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FE Analysis of Tangent Cam for Different Positions of the Roller Follower

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Abstract

The cam and follower assembly is been used to convert rotating motion into reciprocating or oscillating motion. The cam is made in contact with the follower at all time by the use of retaining springs. To give a reciprocating action, when the follower is lifted to certain height by the cam, there is generation of the stresses. Here these stresses are investigated by finite element analysis of the tangent cam at all possible positions where follower is being lifted. A 10 N load is applied at the line contact of the cam and the follower. When 'Jump phenomenon' has been taken place, the follower reciprocates rigorously giving higher impact at the points where the cam lifted the follower. A tangent cam has been modeled in Solidworks 2014 edition. Six different positions of the follower are considered. The follower is in line contact of the cam. A finite element model is made in ANSYS v15.0. The model is meshed using SOLID186 elements. Von mises stresses has been found out and plotted at all the positions comparatively. The vector plot has been used to get the effect these stresses on the material of the cam and depth of the effect due the loading.

Keywords: Tangent cam, Von mises stresses, vector plot, jump phenomenon.

I. Introduction

Cam is the rotating element of machine which gives reciprocating or oscillating motion to the output element which is known as follower. The cam is assumed to be operating at uniform speed and the follower reciprocates or oscillates at some uniform speed. Due to that cam and followers have been used in IC engines as well as automatic attachments of the machine. Cam and follower is a complex lubricated mechanism which is used in Engine assembly having variation in load and speed. Normally Cam is designed for the specified or required motion of the follower, which gives irregular shaped cam. Tangent cam is the type of cam in which the design is based on standard geometrical circles i.e. base circle and nose circle, tangent is used to joint these circles. Tangent cams are vital machine element in automatic attachment of the machinery. Notable research is been carried out by various researchers in the field of cam and follower which is used in operating mechanisms of different machines. Some of them used experimental analysis to study the tangent or arc cam [1]. The tangent or arc cam can be of two arcs or four arc. Experimental study reveals that the operation of cam and follower is feasible. Cam with specified contour is also applied over the large range of applications. The investigator did the curvature analysis of a cam with specified contour by using the mathematical relation being derived by them [2]. They have applied the cam with different surfaces of the follower i.e. hyperboloid and globoid surface. Instead of keeping the Cam mechanism with lower paired follower, it would also get the expected movement law by means of higher pair touch drive follower. The displacement curve of the follower is also plot by using Pro-e datum graph function. The cam can be design by the powerful software Pro-e for different positions of the cam [3]. Cam can also be design on the powerful software DYNACAM. The researchers did this for radial and globoidal cam for tool changing mechanism of automatic machineries by that we can also draw displacement, velocity, acceleration and jerk of the follower [4]. Materials point of view some analysts did friction and wear test of the surface of the cam considering pair of material in contact [5]. Based on the motion of the output, a mechanism can be design where we can used cam and follower instead of rotor-crank mechanism. Some investigators pointed out that, in order to have the cam fully rotate for every full rotation of the roller-crank, the cam cannot be a closed profile; rather the roller traverses the open cam profile twice in each cycle [6]. Arbitrary equations can specify the motion of the cam [7]. A 2-3 polynomial cam profile shows discontinuous follower motion at the ends of the stroke making it unsuitable at higher speeds. A 3-4-5 polynomial cam profile has an extended control as it provides zero acceleration at the end points and no control over the follower jerks at end points. They have used design software package SOLIDWORKS for the analysis. We can also make simulation of motion of the cam and follower mechanism in simulink as well as in Dynacam. Some researchers did this and compared them well [8]. The follower is made in touch with the cam at all time with the help of retaining springs. But when the follower is lifted to certain height by the cam, there is a stresses which are generated over there. Here these stresses are investigated by finite element analysis of the tangent cam at all possible positions where follower is being lifted.

