STRESS ANALYSIS OF CONNECTING ROD BY FINITE ELEMENT METHOD AND EXPERIMENTAL METHOD

[1]Hrishikesh Uttamrao Gadekar, [2]Prof. K.S. Mangrulkar
[1]PG Student, [2] Asst. Professor
Department of Mechanical Engineering,
N. B. Navale Sinhgad College of Engineering, Solapur, India

Abstract*—The connecting rod is one of important part of any IC engine assembly. Its function is to convert reciprocating motion into rotary motion. This paper gives analysis of I.C. engine connecting rod under different loading conditions with the help of ANSYS simulation tool and photoelasticity method. In this paper loads are applied to small end and its corresponding results are calculated and compared it with polariscope readings. The parameters like von misses stress, shear stress, elastic strain, deformation of structural steel were obtained from ANSYS software are compared with cast iron and corresponding results were found out.

***Keywords*—Connecting rod, CATIA V5, Polariscope, ANSYS**

I. INTRODUCTION

Automobile internal combustion engine connecting rod is one of the critical component. It connects reciprocating piston to rotating crankshaft, thus transmitting the thrust of piston to the crankshaft, and is subjected to complex loading. It undergoes high cyclic loads of the order of 108 –109 cycles, which range from high compressive loads because of combustion, to high tensile loads because of inertia.

Inertia load is a time-varying quantity and can refer to inertia load of the connecting rod or of the piston assembly. Connecting rod is undergo both compressive and tensile loading during its operation. The axial compressive load is greater than that of tensile load. Therefore the design is analyzed for compressive loads. The loads are applied to small end keeping big end fixed.

The main aim is to determine the Von Mises stresses, shear stress, elastic strain, deformation. For this a three dimensional model of connecting rod is prepared in CATIA V5 software with dimensions taken as from actual model of 150 cm^3 Bajaj Pulsar 150. The connecting rod is coated with epoxy resin and photo elastic readings were taken.

II. PROBLEM FORMULATION

For the analysis of I.C.Engine connecting rod the most critical area is considered and accordingly the two dimensional model of connecting rod is formed. The different dimensions of the connecting rod is shown in the figure (1) below. Ten loads starting from 40kg, 50kg, 60kg, 70kg, 80kg, 90 kg, 100kg, 110 kg, 120kg, 125 kg were applied at one end i.e, small end and the big end is kept fixed. The stresses calculated from FEA were compared experimentally by Photoelasticity.

i) material fringe value($F\sigma$) = 14.55N/mm
ii) Model thickness(h) = 7mm
iii) Maximum principal stress($\sigma 1$) = $NF\sigma/h$ N/mm^2

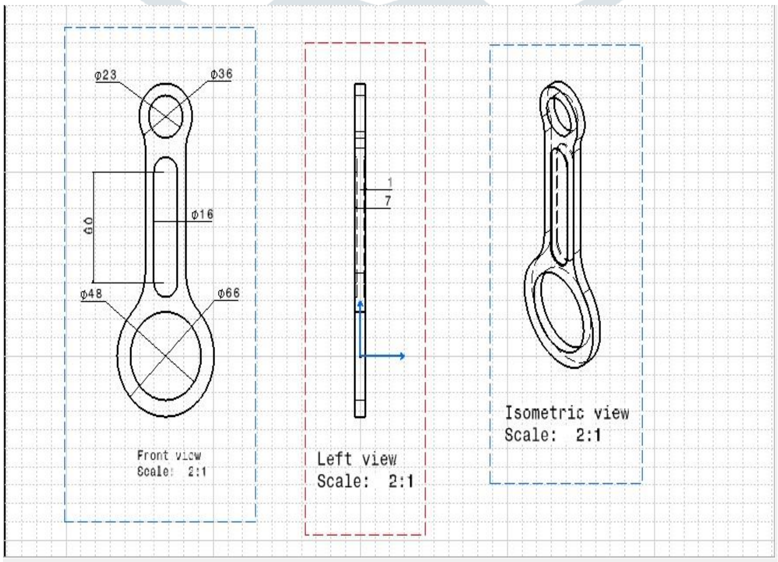


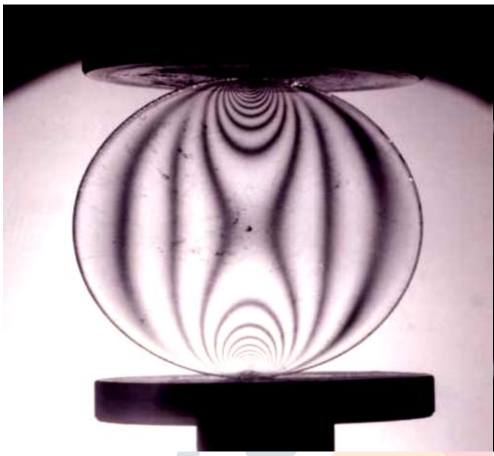
Fig.1 Calibration of photoelastic material according to consideration

