and stresses on cam and follower mechanism.

IV. SOLID MODELING OF CAM AND FOLLOWER

To perform finite element analysis of cam with knife edge follower, the solid model of the same is essential. **Figure 1** shows a solid model of Cam and Follower.

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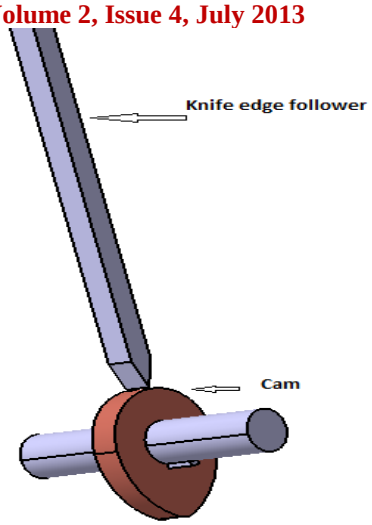

Fig 1. Existing cam and follower mechanism.

V. FINITE ELEMENT ANALYSIS PROCEDURE

Cam follower first modeled in CATIA V5 which is excellent CAD software, which makes modeling so easy and user friendly. The model is then transferred in IGES format and exported into the Analysis software ANSYS 11.0. The Cam and Follower is analyzed in ANSYS in three steps. First is preprocessing which involves model-ing, geometric clean up, element property definition and meshing. Next step includes solution of problem, which involves imposing boundary conditions on the model and then solution runs. Next in sequence is post processing, which involves analyzing the results plotting different parameters like stress, strain, natural frequency.

A. Finite Element Mesh Generation and Contact Element Type

The objective in building a solid model is to mesh that model with nodes and elements. Once the creation of solid model is completed, set element attributes and establishing meshing controls, which turn the ANSYS pro-gram to generate the finite element mesh. For defining the elements attributes, the user has to select the correct element type. This is most important task in finite element analysis because it decides the accuracy and computational time of analysis. In this work Solid 90 is used for meshing of body of Cam and follower. The type of meshing used for follower is FREE mesh which is controlled by two parameters assigned to each mesh surface or volume that affect the size the elements generated. The meshed model and contact region is shown in **Figure 2 & 3**.

