Finite Element Analysis and Weight Reduction of H Beam Connecting Rod Through Composite Material AlSiC using ANSYS

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Abstract---This technical review can clarify that why we will go for finite element method and composite material for optimizing H beam Connecting rod. From the literature survey it is found that most analysis is carried out on I section connecting rod. Researchers have developed a model by using cad software and then imported to the different analysis software. Most of the researchers have neglected the thermal analysis of connecting rod and considered connecting rod as a single piece. In actual condition big end of the connecting rod has two parts which are bolted together after assembled with crankshaft. In future it will be planned to carry the static analysis as well as thermal analysis of H beam connecting rod with considering bolted joint on big end side in latest ANSYS 14. We know that composite materials have properties of high strength to weight ratio as well as good chemical resistance properties so reducing weight and improving strength of Connecting rod by composite material.

Keywords: Finite element method, H beam Connecting rod, Static and thermal analysis, ANSYS and Composite materials.

I. INTRODUCTION

In Automobile Internal Combustion Engine main function of the connecting rod is connects reciprocating piston to rotating crankshaft and transmitting the thrust of the piston to the crankshaft. Every vehicle that uses an internal combustion engine requires at least one connecting rod depending upon the number of cylinders in the engine. A connecting rod consists of a pin-end, a shank section, and a crank-end. Pin-end and crank-end pinholes at the upper and lower ends are machined to permit accurate fitting of bearings. These holes must be parallel. The upper end of the connecting rod is connected to the piston by the piston pin. If the piston pin is locked in the piston pin bosses or if it floats in the piston and the connecting rod, the upper hole of the connecting rod will have a solid bearing (bushing) of bronze or a similar material. A connecting rod is a very important element of internal combustion engine because it is continuously subjecting with compressive and tensile loading as well as thermal stresses.

Connecting rods are typed by the process used to manufacture the rods. The process of making forged connecting rods constitutes forcing the grain of the selected material, such as a steel alloy, in the specified shape of the rod. Manufacturers use different types of steel alloys including 4340 steel or a chrome and nickel alloy. The nickel/chrome alloy increases the strength of the connecting rod without making the finished product brittle. Cast rods are generally the choice of original equipment manufacturers because they handle the load of a stock engine and are less expensive to make. Cast connecting rods possess a seam down the middle that is noticeable and differentiates it from the forged type. Do not use cast rods in high horsepower applications over 450 and going 6,000 rpm.

II. COMPARISON OF I-BEAM AND H-BEAM CONNECTING ROD

Generally lighter-weight I-beam rods are perfect for high-rpm applications and heavier H-beam rods are better suited for high-horsepower, higher-torque applications. Learn what separates aluminum, steel, billet, and titanium connecting rods, and much more! “One of the most common questions we get about connecting rods is what the difference between H beam and I beam rods is, and on top of that, what are the advantages of each.

Fig.1 I beam and H beam Connecting Rod

Here we have a typical I beam connecting rod. As you can see, it has a sort of concave side that runs the length of the rod and has raised edges. And if you were to cut that in half you would essentially have what looks like the letter I. Over here, we have your typical H beam connecting rod, and you can see these have larger flat sides that run the length of the rod and then there is a smaller center section that connects the two flat sides. If you were to cut that in half you would have would essentially be or at least look like the letter H.

III. COMPOSITE MATERIAL

Composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, typological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications.

The major composite classes include organic-matrix composites (OMCs), metal matrix composites (MMCs), and ceramic-matrix composites (CMCs). The term “organic-matrix composite” is generally assumed to include two classes of composites: polymer-matrix composites (PMCs) and carbon-matrix composites (commonly referred to as carbon-carbon composites).

Composite products have good weathering properties and resist the attack of a wide range of chemicals [2]. This depends almost entirely on the resin used in manufacture, but by careful selection resistance to all but the most extreme conditions can be achieved. Because of this, composites are used in the manufacture of chemical storage tanks, pipes, chimneys and ducts, boat hulls and vehicle bodies.FDL manufactured architectural panels for the construction of the Auckland Marine Rescue Centre. Composite panels were chosen because of their ability to withstand salty sea side conditions without corrosion.

IV. Finite Element Method And Ansys

Finite element method is hidden in its words itself. Basic theme is to make calculations at only limited (Finite) number of points and then interpolate the results for entire domain (surface or volume).

