Crank Pin Induction Hardening Using FEA

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Abstract-*Crank pin is made much stronger so as to meet the requirements of rigidity and vibrations. This study aims at increasing the strength of a crank pin by induction hardening process. The initial phase follows stress analysis of a single cylinder crank pin by doing static analysis. Three-dimension model of a crank pin has created using CAD software, meshing has done using Hypermesh 12.0 and ANSYS 13 is used to analyze the stress status on the crank pin. The maximum deformation, maximum stress point are results of the analysis. Induction hardening on crank pin has done to increase its strength. This new model has analyzed considering induction hardening effects.*

Keywords- Crank pin, induction hardening, CatiaV5R19, Hypermesh 12.0, ANSYS 13, static analysis.

I. INTRODUCTION

In a reciprocating engine, the crank pins, also recognized as crank journals are the journals of the big end bearings, at the tops of the connecting rods opposite to the pistons.

Mechanical cranks convert linear motion into rotary motion or vice versa. In general, crank consists of a main shaft which rotates a crank pin which revolves like a planet around it, and a crank throw to steadily connect them. Handles or knobs on hand-driven cranks may either include the crank pins rank pins are most often parallel to their main shafts. For cranks that can rotate through a full 360 degrees.

In every technical field cranks are used where manual motion is converted into rotary motion. Fishing reels, manual winches, meat grinders, and garden hose reels all use cranks to allow people to easily create continuous rotary motion. Bicycle pedals function as crank pins between the rider's foot and the pedal crank that drives the chain. There are two types of cranks. The first type is the continuously rotating crank, such as in engine crankshafts, where the crank can continuously turn through more than 360 degrees without reverse. The second is the partial circle crank, where the entire rotary motion of the main shaft may be 90 degrees or less, as with steering linkages or ventilation damper adjustments.Gasoline and diesel engine crankshafts usually consists crank pin journals each surrounded along the length of the crankshaft by main bearing journal. Crankshafts are usually cast or forged as one piece. Fig 1 shows photoghraph of two wheeler crank pin. They are ground to be absolutely smooth to present a long-wearing surface to the piston connecting rod and bearing connected to them.

Fig.1 Photograph of two wheeler crank pin.

II. LITERATURE REVIEW

Several studies have been done relating to the Design and Analysis of crank pin. Following is a list of researchers who has worked in this area of crankpin and induction hardening.

M. Senthil Kumar, [1] has done detailed study on crankshafts of two wheeler made from C45 steel. Reason for failure is identified as wear due to lower hardness, inappropriate lubrication and high operating oil temperature.The conclusion from the study was that the crankpin wears at the centre and caused failure.. Two critical locations have been identified and Finite Element Analysis result confirmed that the highly stressed regions are the contact region with the web and centre of crank pin where oil hole is provided.

Momin Muhammad Zia Muhammad Idris, [2] has done strength analysis on crankshaft of a single cylinder two stroke petrol engine, to enhance its design, using PRO/E and ANSYS software.It is found that weakest areas in crankshaft are crankpin fillet and journal fillet. A calculation method is used to validate the model. The paper also proposes a design modification in the crankshaft to reduce its mass.

Divyesh B. Morabiya, [3] worked on study and analysis on crankpin of crankshaft of a single cylinder two stroke petrol engine The static analysis is done using FEA. The validation model of crankpin is attached with statically and dynamically result of Von misses stress and shear stress are within the limits. His research work consists of two major sections: 1) Static analysis 2) Optimization of weight and cost reduction and ultimately increase efficiency of engine.

K. Thriveni, [4] worked on static analysis on a crankshaft from a single cylinder 4-stroke I.C Engine. The modeling of the crankshaft is done using CATIA-V5 Software. Finite element analysis (FEA) is performed to obtain the variation of stress at foremost locations of the crank shaft using the ANSYS software and applying the boundary conditions. The validation of model is related with the Theoretical and FEA results of Von-misses stress and shear stress are within the limits. The maximum deformation looks at the centre of the crankpin neck surface. The maximum stress acts at the fillet areas between the crankshaft journal and crank cheeks and near the central point journal.

