MODELING AND SIMULATION OF CONNECTING ROD BY CONVENTIONAL AND COMPOSITE (MMC) MATERIALS

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Abstract— A Connecting rod could be a rigid member that connects a piston to a crank or rotating shaft in a very ICE. At the side of the crank, it forms an easy mechanism that converts reciprocal motion into rotating motion. A rod might also convert rotating motion into reciprocal motion, its original use. A rod could transmit either push or pull, permitting the rod to rotate the crank through each halves of a revolution. In a very few two-stroke engines the rod is barely, needed to push. Usually the rod is producing by exploitation formation method by cast steel materials. Currently a day’s composite materials are wide employed in the engineering field. The overall characteristics possessed by the composite materials are found to be the rationale for exploitation it within the automotive applications. whereas the Composite connecting rods are lighter and should supply higher compressive strength, stiffness and fatigue resistance than typical connecting rods and their style still represents a significant technical challenge. The most objective of the project is to analysis of Connecting rod with typical and composite material. The connecting rods are usually employed in the inner combustion engines and are subjected to countless varied stress cycles resulting in fatigue failure. However during this method we tend to sculptural the rod by exploitation some typical (Al7175-T66, C70S6, AISI4140 and Ti-6AL-4V) and Composite materials (LM 25 Aluminum MMC, KELER CNT MMC, CVI-C/SIC, and 25Si3N4-Mg MMC). For modeling rod we tend to exploitation CATIA V5 computer code and for simulating the rod of each typical and composite material we tend to used NX NASTRAN computer code. By getting results of Stress, Strain and Displacement we tend to propose the simplest material for coming up with of rod.

Keywords : Connecting rod, Convectional alloy materials, Composite material, CATIA V5 , NX NASTRAN, Stress, Strain and Displacement.

I. INTRODUCTION

A rod may be a rigid member that connects a piston to a crank or rotating shaft in a very internal-combustion engine. beside the crank, it forms an easy mechanism that converts mutual motion into rotating motion. a rod may additionally convert rotating motion into mutual motion, its original use. Earlier mechanisms, like the chain, might solely impart actuation motion. being rigid, a rod might transmit either push or pull, permitting the rod to rotate the crank through each halves of a revolution, in a very few two-stroke engines the rod is simply needed to push. Today, the rod is best identified through its use in burning piston engines, like automobile engines. a rod is an engine part that transfers motion from the piston to the rotating shaft and functions as a lever arm. rods square measure normally made of solid metallic element alloy and square measure designed to resist dynamic stresses from combustion and piston movement. The tiny finish of the rod connects to the piston with a piston pin. the piston pin, or pin, provides a pivot purpose between the piston and rod. spring clips, or piston pin locks, square measure wont to hold the piston pin in situ.

The big finish of the rod connects to the crankpin journal to supply a pivot purpose on the rotating shaft. Connecting rods square measure produces mutually piece or two-piece parts. A rod cap is that the removable section of a two-piece rod that has an effect surface for the crankpin journal. The rod cap is connected to the rod with 2 cap screws for installation and removal from the rotating shaft.
1.2 HISTORY

Evidence for the rod seems within the late third century Hierapolis sawmill in Roman Asia (modern Turkey). It conjointly appears in a sixth-century Byzantine-era sawmill excavated at Ephesus, Anatolia (modern Turkey) and Gerasa, Roman Asian nation. The crank and rod mechanism of those Roman-era watermills regenerate the move of the waterwheel into the linear movement of the saw blades. Someday between 1174 and 1206 within the Artuqid State (Turkey), the Arab inventor and engineer Al-Jazari represented a machine that incorporated the rod with a rotating shaft to pump water as a part of a water-raising machine, tho’ the device was improved. In Renaissance European country, the earliest proof of a − albeit automatically misunderstood − compound crank and connecting-rod is found within the sketch books of Taccola. A sound understanding of the motion concerned is displayed by the painter Pisanello (d. 1455) United Nations agency showed a piston-pump driven by a water-wheel and operated by 2 straightforward cranks and 2 connecting-rods. By the sixteenth century, proof of cranks and connecting rods within the technological treatises and design of Renaissance Europe becomes abundant; Agostino Ramelli’s the various and Art factitious Machines of 1588 alone depcits eighteen examples, variety that rises within the Theatrum Machinarum Novum by Georg Andreas Böckler to forty five completely different machines.

