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Analysis of Connecting Rod under Different Loading Condition Using Ansys Software

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Abstract— The Connecting rod is a high volume production from automobile Side. Connecting rod is subjected to more Stress than other engine components. Failure and damage are also more in connecting rod, So stress analysis in Connecting rod is Very important. In this study, detailed load analysis was performed on connecting rod, followed by finite element method in Ansys-13 medium. In this regard, In order to calculate stress in Different part of connecting rod, the total forces exerted connecting rod were calculated and then it was modeled, meshed and loaded in Ansys software. The maximum stresses in different parts of connecting rod were determined by Analysis. The maximum pressure stress was between pin end and rod linkages and between bearing cup and connecting rod linkage. The maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkage. It is suggested that the results obtained can be useful to bring about modification in Design of connecting rod.

Index Terms—Tractor; Engine; Connecting Rod; Finite Element; Stress Analysis; Ansys software

I. INTRODUCTION

Connecting rods are widely used in variety of car engines. The function of connecting rod is to transmit the thrust of the piston to the crankshaft, and as the result the reciprocating motion of the piston is translated into rotational motion of the crankshaft. It consists of a pin-end, a shank section, and a crank-end. Pin-end and crank-end pin holes are machined to permit accurate fitting of bearings. One end of the connecting rod is connected to the piston by the piston pin. The other end revolves with the crankshaft and is split to permit it to be clamped around the crankshaft. The two parts are then attached by two bolts. Connecting rods are subjected to forces generated by mass and fuel combustion. These two forces results in axial and bending stresses. Bending stresses appear due to eccentricities, crankshaft, case wall deformation, and rotational mass force. Therefore, a connecting rod must be capable of transmitting axial tension, axial compression, and bending stresses caused by the thrust and pull on the piston and by Centrifugal force (Afzal and Fatemi, 2003). A connecting rod is subjected to many millions of repetitive cyclic loadings. Manufacturing technology of this machinery and also its quantity must be reached to optimum level. Above statements show the importance of stress analysis in Connecting rod for optimizing them. In this regard, dynamic stress analysis in connecting rods of this tractor was studied

II: MATERIALS AND METHODS:-

Properties of Connecting Rod Material (C70S6):-

Tensile Yield Strength	550 MPa
Tensile Ultimate Strength	900MPa
Compressive Yield Strength	550MPa
Compressive Ultimate Strength	600Mpa
Poisson Ratio	0.3
Density	7850 Kg/m3
Young’s Modulus	210000 MPa

III: Calculating Forces Exerted on Connecting Rods:-

In order to calculate stress in connecting rods it was analyzed for 3 separate parts, because the nature of forces exerted on difference parts of connecting rods are different.

1.1 Calculating forces exerted on pin end:-

The total force exerted on pin end in one cycle is state as: $F_{com} = F_g + F_i$

$$(P_g - P_0)A_p - (m_p + m_{se})Rw^2(\cos\alpha + \lambda\cos 2\alpha) \quad \ldots\ldots\ldots(1)$$

Where,

P_o = Atmosphere pressure (KPa),

A_P = Piston area (m),

M_P = Piston and pin mass (kg),

M_S = Mass of above part of pin end (kg),

Ù = Revolution speed (rpm),
R =crankshaft radius (m),
F_g = force resulted by gas pressure in combustion chamber (N).

The maximum pressure force exerted on connecting rod is happened in the maximum torque but the maximum tensile force happened in the maximum revolution speed. Hence, to calculate the maximum pressure force exerted on pin end, 1300 rpm, and to calculate the maximum tensile force, 2200 rpm, were considered (as the information taken from company). Figures 1 and 2 obtained for total force exerted on pin end considering Eq.1. As shown in figures 1 and 2, the maximum pressure force exerted on pin end was 21600 N.

1.2. Calculating forces exerted on Rod:-

The total force exerted on rod in one cycle is state.

$$F_{com} = F_g + F_i$$

$$(P_g - P_0)A_p - (m_p + m_{crp})Rw^2(\cos\alpha + \lambda\cos 2\alpha) \quad .... (2)$$

Where M_{crp} is mass of connecting rods above part from gravity centre (kg)As stated above ,to calculate the maximum pressure force exerted on Small end (pin end) side is 21600N (Company Data)

