FEA and Experimental analysis to improve buckling strength of 4-wheeler connecting rod

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Abstract : Each vehicle that utilizes an inward ignition engine requires in any event one connecting rod contingent on the quantity of chambers in the engine. It experiences high cyclic loads of the request for 108 to109 cycles, which go from high compressive loads because of burning, to high tractable loads because of idleness. In this manner, sturdiness of the part is of basic significance. Because of these components the connecting rod has been the subject of research for various perspectives, for example, creation, materials, execution reproduction, and so on. When structuring an associating rod, one needs to focus on the buckling strength of the pole. The buckling strength is vigorously influenced by the shaft area, and Johnson's buckling condition is utilized to assess the buckling strength of a given rod segment. Design of 4-wheeler connecting rod in CATIA software. Finite Element Analysis (FEA) is regularly used to assess the buckling strength of a rod that has complex changes in pillar area. we will likewise reinforce 2 mm layer of carbon fiber on shank length of associating rod. Once more, we will perform Finite Element Analysis on carbon fiber strengthen associating pole for finding buckling strength. Test testing will be performed on UTM.

***IndexTerms* - FEA, Carbon fibre, UTM, Buckling strength.**

I. INTRODUCTION

Due to interest for scaled back engine, more noteworthy explicit force and expanded mechanical effectiveness, responding power chamber segments are relied upon to apply less power on the chamber dividers to all the more productively move the ignition power in the chamber to a responding movement by the crankshaft, predominantly by methods for lighter weight. Simultaneously, these lighter chamber segments are relied upon to keep up adequate quality and security even as inward ignition engines have fundamentally expanded both explicit force and greatest speed during the most recent decade. One basic chamber part is the associating rod, which moves the wavering development of the cylinder into the pivoting development of the crankshaft. The interfacing rod must not just give the firmness and the solidarity to withstand the chamber weight and idleness powers of the engine, however should likewise be of negligible mass. Moreover, the hydrodynamic exhibition of the little end and large end must be thought of and enhanced so as to improve wear and grinding properties and to meet harder NVH prerequisites. An answer for an advanced segment format will be given that joins amazing quality and improved solidness with decreased mass. This streamlined arrangement will empower automakers to plan engines with higher eco-friendliness and more noteworthy dependability so as to address the difficulties of things to come.

LITERATURE REVIEW

Masahiro Yukiokaet al. [1] The buckling strength is intensely influenced by the shaft area, and Johnson's clasping condition is utilized to evaluate the buckling strength of a given rod segment.

In any case, late desires for light weight, low NVH, and low fuel utilization engines require upgrading the connecting rod segment geometries to be continuously transforming from the little end to the huge end.

This strategy can dissect semi static and dynamic issues, and is helpful for computing the in-situ buckling strength of a rod.

This report looks at a few techniques that can be utilized to anticipate connecting rod buckling, with the objective of structuring a lighter interfacing rod.

Md Tauseef Alamet al. [2] Be that as it may, failure in interfacing rod is frequently detailed which is related to either exhaustion, twisting, bearing failure or gathering issues. This examination manages one of such failure of interfacing rod detailed during weakness testing. This further builds the feeling of anxiety on the associating pole. Thus, it is important to guarantee the mechanical dependability of the parts like connecting rod as its failure may bring about disastrous engine failure.

Michael T. Lappet al. [3] This paper will concentrate on every one of the four basic territories of the connecting rod- the little end or pin end, the shank or I-bar, the crankshaft or enormous end and the catapulted joint.

The impact of this connecting rod mass decrease in a six-chamber engine can bring about a complete engine responding mass decrease of up to 2kg. This mass decrease will both improve dependability and reduction CO2 emanations and fuel utilization.

Pravardhan S. Shenoyet al. [4] The weariness quality was the hugest factor in the improvement of the associating pole. The examination brings about an upgraded connecting rod that is 10% lighter and 25% more affordable, when contrasted with the current associating pole.