1.2.1 External-combustion engine

The first external-combustion engine, Newcomen’s part engine, was single-acting: its piston solely did add one direction and then these used a series instead of a rod. Their output rocked back and forth, instead of rotating endlessly.

1.4 FORMS OF ROD ASSEMBLY

The rod is that the link that transmits forces between the piston and also the rotating shaft. Connecting rods should be sturdy enough to stay rigid below load and however be light-weight enough to scale back the inertia forces that square measure made once the rod and piston stop, amendment direction, and begin once more at the top of every stroke.

1.5 FAILURES OF CONNECTING ROD

Connecting rods square measure a number of the toughest operating elements within An engine. They direct the downward force of the pistons to the crank throws to form motility force. The rods ought to be sturdy enough to resist the best combustion masses without bending or buckling stressed.

Bearing failures might occur as a results of extreme overloading of the bearing, heating the bearing (insufficient oil flow), or oil starvation because of oil aeration, pump cavitation, a pickup obstruction or oil sloshing aloof from the pickup. Loss of lubrication may additionally be from employing a skinny oil that lacks the shear strength to remain between the rod bearings and crank journal.

Rod failures also can occur as a results of metal fatigue. Atiny low surface blemish, nick, scratch or imperfectness on a rod can concentrate stress. Eventually, this could result in small cracks within the metal and ultimately a fracture that...
causes the rod to interrupt. Most performance rods have a machined swish surface to scale back the danger of stress fractures. Shot peening conjointly helps dissipate surface stresses for improved sturdiness and strength.

1.7 SPECIFICATIONS OF CONNECTING ROD

Specifications of Connecting rod is considered from the existing model of apache 180 model as follows

- Load applied = 15 KN
- Length of connecting rod = 180 mm
- Big end outer diameter = 55 mm
- Big end inner diameter = 45 mm
- Small end outer diameter = 30 mm
- Small end inner diameter = 20 mm

As per the above specification we designed connecting rod and simulation is done on various conventional and composite materials.

II. LITERATUTRE REVIEW

[1] Webster et al. (1983) performed 3 dimensional finite part analysis of a high-speed diesel motor rod. For this analysis they used the most compressive load that was measured by experimentation, and therefore the most tensile load that is basically the inertia load of the piston assembly mass. The load distributions on the piston pin finish and crank finish were determined by experimentation. They modelled the rod cap on an individual basis, and conjointly modelled the bolt pretension victimisation beam parts and multi purpose constraint equations. [2] D. Yoo et al. (1984) used undulation equations of physical property, material by-product plan of time mechanics and a poster joint variable technique to calculate form style sensitivities of stress. The results were utilized in associate degree reiterated improvement rule, steepest descent rule, to numerically solve associate degree best style drawback. the main focus was on form style sensitivity analysis with application to the instance of a rod. the strain constraints were obligatory on principal stresses of inertia and firing hundreds. however fatigue strength wasn't self-addressed. The opposite constraint was the one on thickness to ensure it removed from zero. they might acquire two hundredth weight reduction within the neck region of the rod. [3] E. Folgar et al. (1987) developed a fibre fp/metal matrix composite rod with the help of fea, and hundreds obtained from kinematic analysis. Fatigue wasn't self-addressed at the planning stage. However, prototypes were fatigue tested. The investigators known style hundreds in terms of most engine speed, and hundreds at the crank and piston pin ends. They performed static tests during which the crank finish and therefore the piston pin finish failing at completely different hundreds. Clearly, the 2 ends were designed to face up to completely different hundreds. [4] F. Serag et al. (1989) developed approximate mathematical formulae to outline rod weight and value as objective functions and conjointly the constraints. The improvement was achieved employing a geometric programming technique. Constraints were obligatory on the compression stress, the bearing pressure at the crank and therefore the piston pin ends. [5] G. Sarihan and song (1990), for the improvement of the pin finish, used a fatigue load cycle consisting of compressive gas load like most torsion and tensile load like most i