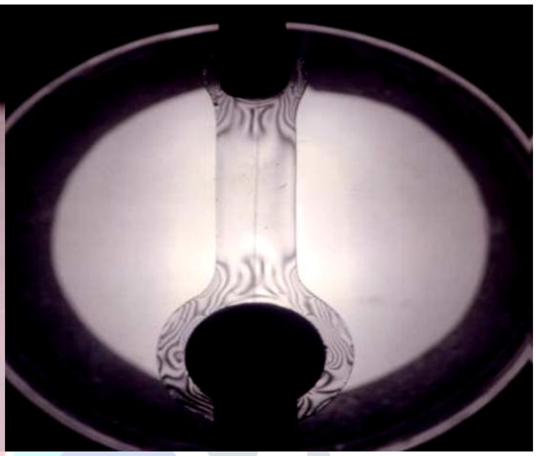
III. PHOTOELASTIC INVESTIGATION OF I.C. ENGINE CONNECTING ROD

The photoelastic model with above mentioned specification is prepared from Araldite AY103 with hardner HY951. The standard transmission polariscope (photograph 1) is used for the investigation.

PHOTOGRAPH(1)

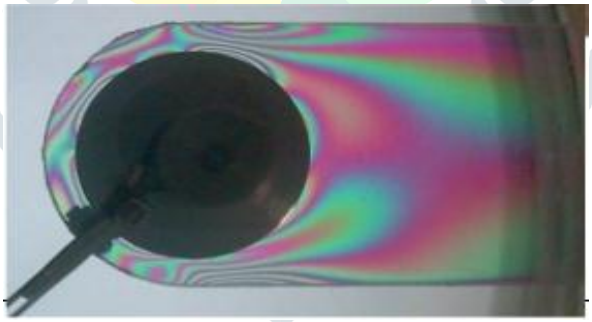
The calibration of photoelastic material is carried out using standard specimen of circular disc subjected to diametral compression [photograph 2].





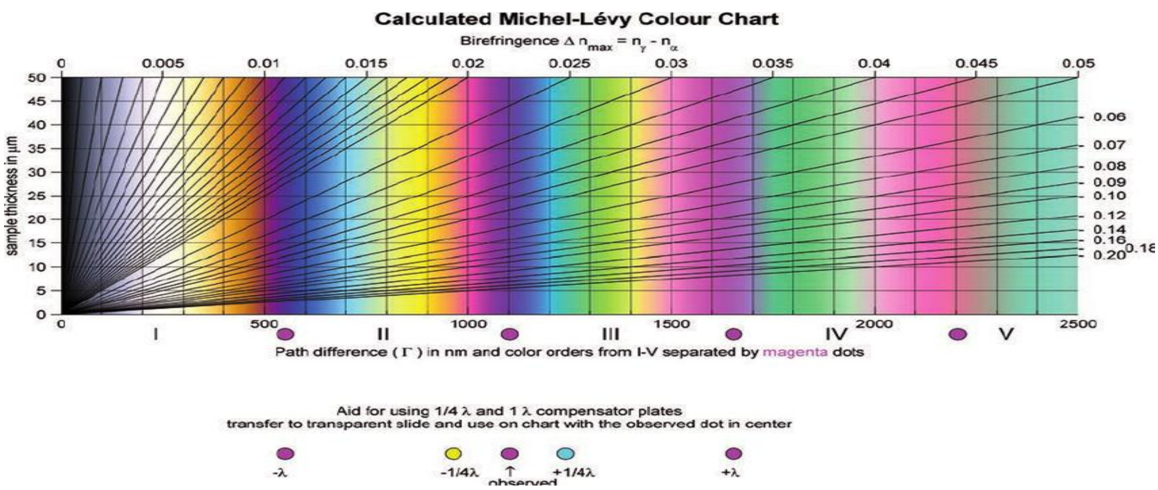
PHOTOGRAPH(2) **PHOTOGRAPH(3)**

The photograph (3) shows the fringes developed in the connecting rod at small and big ends.



PHOTOGRAPH(4)

The photograph (4) Fringe pattern under loading at small end



PHOTOGRAPH(5) The photograph(5) fringe order chart for calculation of stress

IV. EXPERIMENTAL RESULT FOR CONNECTING ROD UNDER DEFINED LOADING:

Sections on connecting rod under examined	Load in "Kg"	Load in "N"	Calculated fringe order(N)	Maximum principal stress (σ) x 10^6 = N*$F_σ$ / h N/mm^2
Section at small end	40	392.4	1.7	3.53
	50	490.05	2.01	4.177
	60	588.6	2.4	5.00
	70	686.7	2.8	5.82
	80	784.8	3.2	6.65
	90	882.9	3.8	7.89
	100	981	4.2	8.73
	110	1079.1	4.5	9.35
	120	1177.2	4.7	9.76
	125	1226.25	4.9	10.18

V. FINITE ELEMENT ANALYSIS OF I.C. ENGINE CONNECTING ROD:

For FEA different loads starting from 40kg to 125kg are applied at small end of connecting rod keeping big end fixed.