In this manner, as opposed to utilizing numerical streamlining methods for weight decrease, quantitative outcomes were inspected subjectively, and the structure changed. The load cycle that was utilized comprised of compressive gas load relating to a greatest torque and a malleable burden comparing to most extreme idleness load. The changed Goodman condition with exchanging and mean octahedral shear pressure was utilized for weakness examination.

Heewook Moon[5] In prediction of the critical buckling load of structures, here considered both elastic buckling load and plastic material behavior.

Here we modified Merchant Rankine formula with aid of FEA and a subspace iteration method. The developed method here was verified by buckling experiments and applied to no.of connecting rods. Result is a guideline of buckling failure is built using the buckling safety factor defined . A modified method predicts more reliable critical buckling load by considering the realistic geometry of connecting rod and the engine running condition.

D Gopinath [6] Each & Every vehicle that uses an internal combustion engine requires at least one connecting rod depending upon the number of cylinders in the engine.

So, this study has dealt with 2 subjects, one is static load stress analysis of the connecting rod for three materials, and second is optimization for weight of forged steel connecting rod.

The stresses were found in the existing connecting rod for the given loading conditions.

The topology optimization technique is used to achieve the objectives of optimization which is to decrease the weight of the connecting rod.

1.1 Problem Statement

The connecting rod can be structured and advanced under a load run including malleable load, most extreme engine speed as one outrageous load, and compressive load comparing to the pinnacle gas pressure as the other extraordinary load. Moreover, the current 4-wheelerconnecting rod can be supplanted with another connecting rod made of better that is lighter and more affordable because of the steel's break split capacity. However, a similar exhibition can be normal as far as segment sturdiness. Buckling strength is profoundly affected by the yield worry of the associating pole material.

1.2 Objectives

- Modelling four-wheeler connecting rod in CATIA V5 software.
- To perform static analysis for existing 4-wheeler connecting rod with composite reinforcement to determine the enhancement in mechanical properties under buckling analysis in ANSYS 19 software.
- Manufacturing of carbon fibre reinforced connecting rod by using hand lay -up method on connecting rod.
- To perform experimental testing of new carbon fibre reinforced connecting rod on UTM.
- Validation of experimental testing and FEA results.

1.3 Methodology

Step 1: -Initially research paper are studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about buckling strength of connecting rod.
Step2: -Research gap is studied to understand new objectives for project.
Step 3: - After deciding the components, the 3 D Model and drafting will be done with the help of software.
Step 4: - In manufacturing existing connecting rod is reinforced with carbon fibre for UTM test.
Step 5: -The testing will be carried out and then the result and conclusion will be drawn.

II. CATIA MODEL

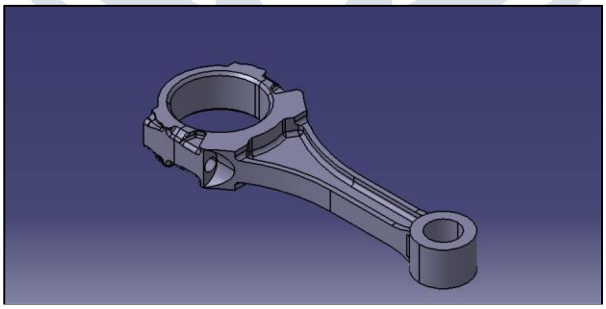


Fig.1: CATIA model of 4-wheeler connecting rod

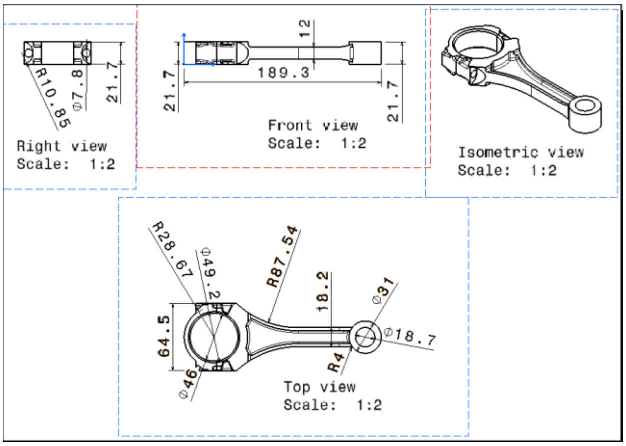


Fig.2: Drafting of 4-wheeler connecting rod

III. Static & Buckling Analysis

3.1 Material Properties

Table 1 Material properties of C70 steel

Properties of Outline Row 3: C70 STEEL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Pois...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

