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AN EXPERIMENTAL STUDY ON DESIGN OF CONNECTING ROD FOR A MOTORBIKE

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ABSTRACT:

In the engine of the automobile, connecting rod is a high volume production and critical component. The Connecting rod connects piston and the crankshaft, and it is responsible to transmit the power from the piston to crankshaft thus, converting the reciprocating motion of the piston into rotating motion of the crankshaft. Generally, connecting rods which are manufactured using carbon steel and composite materials are finding their use in industry. In vehicle engines, the connecting rod is subjected application to high cyclic loads. High compressive loads are due to combustion in the cylinder of the automobile engine, and high tensile loads are due to weight of the connecting rod. The main objective of the present work is to review the weight optimization of a connecting rod in vehicle engine at different loads. To get the idea about designing the connecting rod, various stresses are considered while designing the connecting rod and epoxy resin is used as base material. To get the idea about designing the connecting rod by Finite Element Method (FEM) using ANSYS WORKBENCH 9.0 software for the modelling and analysis of connecting rod.

Keywords: Reciprocating motion, Cyclic loads, Compressive loads, Weight optimization, Finite Element Method, Epoxy resin, Modelling & analysis

INTRODUCTION:

A Connecting rod is the link between the rotating crank shaft and reciprocating piston. Small end of the connecting rod is connected to the piston. The big end of the connecting rod is connected to the crankshaft. The main function of the connecting rod is to transform the reciprocating motion of the piston into the rotary motion of the crankshaft. The connecting rods are generally manufactured by forging & casting. However, with the progress of technology, the connecting rods present days are also cast from malleable or spheroid graphite cast iron, depending upon the requirements. In general, forged connecting rod are

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compact in design and light in weight which is an advantage from inertia view point. It has consist of mainly three parts namely- a pin end, a shank region and a crank end. The pin end is connected to the piston and crank end is connected to crankshaft. A combination of axial and bending stresses act on the rod in operation. The axial stresses are generated due to cylinder gas pressure and the inertia force arising on account of reciprocating motion. Whereas bending stresses are produced due to the centrifugal effects. To provide the maximum rigidity with minimum weight, the cross section of the connecting rod is made as I – section. The ends of the connecting rod is a solid eye or a split eye, this end holding the piston pin. The big end works on the crank pin and is always split. In some connecting rods, a hole is drilling between two ends for carrying lubricating oil from the big end to the small end for lubrication of piston and the piston pin.

Design of Connecting Rod:

In designing a connecting rod the following dimensions are required to be determined:

1. Dimension of cross section of connecting rod
2. Dimension of the crank pin at the big end and the piston pin at the small end
3. Size of the bolts for securing the big end cap
4. Thickness of the big end cap

Force Calculation

Load due to gas pressure on piston (F_g)

$$F_g = (\pi d^2 \div 4) * p_{max} .$$

Inertia force due to reciprocating parts

(F_i)

$$F_i = \frac{1000\, WrV^2}{gr}\left(Cos\ \theta \pm \frac{Cos\ 2\theta}{n^1}\right)$$

Where, W = Weight of reciprocating parts in N

r = Crank radius

θ = Crank angle from the dead centre

V = Crank velocity m/s

$$n^1 = \frac{l}{r}$$

l= length of connecting rod, r = crank radius

So, total force on connecting rod, (F) =

$F_g + F_i$

Material Properties

Material selected	Epoxy Resin
Mass density of the Material (ρ), Kg/mm3	$2.6 * 10^3$
Tensile modulus along X-direction (Ex), MPa	34000
Tensile modulus along Y-direction (Ex), MPa	6530
Tensile modulus along Z-direction (Ex), MPa	6530
Tensile strength of the material, MPa	900
Compressive strength of the material, MPa	450
Shear modulus along XY-direction (Gxy), MPa	2433
Shear modulus along YZ-direction (Gyz), MPa	1698
Shear modulus along ZX-direction (Gzx), MPa	2433
Poisson ratio along XY-direction (NUxy)	0.217
Poisson ratio along YZ-direction (NUyz)	0.366
Poisson ratio along ZX-direction (NUzx)	0.217