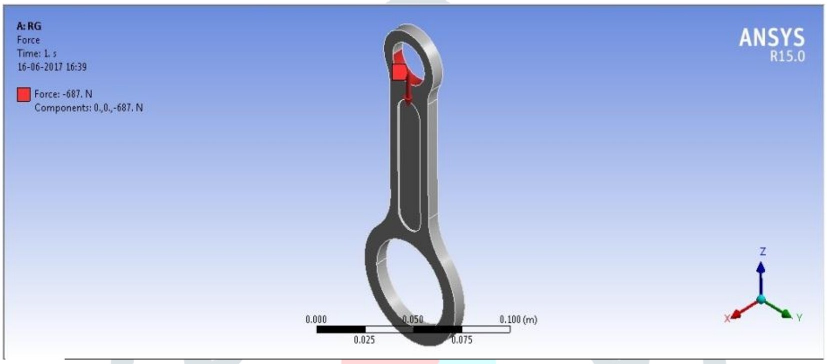


Fig. 2 Connecting rod under loading

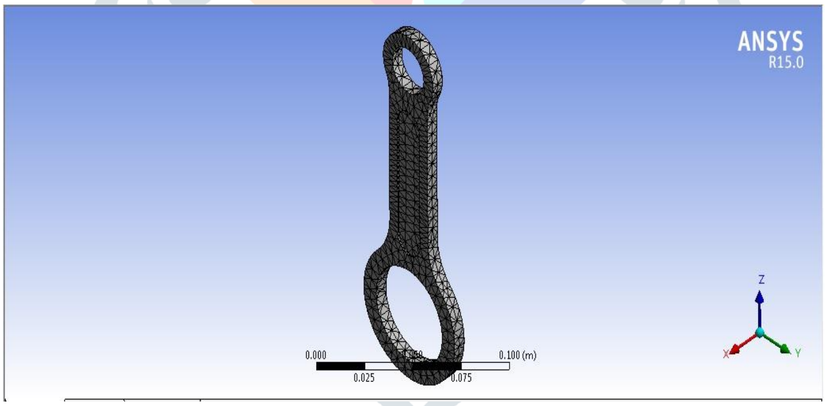


Fig. 3 Model of connecting rod in ANSYS 15.0 in meshed condition

In above fig., the meshing is done under below mentioned statics
Nodes=7015, elements=3538, mesh metrics =none
The following figure shows the static load distribution under loading for structural steel as material and results for Von mises (equivalent) stresses:

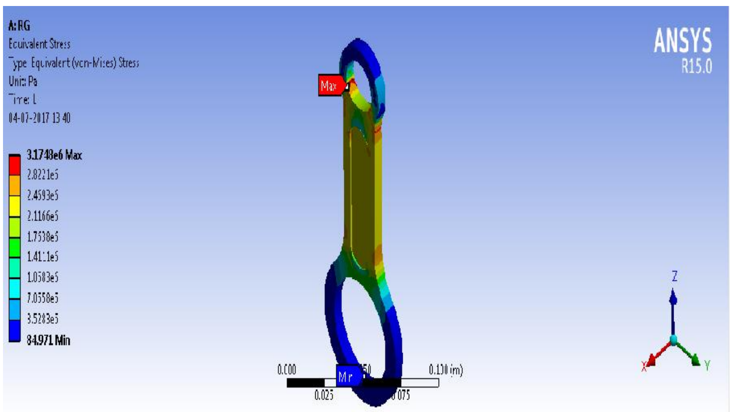


Fig. 4: Connecting rod in ANSYS 15.0 with load of 392.4 N

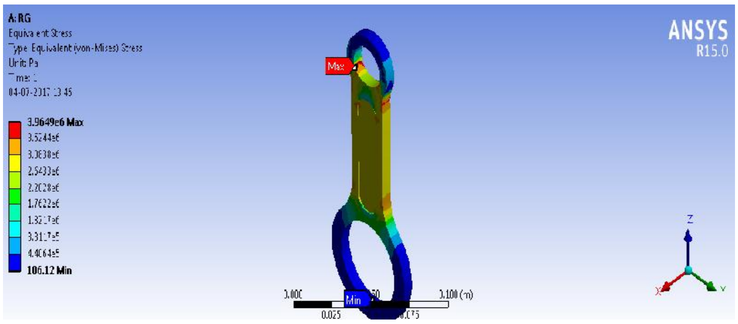


Fig. 5: Connecting rod in ANSYS 15.0 with load of 490.05 N

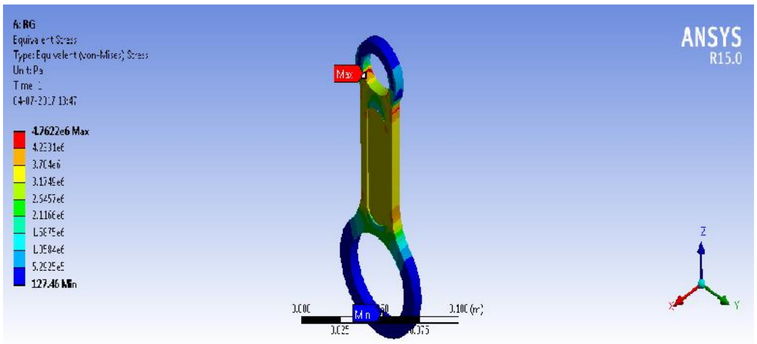


Fig. 6: Connecting rod in ANSYS 15.0 with load of 588.6 N

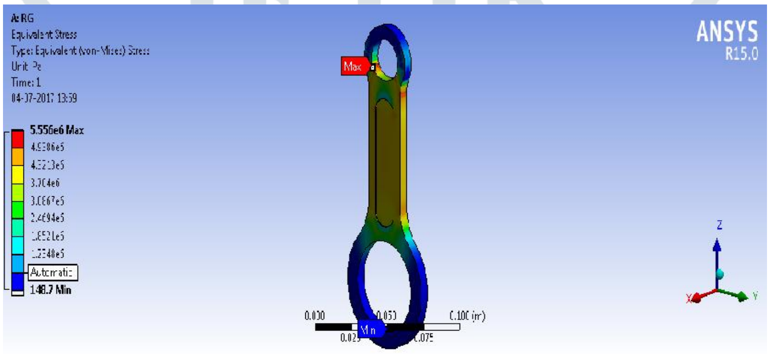


Fig. 7: Connecting rod in ANSYS 15.0 with load of 686.7 N

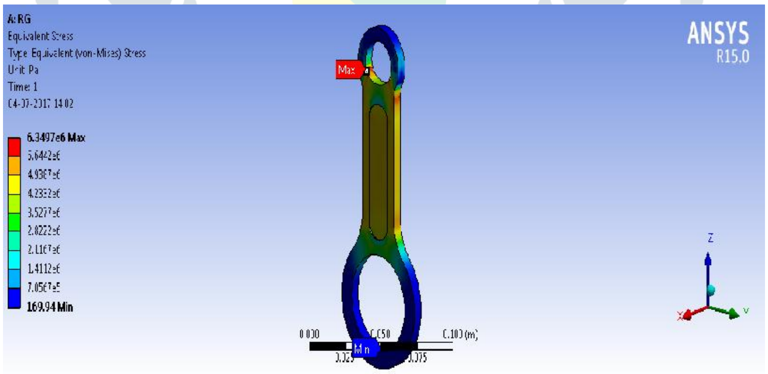


Fig. 8: Connecting rod in ANSYS 15.0 with load of 784.8 N

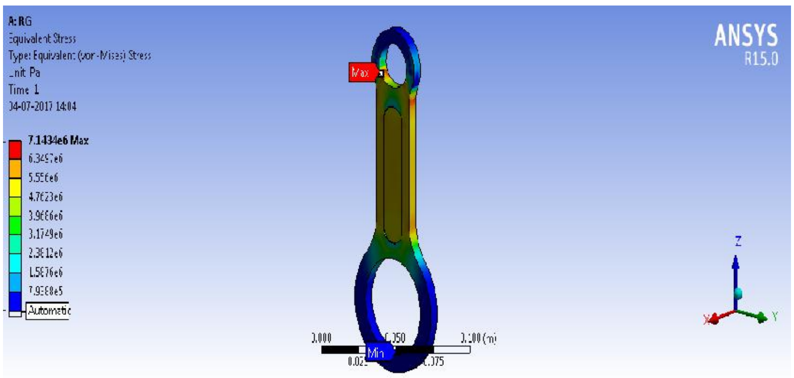


Fig. 9: Connecting rod in ANSYS 15.0 with load of 882.9 N

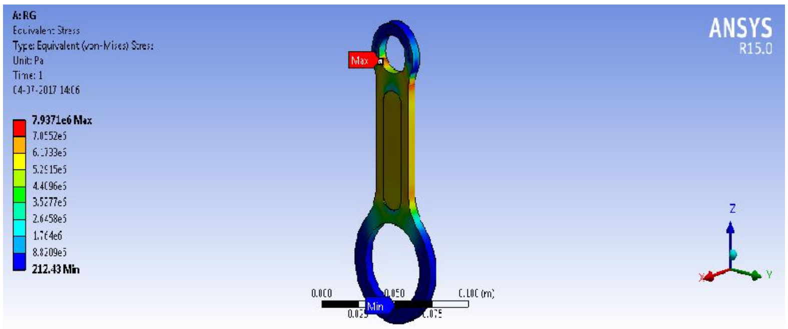


Fig. 10: Connecting rod in ANSYS 15.0 with load of 981 N

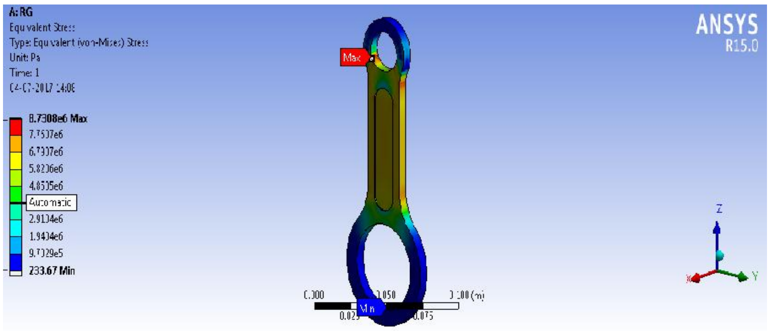


Fig. 11: Connecting rod in ANSYS 15.0 with load of 1079.1 N

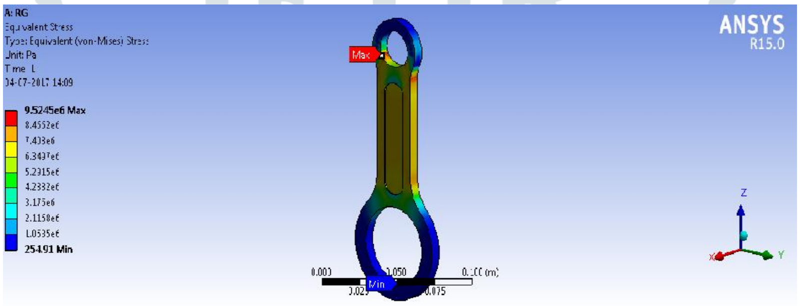


Fig. 12: Connecting rod in ANSYS 15.0 with load of 1177.2 N

