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GEOMETRICAL NONLINEAR ANALYSIS OF CONNECTING ROD

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ABSTRACT

The main function of connecting rod is to convert linear motion of piston to reciprocating motion of crankshaft. It is the main component of internal combustion (IC) engine. It is the most heavily stressed part if IC engine. During its operation various stresses are acting on connecting rod. The influence of compressive stress is more in connecting rod due to gas pressure and whipping stress.Connecting rod is one of the important components of the whole engine assembly as it acts as a mediator between piston assembly and crankshaft. This paper deals with nonlinear static analysis of structural steel of connecting rod. This analysis is important to produce the connecting rod stronger; the design will influence the engine performance. Specifications of connecting rod have been evaluated to calculate the loads acting on it. In this work we carried out nonlinear analysis to check the connecting rod under the nonlinear condition.

Keywords: *Connecting rod, geometrical nonlinear, stress, piston, IC engine.*

I. INTRODUCTION

In a reciprocating piston engine, the connecting rod connects the piston to the crank or crankshaft. In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of aluminum (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft. Connecting rods, especially in racing engines, may be called "billet" rods, if they are machined out of a solid billet of metal, rather than being cast. The con rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and being compressed with every rotation, and the load increases to the third power with increasing engine speed. Failure of a connecting rod, usually called "throwing a rod" is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase and thereby rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance, or from failure of the rod bolts from a defect, improper tightening, or re-use of already

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used (stressed) bolts where not recommended. This is because production auto parts have a much larger factor of safety, and often more systematic quality control.

The connecting rod is a major link inside of a combustion engine. Lighter connecting rods help to decrease load caused by forces of inertia in engine as it does not require big balancing weight on crankshaft it connects the piston to the crankshaft and is responsible for transferring power from the piston to the crankshaft and sending it to the transmission. There are different types of materials and production methods used in the creation of connecting rods. The most common types of materials used for connecting rods are steel and aluminum.

II. NONLINEAR ANALYSIS

The nonlinear load-displacement relationship—the stress-strain relationship with a nonlinear function of stress, strain, and/or time; changes in geometry due to large displacements; irreversible structural behavior upon removal of the external loads; change in boundary conditions such as a change in the contact area and the influence of loading sequence on the behavior of the structure—requires a nonlinear structural analysis. The structural nonlinearities can be classified as geometric nonlinearity, material nonlinearity, and contact or boundary nonlinearity.

Geometric nonlinearities arise from the presence of large strain, small strains but finite displacements and/or rotations, and loss of structural stability. Large strains, over 5% may occur in rubber structures and metal forming. Slender structures such as bars and thin plates may experience large displacements and rotations with small strains. Initially stressed structures with small strains and displacements may undergo a loss of stability by buckling.

Material nonlinearities arise from the presence of time-independent behavior, such as plasticity, time-dependent behavior such as creep, and viscoelastic/ viscoplastic behavior where both plasticity and creep effects occur simultaneously. They may result in load sequence dependence and energy dissipation (irreversible structural behavior).

III. MATERIAL PROPERTY AND BOUNDARY CONDITIONS

For the analysis we have taken structural steel material and applying the calculated compression load on connecting rod. For the linear analysis we have load step is one. But for nonlinear, load is divided into into 10substeps.

TABLE: Material Property of rod

Sl.No	Property	Value
1	Density	7.850Kg/mm^{-6}
2	Young’s modulus	2E5MPa
3	Tensile yield strength	250MPa
4	Poisson ratio	0.3