II. Problem Description

A tangent cam has been modeled in Solidworks 2014 edition. Six primary positions of the follower are considered (Fig. 1). The follower is in line contact of the cam. A finite element model is made in ANSYS v15.0. The model is meshed using SOLID186 elements. SOLID186 is a higher order 3-D 20-node solid element. It exhibits quadratic displacement behavior and has three degrees of freedom per node: translations in the nodal x, y, and z directions. While meshing the tetrahedral option of the SOLID186 is used. Since this is similar to SOLID187 element, which is a 10 node element, so a model is meshed using SOLID187 as well and results are compared. The SOLID186 element on all test accounts showed better convergence for this particular problem as compared to SOLID187 and hence was used throughout the analysis. A mesh sensitivity analysis using SOLID186 was carried out to select a suitable mesh size that would be accurate but has optimum computation cost. Fig. 2 shows the details of mesh sensitivity analysis. From this plot, we could say that the convergence has been achieved in the analysis. In the position A load of 10 N is assumed to be acting at the line contact of cam and follower. A meshed figure is shown in Fig. 3.

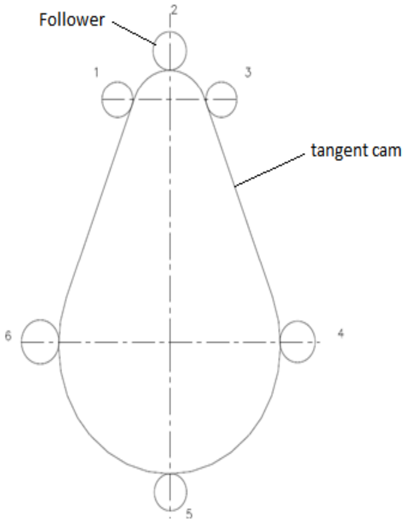

Figure 1: Positions of the follower considered for the analysis.

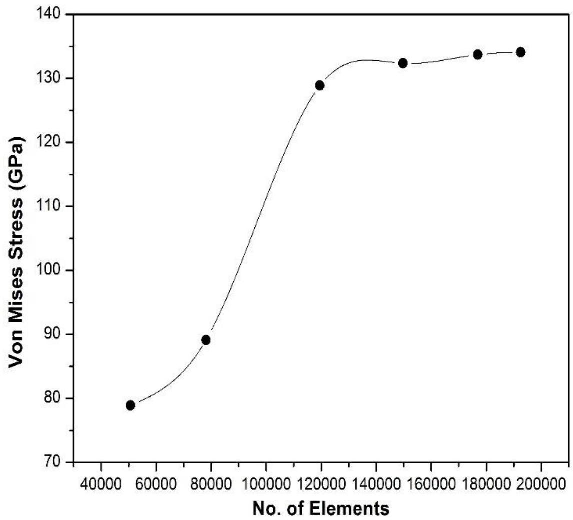

Figure 2: Mesh convergence study.

III. Results and Discussion

Problem considered here is to investigate the maximum stresses in the cam when it will lift the follower at certain position. Geometrically when the follower is at the top position (position A), cam has to lift it with maximum value of the stroke of the follower. That's why maximum Von Mises stresses encountered at that point is highest. Material of the cam should be such that it sustains the maximum stresses here. These Von Mises stresses and factor of safety of the material must be consider for design the cam, because cam has to rotate at high speed. And due to high speed of rotation of the cam there may be the problem of 'Jump phenomenon' of the follower. If these jumps are not reduced, there may be high impact loads acting on the surface of the cam. The contour plots for Von Mises Stresses at different positions of follower are shown in Fig. 3 - Fig. 8. Fig. 9 shows a comparison of the maximum Von Mises stresses at all the positions of the follower. From the Vector plot of Von Mises Stress at various follower position, we could say that, as the maximum stresses are occurring at the tip of the surface of the cam, but the area from the tip surface upto cam shaft has been affected. This shows the impact of the load on the whole material of the cam.