Stress Failure. Rod Bearing Failure
III. INTRODUCTION TO CAD/CATIA

3.1 INTRODUCTION TO CAD

CAD (CAD), jointly called CAD and drafting (CADD), is that the use of pc systems to help within the creation, modification, analysis, or optimisation of a style. Computer-aided drafting describes the method of making a technical drawing with the employment of pc computer code. CAD computer code is employed to extend the productivity of the designer, improve the standard of style, improve communications through documentation, and to form a information for producing. CAD output is usually within the style of electronic files for print or machining operations. CAD computer code uses either vector based mostly graphics to depict the objects of ancient drafting, or might also manufacture formation graphics showing the general look of designed objects.

CAD is a vital industrial art extensively employed in several applications, as well as automotive, building, and region industries, industrial and branch of knowledge style, medical specialty, and lots of additional. CAD is additionally wide accustomed manufacture pc animation for camera work in movies, advertising and technical manuals. the trendy ubiquitousness and power of computers implies that even fragrance bottles and shampoo dispensers ar designed victimization techniques unparalleled by engineers of the Sixties.

NECESSARY CAPABILITIES OF CAD

Wonderful things with CADD, that ne'er thought attainable whereas making drawings with a pen or pencil. the subsequent ar a number of the necessary capabilities that create CADD a robust tool:

i. Flexibility in redaction

ii. Storage and access for drawings

iii. Project coverage

iv. Engineering analysis

v. Design

3.4 GEOMETRIC MODELING

Geometric modeling could be a branch of math and process pure mathematics that studies strategies and algorithms for the mathematical description of shapes.

The shapes studied in geometric modeling ar principally two- or three-dimensional, though several of its tools and principles will be applied to sets of any finite dimension. Three-dimensional models ar central to CAD and producing (CAD/CAM), and wide employed in several applied technical fields like civil and applied science, design, earth science and medical image process.

Geometric models ar typically distinguished from procedural and object-oriented models, that outline the form implicitly by Associate in Nursing opaque algorithmic rule that generates its look. trendy CAD system defines objects in 3-D so the designer will construct 3-D model of objects handily and store the information of the model within the pc.

Geometric modeling will be classified into 3 types:

a) Wire frame modeling.

b) Surface modeling.

c) Solid modeling.

3.5 INTRODUCTION TO CATIA

CATIA (Computer motor-assisted Three-dimensional Interactive Application) could be a multi-platform CAD/CAM/CAE business computer code suite developed by the French company Dassault Systems. Written within the C++ programing language, CATIA is that the cornerstone of the Dassault Systems product lifecycle management computer code suite.

CATIA could be a feature based mostly, constant quantity solid modeling program. As such, its use is considerably totally different from standard drafting programs. In standard drafting (either manual or pc assisted), numerous views of [a part|a neighborhood|an area|a district|a region|a locality|a vicinity|a section] are created in an endeavor to explain the pure mathematics. every read incorporates aspects of assorted options (surfaces, cuts, radii, holes, protrusions) however the options aren't singly outlined. In feature based mostly modeling, every feature is singly delineated then integrated into the half. the opposite vital facet of standard drafting is that the half pure mathematics is outlined by the drawing. If it’s desired to vary the scale, shape, or location of a feature, the physical lines on the drawing should be modified (in every affected view) then associated dimensions ar updated. once victimization constant quantity modeling, the options ar driven by the size (parameters). to change the diameter of a hole, the hole diameter parameter worth is modified. A maker can then use the IGES file to program the American state machines which is able to directly produce the mildew for the elements. In several such style cycles, the sole print created are going to be Associate in Nursing scrutiny drawing with vital and envelope dimensions shown.

3.5.1 CATIA Application

Unremarkably stated as 3D Product Lifecycle Management computer code suite, CATIA supports multiple stages of development (CAx), from conceptualization, style (CAD), producing (CAM), and engineering (CAE). CATIA facilitates
cooperative engineering across disciplines, as well as emergence style, applied science, instrumentality and systems engineering. CATIA provides a set of emergence, reverse engineering, and visual image solutions to form, modify, and validate complicated innovative shapes.