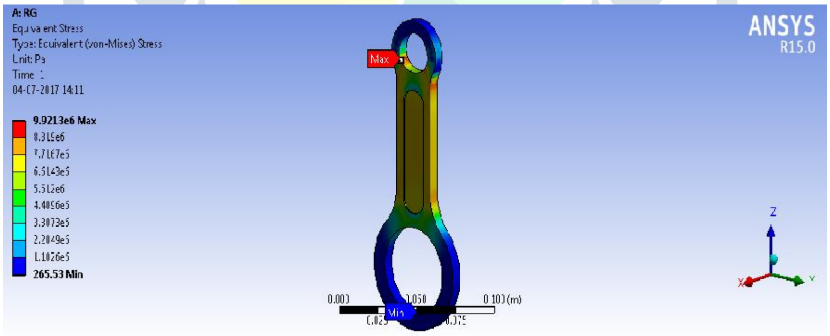


Fig. 13: Connecting rod in ANSYS 15.0 with load of 1226.25 N

VI. DETERMINATION OF VARIOUS STRESSES IN STRUCTURAL STEEL AND CAST IRON OF I.C. ENGINE CONNECTING ROD:

For the finite element analysis three load of 100kg= 981N is used. For this analysis triangular plate element with six degrees of freedom per node is considered. The analysis is carried out using CATIA V5 R20 and ANSYS WORKBENCH 15.0 software. The normal load is applied at the small end of connecting rod keeping big end fixed.

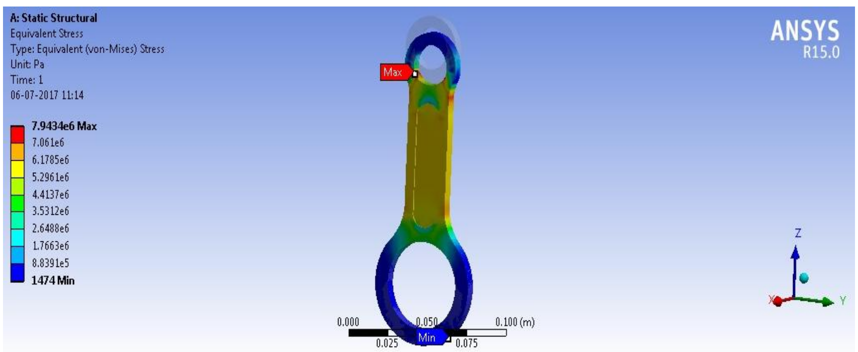


Fig. 14: Connecting rod in ANSYS 15.0 with load of 981 N and Cast Iron as material

VII. SHEAR STRESSES BETWEEN STRUCTURAL STEEL AND CAST IRON:

From both these figures, the maximum shear stress occurs at the piston end of the connecting rod is 3.2534 Mpa and minimum stress occurs at the crank end of the connecting is -0.000032657 Mpa. for Cast Iron rod.

