Linear, Bilinear and Multibody Dynamic Analysis of Modified I Section Cam in Single Cylinder Four Stroke Engine

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Abstract- *Linear, bilinear and multibody dynamic stresses induced in conventional cams and scooped cams were studied in this work. Cams were scooped in such a way that I cross section obtaining in load bearing area. To study geometric models were developed in unigraphic and than analyzed in Ansys 14.5. Scooped cams have better strength compare to conventional cams.*

Keywords- Multibody dynamics, Cam, Follower, FEA.

I. INTRODUCTION

Cam and follower component is being utilized as a part of various types of I.C engines as it is utilized to get an unending assortment of movements. Cam and follower acting assumes an extremely crucial part in the operation numerous machines. For the most part it is being utilized as a part of automatic types that incorporates screw machines, shoe machines, textile machinery, printing presses, gear-cutting types of equipments, and so on.

Cam is a machine component having a curved groove which by turn movement gives a pre determined movement to other component called follower. Cam likewise utilized for obtaining irregular movements that are difficult to get from different linkages. Cam mechanism is utilized to change over the rotary motion to linear motion. There are different types of cam and follower system which mainly depends upon the kind of contact made between the surface of cam and follower.
Cam is a mechanical linkage utilized for the most part to transform rotational movement into linear movement or vice versa. It can be likewise said that as a protrusion on a turning part in machinery that has been designed to build sliding contact with another part. The cam follower is energizing mechanical device used to change over the movements of any connection into favored way.

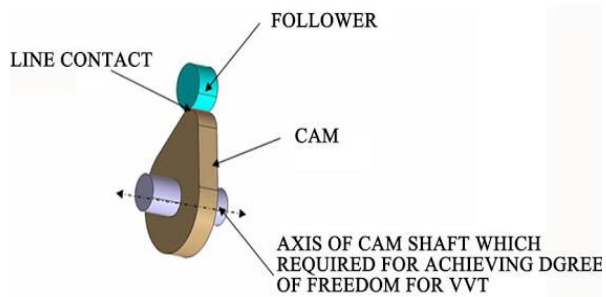


Fig.1.1 Cam and Follower Mechanism

Cam and follower is primarily utilized as a part of engines for driving the valve timing during the initial conditions. It is likewise utilized control the fuel and exhaust gasses blow out. It is changed by various valve timing because of complex mechanism and fuel economy. An rigid part is upheld to the cam follower that controls the movement and controls the irregular movements and damage.

The stress and weight decrease of the piston which is extensive impact on its dynamic behavior and conveyed multibody dynamic analysis of an IC engine piston for shape optimization. The connecting rod of a kirloskar TV1 diesel engine producing a rated output of 5.2kw at 1500rpm is considered for the study. Authors additionally experienced the investigation of aluminum forged piston. In this paper they have acquire load curves from the pressure crank angle plots. They have showed the development of the stress distribution and also obtained deformation in the piston. The outcomes acquired or analyzed in this paper gave the stress concentration found furthermore accomplished in decrease of von-misses stress. The induced normal stresses gave the outcome which optimizes weight of piston where with chamfering and filleting the value of induced maximum von-misses stress decreased by 34.05% and von misses strain decreased by 33.97%. The induced normal stress is reduced by 44.8%, and Induced normal strain is decreased by 37.1 %and at last Weight was reduced by 0.161%. [1]

Study of an earlier assembly model and design of the connecting rod and done multibody dynamic analysis and simulation of engine model. The following steps were carried out and the pre- processing part was finished and the boundary conditions are identified, the FE analysis parts were carried after to get the result. The FE result is inter predicted with the yield strength of the component material and FOS was calculated. Done meshing through the hyper mesh software and the result of stress and displacement were plotted. The different input velocities were taken at trial and error method. The obtained results concluded that the given engine particular speed is 4mm/s for the correspondence stress. If the speed is less than 4mm/s the obtained design will be safe were as it is beyond the 4mm/s the developed the design or model will be failed. [2]

Existing cams used in internal combustion engines have a verity of line contact with follower. The authors made an attempt to change a flat face of the follower by using optimization technique since line contact between current cam and follower mechanism results high frictional losses and results in low mechanical efficiency. As the length of contact increases the stress values also comparatively increases this is less than that of allowable stress value. As the result they have changed the geometry by varying parameters like length of contact and radius of the roller and follower have minimized by reducing the line contact so that the frictional losses will be less which results improves mechanical efficiency of the cam and follower mechanism.[3]

Study of load analysis and multibody dynamic analysis of connecting rod which are used in two wheeler vehicles. In this paper they have mainly focused on the weight reduction of the connecting rod and have made a design by removing the material at the center of the connecting rod. They have determined the static linear, bilinear, thermal and modal analysis at different frequencies and fatigue analysis of connecting rod. It was concluded that the design was safe through the FEM results which was optimized of connecting rod. [4]

II. MATERIAL SELECTED FOR CAM AND FOLLOWER

The most commonly used material for the cam and follower is chromium steel with designation of 100Cr6. Table 2.1 shows the material property for Chromium steel.