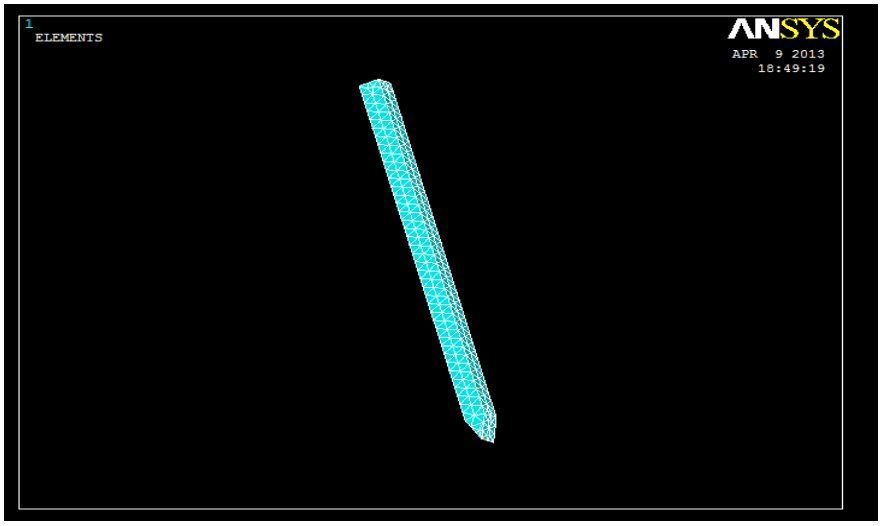

Fig 2 meshing of follower

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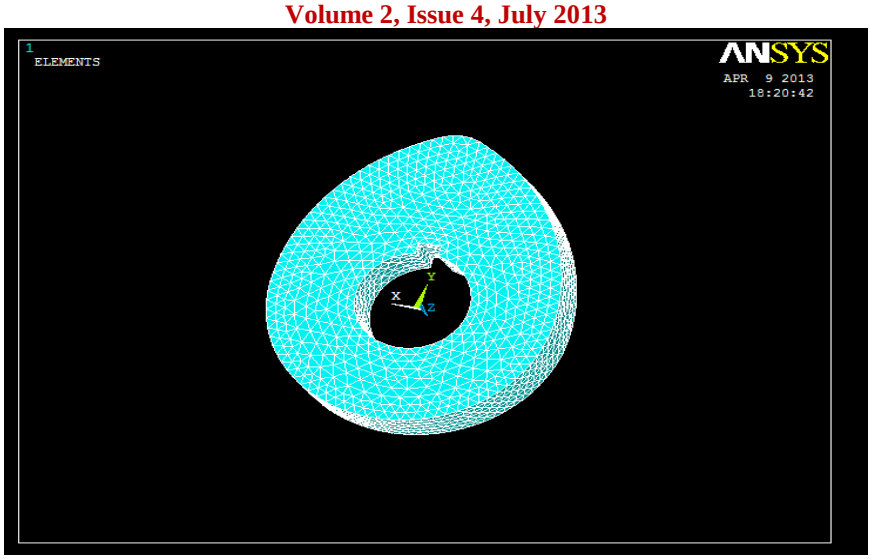

Fig 3 meshing of Cam

B. Boundary Conditions

A free modal analysis was performed to determine the natural frequencies of the existing follower and modified follower by Ansys software. Block Lancoz solver was used and expansion pass settings were set as 12 modes to extract and 12 modes to expand. Zero to infinity range was set to calculate the natural frequencies of cam and follower.