Table 1: Material Properties for Connecting Rod

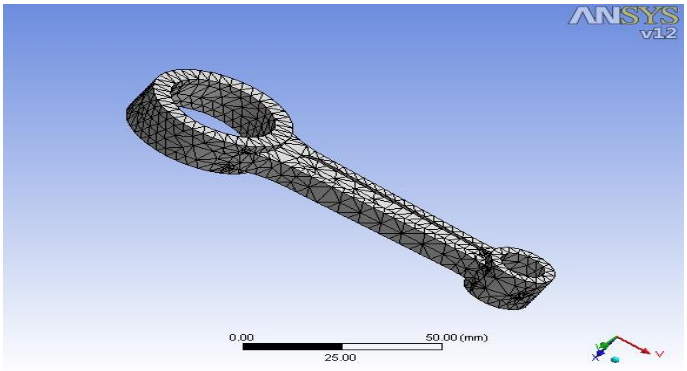

Fig.1.1 Meshed model of connecting rod in ANSYS

BOUNDARY CONDITIONS

Loading: After completion of the finite element model, boundary condition and loads are applied. User can define constraints and loads in various ways. All constraints and loads are assigned as per set ID. This helps the user to keep track of load cases. The boundary condition is the collection of different forces, supports, constraints and any other condition required for complete analysis. Two cases are analysed for each case, one with load applied at the crank end and restrained at the piston end, and the other with load applied at the piston end and restrained at the crank end. An axial Load of 4319 N is applied on the connecting rod at the small end, and cylindrical support is given at the crank end. The same loading conditions also applied for the buckling load. Buckling load = 4319*5.00069 =21598 N, for fatigue failure analysis the loading condition are fully reversed.

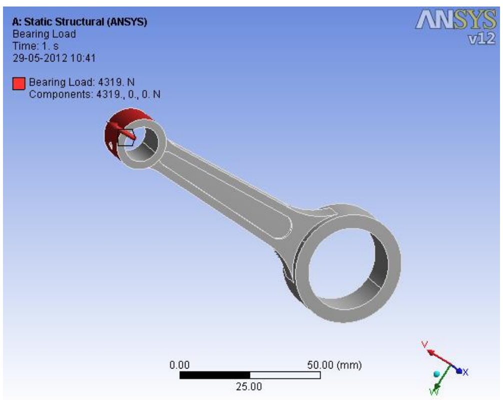

Fig.1.2 Applied constraints on the connecting rod by applying load on piston pin side

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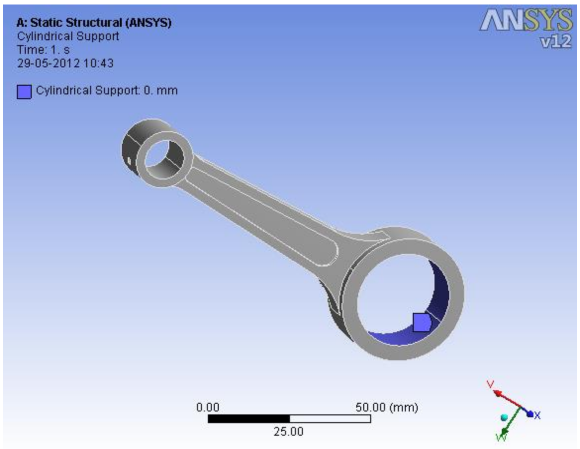

Fig.1.3 Applied constraints on the connecting rod by applying cylindrical support at another side

FEA RESULTS FOR AXIAL LOAD (8638N)