1.3. Calculating forces exerted on crank end:-

The combustion pressure force doesn't have effect on crank end, but it is affected by inertia force. Also, screws in crank end are over load. Always, they preloaded 2 to 4 time related to the maximum inertia force to prevent departing of two bearing cup. Inertia force results tensile stress and preloading force results pressure stress in crank end of connecting rod. Preloading (MPa) in screws to link bearing cup and above part of crank end strongly and also to prevent screws' breaking is equal to:

$$P_{t,l} = \frac{3P_{jr\max}}{i_b} \quad .... (3)$$

Where *ib* is number of screws in crank end and
Pjr max is the maximum inertia force exerted on crank end of connecting rods.
The inertia force exerted on crank end was calculated as

$$P_{jr} = -w^2R\left[(m_p + m_{crp})(\cos\alpha + \lambda\cos 2\alpha) + m_{crc} - m_c \right] \quad (4)$$

Where m_p = Mass of the piston assembly(kg), m_{crc} = concentrated mass of connecting rods on the crank end, m_{crp} = concentrated mass of connecting rods on the pin end ,m_c = concentrated mass of crankshaft on crank end.
Figure 1 show the inertia force exerted on crank end versus crank angle diagram in one cycle. Maximum inertia force exerted on crank end was 86400 N

IV: Modeling, Meshing and Loading Forces on Connecting Rod:-

After calculating forces exerted on different parts of connecting rod in most critically state, it was modeled and meshed in ANSYS, software. Mesh size is 1 mm, Smoothing is high And Relevance center is fine Then We obtained Node of 259579 and Element of 152873.It is very fine meshing so Result obtained is very Accurately and Fine.

Material properties of connecting rod.:-

Young's Modules (MPa)	210000
Poisson Ratio	0.33
Density (Kg/M3)	7850

To calculating stress in each connecting rod parts, calculated forces for each parts was exerted on corresponding pats in modeled connecting rod in ANSYS, software's medium considering following notes: Inertia forces were evenly exerted on pin end inner level (Fig.1) The value of these forces was calculated using following formula:

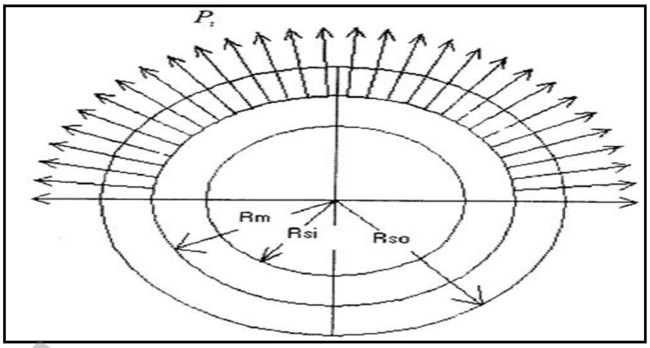

Fig.1:-Inertia force distributing on pin end(Kolchin, A., V. Demidov)

$$P_i = \frac{F_i}{2r_m l_s} \quad \left(\frac{N}{m^2}\right) \quad ....(5)$$

l_s is pin end width (m), F_i is inertia force and rm is pin end mean radius (m).

2. As seen in figure 7, the force resulted from combustion pressure were sinusoidal exerted on pin end inner level (Kolchin, A., V. Demidov, 1984). The value of this force was calculated using following formula:

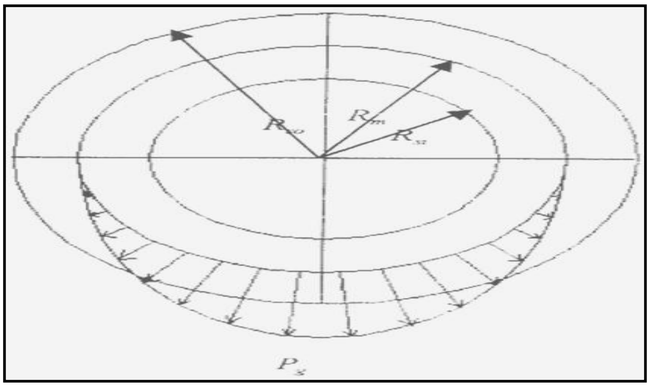

Fig.2:-Force resulted from combustion pressure distributing on pin end. (Kolchin, A.,V. Demidov)

$$P_g = \left[\frac{2F_g}{\pi r_m l_s}\right]\sin\theta \quad \left(\frac{N}{m^2}\right) \quad .... (6)$$

Where P_g is force per unit area (N/m) and Fg is force resulted from combustion (N).

3. The force resulted from falsifying of pin end's linier

and also from friction between linier and piston pin that were exerted on pin end inner level all situations. These forces cause pressure stress in linier and tensile stress in connecting rod.

4. To obtain stress resulted from preloading in crank end, the force must be evenly exerted on both side of that. Then, average pressure was obtained from dividing force by backrest level of screws.

V: RESULTS AND DISCUSSION:-

Stress analyzing in different parts of connecting rod:-
There are two different condition were considered
1) Pin end Compressive force
2) crank end compressive force.