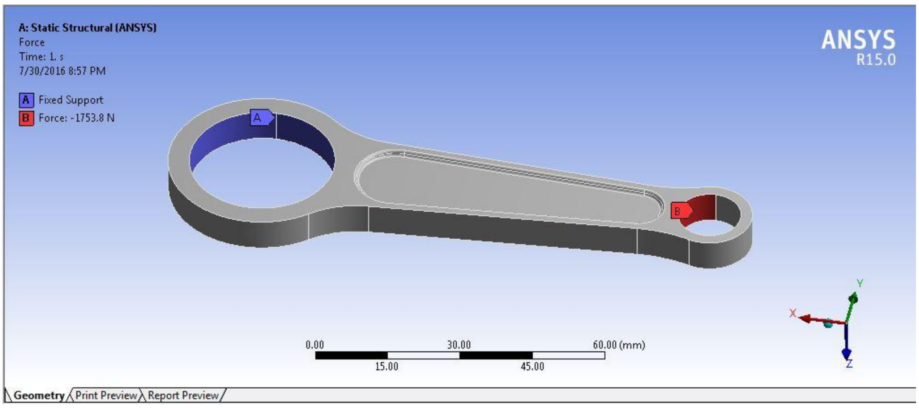
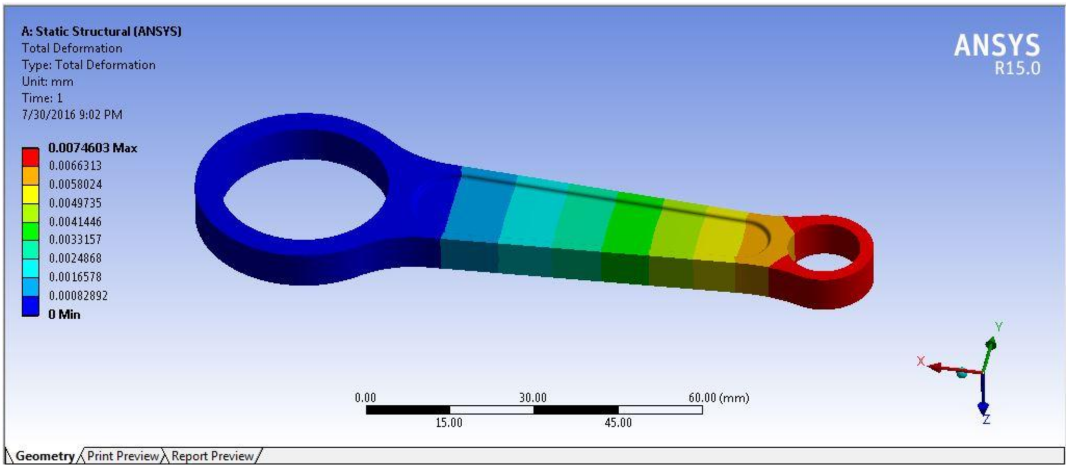


Fig1: Boundary Condition

For the boundary conditions, we are fixing the big end of connecting rod and load is applied at the small end of connecting rod.

IV. RESULTS AND DISCUSSIONS



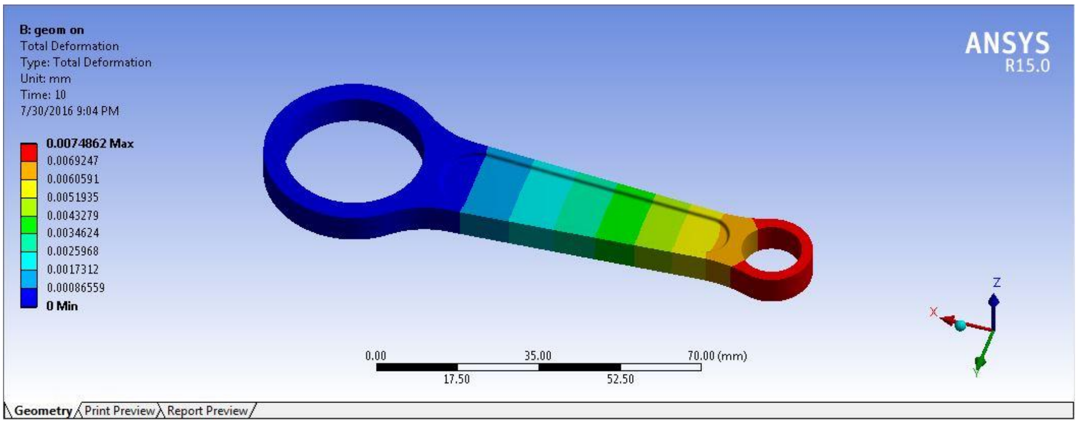


Fig 2: Deformation for linear and nonlinear.

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From the below graph we can observe that, analysis is conducted for both linear and nonlinear and we got the results. Results shows that deformation is lesser in linear and larger in nonlinear because we are switching on the larger deflection.