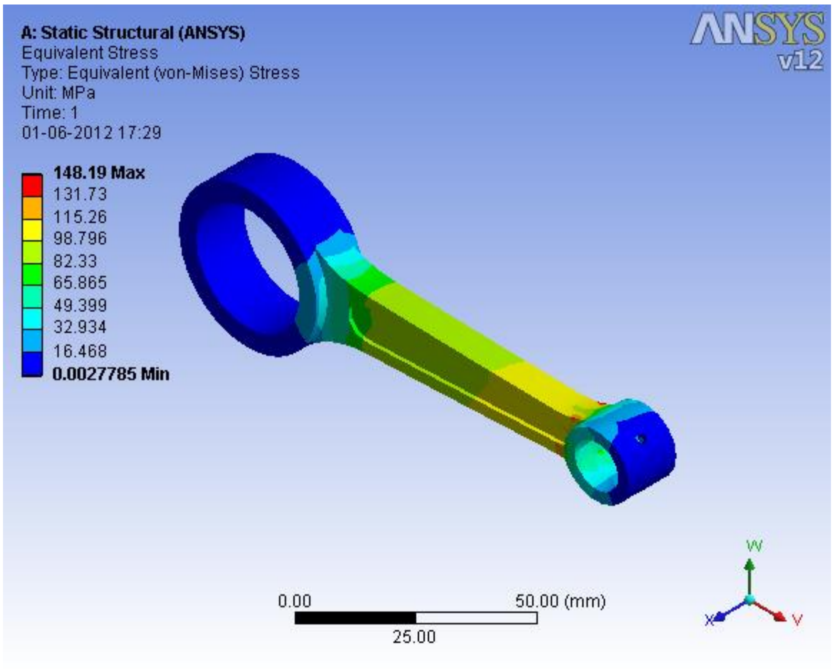

Fig.1.4 Equivalent (Von-Mises) Stress (for load =8638N)

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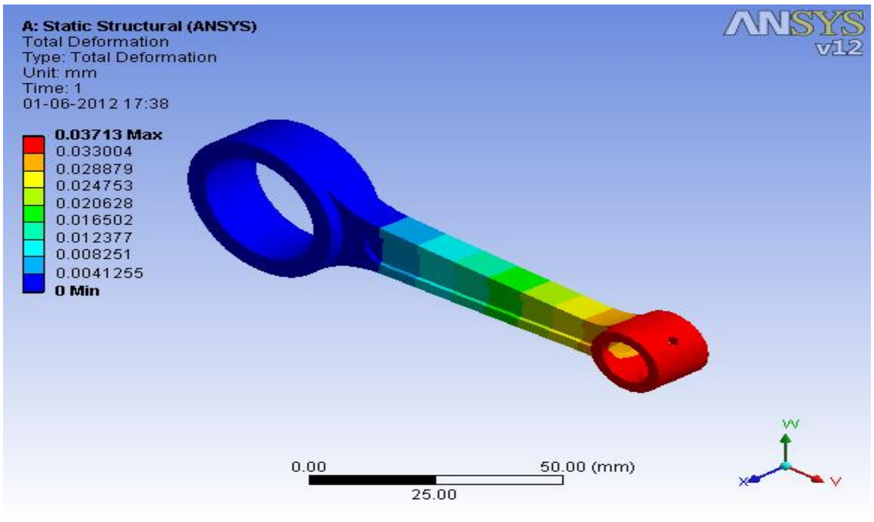

Fig.1.5 Total Deformation (for load =8638N)