C. Analysis Result

In this section detail of finite element analysis and element behavior is given

1 Static analysis result of Cam and Follower

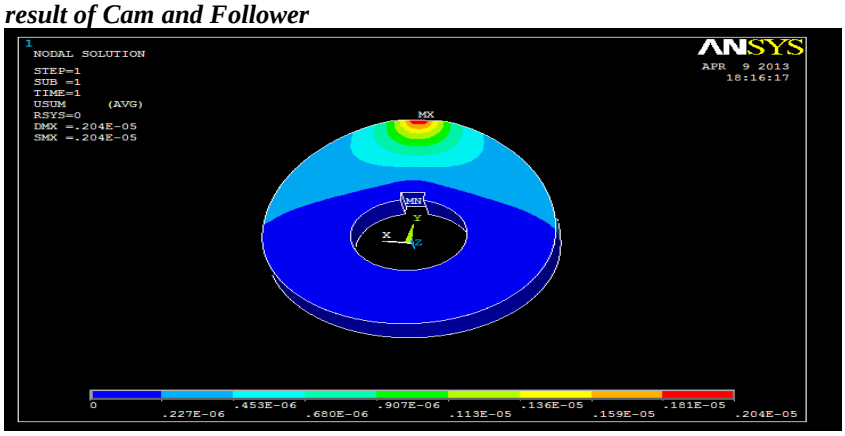

Fig {a} deflection of CAM

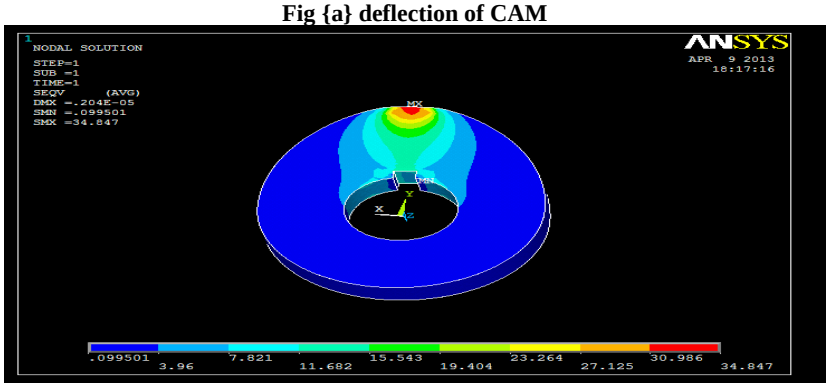

Fig {b} Equivalent stress (von-misses) in static on CAM

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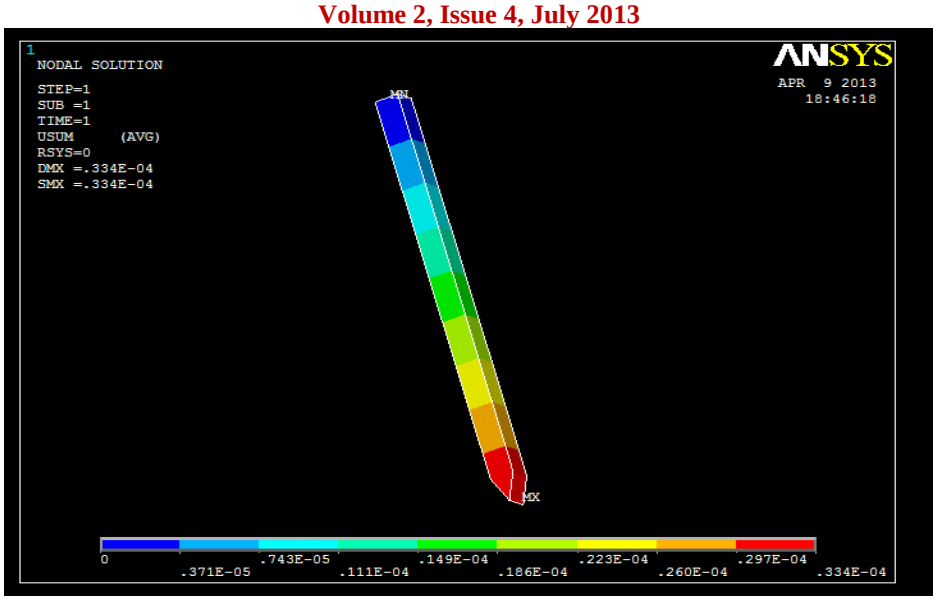