3.2 Finite Element Analysis

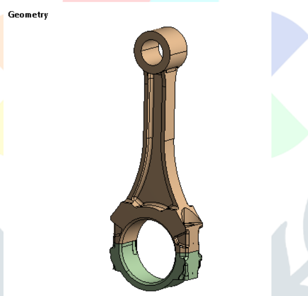


Fig.3: CATIA model imported in ANSYS

3.3 Mesh

In ANSYS meshing is a performed as similar to discretization process in FEA procedure in which it breaks whole components in very small elements and nodes. So, in analysis boundary condition equation are solved at these elements & nodes. ANSYS Meshing is general-purpose, intelligent, automated high-performance product. It will produces the most appropriate mesh for accurate, efficient Multi physics solutions. Mesh well suited for a such specific analysis can be generated with a single mouse click for all parts in a model. Full & all controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it.

Statistics	
Nodes	19315
Elements	10430

Fig.4: Meshing of connecting rod

- TATA INDICA ENGINE Specifications of connecting rod
- Maximum pressure exerted on small end of piston is considered around 6MPa

3.4 Boundary Conditions

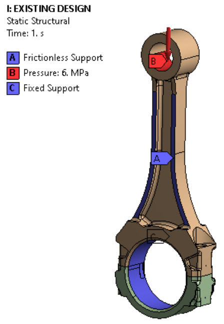


Fig.5: Boundary condition for buckling analysis

In present research boundary condition are applied as per calculation performed to determine stress and deformation and compare with carbon reinforced connecting rod.

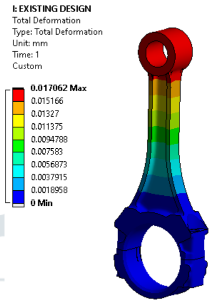


Fig.6: Total deformation result

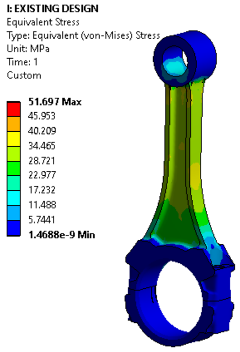


Fig.7: Equivalent stress plot for existing connecting rod

3.5 Connecting rod with composite material reinforcement

Table. Material properties of carbon epoxy

Properties of Outline Row 5: Epoxy Carbon UD (395 GPa) Prepreg

	A	B	C
1	Property	Value	Unit
2	Density	1.54E-09	tonne mm^-3
3	Orthotropic Secant Coefficient of Thermal Expansion		
8	Orthotropic Elasticity		
9	Young's Modulus X direction	2.09E+05	MPa
10	Young's Modulus Y direction	9450	MPa
11	Young's Modulus Z direction	9450	MPa
12	Poisson's Ratio XY	0.27	
13	Poisson's Ratio YZ	0.4	
14	Poisson's Ratio XZ	0.27	
15	Shear Modulus XY	5500	MPa
16	Shear Modulus YZ	3900	MPa
17	Shear Modulus XZ	5500	MPa
18	Orthotropic Stress Limits		
19	Tensile X direction	1979	MPa
20	Tensile Y direction	26	MPa
21	Tensile Z direction	26	MPa
22	Compressive X direction	-893	MPa
23	Compressive Y direction	-139	MPa
24	Compressive Z direction	-139	MPa
25	Shear XY	100	MPa
26	Shear YZ	50	MPa
27	Shear XZ	100	MPa