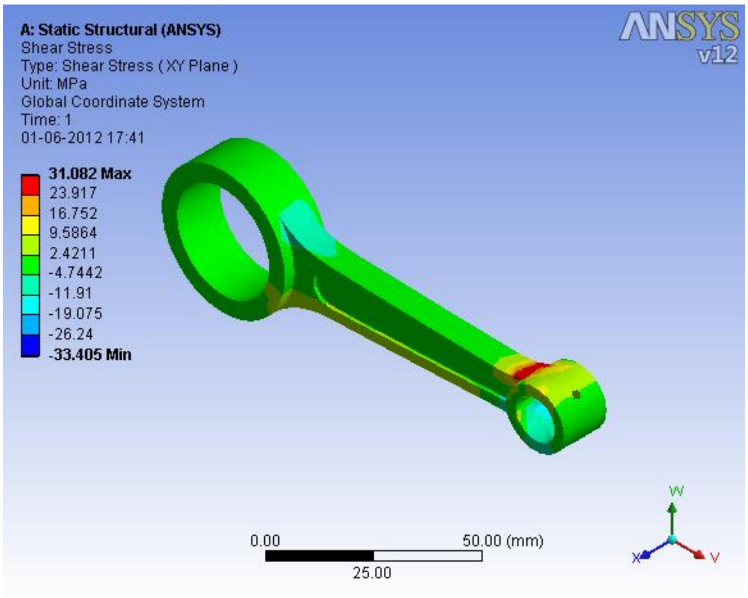

Fig.1.6 Shear Stress (for load =8638N)

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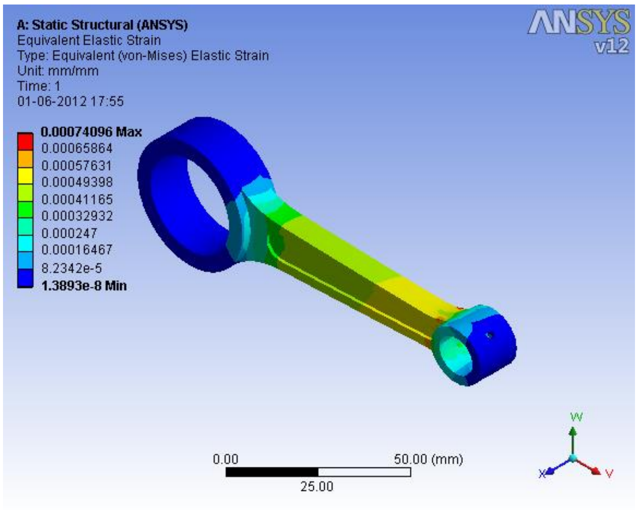

Fig.1.7 Equivalent Elastic strain (for load =8638N)

FEA RESULTS FOR BUCKLING LOAD (21598 N)

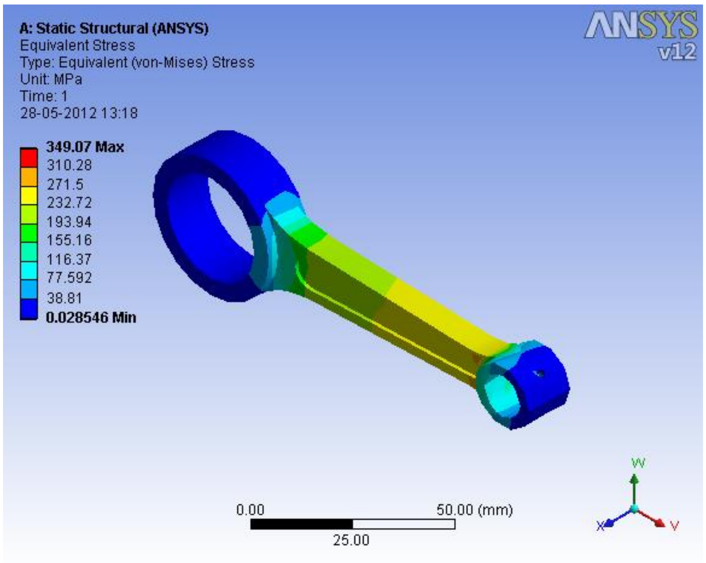

Fig.1.8 Equivalent (Von-Mises) Stress (for load =21598N)