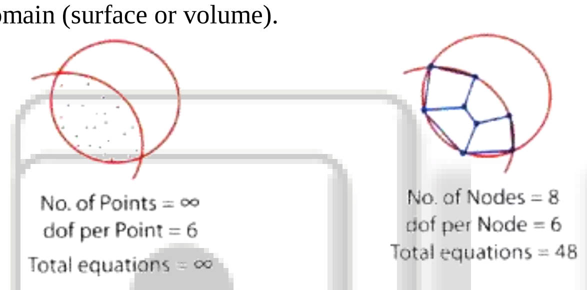

Fig. 2: Finite Element Method

Today ANSYS is viewed as a “household item” in many design and research institutions here in the United States and around the world. It is regarded by many engineers and researchers as a modern, robust, accurate, and visually sensible tool to provide solutions for many engineering and scientific problems [12].

V. Static Structural Analysis Of H Beam Connecting Rod

In this study, detailed load analysis was performed on connecting rod, followed by finite element method in Ansys-14. 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-14.

Static structural analysis of connecting rod carried out with following four different considerations. For the analysis two materials are applied first one is SAE 4340 standard steel material which is used mostly for the application of connecting rod. Second one is ALSIC metal matrix composite which have the low density but good strength.

- I beam connecting rod as a single part
- H beam connecting rod as a single part
- I beam connecting rod as a assembly (bolt joint)
- H beam connecting rod as a assembly (bolt joint)

First step start with engineering data, in which required to define the material for the given project from the existing material library but if our required material is not available in the library then need to edit the new material with its properties, and finally define the material for the analysis. In present work it is required to edit two materials for static analysis.

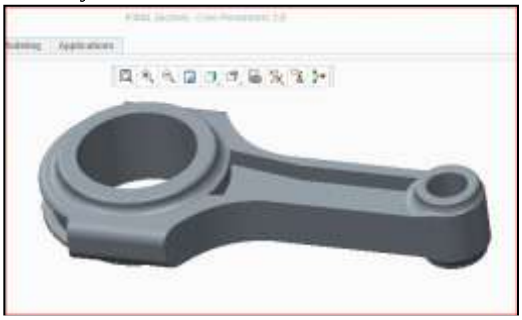

Fig. 3: I beam model

Fig. 4: H beam model

In Ansys there are two ways to do the modeling and analysis one is in APDL and other one is in workbench. In workbench once you are in the Mechanical application, you can move between its components by highlighting the corresponding object in the Tree as needed. Click on the Mesh object in the Tree to access Meshing application functionality and apply mesh controls.

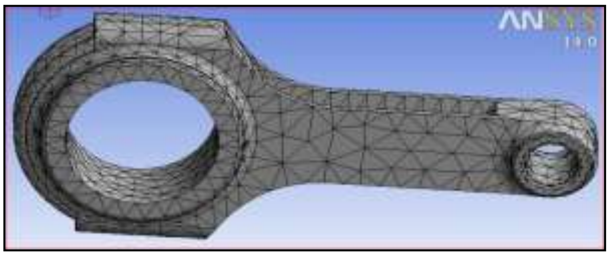

Fig. 5: Meshing in H beam (size 10mm)

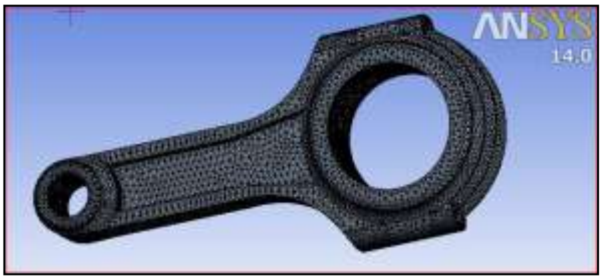

Fig. 6: Meshing in I beam (2mm size)

There are several types of loads that can be defined in ANSYS for different types of analyses as Nodal forces, Surface loads, Body loads, and Inertial loads. We can apply loads either on the solid model or directly on the FEA model.

Boundary Conditions are defined as specified values for degrees of freedom (DOF).These are defined by ‘D’ command in ANSYS. Boundary Conditions are required to define the support condition of an FE model. There are two different loading conditions compressive and tensile loading that we considered for the static analysis. For these two cases we are considering two different materials, one is aluminum alloy and second one is composite material. Analysis is based on Loading Condition; Von misses Stress, and Total Deformation

It is a very important step of the analysis in which proper boundary condition mast be applied, because Ansys will take any boundary condition that applied by the user. Here consideration of fixed support for the big end of connecting rod and applying load to small end it may be compressive or tensile.