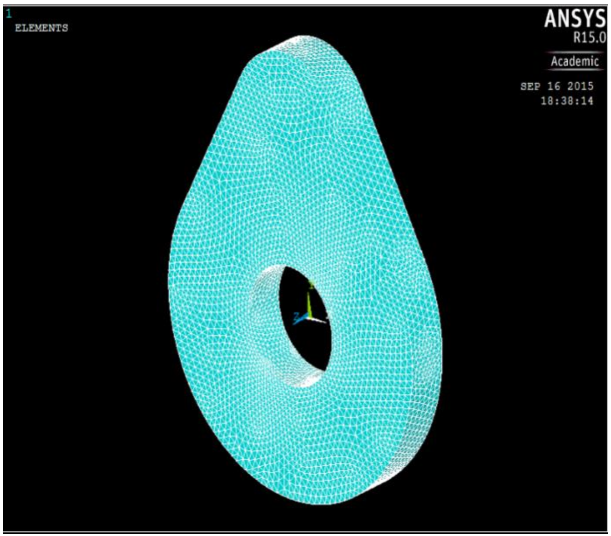

Figure 3: A typical meshed model used in the analysis.

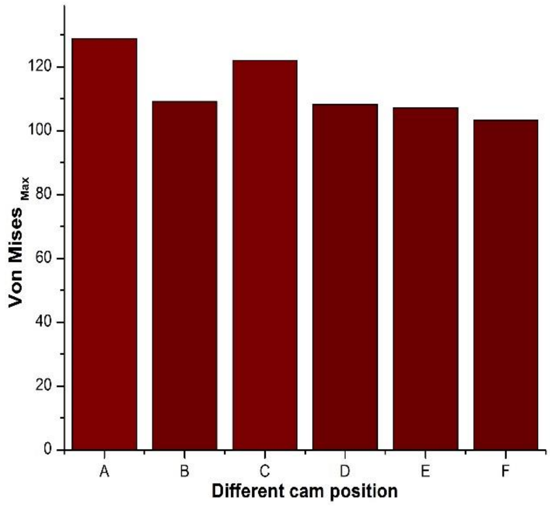

Figure 4: Comparison of Von Mises Stress at various cam positions.

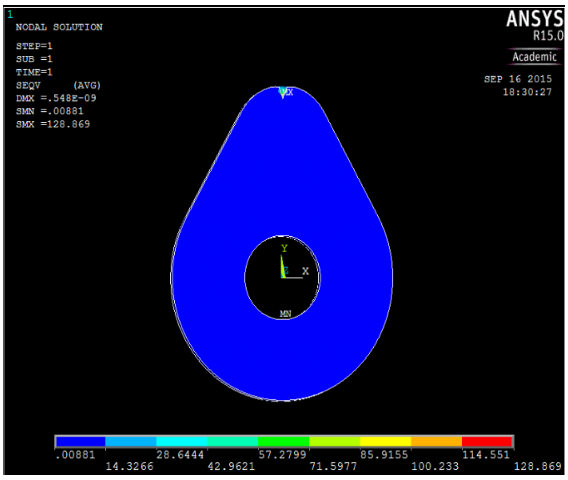

Figure 5: Contour plot of Von Mises Stress at follower position A.

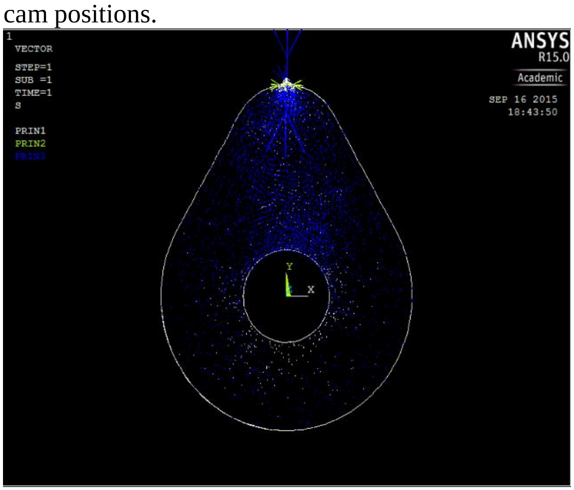

Figure 6: Vector plot of Von Mises Stress at follower position A.