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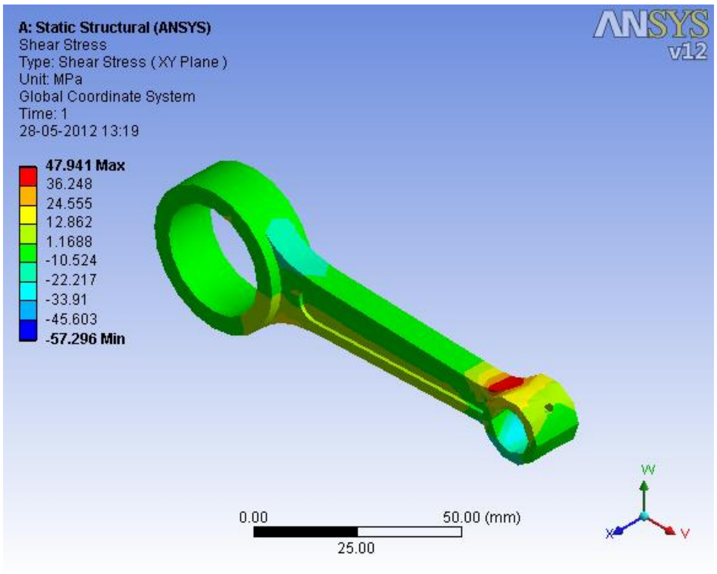

Fig.1.9 Shear Stress (for load =21598N)

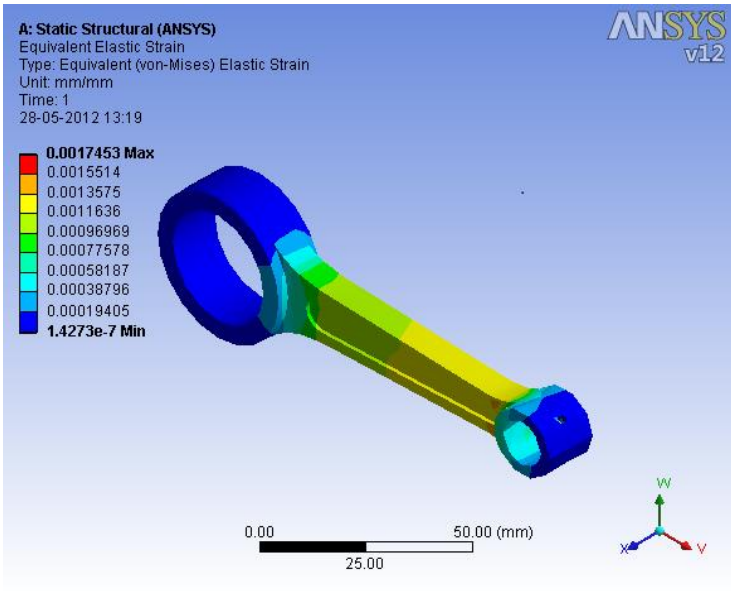

Fig.1.10 Equivalent Elastic strain (for load =21598N)

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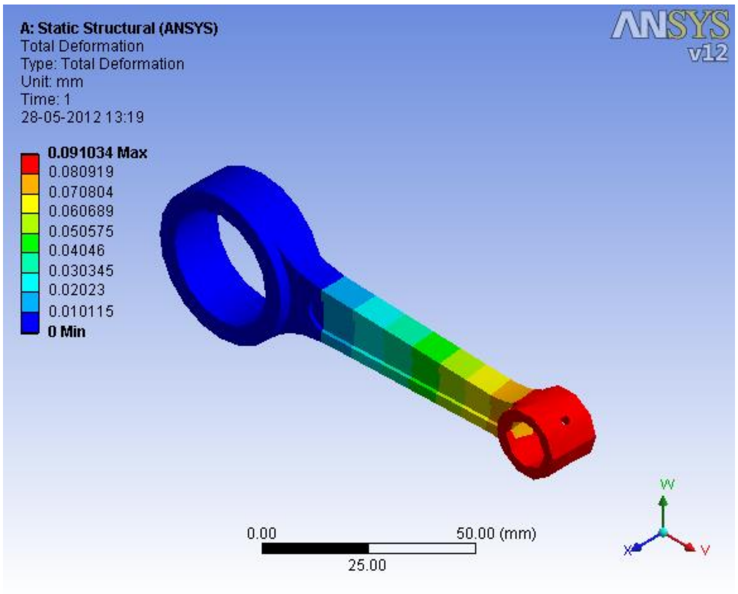