Prof. N.P.Doshi, [5] studied connecting rod used in light commercial vehicle of tata motors is selected.In present work analytical result compared with numerical result among all load conditions the maximum value of equivalent stress was found to be 197.41 MPa while crank end of connecting rod is in tension. This stress is less than yield strength of material. It provides a factor of safety of 3.2.So the existing design is safe. The minimum stresses among all loading conditions, were observed at crank end cap as well as at piston end. So the material can be reduced from those portions. For additional optimization , dynamic analysis of connecting rod is needed. After considering dynamic load conditions once again FEA will have to be done. It will give more accurate results than existing.

SandipM.Sorte, [6] worked on stress analysis of a single cylinder crank pin of TVS Scooty Pep crankshaft assemblage. Three dimensional models of crankshaft and crankpin forces were generated using Pro/ENGINEER software and ANSYS was used to analyze the stress level on the crank pin. The maximum deformation, maximum stress point and dangerous areas are decided by the stress analysis. The relationship between the crank rotation and load acting on crank pin would provide a valued theoretical foundation for the stress calculation and enhancement of crankpin and engine design.

III. DESIGN AND STATIC ANALYSIS OF CRANK PIN

This chapter design and analysis of crankpin of dissertation includes design and analysis of existing crankpin of TVS moped engine. Dimensions of the existing crankpin assembly have been extracted from the avalaible data and CAD model has been prepared in CATIA V5 as shown in fig. 3. The finite element analysis is carried out by using Hypermesh and ANSYS.

CAD MODELLING:

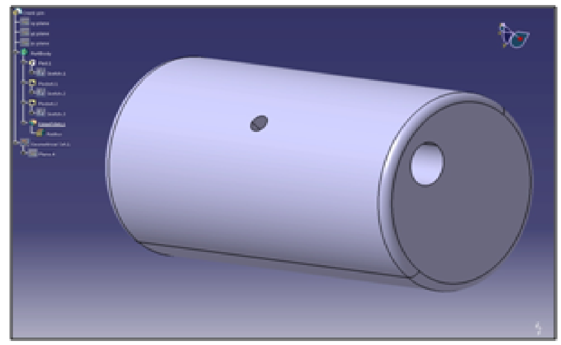


Fig.2 CAD model of crankpin drawn in CATIAV5

ANALYSIS:

Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages and are implicitly incorporated in this text, although we do not necessarily refer to the steps explicitly in the following chapters.

[A] Preprocessing:

1) Meshing:

A structure or component consists of infinite number of particles or points hence they must be divided in to some finite number of parts. In meshing we divide these components into finite numbers. Dividing helps us to carry out calculations on the meshed part. We divide the component by nodes and elements. We are going to mesh the components using 3D elements. As all dimension of crank pin are in proportion we use the tetra-hedral elements for meshing.

While meshing mesh size of an element is to be taken into consideration because all software's have some limits for the number of elements. Less the mesh size more will be the number of elements and coarse the mesh size less will be the number of elements. As the number of elements increases the run time increases. After meshing elements are to be checked for Quality i.e. elements have some definite quality criteria which should be met by all elements. A quality criterion consists of minimum and maximum angles of the elements, jacobian, warpage etc.

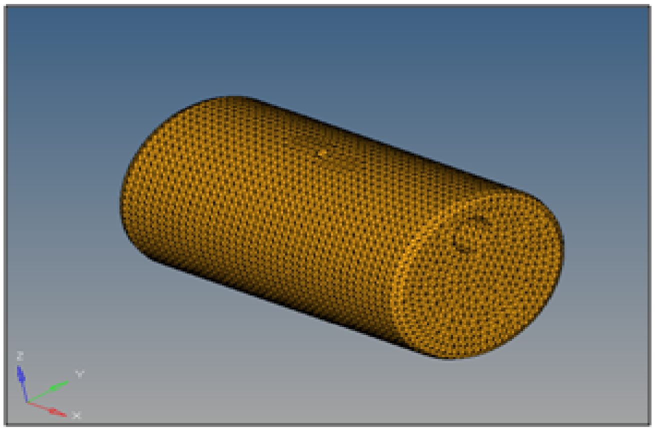


Fig.3 tetra-hedral meshing on crank pin

Number of nodes: 8863
Number of elements: 39820
Element size = 1mm

2) Boundary Condition:

ϴ= angle of inclination of crank from top dead center
Ø= angle of inclination of connecting rod with the line of stroke
dc= diameter of crank pin = 23mm
lc= length of crank pin = 40mm
FT= tangential force on crank pin, FQ sin (ϴ+Ø) ….(4)
FR= radial force on crank pin, FQ cos (ϴ+Ø) ....(5)
Using eqn (4) and (5) following results are calculated for the corresponding angles:

Table 1: Tangential force and Radial force

Sr No.	Ø	ϴ	FT	FR
1	28	90	11.4e3	-6.1 e3
2	0	180	0	-12.3e3
3	28	270	-11.4e3	6.1 e3
4	0	360	0	12.3e3

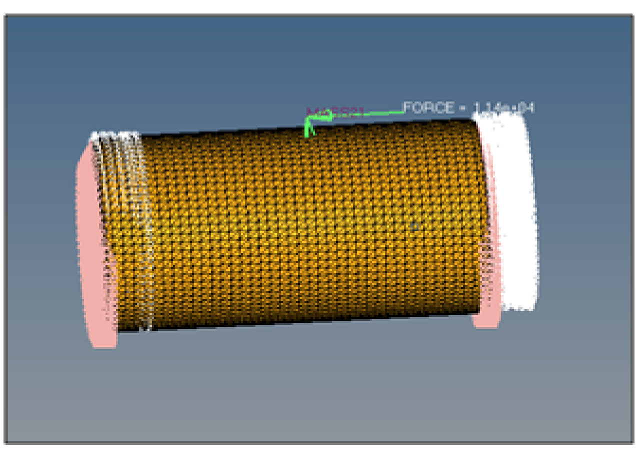


Fig.4 Constraints and forces applied on model in Hypermesh

[B] Solution and Post-processing:

Meshed and boundary condition applied model is imported to the solver. Analysis process starts after applying run in the solver software. Software first calculates the deflection with respect to the boundary conditions applied. Then on the basis of deflection it calculates strain. Once the strain is calculated we know modulus of elasticity then we can calculate the stress values. Results are viewed and accordingly modifications are suggested. Modifications are suggested according to high stress regions obtained. If the stresses are beyond the permissible limits then changes such as change in material, change in thickness of component or addition of ribs etc are made according to suitability. The calculation of stress depends upon the failure theory suitable for the analysis.

Following are the results displayed for stress and deformation:

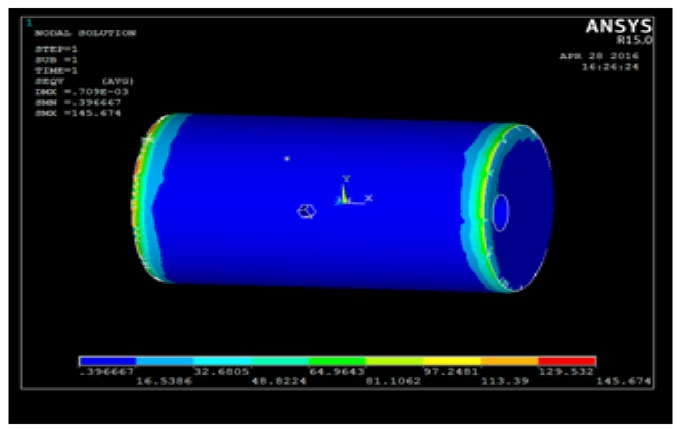


Fig.5 von-mises stress for crankpin

Stress value for crankpin is 145.67 N/mm^2 which is well below the critical value. Hence, design is safe.