Following results were obtained after exerting forces in ANSYS medium.

	Load	Max. Stress (Mpa)	MAX. Strain(Micron/mm)	Total Deformation (micron/mm)
Big End Comp.	86400N	359.84	1.7	152.1
Small End Comp.	86400N	358.75	1.7	135.3
Big End Tensile	21600N	429.02	2	155.2
Small End Tensile	21600N	469.88	2.9	188.5

F.O.S = Ultimate Stress / Maximum Stress

= 600/359.84

= **1.66**

Case I:-Crank End Compressive Analysis.

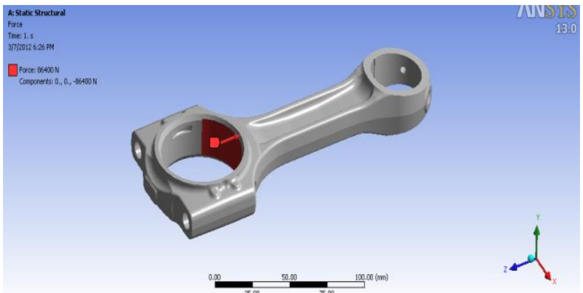

Fig 3 Connecting rod loading Condition

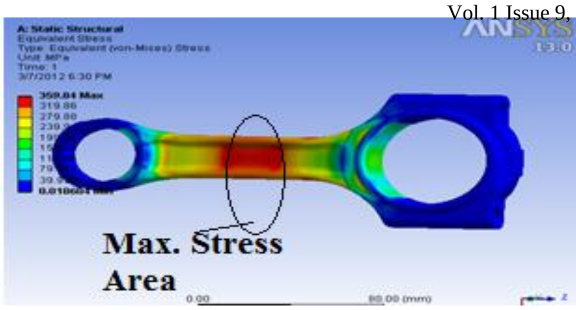

Fig 4 Connecting rod Von misses Stress Distribution.

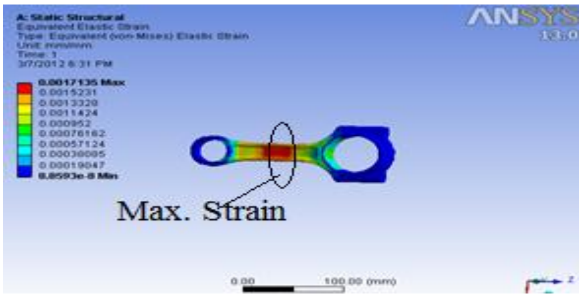

Fig 5 Connecting rod Von misses strain

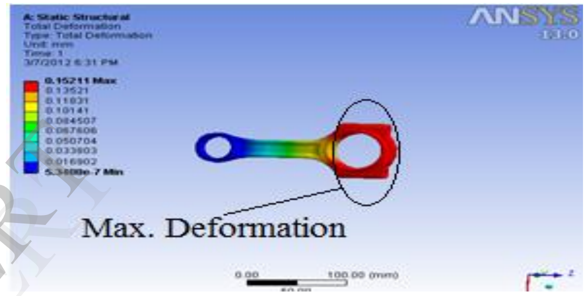

Fig 6 Connecting rod Total Deformation

Case II:-Pin End Compressive Analysis:-

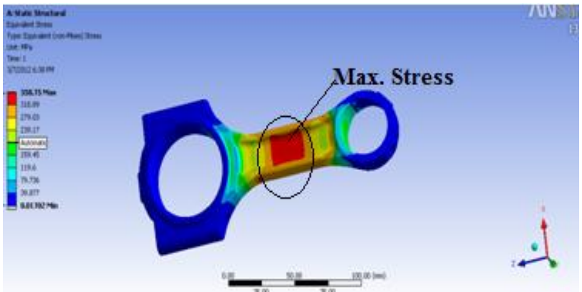

Fig. 7 Connecting rod Von misses Stress Distribution.

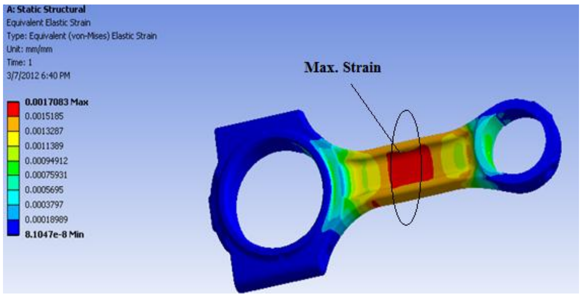

Fig 8 Connecting rod Von misses strain

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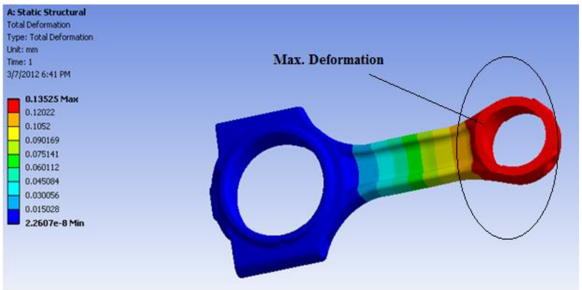

