FEA Analysis Of Connecting Rod Using Alloy Materials

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Abstract

The static analysis of a connecting rod comprised of three distinct kinds of composite alloys is the goal of this study. In this study, the connecting rod material (structural steel) is replaced with a newly created Aluminum alloy (Silicon carbide). CATIA V5 is used to generate the connecting rod model, which is then loaded into the ANSYS 14 workbench for Static. Following the study, a comparison is done in terms of maximum primary stress, equivalent stress, and total deformation between an existing steel connecting rod and the three composite connecting rods. All of these characteristics are determined analytically and compared to FEA findings. All of these findings are within the expected range, and the values of these materials are comparable to steel. The project is broken into three stages. First, there's the notion, followed by an assessment of current information. Modeling, static analysis, and a comparison of elastic strain, total deformation, and maximal von Misses stress value in alloy connecting rods are the next three steps.

Keywords:***:***Automobile, Engine, Finite element analysis, Static analysis, Load, Aluminum alloy (Silicon carbide).

1. INTRODUCTION

Aluminum is the most prevalent metal and the third most abundant element in the Earth's crust, after oxygen and silicon. It makes up around 8% of the Earth's solid surface by weight. Aluminum is one of the most useful metals because of its simple availability, high strength-to-weight ratio, easy machinability, durability, ductility, and malleability. It has a variety of features, including being light, strong, and long-lasting, being very corrosion resistant, being a good heat and electricity conductor, being highly reflective, being very ductile, entirely impermeable, and odourless, and being 100% recyclable. It has an atomic number of 13, a mass of 26, and a melting point of 730°C. Aluminum has a density of 2700gm per cubic centimetre at 293k and a hexagonal tight packing crystal structure. Various investigations on metal matrix composites have been conducted in the past. The most widely utilised particulates to strengthen metal or alloy matrixes of aluminium or iron are SiC, TiC, WC, and B4C, but research on SiC in ADC-12 alloy is still uncommon and limited. However, since only a few research have been published, the knowledge and data on mechanical characteristics are restricted, making this work particularly important. Furthermore, no study has been done on SiC reinforced ADC-12 composites that were manufactured using an ultrasonic aided stir casting method [1]-[5]. As a result, this study topic is still underdeveloped, and a lot more work may be done in this area. In this study, ultrasonic aided stir casting was used to create and treat SiC particles reinforced ADC-12 composites test samples. As a result, the mechanical behaviour of treated specimens was investigated using the parameters of varying wt. percent SiC addition in the ADC-12 alloy [3]. A 3D model of the connecting rod for a single cylinder 4-stroke Petrol engine was used for further static analysis. The model was created using solid modelling software (CATIA) and then analysed with HYPERWORKS 11 to calculate Von-Mises and Shear stresses for the specified loading situation [6]-[10].

2. MATERIAL PROPERTIES

Aluminium is a chemical element that belongs to the boron group and has the atomic number 13 and the symbol Al. It's a soft, ductile silvery white metal. In the Earth's crust, aluminium is the third most plentiful element (after oxygen and silicon) and the most abundant metal. It makes up around 8% of the Earth's solid surface by weight.

Table 1.1 Properties of Aluminium powder

1	Molecular formula	AL
2	Atomic number	13
3	Element category	Other metal sometimes considered a metalloid
4	Odor	Odourless
5	Standard atomic weight	26.9815385
6	Density	$2.70 g.cm^{-3}$
7	Melting point	933.47 k,660.32°C,1220°C,4478°F
8	Boiling point	2743 K,2470°C,4478°F

9	Solubility in water	Insoluble
10	Solubility	Insoluble in diethyl ether,practically insoluble in ethano
11	Thermal conductivity	237W.m^{-1} .K^{-1}
12	Youngs modulus	70GPa
13	Shear modulus	26GPa
14	Bulk modulus	76GPa
15	Micron size	200mesh(74µm)
16	Poisson ratio	0.35

The chemical properties of silicon carbide are stable, and it has a high thermal conductivity, a modest coefficient of thermal expansion, and strong abrasion resistance. Heat shock, compact size, light weight, and high strength, energy saving effect, made of sophisticated refractory materials. Low-grade silicon carbide (approximately 85 percent SiC) is an effective deoxidizer that may speed up the steelmaking process, enhance chemical composition control, and improve steel quality.

item	SiC	Fe2O3	F.C	proportion
I	≥97%	≤1.2%	≤0.3%	3.2g/cm3
II	≥90%	≤1.5%	≤0.5%	

There are around 250 different crystalline forms of silicon carbide. Silicon carbide in a glassy amorphous state is also generated by pyrolysis of preceramic polymers in an inert environment. Polytypes are a vast array of comparable crystalline structures that define SiC polymorphism. They are two-dimensional versions of the same chemical substance that vary in the third dimension. As a result, they may be thought of as layers piled in a certain order.
The most frequent polymorph is alpha silicon carbide (-SiC), which is generated at temperatures over 1700 °C and has a hexagonal crystal structure (similar to Wurtzite). At temperatures below 1700 °C, the beta modification (-SiC) with a zinc blende crystal structure (similar to diamond) is created. The beta form has had few commercial applications until recently, but due to its greater surface area than the alpha form, it is increasingly gaining popularity as a support for heterogeneous catalysts.