Fig{c} Deflection of FOLLOWER

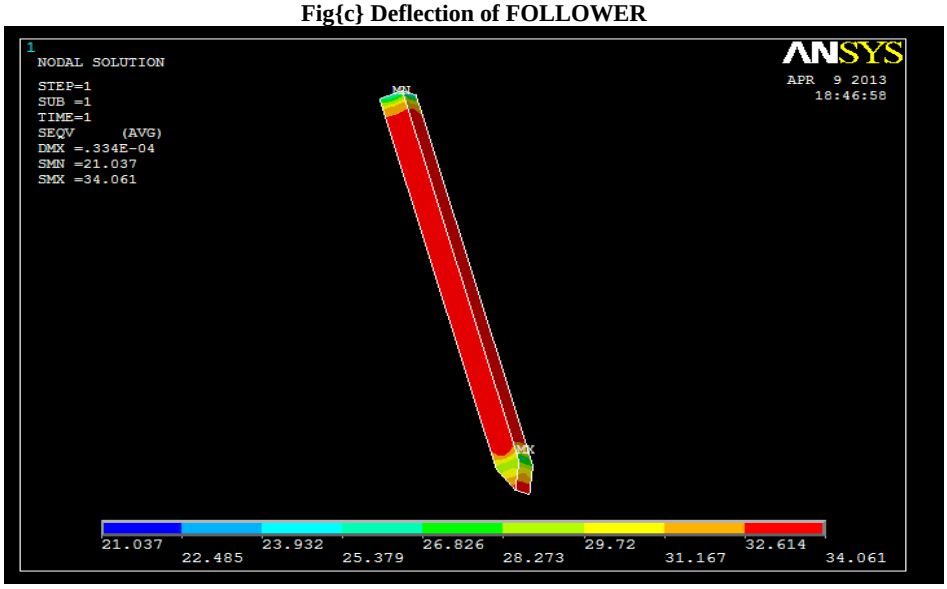

Fig {d} Equivalent stress (von-misses) in static on FOLLOWER

2Dynamic analysis result of CAM and FOLLOWER

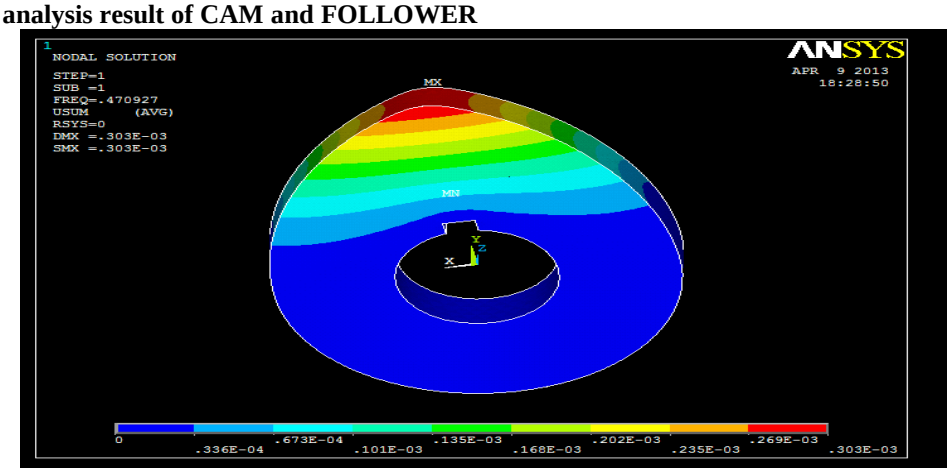

Fig. {e}first Set FREQUENCY in Vibration analysis of CAM

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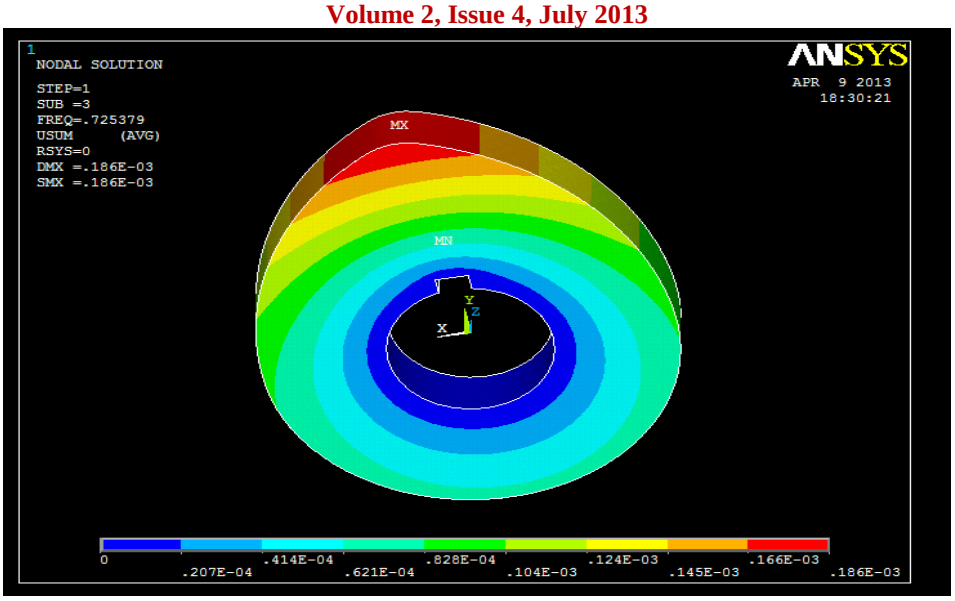