Table 2.1 Material property for chromium steel

Density(*1000kg/m^3)	7.7-8.03
Poison's ratio	0.27-0.30
Elastic modulus (GPa)	190-210
Tensile strength (MPa)	1158
Yield strength (MPa)	1034

III. GEOMETRICAL MODELLING AND FINITE ELEMENT ANALYSIS

Fig 3.1 Cam and follower model

Commercially available software package UG is used for the modeling the cam and follower. Cam is designed according to the required dimensions. The dimensions of the cam and follower are identical with the two wheeler vehicles. All the parts are assembled together and constrained according to the required position in mechanical-assembly design. The three dimensional model of cam and follower is as shown in Fig 3.1.

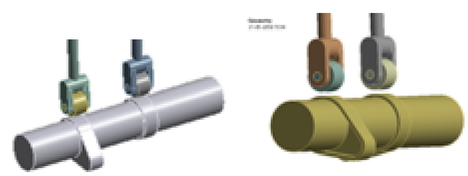


Fig 3.2 (a) Regular cam Fig 3.2 (b) Scooped cam

Two different models are used in the present study. Fig 3.2(a) representing the existing model and Fig 3.2 (b) representing the modified model (scooped model). Load bearing capacity of I–section is more compared to regular rectangular cross section. Scooping of material from cam surface as shown in figure 3.2(b) provides an opportunity to have I section in load bearing area. It is expected that this I section would increase the overall efficiency by reducing the weight of the cam.

3.1 MESHED MODEL OF CAM AND FOLLOWER ASSEMBLY.

Meshing is defined as separating of a complete model into finite elements. This process defines the model form in 3D space; the elements are the building blocks of the analysis model. Accuracy of the analysis depends on the choice of the right kind of elements for the geometry which the model possesses. The Hex Dominant Method is used for meshing the cam and follower and the meshed model is as shown below Fig 3.3.

Fig 3.3 Meshed model for 2mm scooped cam

Table 3.1 Statistics for cam and follower

Statistics	Nodes	Elements
Meshed model for 2mm scooped cam	17803	10445

3.2 Boundary conditions details for FE model of cam and follower

The appropriate boundary condition is applied for the FE model developed to perform analysis like linear and non linear static analysis for the cam and follower assembly. The details are as shown below.

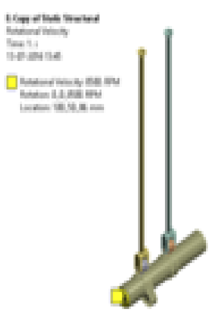
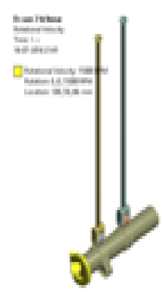


Fig 3.4 Linear analysis



3.5 Bilinear analysis

Fig 3.4 shows the cam and follower which boundary condition of rotational velocity of 8500 rpm and Fig 3.5 shows the boundary conditions of bilinear analysis of cam and follower, for most horrible condition the rotational velocity or speed will be raised 15000 rpm.

IV. RESULT AND DISCUSSIONS

4.1 LINEAR STATIC ANALYSIS FOR 2MM SCOOPED CAM

Static structural analysis is done to find maximum von-misses stress developed in cam and follower. In linear analysis, the stress will be proportional to strain. The maximum stress is developed at the point lobe surface on cam and minimum stress is produced at the end of the follower.

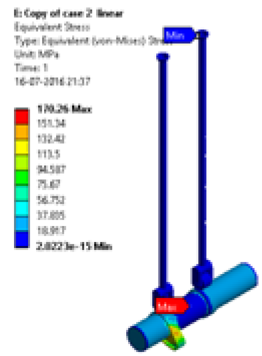


Fig 4.1 Equivalent stress

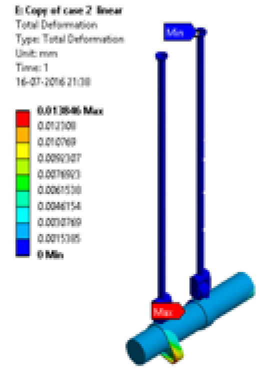


Fig 4.2 Total deformation

Fig 4.1 shows the equivalent stress for the linear static analysis of 2mm scooped cam. The Maximum stress is 170.26 MPa and minimum stress is 2.0223e-15 MPa which observed from analysis.