Fig 9 Connecting rod Total Deformation

Case III:-Crank End Tensile Analysis

Fig 10 Connecting rod loading Condition

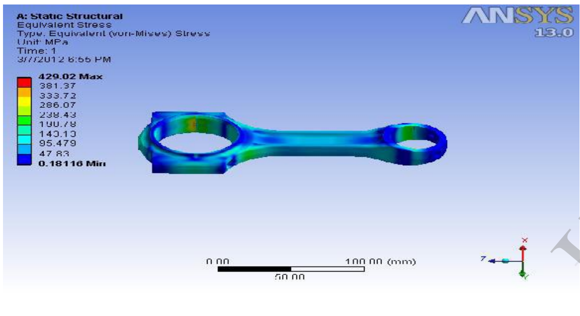

Fig 11 Connecting rod Von misses Stress Distribution.

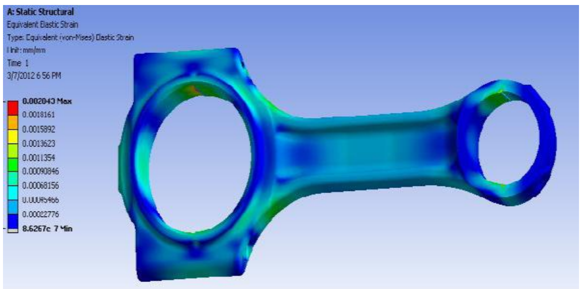

Fig 12 Connecting rod Von misses strain

Case VI:-Pin End Tensile Analysis

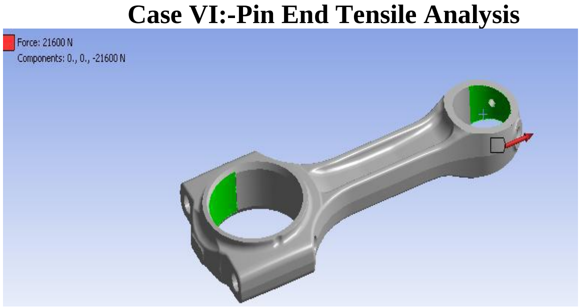

Fig 13 Connecting rod loading Condition

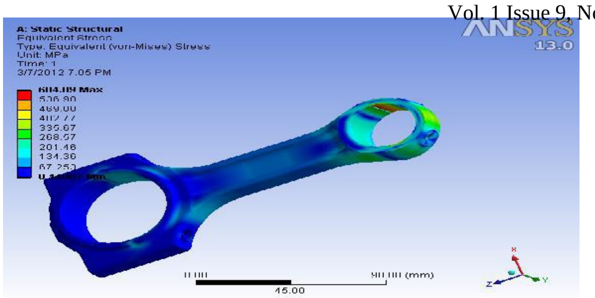

Fig 14 Connecting rod Von misses Stress Distribution.

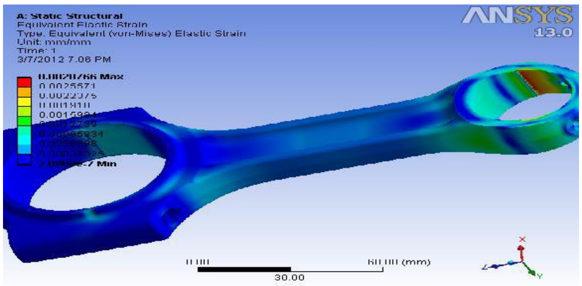

Fig 15 Connecting rod Von misses strain

VI Conclusion:-

The following conclusions obtained from this study:
1) The maximum stress is between pin-end and rod-linkage, and between bearing-cup and connecting rod linkage.
2) The maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkage.
3) Results of FEM method and results of experimental equations were similar (Maximum difference was only ±13%) this shows accuracy of our modeling, meshing and loading
4) Common stresses in C70S6_Split connecting rods like this connecting rod is between 350 to 650 MPa. It can be extract that cause of high fail of this component is over stresses of common range.
5) Value of F.O.S. (Factor of Safety) of connecting rod is between 1.6 to 1.7. Which indicate Safe Design of Connecting Rod.

VII Future Scope:-

In This Study we consider only Static Analysis. This study can be extended by Dynamic Analysis also for that we have T-θ Diagramed is needed. Also optimization study is done.

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