Fig. {f} Second Set FREQUENCY in Vibration analysis

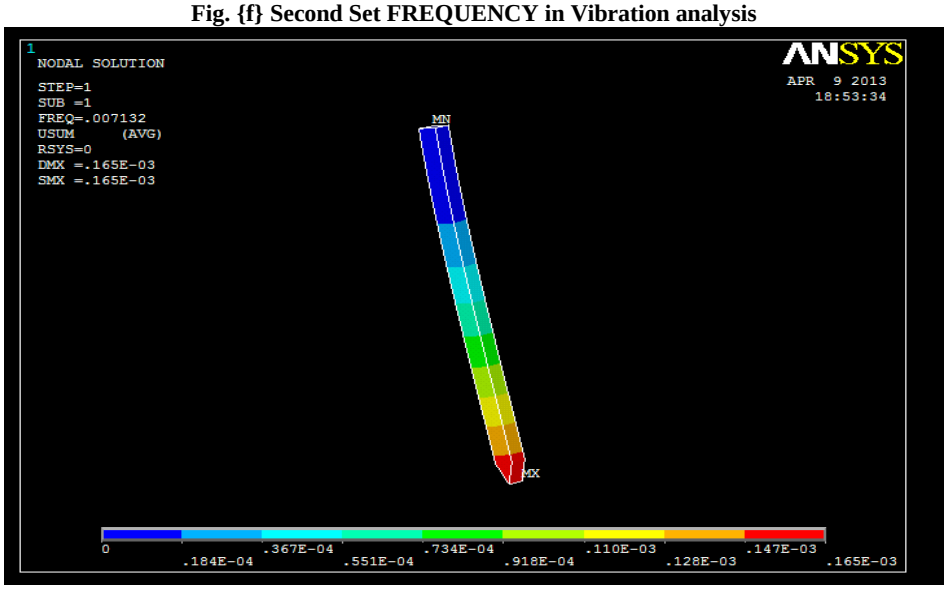

Fig. {g} first Set FREQUENCY in Vibration analysis of FOLLOWER

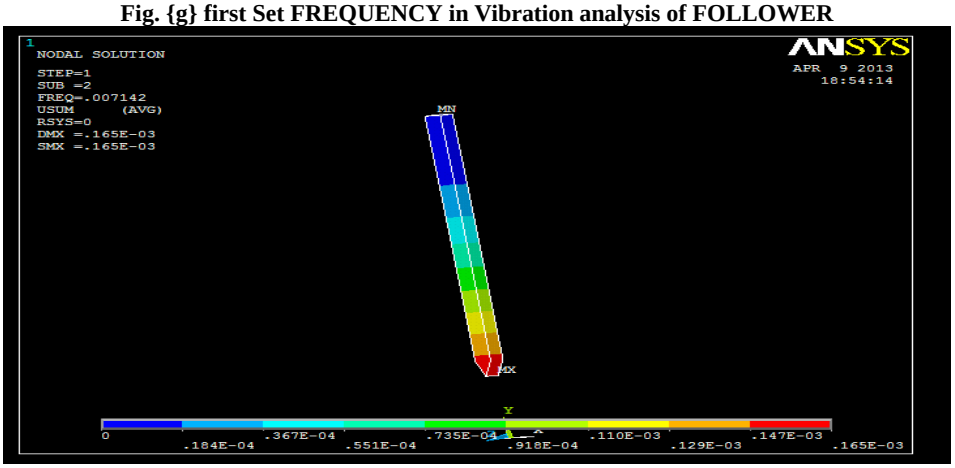

Fig. {h} Second Set FREQUENCY in Vibration analysis

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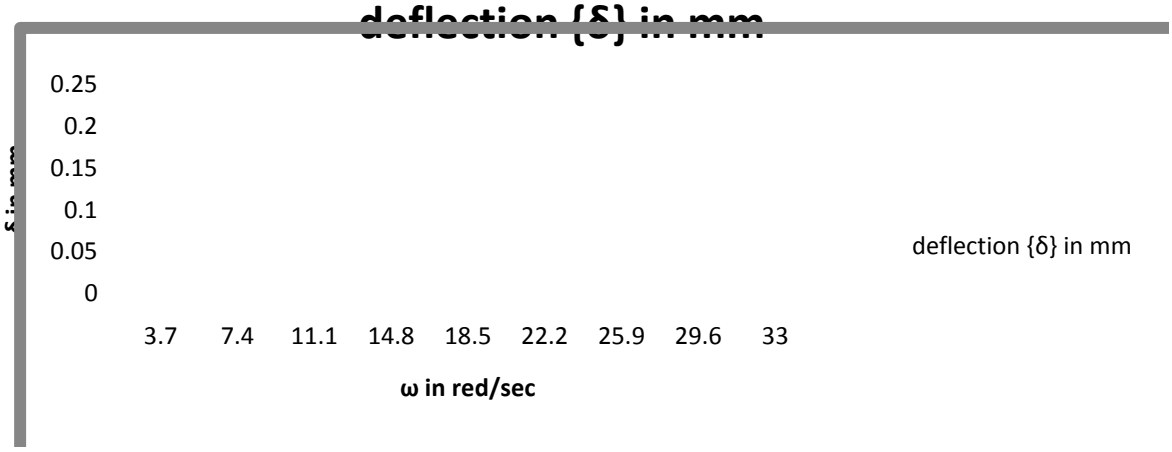
VI. ANALYSIS RESULTS DISCUSSION

6.1 Static analysis result of Cam and follower

1 Deflection of Cam in static

ω red/sec	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33
δ in mm	0.0227	0.0453	0.0680	0.0907	0.113	0.136	0.159	0.181	0.204