From the Fig 4.2. It can be seen the maximum deformation is observed at scooped place with value of 0.013846mm.

Finding allowable stress for scooped cam

- If factor of safety 2

Allowable stress = yield strength/ FOS
= 1034/2
= 517 MPa

So, In the FEM result equivalent stress < allowable stress i.e., **170.26 MPa < 517 MPa** thus, The modified cam is considered for safe operations with less deformation and stress respective more life.

4.2 BILINEAR STATIC ANALYSIS FOR 2MM SCOOPED CAM

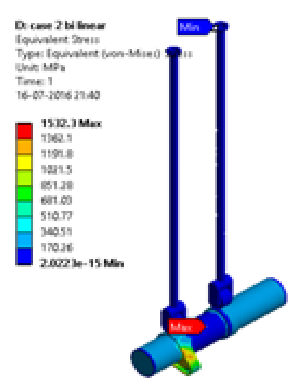


Fig 4.3 Equivalent stress

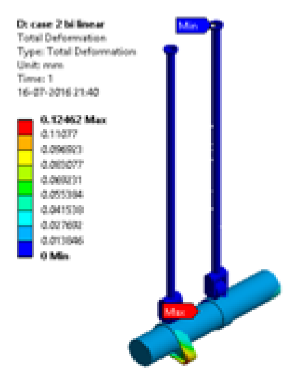


Fig 4.4 Total deformation

Fig 4.3 shows the bilinear analysis of 2mm scooped cam. The material after yield point behaves as plastic where the material cannot regain its original length even when load is removed. The stress as 1532.3 MPa is developed at the I-section of the cam and minimum stress is 2.0223e-15MPa is seen on follower.

Fig 4.4 shows the total deformation of 2mm scooped cam. The maximum deformation is 0.12462 mm is developed at the scooping of the cam.

4.3 MULTIBODY DYNAMIC ANALYSIS FOR 2MM SCOOPED CAM

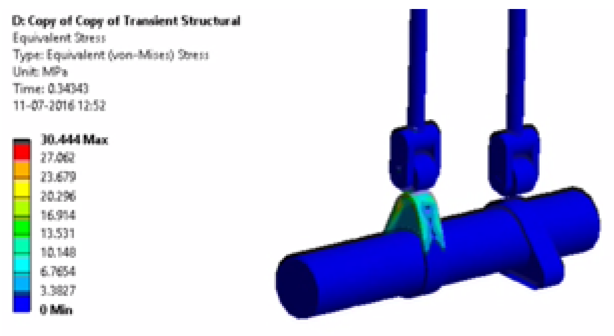


Fig 4.5 Equivalent stress for multibody dynamics analysis

The equivalent stress for 2mm scooped cam in multibody dynamics analysis is as shown in the Fig 4.5. The rigid multibody dynamics simulation is realized with imposed rotation speed 8500rpm. The assembly of different components subjected to different stresses where the cam is subjected to a nearer the end of the lobe face, the maximum stress will be developed at the end of the lobe for the given boundary conditions, the maximum stress is 30.444MPa which is observed at the analysis of cam and follower assembly.

V. CONCLUSION

In the present investigation the existing and modified cam and follower assembly were designed and analyzed using Finite Element Analysis. The obtained results are well within permissible values. Through above analysis for the cam and follower of a single cylinder 4 stroke engine, the following conclusions were drawn.

- I-Cross Section is created in cam by scooping some of the material from the regular cam, which reduced the weight by 2.98% for the 1mm scooped cam and for 2mm scooped cam by 5.97% compared to regular cam.
- Comparing the von-misses stress distribution, the I Section cam has shown better resistance to deformation and stress induced. 2mm scooped cam has shown better strength compared to 1mm scooped and regular cam.
- It is observed through static linear analysis that 2mm Scooped cam has 16.16% lesser equivalent stress and deformation by 8.29% compared to regular cam.
- The bilinear analysis of 2mm scooped cam, the von-misses stress is 1532.1 MPa is developed due to the elastic-plastic behavior of material. The total deformation of bilinear analysis is of 0.12462mm.
- From the multibody dynamic analysis of 2mm scooped cam, the equivalent stress is 30.444MPa which is lesser than that of yield strength of the material.

Consolidating all the above results, it could be conclude that the new modified cam with 2mm scooping can provide better strength and can increase the fatigue life of it.

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