3.6 MODELING OF CONNECTING ROD IN CATIA

Modeling of complete connecting rod involves the following steps

NX - NASTRAN SIMULATION

NASTRAN is essentially a thinker for restricted part examination. Yet, it does not have utility that takes into consideration diagrammatically constructing a model or lattice. All data and yield to the program is as content documents. Be that because it might, varied product sellers advertise pre-and gift processors planned on improve building a restricted part demonstrate and breaking down the outcomes. These product devices incorporate utility to import and contour the CAD pure mathematics, and work with restricted elements, and apply burdens and restrictions. NX apparatuses that change the consumer to gift Associate in Nursing investigation to NASTRAN, and import the outcomes and show them diagrammatically, nevertheless pre-and post-handling skills, we've some NASTRAN sellers have incorporated additional developed nonlinear capacities into their NASTRAN things.

NASTRAN programming application was composed to assist set up more practical house vehicles, as an example, the ballistic capsule. NASTRAN was discharged to the overall population in 1971 by NASA’s workplace of Technology Utilization. The business utilization of NASTRAN has investigated the conduct of versatile structures of any size, shape, or reason, as an example, the automotive business utilizes the program to configuration front suspension frameworks and dominant linkages. it's likewise utilised in structuring railroad tracks and autos, spans, management plants, high rises, and
flying machine. NASTRAN was written into the U.S. house Foundation's house Technology Hall of Fame in 1988, one in every of the most advancements to urge this far-famed respect.

4.3 INTRODUCTION OF FEA

Limited component Analysis (FEA) may be a quite computer program that uses the restricted part strategy to research a cloth or protest and find out however connected burdens can influence the fabric or structure. FEA will facilitate decide any functions of disadvantage during a structure before it’s created. FEA programs ar all the a lot of usually accessible with the unfold of all the a lot of ground-breaking PCs, but ar still for the foremost half utilised in aviation and different high-push applications. The examination is finished by creating a piece of focuses within the state of the protest that contains information concerning the fabric and therefore the question at every purpose for investigation. nevertheless deciding the response to fret upon an issue, FEA will likewise examine the impact of vibrations, weakness, and heat exchange.

Limited part examination (FEA) may be a genuinely late order crossing the bounds of arithmetic, material science, and building and software system engineering. The technique has wide application and appreciates broad usage within the concomitant territories

- Structural investigation
- Thermal investigation
- Vibration and dynamic investigation
- Bulking investigation

The Finite component Analysis (FEA) section of empowers primarily take a look at and anticipate the conduct of structures and pay attention of complicated auxiliary building problems subjected to static and dynamic stacking conditions. At that time the stage utilizes versatile numerical methods that may reason scientific articulations and would be exceptionally testing owing to complicated stacking, geometries or material properties.

4.3.1 Basic steps concerned in FEM

- Discritization of the house
- Application of limit conditions
- Solution for the framework conditions
- Assembling the framework conditions
- Post handling the outcomes

4.4 GENERALIZED PROCEDURE FOR FEA

The restricted part strategy is contained 3 noteworthy stages:

- Pre-Processing
- Solution
- Post-Processing

4.5 SIMULATION OF PROCEDURE OF CONNECTING ROD

We complete a study to performing the following steps:
EXPERIMENTAL SIMULATION OF CONNECTING ROD ON VARIOUS MATERIALS

5.1 CONVECTIONAL ALLOY MATERIALS

Conventional alloy style, one primary part like iron, copper, or aluminum is chosen for its properties. Then, tiny amounts of further components are side to boost or add properties. Even among binary alloy systems, there are few common cases of each components being employed in nearly-equal proportions like Pb-Sn solders. Therefore, abundant is thought from experimental results concerning sections close to the perimeters of binary section diagrams and therefore the corners of ternary phase diagrams and far less is thought concerning phases close to the centers. In higher-order (4+ components) systems that can't be simply pictured on a 2-dimensional section diagram, nearly nothing is thought. Following conventional alloys are considered for designing the connecting rod based on its chemical composition and mechanical properties