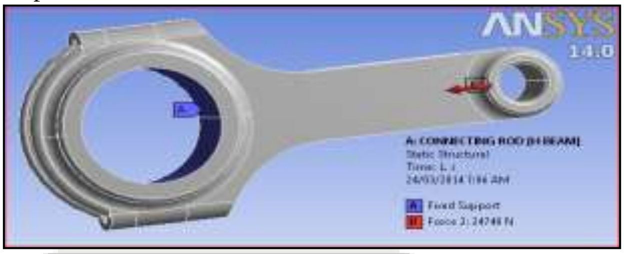

Fig. 7: H beam connecting rod with compressive load

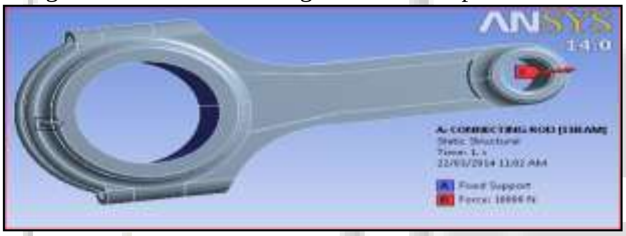

Fig. 8: I beam connecting rod with tensile load

Equivalent stress is often used in design work because it allows any arbitrary three-dimensional stress state to be represented as a single positive stress value. Equivalent stress is part of the maximum equivalent stress failure theory used to predict yielding in a ductile material.

Physical deformations can be calculated on an inside a part or an assembly. Fixed supports prevent deformation; locations without a fixed support usually experience deformation relative to the original location. Deformations are calculated relative to the part or assembly world coordinate system.

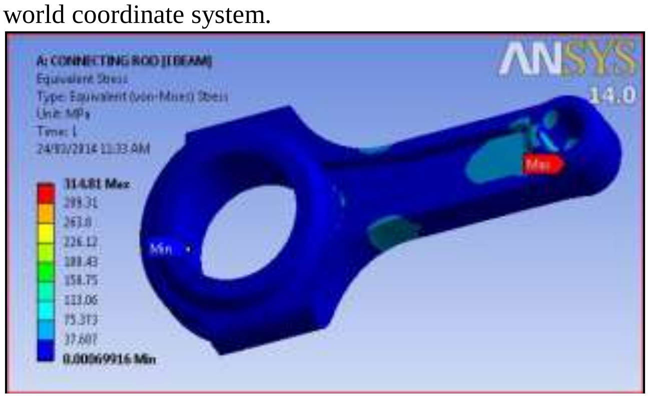

Fig. 9: I beam (2mm size) Equivalent (von-Mises)

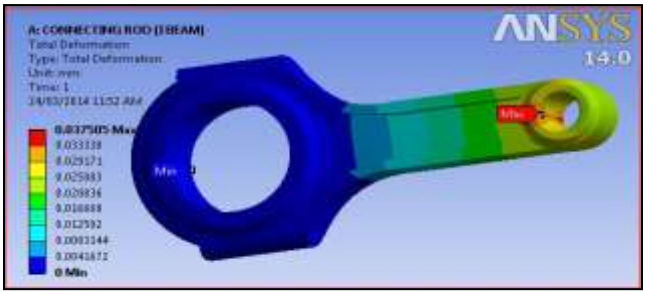

Fig. 10: I beam (2mm size) Total deformation

VI. SUMMARY OF RESULTS

EQUIVALENT STRESS (MPA) COMPRESSIVE LOAD-24740N

MATERIAL	MESH SIZE(MM)	I BEAM	H BEAM
SAE4340 STEEL	2	349.25	303.05
	3	307.56	288.64
	6	197.79	178.25
	10	151.28	147.66
ALSIC-MMC COMPOSITE	2	362.59	311.76
	3	312.34	300.55
	6	199.85	181.54
	10	154.02	149.83

EQUIVALENT STRESS (MPA) (TENSILE LOAD-10000N)

MATERIAL	MESH SIZE(MM)	I BEAM	H BEAM
SAE4340 STEEL	2	127.89	104.5
	3	89.79	94.3
	6	76.94	87.68
	10	64.14	63.24
ALSIC-MMC COMPOSITE	2	130	106.3
	3	98.34	96.23
	6	92.65	90.167
	10	66.36	64.59

VII. CONCLUSION

The maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkage. Here all above analysis carried out on the based of single piece connecting rod, but in actual condition it is in two pieces which are bolted together.

H beam connecting rods are a little bit stiffer and rigid, that makes them ideal for higher horsepower and higher torque applications but have more weight for the same power developed compare to I beam connecting rod. Here to reduce the weight we are change the standard material of connecting rod to the composite material and optimizing with static analysis in ANSYS.

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