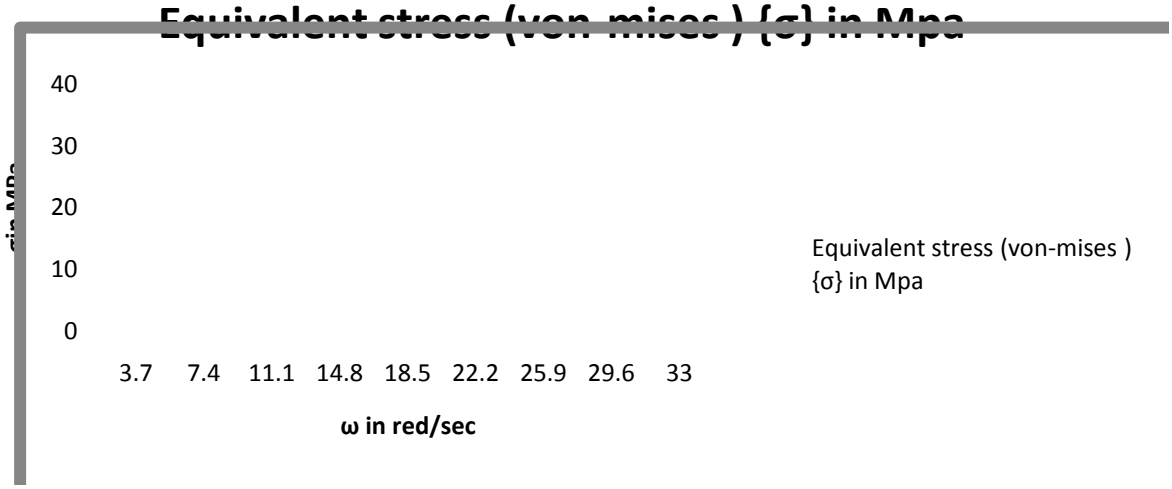


Graph 1 Angular velocity vs Deflection of Cam

From the graph and analysis result we can conclude that at maximum load condition i.s. 32.99 red /sec the moment of graph is rapidly increase. From the analysis result the blue color area is maximum the deflection of cam is 0 mm to 0.0227 mm, it indicate that deflection is negligible. the red color area is minimum in flank section (i.s. maximum contact area).in that section deflection of cam in between 0.181 mm to 0.204 mm. Hence , design is safe.

2 Equivalent stress (von-mises) in static for Cam

ω red/sec	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33
σ in MPa	3.96	7.821	11.682	15.543	19.404	23.264	27.125	30.986	34.847



Graph 2 Angular velocity vs Equivalent stress of Cam

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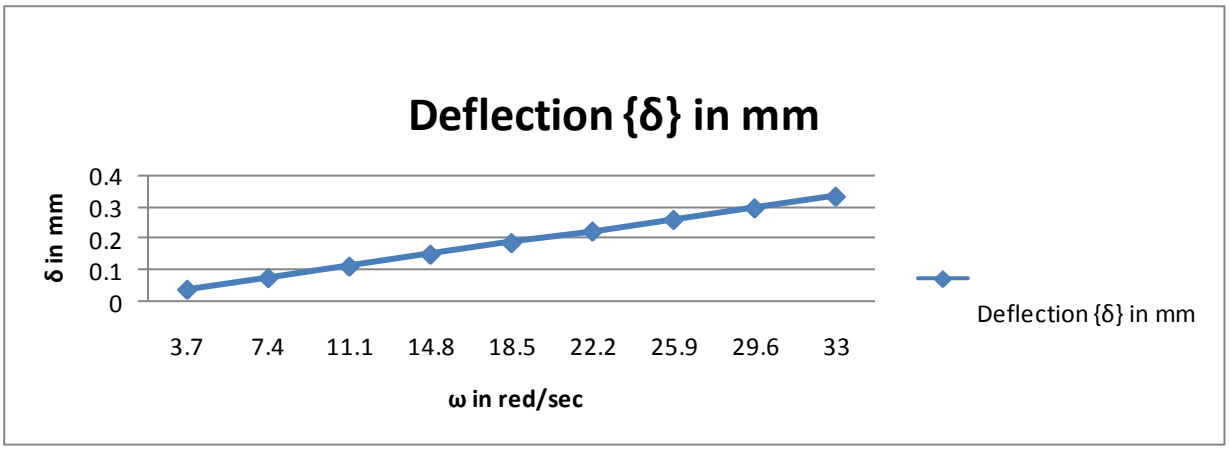
From the graph the stress in cam is continuously increase and it is maximum at flank i.s. 34.847MPa.From the analysis result the blue color area is maximum its range is 0.099501MPa to 3.96MPa for no load condition and red color area is minimum its range is 30.96MPa to 34.847MPa, for maximum load. from the result the design is safe.