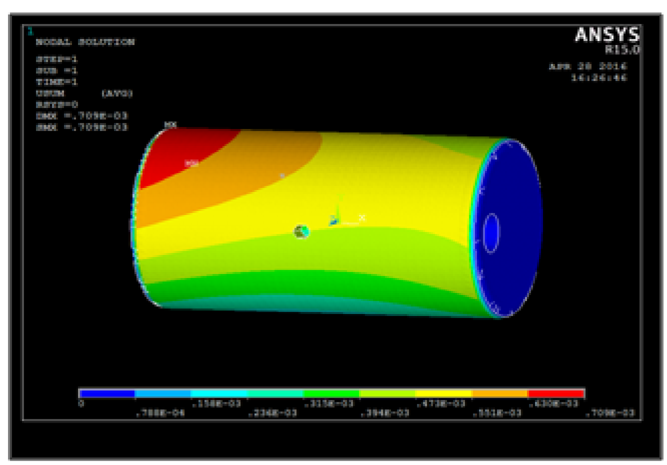


Fig.6 Displacement result for crankpin

From fig, deformation for crankpin is 0.7e-3 mm.

IV. ANALYSIS WITH VARIOUS CASE DEPTHS

Iteration 1:
Induction Hardening with 1mm case depth:

CAD model:

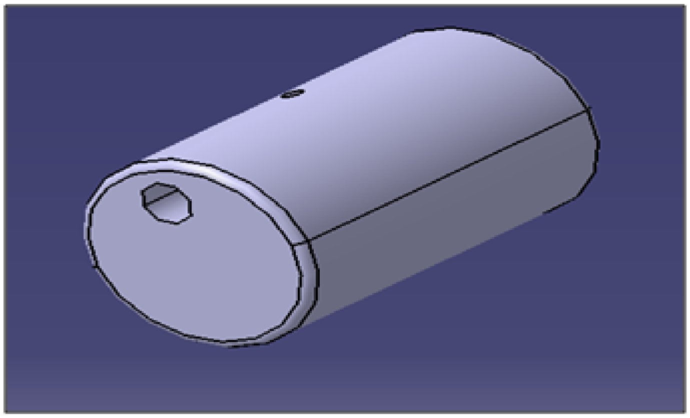


Fig.7 CAD model of crankpin with 1mm case depth

Meshed model

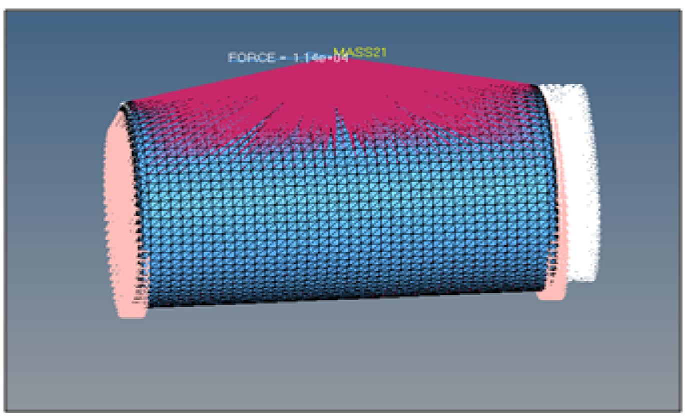


Fig.8 Meshed model of crankpin with 1mm case depth

Following are the results displayed for stress and deformation:

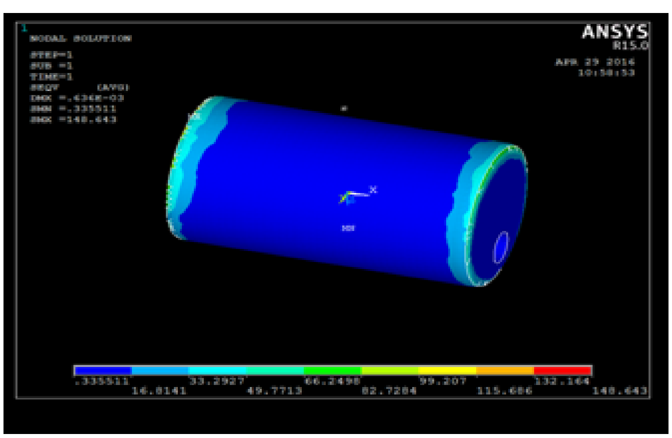


Fig.9 Von-mises stress for crankpin

Stress value for crankpin is 148.64 N/mm^2 which is well below the critical value. Hence, design is safe.