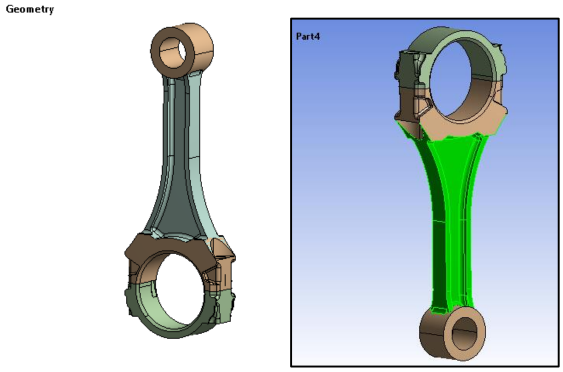
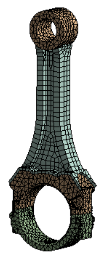


Fig.8: Detailed view of connecting rod with carbon fibre reinforcement



Statistics	
Nodes	20193
Elements	11266

Fig.9: Details of meshing

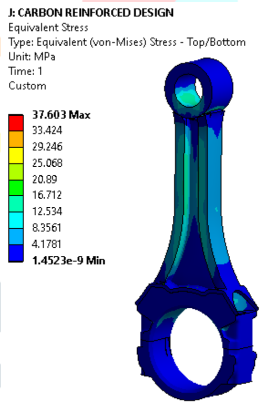


Fig.10: Equivalent stress plot for modified connecting rod

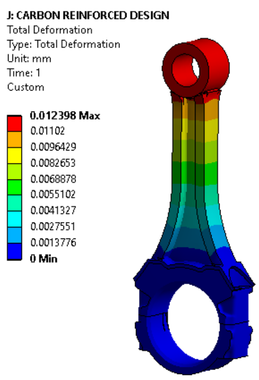


Fig.11: Total deformation plot for 2 mode shape eigen buckling

It is observed from analysis that carbon reinforced connecting rod stress and deformation are lower than existing design. So, it is be fetial to use reinforced connecting rod for future application.

3.6 Manufacturing process of carbon fibre reinforced connecting rod

- Initially exiting connecting rod is selected.
- A rectangular section carbon fibre strip is prepared with dimension of shank length of connecting rod.
- Solution is prepared with epoxy (50 ml) and hardener (1.5 bottle cap) is poured and gently stirred to form homogeneous solution.
- Layer by layer reinforcement is provided with first layer lying up and gently applying epoxy solution with brush and repeating this process for required layers.
- After application of layers it is left to solidify for 24 hours and reinforced connecting rod is finished with finishing process and ready for experimental setup for UTM testing.

IV. EXPERIMENTAL SETUP

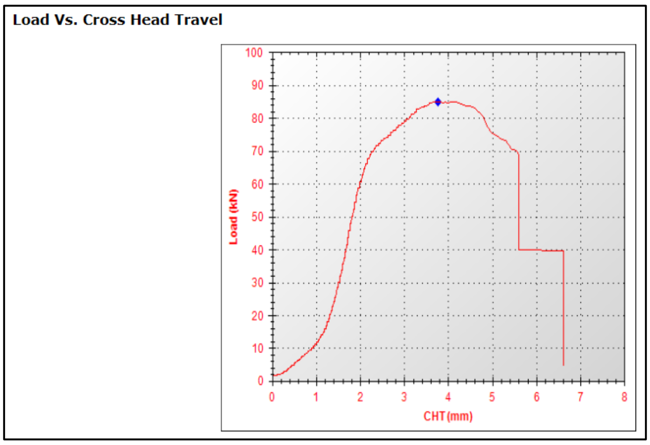
4.1 Universal testing machine (UTM)

Once the machine is started then it begins to apply an increasing load on specimen. Throughout & over the tests a control system and its associated software record the all load and both extension or compression of the component. UTM is used for experimental proposes :- Max Capacity 400KN, Measuring range 0-400KN Least Count 00.04KN Clearance for compression test 0-700mm

4.2 Experimental Procedure

•Dimension of connecting rod is measured at three different places along its height/length to determine the average cross-section area.
•Ends of the connecting rod should be plane. For that the ends are tested on a bearing plate.
•The connecting rod is placed centrally between the two compressions plates, such that the center of moving head is vertically above the center of specimen.
•Load is applied on the connecting rod by moving the movable head.
•The load and corresponding contraction are measured at different intervals. Load is applied until the final result obtain.