3 Deflection of Follower in static

ω red/sec	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33
δ in mm	0.0371	0.0743	0.111	0.149	0.186	0.223	0.260	0.297	0.334

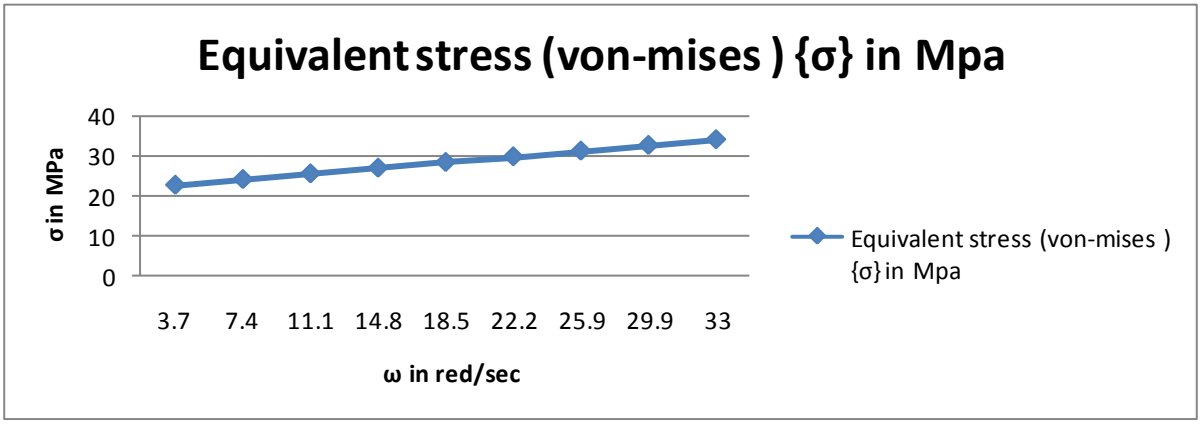


Graph 3 Angular velocity vs Deflection of Follower

From the graph and analysis result we can conclude that at maximum load condition i.s. 32.99 red /sec the moment of graph is rapidly increase. From the analysis result the blue color area is maximum the deflection of Follower is 0 mm to 0.0371 mm, it indicate that deflection is negligible. the red color area is minimum on knife edge section (i.s. maximum contact area).in that section deflection of Follower in between 0.297 mm to 0.334 mm. Hence , design is safe.

4 Equivalent stresses (von-mises) in static for Follower

ω red/sec	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33
σ in MPa	22.485	23.932	25.379	26.826	28.273	29.72	31.167	32.614	34.061



Graph 4 Angular velocity vs Equivalent stress of Follower

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From the graph the stress in cam is continuously increase and it is maximum at Knife edge i.s. 34.061MPa.From the analysis result the blue color area is minimum its range is 21.037MPa to 22.485MPa for no load condition and red color area is maximum its range is 32.614MPa to 34.061MPa, for maximum load. From the result the design is safe

B. Vibration analysis result of Cam and follower

1 Vibration Analysis of Cam

In vibration analysis to calculate the two set of frequency for cam. Figure shows the modal analysis at the 0.470927 Hz frequency and element behavior. Red colour zone indicates the deformation of Cam having range from 0.269 mm [min.] to 0.303 mm [max.]. Blue colour zone indicates the deformation of cam having range from 0.0 mm [min.] to 0.336 mm [max.]. Figure shows the modal analysis at the 0.725379 Hz frequency & element behavior. Red colour zone indicates the deformation of Cam having range from 0.166 mm [min.] to 0.186 mm [max.]. Blue colour zone indicates the deformation of Cam having range from 0.0 mm [min.] to 0.207 mm [max.]. From the result the maximum deformation of cam is 0.303 mm in first set of frequency it is within limit, so design is safe.

2 Vibration Analysis of Follower

In vibration analysis to calculate the two set of frequency for Follower .Figure shows the modal analysis at the 0.007132 Hz frequency and element behavior. Red colour zone indicates the deformation of follower having range from 0.147 mm [min.] to 0.165 mm [max.]. Blue colour zone indicates the deformation of follower having range from 0.0 mm [min.] to 0.184 mm [max.]. Figure shows the modal analysis at the 0.007142 Hz frequency & element behavior. Red colour zone indicates the deformation of follower having range from 0.147 mm [min.] to 0.165 mm [max.]. Blue colour zone indicates the deformation of follower having range from 0.0 mm [min.] to 0.184 mm [max.]. From the result the maximum deformation of Follower is 0.165 mm is same in both set of frequency it is within limit, so design is safe.

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