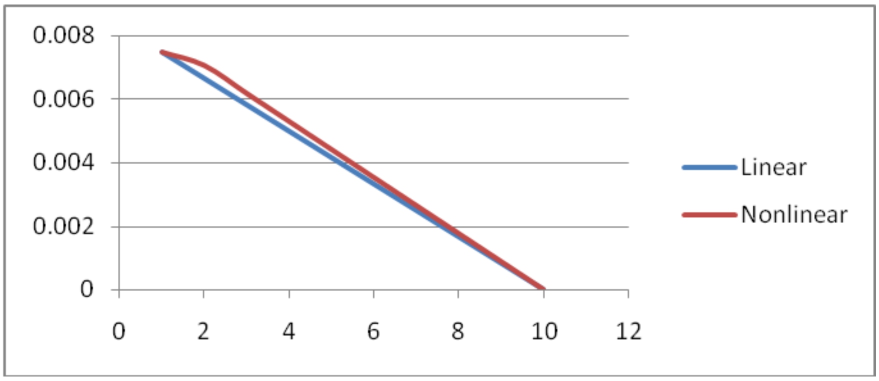

Fig 3: Variation between linear and nonlinear.

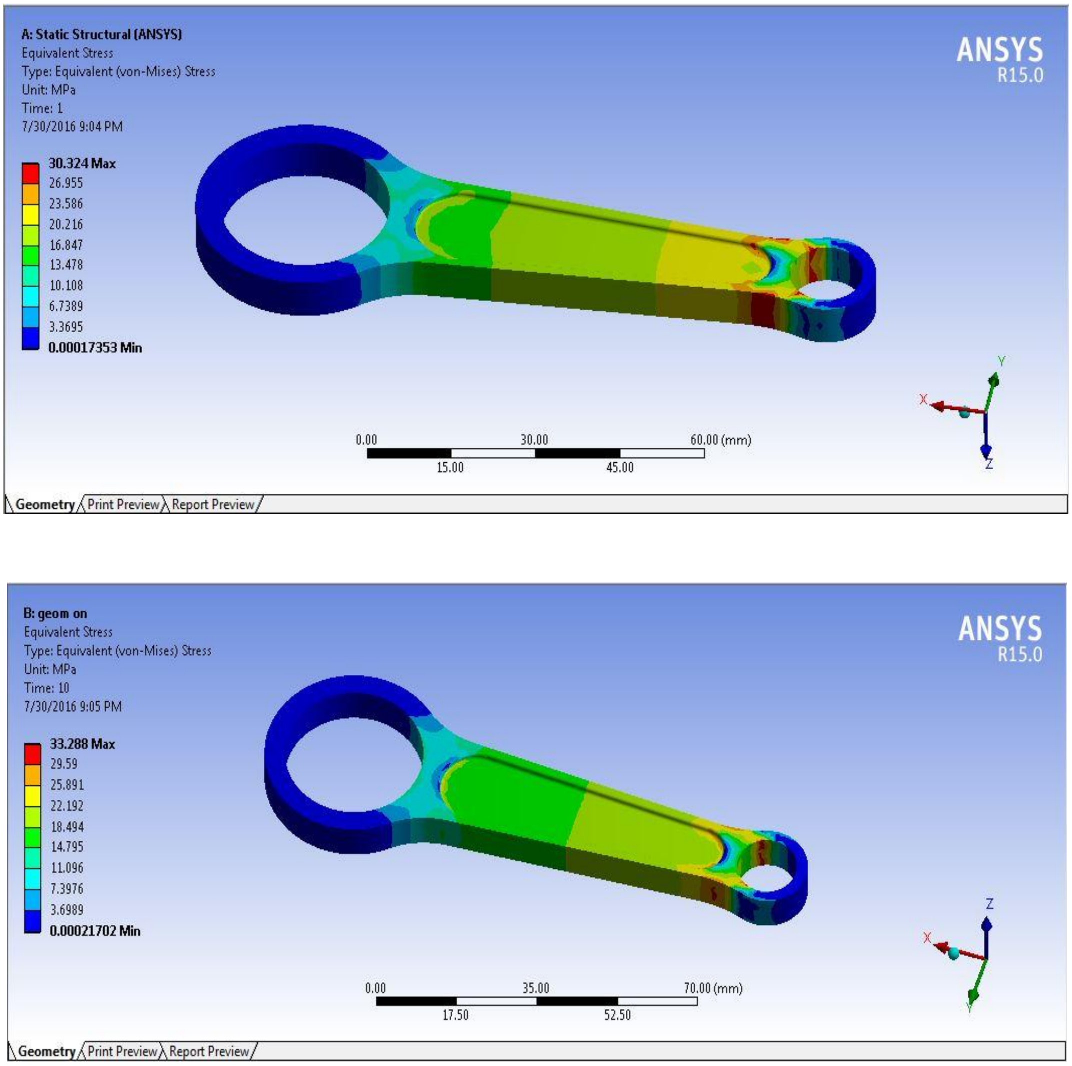

Fig 4: Stress results for linear and nonlinear.