Fig.12: experimental testing



Graph. Load vs cross head travel

4.2 Experimental FEA

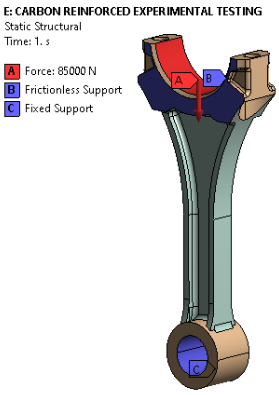


Fig.13: experimental testing

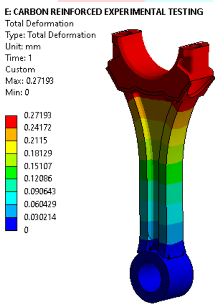


Fig.14: total deformation

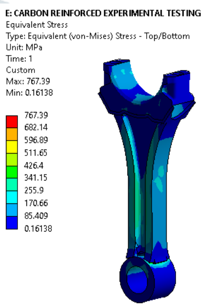


Fig.15: equivalent stress

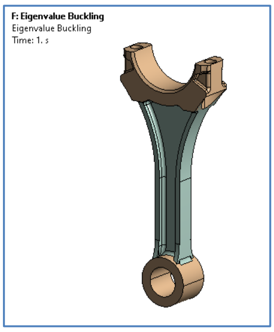


Fig.16: eigenvalue buckling

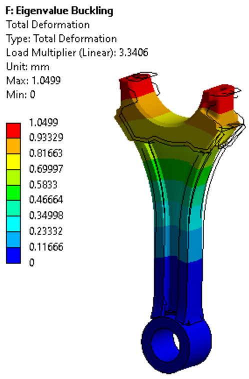


Fig.17: total deformation

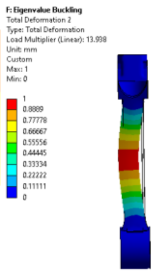


Fig.18: total deformation 2

Tabular Data

	Mode	Load Multiplier
1	1.	3.3406
2	2.	13.938

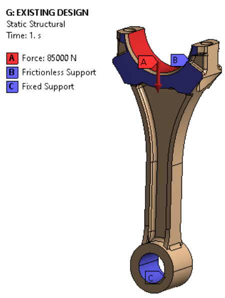


Fig.19: experimental testing

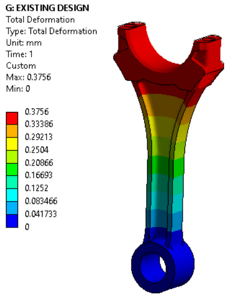


Fig.20: total deformation

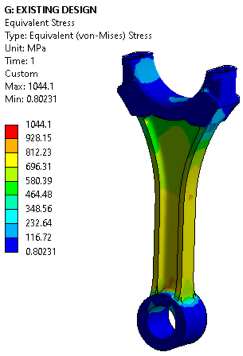


Fig.21: equivalent stress

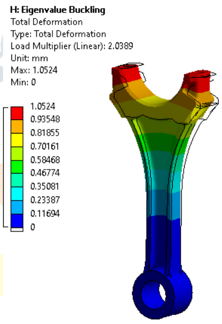


Fig.22 total deformation

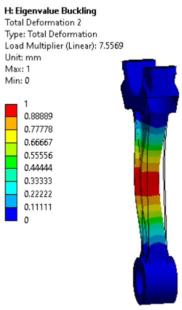


Fig.23: total deformation 2

Tabular Data

	Mode	Load Multiplier
1	1.	2.0389
2	2.	7.5569

V. CONCLUSION

- It is observed from experimental testing that buckling load is around 85 KN and also reanalysis is performed to observe the buckling of connecting rod..
- In existing design stress induced are much greater than reinforced design along with load multiplier less than modified design that is 2.0 and 7.55 compared to 3.34 and 13.93.
- So by carbon reinforcement on existing design have improved buckling strength along with less stress concentration and deformation under existing boundary conditions.

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