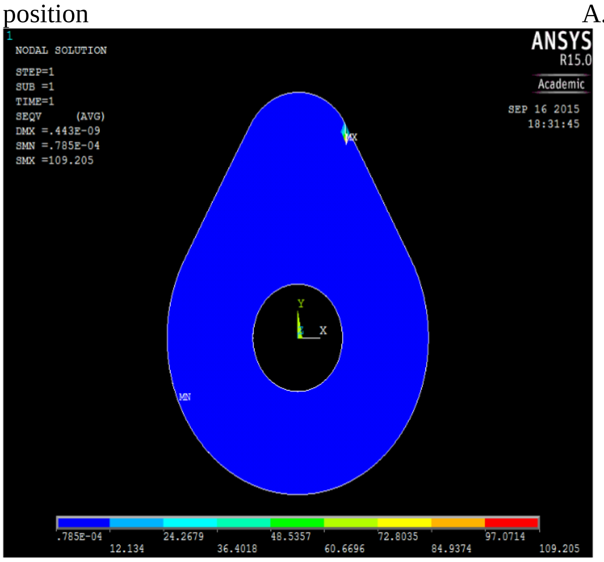

Figure 7: Contour plot of Von Mises Stress at follower position B.

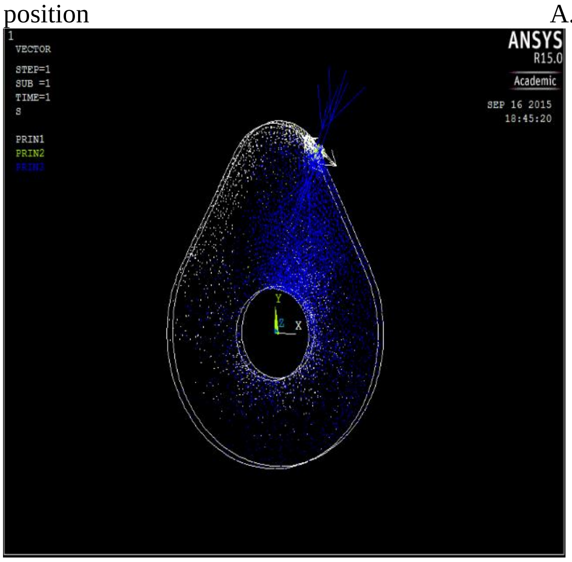

Figure 8: Vector plot of Von Mises Stress at follower position B.

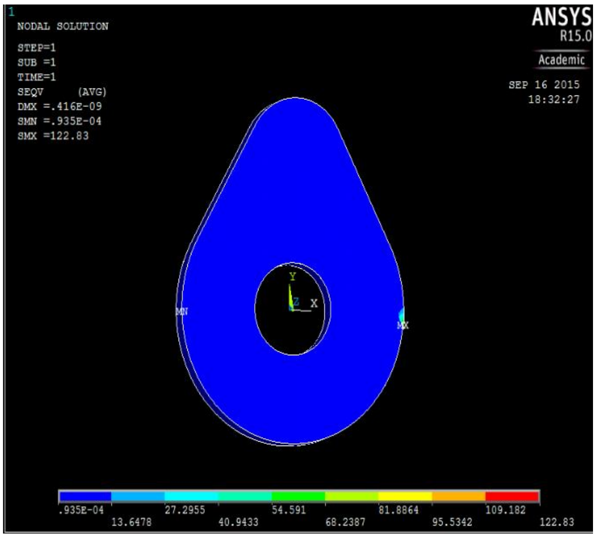

Figure 9: Contour plot of Von Mises Stress at follower position C.

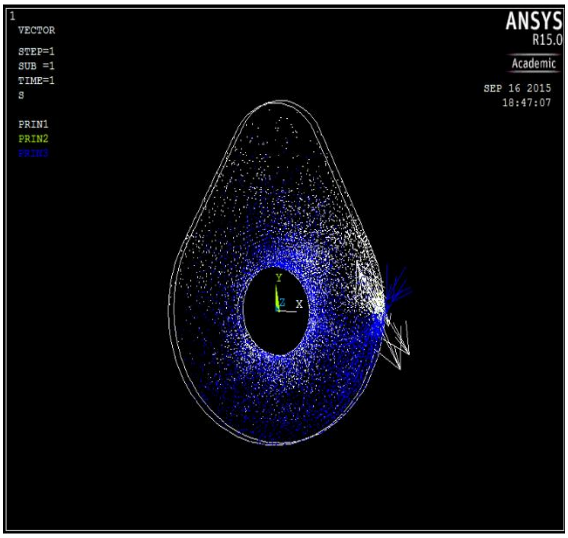

Figure 10: Vector plot of Von Mises Stress at follower position C.