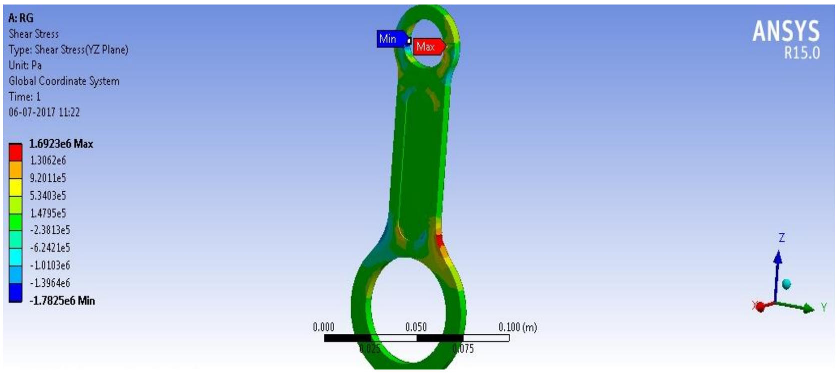


Fig. 15: Connecting rod in ANSYS 15.0 with load of 981 N and Structural steel as material

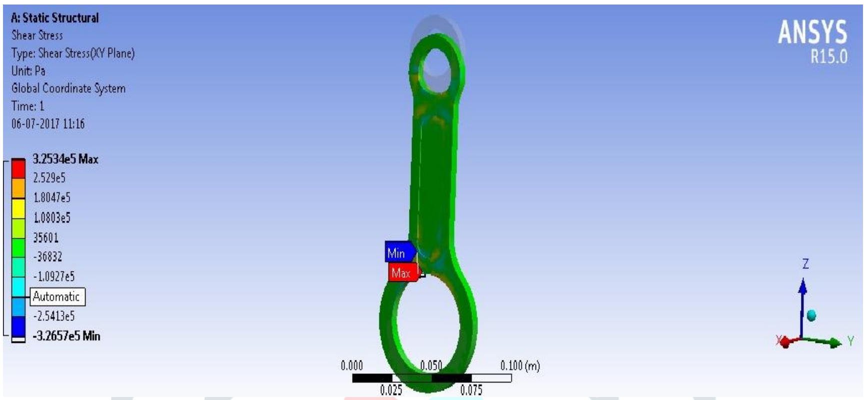


Fig. 16: Connecting rod in ANSYS 15.0 with load of 981 N and Cast Iron as material

VIII. EQUIVALENT ELASTIC STRAIN BETWEEN STRUCTURAL STEEL AND CAST IRON:

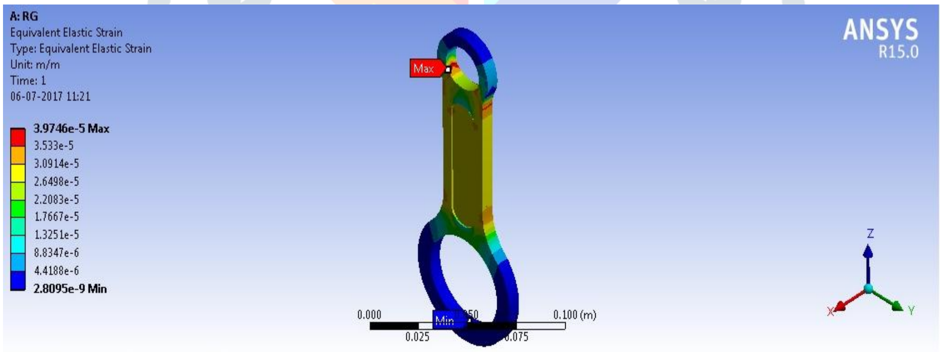


Fig. 17: Connecting rod in ANSYS 15.0 with load of 981 N and Structural steel as material