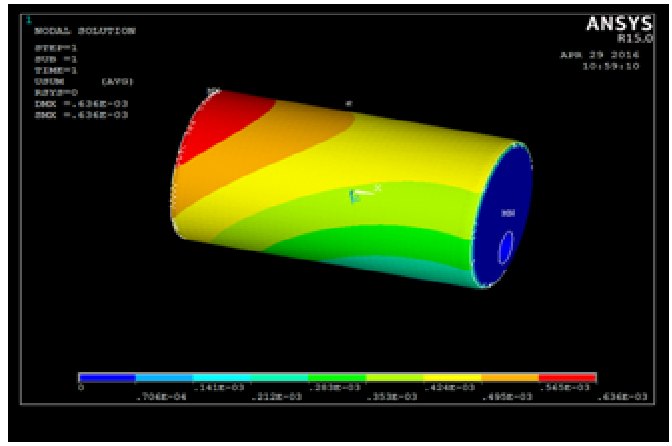


Fig.10 Displacement result for crankpin

The maximum displacment is coming out to be 0.63e-3mm.

Iteration 2:
Induction Hardening with 1.5mm case depth:

CAD model:

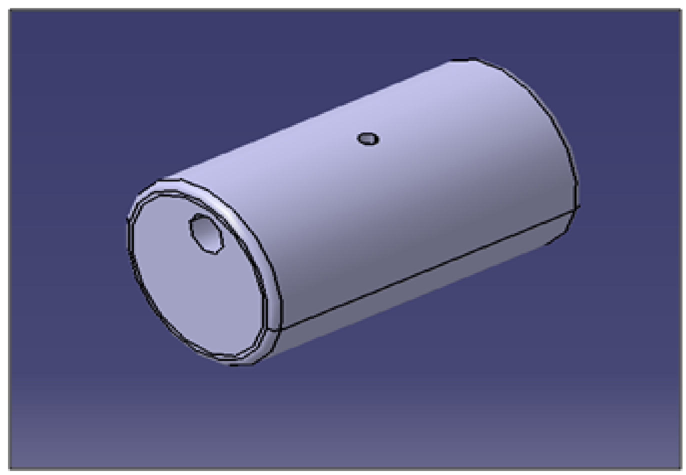


Fig.11 CAD model of crankpin with 1.5mm case depth

Meshed model

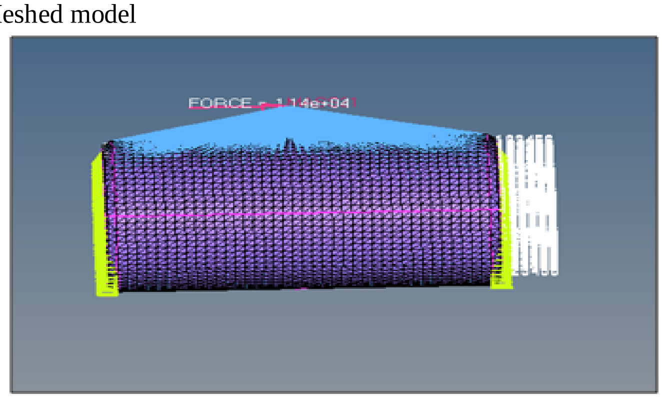


Fig.12 Meshed model of crankpin with 1.5mm case depth

Following are the results displayed for stress and deformation