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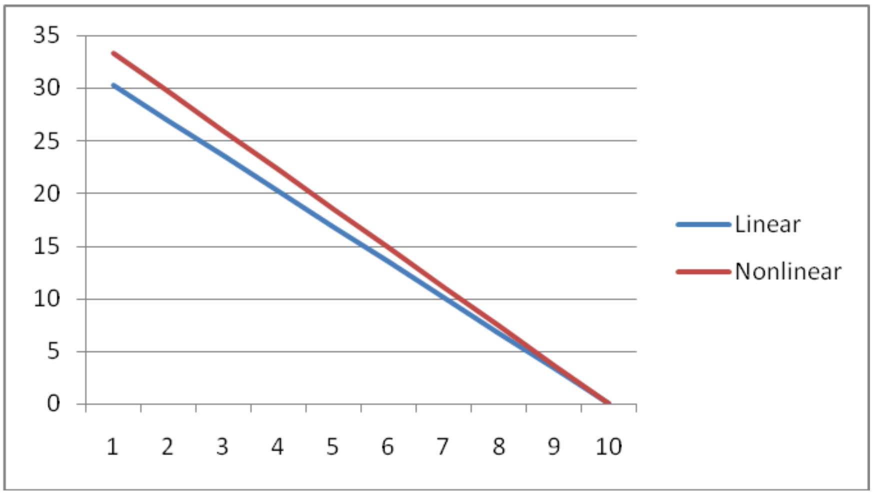

Fig 5: Variation of stress for linear and nonlinear.

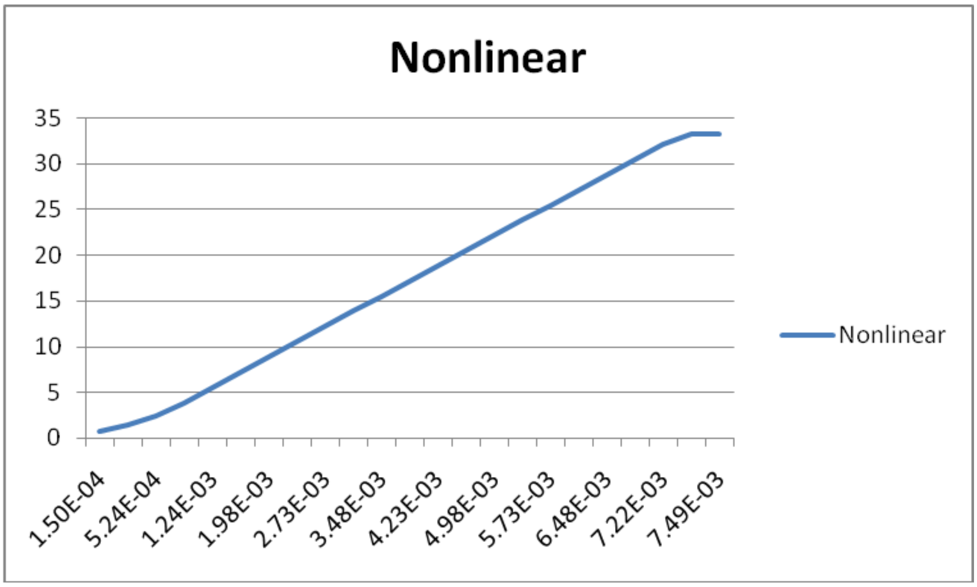

Fig 6: Nonlinear behavior of connecting rod.

Once we carried out the nonlinear analysis, we have to check whether it is following the nonlinear behavior. So because of that reason here we plotted stress vs. deformation graph from that graph it is clear that it following nonlinear behavior.

TABLE 2: Results comparison

	Max Deformation(mm)	Max Stress(MPa)	Max Strain
Linear analysis	0.0074603mm	30.324MPa	0.00015162
Nonlinear analysis	0.0074862mm	33.288Mpa	0.00016644

V. CONCLUSIONS

Design and analysis of connecting rod is carried out for two wheeler vehicle. In this we analyzed connecting rod for both linear and nonlinear analysis with calculated load.

- Structural analysis for linear and nonlinear is carried out on connecting rod.
- From all graph, we can say that for nonlinear analysis it takes the more iteration and time and it gives maximum value as we are conducted geometrical nonlinear analysis.
- From linear and nonlinear analysis, it is clear that stress values are within the limiting range so the design is safe.
- By the nonlinear analysis, when we plot the stress vs deformation we are getting nonlinear behavior of connecting rod.

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