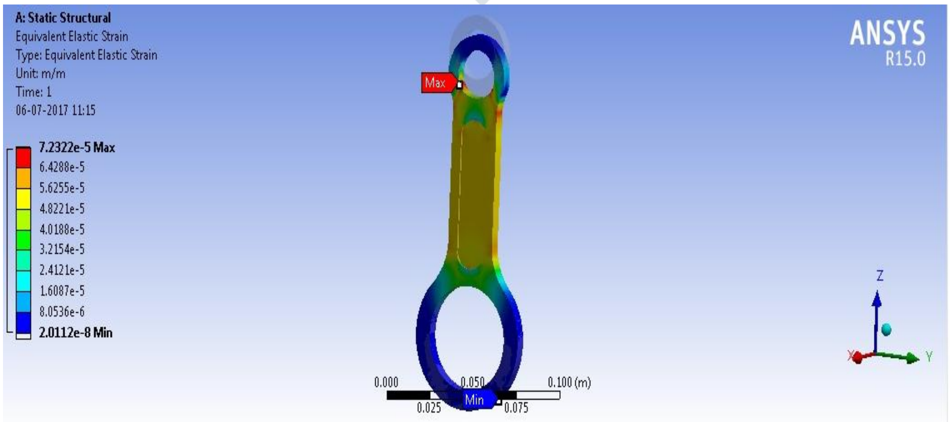


Fig. 18: Connecting rod in ANSYS 15.0 with load of 981 N and Cast Iron as material

The maximum Equivalent elastic strain occurs at the piston end of the connecting rod is 7.232 x 10^{-5} m/m and minimum strain occurs at the crank end of the connecting rod is 2.0112 x 10^{-8} m/m.

IX. TOTAL DEFORMATION BETWEEN STRUCTURAL STEEL AND CAST IRON:

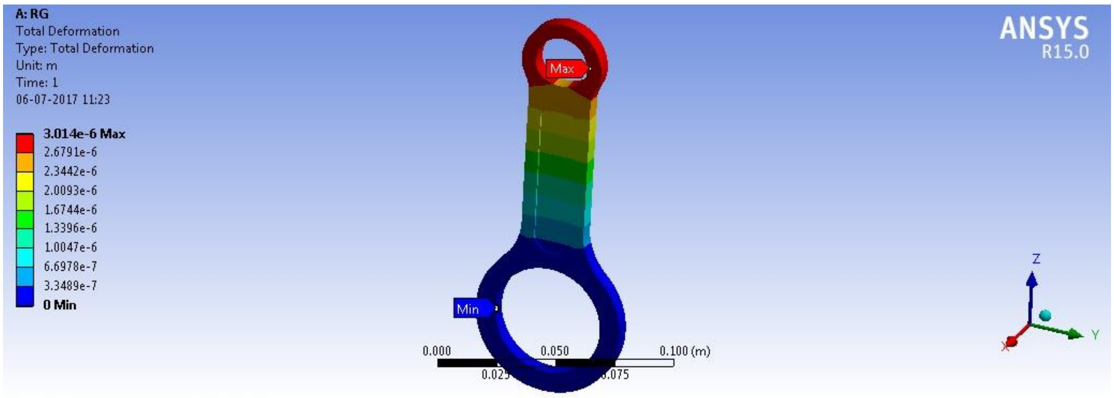


Fig. 19: Connecting rod in ANSYS 15.0 with load of 981 N and Structural steel as material

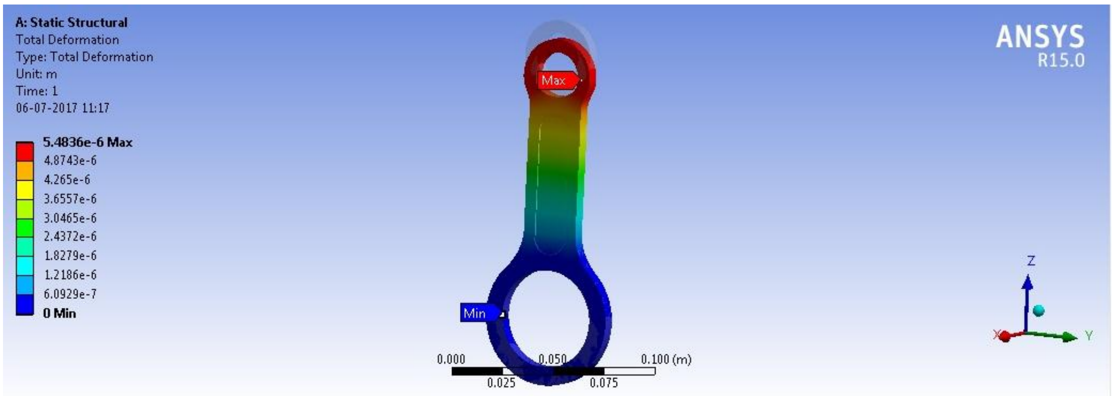


Fig. 20: Connecting rod in ANSYS 15.0 with load of 981 N and Cast Iron as material

From both these figures, the maximum total deformation occurs at the piston end of the connecting rod is 5.4836 x 10^{-6} m and minimum total deformation occurs at the crank end of the connecting is 0.