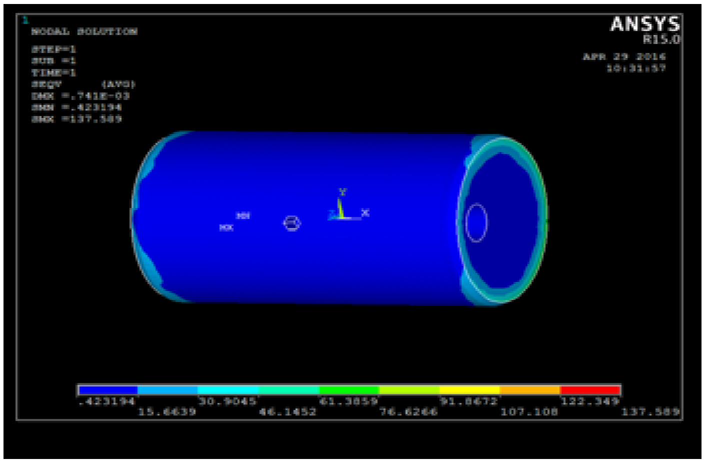


Fig.13 Von-mises stress for crankpin

Stress value for crankpin is 137.58 N/mm^2 which is well below the critical value. Hence, design is safe.

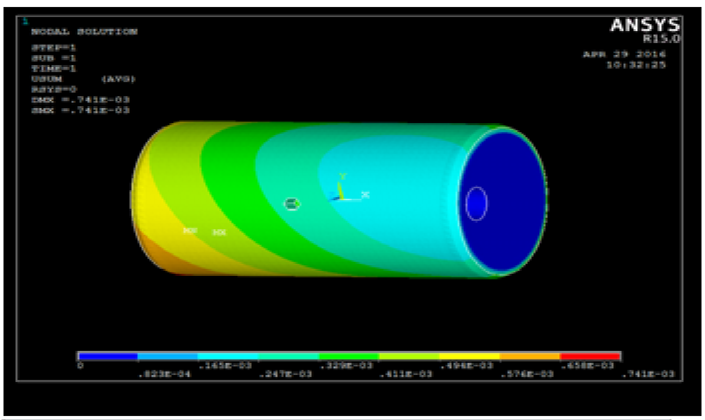


Fig.14 Displacement result for crankpin

The maximum displacment is coming out to be 0.7e-3 mm

Iteration 3:
Induction Hardening with 2mm case depth:

CAD model:

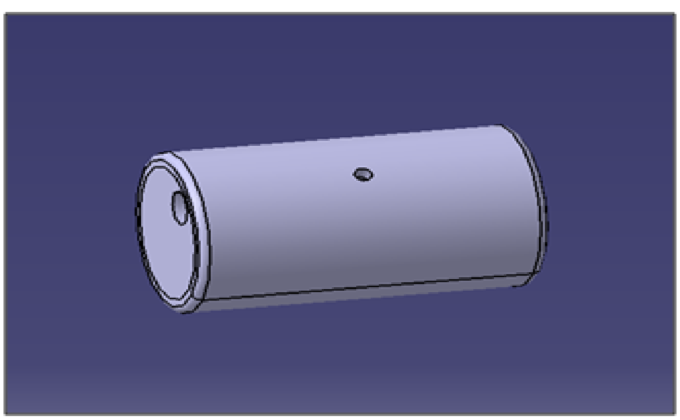


Fig.15 CAD model of crankpin with 2mm case depth

Meshed model:

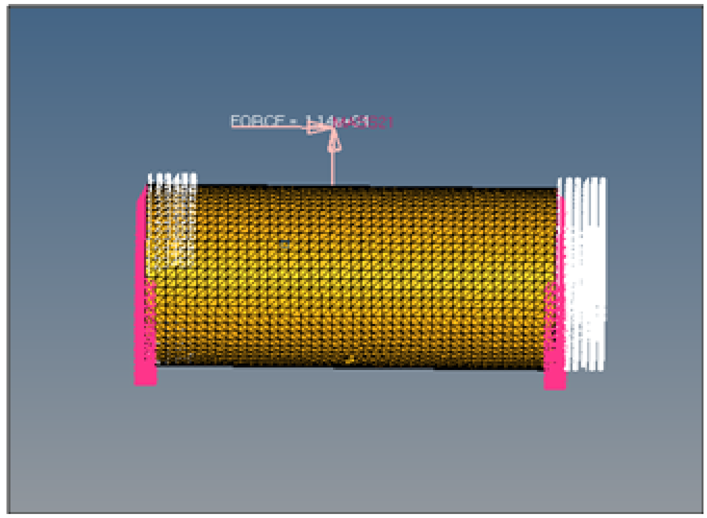


Fig.16 Meshed model of crankpin with 2mm case depth

Following are the results displayed for stress and deformation

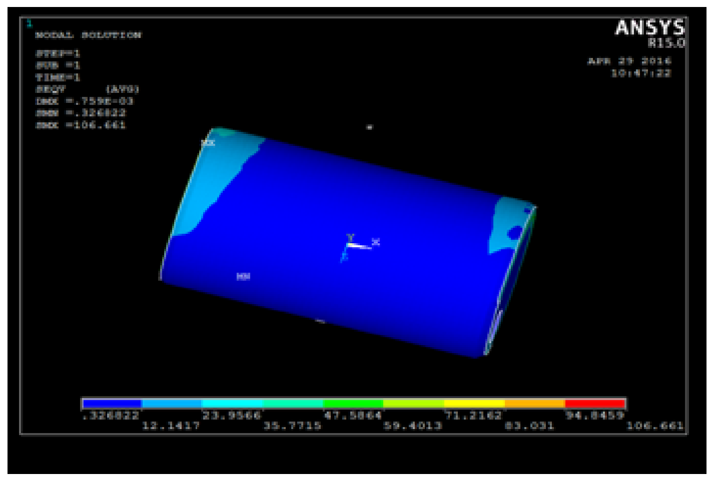


Fig.17 Von-mises stress for crankpin

Stress value for crankpin is 106.66 N/mm^2 which is well below the critical value. Hence, design is safe.

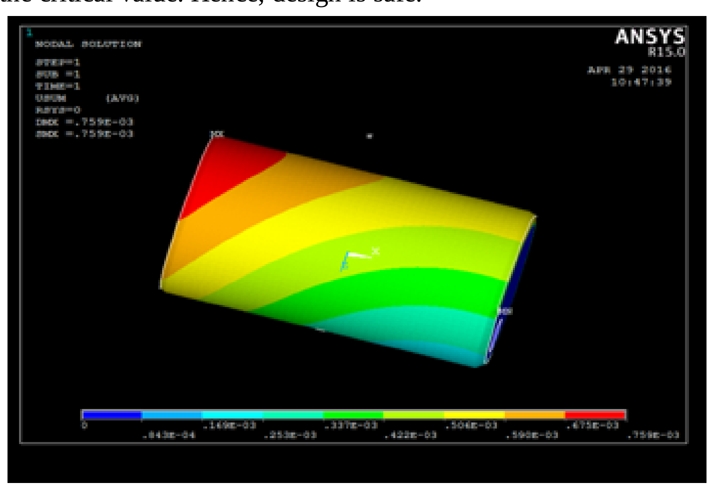


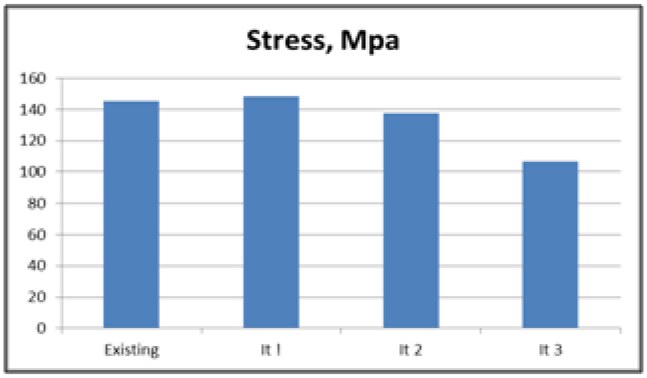
Fig.18 Displacement result for crankpin

The maximum displacment is coming out to be 0.75e3 mm.

V. RESULT

Table 2: Comparison of stresses & Deformation

	Stress (N/mm2)	Deformation (mm)
Existing	145.6	0.7e-3
Iteration 1	148.6	0.63e-3
Iteration 2	137.5	0.74e-3
Iteration 3	106.6	0.75e-3



Graph1 comparision of stresses.

VI. CONCLUSION

From results of finite element analysis it is observed that stresses are minimum for case depth of 2 mm. It is also observed that all the analysis have stress values less than their respective permissible yield stress values.So the design is safe.

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