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Mass</th>
<th>Density</th>
<th>Young's modules of flexibility</th>
<th>Poisson proportion</th>
<th>Yield quality</th>
<th>Tensile quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>A17176-T66</td>
<td>0.4446</td>
<td>2800 kg/m³</td>
<td>72 Gpa</td>
<td>0.33</td>
<td>520 Mpa</td>
<td>590 Mpa</td>
</tr>
<tr>
<td>AISI4140</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C70S6</td>
<td></td>
<td>7850 kg/m³</td>
<td>200 Gpa</td>
<td>0.3</td>
<td>552 Mpa</td>
<td>966 Mpa</td>
</tr>
<tr>
<td>Ti-6Al-4V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1.1 SIMULATION OF T7175-T66 ALUMINUM ALLOY CONNECTING ROD

Properties of T7175-T66
- Mass : 0.4446 kg
- Density : 2800 kg/m³
- Young's modules of flexibility : 72 Gpa
- Poisson proportion : 0.33
- Yield quality : 520 Mpa
- Tensile quality : 590 Mpa

5.1.2 SIMULATION OF AISI 4140 ALUMINUM ALLOY CONNECTING ROD

Properties of AISI 4140
- Mass : 0.7723 kg
- Density : 7.85 kg/m³
- Young's modules of flexibility : 200 Gpa
- Poisson proportion : 0.28
- Yield quality : 415 Mpa
- Tensile quality : 655 Mpa

5.1.3 SIMULATION OF C70S6 FORGED ALLOY CONNECTING ROD

Properties of C70S6
- Mass : 0.7878 kg
- Density : 7850 kg/m³
- Young's modules of flexibility : 200 Gpa
- Poisson proportion : 0.3
- Yield quality : 552 Mpa
- Tensile quality : 966 Mpa
5.1.4 SIMULATION OF Ti-6Al-4V TITANIUM ALLOY CONNECTING ROD

Properties of Ti-6Al-4V

- Mass: 0.2605 kg
- Density: 4430 kg/m$^3$
- Young's modulus of flexibility: 121 Gpa
- Poisson proportion: 0.34
- Shear modules of versatility: 73 Gpa
- Yield quality: 805 Mpa
- Tensile quality: 845 Mpa

5.2 COMPOSITE MATERIALS

A material (also known as a composition material or shortened to composite, that is that the common name) could be a material made of 2 or a lot of constituent materials with considerably totally different physical or chemical properties that, once combined, manufacture a fabric with characteristics totally different from the individual parts. The individual parts stay separate and distinct among the finished structure, differentiating composites from mixtures and solid solutions. The new material is also most popular for several reasons. Common examples embody materials that are stronger, lighter, or less costly when put next to ancient materials.

MMCs are created by dispersing a reinforcing material into a metal matrix. The reinforcement surface may be coated to stop a reaction with the matrix. as an example, carbon fibers are unremarkably employed in aluminum matrix to synthesize composites showing density and high strength. However, carbon reacts with aluminum to come up with a brittle and soluble compound Al4C3 on the surface of the fibre. to stop this reaction, the carbon fibres are coated with nickel or atomic number 22 boride.

5.2.1 SIMULATION OF LM 25 MMC CONNECTING ROD

Properties of LM 25 MMC

- Mass: 0.2493 kg
- Density: 2680 kg/m$^3$
- Young's modulus of flexibility: 71 Gpa
- Poisson proportion: 0.32
- Shear modules of versatility: 26.5 Gpa
- Yield quality: 220 Mpa
- Tensile quality: 281 Mpa

5.2.2 SIMULATION OF KEVLER MMC CONNECTING ROD

Properties of KEVLER MMC

- Mass: 0.1335 kg
- Density: 1350 kg/m$^3$
- Poisson proportion: ---
- Young's modules of flexibility: 214 Gpa
- Tensile quality: 1550 Mpa
- Shear modules of versatility: - Gpa
- Yield quality: --- Mpa
5.2.3 SIMULATION OF CVI-C/SIC CONNECTING ROD