X. RESULT:

Sr. No.	Load(P) in "Kg"	Load(P) in "N"	Computed values of Von mises stresses induced For small end section		Percentage Error
			Experimental Result in Mpa	Finite Element Method Result in Mpa	
1	40	392.4	3.53	3.17	10.19
2	50	490.05	4.177	3.96	5.195
3	60	588.6	5.00	4.76	4.8
4	70	686.7	5.82	5.55	4.639
5	80	784.8	6.65	6.34	4.66
6	90	882.9	7.89	7.143	9.46
7	100	981	8.73	7.937	9.083
8	110	1079.1	9.35	8.73	6.63
9	120	1177.2	9.76	9.52	2.459
10	125	1226.25	10.18	9.221	9.420

TABLE NO. 1: FEA AND PHOTOELASTICITY COMPARISON

1. As the Fem values are approximate values but they are found close to the experimental values a the error in the results are very less. Hence the reliability of FEM method is good in giving the results approximately equal to the experimental method.
2. The average percentage error is 6.6536 %. So our objective is achieved.

FEA RESULTS:

Sr. No.	Type	Structural Steel	Cast Iron
1	Von mises stress	7.944 Mpa	7.937 Mpa
2	Shear stress	1.6923 Mpa	3.2534 Mpa
3	Elastic strain	3.9746	7.2322
4	Total Deformation	0.000003014	0.0000054836

TABLE NO. 2: STEEL AND CAST IRON FEM COMPARISON

XI. CONCLUSION AND FUTURE SCOPE:

1. The stresses induced in the small end of the connecting rod from photoelastic analysis are greater than the stresses induced from Finite element method. The failure of connecting rod occur at neck portion. The average percentage error is 6.6536 %.
2. Maximum stress occurs at the piston end of the connecting rod.
3. Connecting rod design is safe for both materials based on the ultimate strength.
4. Comparing the different results obtained from the analysis, it is concluded that the stress induced in the structural steel is less than the cast iron for the present investigation. Hence structural steel can be used for production of connecting rod for long durability as cast iron is brittle material.

REFERENCES

[1] Webster et al, 1983, “A three dimensional finite element analysis of a high speed diesel engine connecting rod” SAE Technical Paper Series, Paper No. 831322.

[2] Sarihan V and Song J (1990),”Optimization of the wrist pin end of an automobile engine connecting rod with interference fit”, ASME, Vol.24, No. 3, pp. 49-63, ASME Press.

[3] Pai Chuan Lu (1996), “The shape optimization of connecting rod with fatigue life constraint”, IJMPT, Vol. 11, pp 357 -370

[4] Serag, S., Sevien, L. Sheha, G. and El-Beshtawi, I.,1989,“Optimal design of the connecting-rod”, Modeling, Simulation and Control, B, AMSE Press, Vol.24,No.3, pp. 49-63

[5] G.M Sayeed Ahmed, Sirajuddin Elyas Khany and Syed Hamza Shareef, 2014, “Design, fabrication and analysis of a connecting rod with Aluminium alloys and carbon fiber,” IJIRSET, Vol. 3, No. 10.

[6] Abhinav Gautam and k Priya Ajit, “Static stress analysis of connecting rod Using finite element approach, ”IOSRJMCE, Vol10, Issue 1, 2013, pp 47-51.

[7] Suraj Pal et. al., 2012 “Design evaluation and optimization of connecting rod parameters using FEM” IJMER., Vol. 2, Issue 6, pp. 21-25.

[8] P.S. Shenoy, 2004, “Dynamic load analysis and optimization of connecting rod”, University of Toledo.

[9] Vivek C. Pathade, Dr. D. S. Ingole, ”Stress analysis of I.C. engine connecting rod by FEM and photoelasticity.” IOSR-JMCE, Vol. 6, pp. 117-125.

[10] Puran Sigh et al.” Fatigue and structural analysis of connecting rods material due to using FEA”, IJAET, Vol. 4, pp. 245-253, 2015.

[11] Sushant, Victor Gambhir, 2014, “Design and comparative performance analysis of two wheeler connecting rod using two different materials namely Carbon 70, Steel and Aluminum 7068 by finite element analysis.” IJRAME, ISSN:2321.

[12] B. Anusha, Dr. C. Vijaya Bhaskar Reddy,2013, “Comparisons of materials for two wheeler connecting rod using Ansys,” IJETT, Vol. 4, Issue 9.

[13] Dally, J. W., and W. F. Riley. 1991. Experimental Stress Analysis, 3 Edition, New York: McGraw-Hill

[14] Dr. Sadhu Singh, “Experimental stress analysis”, Khanna Publishers, Delhi, 2004.

[15] James W. Phillips, “Experimental stress analysis”, TAM-326