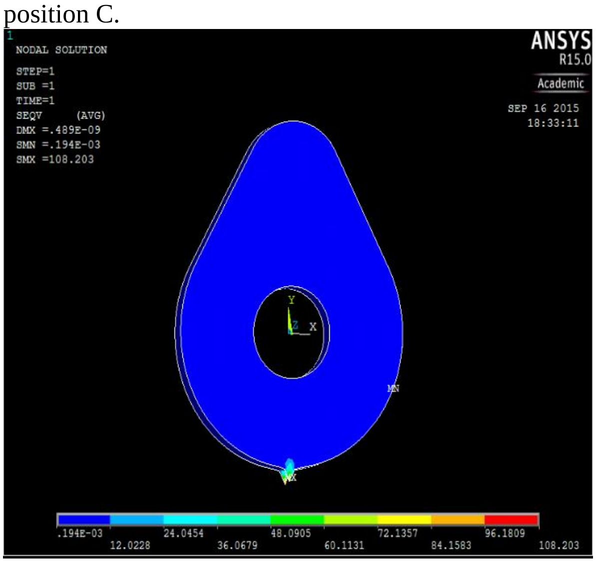

Figure 11: Contour plot of Von Mises Stress at follower position D.

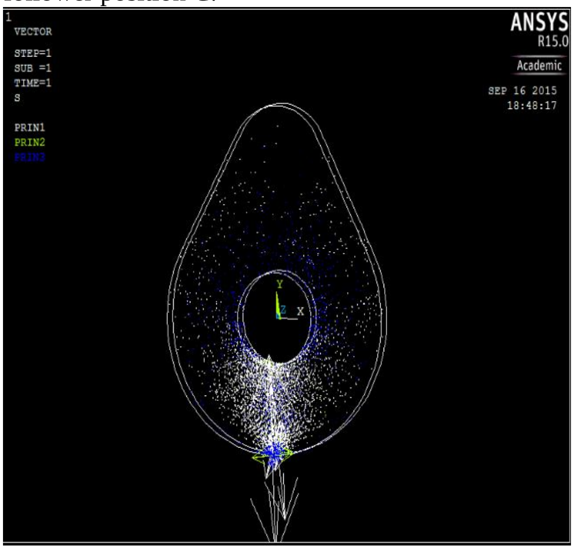

Figure 12: Vector plot of Von Mises Stress at follower position D.

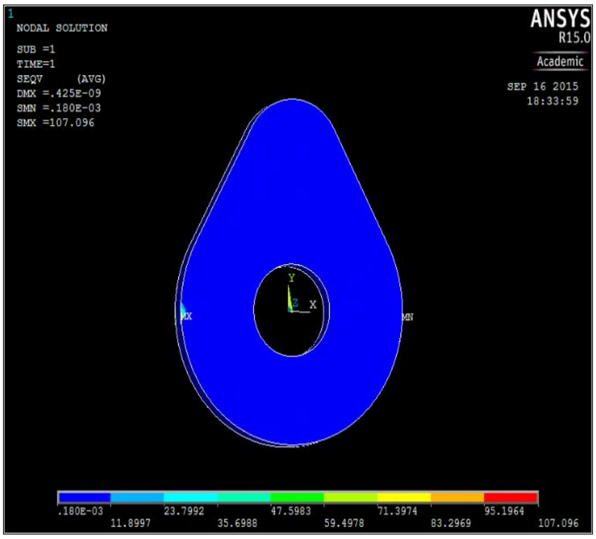

Figure 13: Contour plot of Von Mises Stress at follower position E.