Fig.1.11Total deformation (for load =21598N)

FATIGUE FAILURE RESULTS FOR BUCKLING LOAD (21598 N)

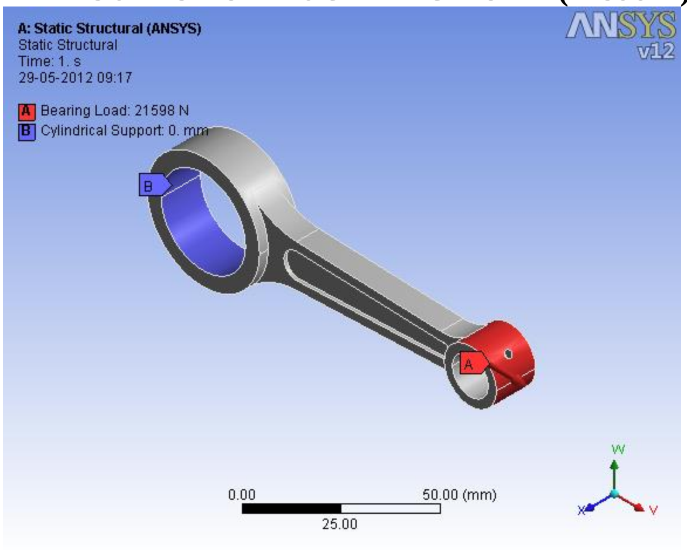

Fig.1.12 Applied constraints on connecting rod (for load=21598N)

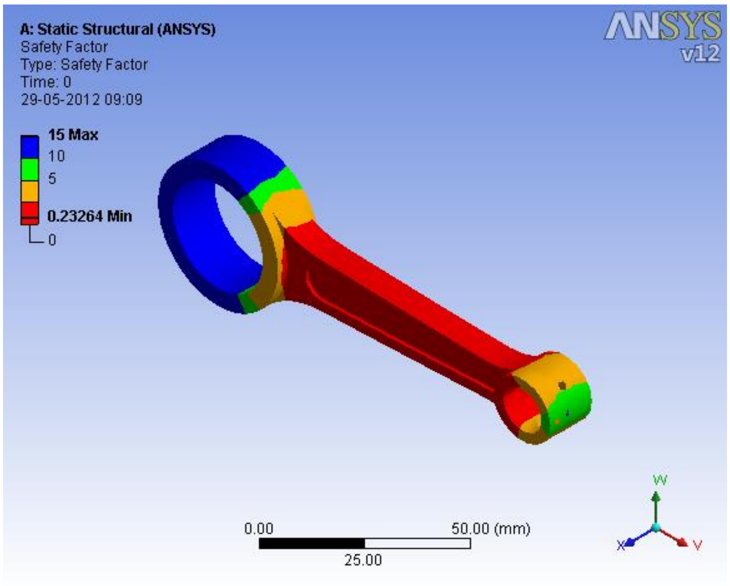

Fig.1.13 Safety factor (for load =21598N)

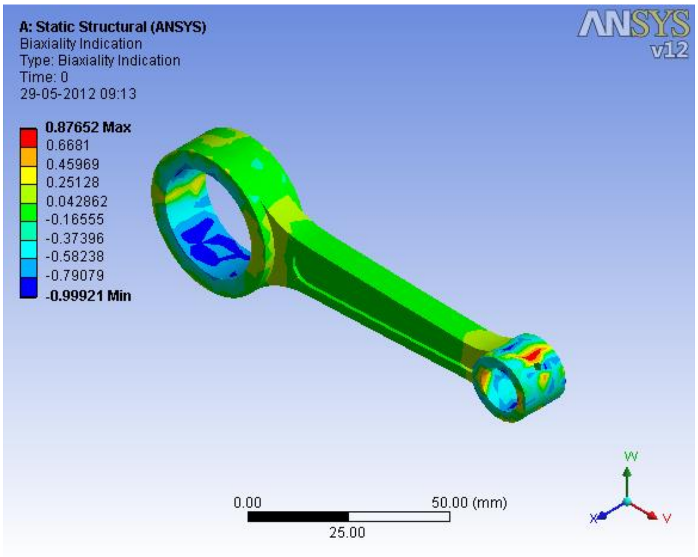

Fig.1.14 Biaxiality indication (for load =21598N)