Properties of CVI-C/SIC
- Mass: 0.2107 kg
- Density: 2100 kg/m³
- Young's modules of flexibility: 95 Gpa
- Poisson proportion: 0.3
- Yield quality: --- Mpa
- Tensile quality: 310 Mpa

5.2.4 SIMULATION OF 25 Si₃N₄-Mg MMC CONNECTING ROD

Properties of 25Si₃N₄-Mg Magnesium MMC
- Mass: 0.1656 kg
- Density: 1800 kg/m³
- Young's modules of flexibility: 133 Gpa
- Poisson proportion: 0.32
- Yield quality: 241 Mpa
- Tensile quality: 355 Mpa

### COMPARISIÓN OF SIMULATION RESULTS FOR CONVENTIONAL ALLOYS AND COMPOSITE MATERIALS(MMC)

<table>
<thead>
<tr>
<th>NAME OF MATERIAL</th>
<th>VON-MISES STRESS IN Mpa</th>
<th>VON-MISES STRAIN</th>
<th>DISPLACEMENT IN mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>A7176-T66</td>
<td>133.064</td>
<td>0.004</td>
<td>1.232E-003</td>
</tr>
<tr>
<td>AISI 4140</td>
<td>106.818</td>
<td>0.197</td>
<td>4.55E-004</td>
</tr>
<tr>
<td>C70S6</td>
<td>107</td>
<td>0.188</td>
<td>4.415E-004</td>
</tr>
</tbody>
</table>
Table 9: Results Comparison of Conventional alloy Vs MMC composite Materials

<table>
<thead>
<tr>
<th>Materials</th>
<th>Stress (MPa)</th>
<th>Strain (x10^-6)</th>
<th>Displacement (mm)</th>
<th>Von Mises Stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti-6Al-4V</td>
<td>107.474</td>
<td>0.174</td>
<td>7.935E-004</td>
<td>1.2844E-006</td>
</tr>
<tr>
<td>LM 25 MMC</td>
<td>137.575</td>
<td>0.039</td>
<td>1.705E-003</td>
<td>4.8201E-007</td>
</tr>
<tr>
<td>KEVLER MMC</td>
<td>116.869</td>
<td>0.079</td>
<td>3.641E-004</td>
<td>2.450E-007</td>
</tr>
<tr>
<td>CVI-C/SIC MMC</td>
<td>116.87</td>
<td>0.08</td>
<td>8.201E-004</td>
<td>1.7123E-006</td>
</tr>
<tr>
<td>25Si3N4-Mg MMC</td>
<td>133.064</td>
<td>0.004</td>
<td>6.670E-004</td>
<td>2.1255E-008</td>
</tr>
</tbody>
</table>

From the above Tabulated Results shows the stress, strain and displacement of Conventional alloy and MMC composite Materials

CONCLUSION

Brief study regarding rod & its operating. Modeling and analysis of connecting rod is finished during this project. Modeling of rod is finished in CATIA V5 style code. The file is saved as catiapart. & to import during this in UG ten.0 and saved as NX.prt file AND IMPORT TO NX-Nastran. The static structural analysis (modal analysis) has disbursed within the NX-NASTRAN code package for rod by totally different typical alloy materials like A7176-T66 Al alloy, AISI4140 High strength low carbon alloy, C70S6 solid alloy and Ti-6Al-4V metallic element alloy. Similarly Composite materials (Metal Matrix composites(MMC) )like lumen twenty five Al MMC,KEVLER CNT MMC, CVI-C/SIC and 25Si3N4-Mg metallic element MMC. From analysis it's discovered that the minimum stresses among all loading conditions, were found at crank finish cap moreover as at piston finish.

From the higher than analysis square m...
10). ISHIDA “STRUCTURAL ANALYSIS OF BUSH BEARING FOR SMALL END CONNECTING ROD USING “PROMECHANICA” ISSN 0975 – 668X| NOV 12 TO OCT 13 | VOLUME – 02. 2344-02