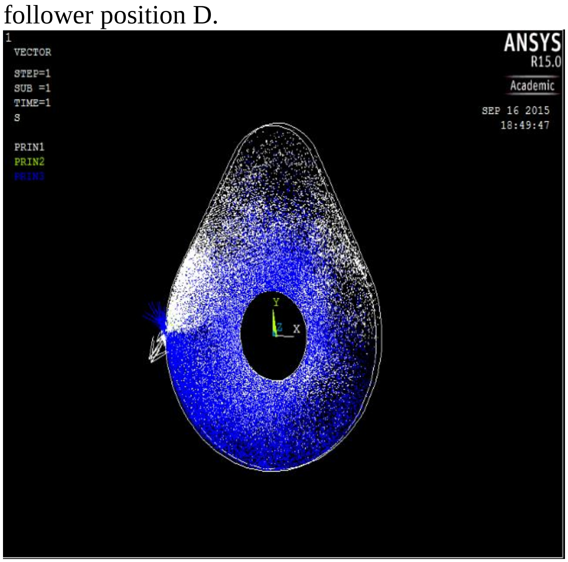

Figure 14: Vector plot of Von Mises Stress at follower position E.

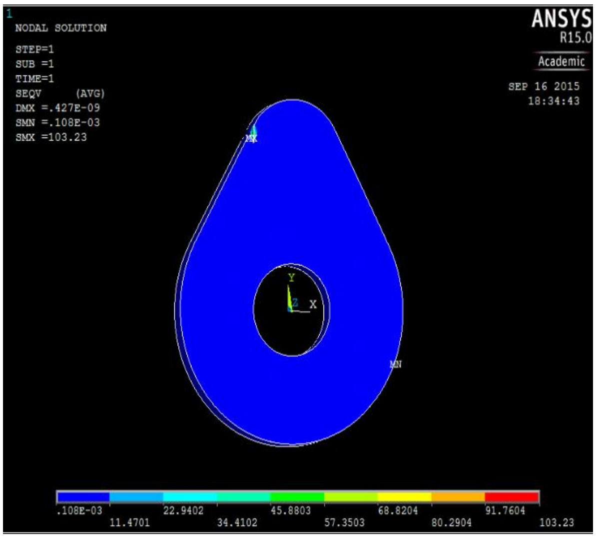

Figure 15: Contour plot of Von Mises Stress at follower position F.

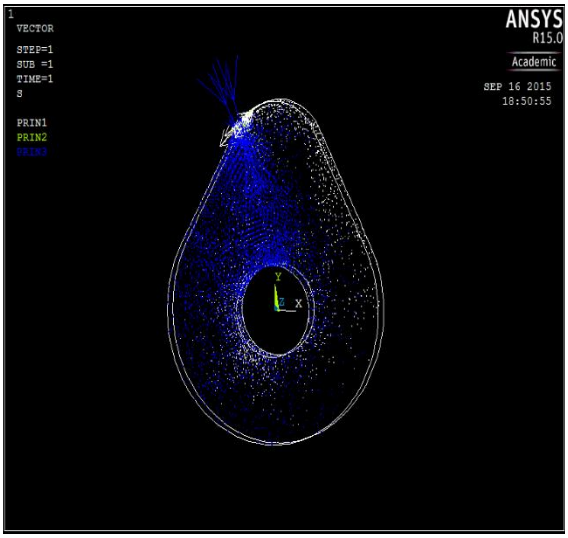

Figure 16: Vector plot of Von Mises Stress at follower position F.

IV. Conclusion

After subjecting the cam at 10 N load and finding the stresses at all possible positions where it will subjected to adverse effect, following conclusions can be made:

1. The stresses found out are savior to affect the performance of the cam and follower system.
2. From comparative analysis of the von mises stress at different position, we can see that, when cam lift the follower at it’s highest position i.e. maximum lift, the stresses are maximum.
3. Since cam has to rotate at high speed in some applications, these stresses at maximum lift are very dangerous which cam start a crack at the surface of the cam and propagate further giving adverse effect on the cam.
4. At the ‘jump phenomenon’, the follower offers very large impact loads. In that condition the stresses becomes more considerable and gives peak effect which can be imagine by this study

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