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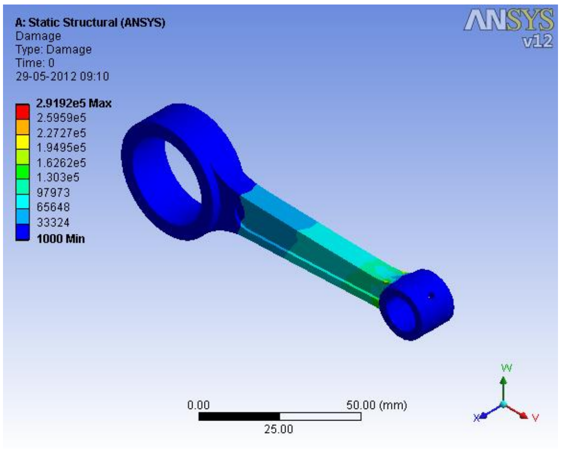

Fig.1.15 Damage (for load =21598N)

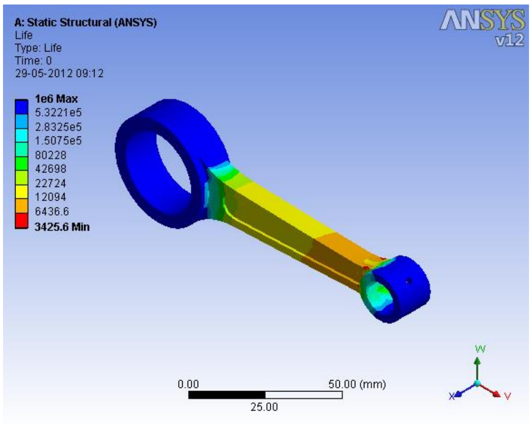

Fig.1.16 Life (for load =21598N)

COMPARISON OF FINITE ELEMENT ANALYSIS RESULTS OF PRESENT MODEL

The FEA results are in close agreement with the existing results. The variation in the Von-Mises stress found to be2.78%. The variation in the shear stress found to be 5.4%.And the variation in elastic strain is 2.6%. So the FEA results are better than the existing results.

After thoroughly examining the FEA results the stresses and strain in the designed model is much below the yield limit. The present design is acceptable and safe for further dynamic simulation.

Result comparison (for static analysis)

Sr. no.	**Parameters**	**Existing result for buckling load(21598N)**	**FEA result for buckling load(21598N)**	**Variation for load (21598 N)**
1	Equivalent von-Misses stress	381.17 MPa	349.07 Mpa	8.4%
2	Shear stress	82.21 MPa	47.941 MPa	41.6%
3	Elastic strain	1.91e-3 mm/mm	1.74e-3 mm/mm	8.9%
4	Total deformation	–	.091034 mm	–

Table No.2: Result Comparisons for static analysis

Result comparison (for fatigue analysis)

Sr. No.	Parameter	Existing result for buckling load(21598N)		FEA results for buckling load(21598N)	
		min	max	min	max
1.	Life	3138.61	1e6	3425 .6	1e6
2.	Safety factor	0.23	15	0.23264	15
3.	Biaxiality indication	-1.0	0.97	-0.999	0.876
4.	Damage	1000	318612.78	1000	2.9192

Table No. 3: Result Comparisons for fatigue analysis

CONCLUSION: The model taken under study has been reviewed thoroughly and it is safe and under permissible limits of applied stresses. The weight parameter of the experimental connecting rod with modification gives sufficient improvement in the prior existing results. Fatigue strength is the crucial parameter of a connecting rod and after modification the fatigue results are in good agreement with the existing results. The maximum stress found at the piston end is reduced by increasing the material near the piston end.

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