SiC is colourless in its purest form. Iron impurities give the industrial product its brown to black hue. The crystals' rainbow-like brilliance is caused by the thin-film interference of a silicon dioxide passivation layer that grows on the surface.

3. INTRODUCTION TO CAD/CAM/CAE

Without computer intervention, the modern world of design, development, manufacture, and so on, into which we have walked, would be unimaginable. Computers have become such a vital element of various areas due to their widespread use. In today's global market, rivalry exists not just in terms of price, but also in terms of quality, consistency, availability, packaging, stocking, and delivery. So, rather than local forces causing companies to adapt better methods like CAD/CAM/CAE, etc., are the necessities compelling industries to embrace current techniques?
The use of computer Aided Engineering (CAE), Computer Aided Design (CAD), and Computer Aided Manufacturing (CAM) setup is a possible fundamental technique for companies to have high quality goods at reasonable prices. In addition, a number of technologies have been added to help simplify and meet the needs. CATIA, PRO-E, and UG are just a few examples.
This penetration of method concern has aided producers in a) increasing productivity, b) shortening lead times, c) reducing prototype costs, d) improving quality, e) designing better goods, and f) reducing costs.
Computer Aided Designing (CAD) is a technology that allows you to develop, modify, analyse, and optimise designs using a computer.
Computer Aided Engineering (CAE) is a technology that analyses, simulates, or studies the behaviour of a computer-generated CAD model.
Computer Aided Manufacturing (CAM) is a technology that uses computers to plan, monitor, and control manufacturing operations.
CAD, CAE, AND CAM ARE REQUIRED The use of CAD, CAE, and CAM has revolutionised the way industries appear and generated healthy, fair competition.

4. INTRODUCTION TO CATIA

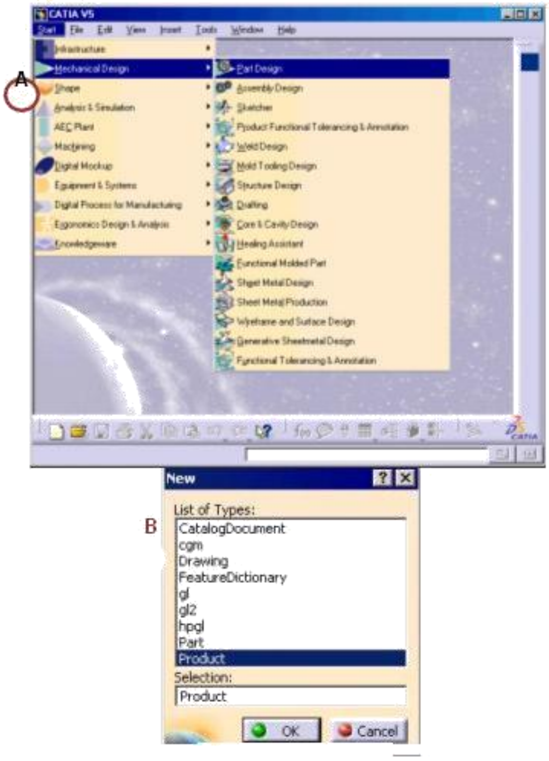
CATIA is a powerful programme that allows you to build detailed and sophisticated designs. The course's objectives are to teach you how to use CATIA to create components and assemblies, as well as how to create basic drawings of those parts and assemblies. This course focuses on the core skills and ideas needed to build a strong foundation for your designs. Mechanical design software is called CATIA. It's a parametric solid modelling design tool with a feature-based graphical user interface that's simple to pick up. You may develop fully associative 3-D solid models with or without restrictions, and utilise automated or user-defined relations to express design intent. This allows you to get your product to market faster and with higher quality. In general, it has resulted in a more rapid approach and innovative thinking.

Modeling in Solids:

In CAD systems, a solid model is the most comprehensive sort of geometric model. It includes all of the wireframe and surface geometry needed to completely define the model's edges and faces. Solid models not only carry geometric information, but also their topology, which connects the geometry. Identifying which faces (surfaces) meet at which edges is an example of topology (curves). This intelligence facilitates the addition of features. If a model needs a fillet, for example, you just choose an edge and set a radius.

5. WORKBENCHES

Workbenches feature a variety of tools that you may require throughout the development of your component. The following two methods may be used to swap between any principal workbenches:



You can tell what workbench you are currently in by the icon displayed in the upper right corner of the window.

The icon's background image will also denote what Solution this workbench is found within. For example, the Green Triangle icon indicates the Mechanical Design Solution.

Figure.1. New Document of Workbench

GENARALLY ALL CAD MODELS ARE GENERATED IN THE SAME PASSION GIVEN BELOW

: Enter CAD environment by clicking, later into part designing mode to construct model.

- : Select plane as basic reference.
-  : Enter sketcher mode.

Figure.2. CAD Models

IN SKETCHER MODE

: Tool used to create 2-d basic structure of part using line, circle etc

: Tool used for editing of created geometry termed as operation

: Tool used for Dimensioning, referencing. This helps creating parametric relation.

Its external feature to view geometry in & out

: Tool used to exit sketcher mode after creating geometry.

Figure.3. Sketcher Mode

2D DRAWING OF CONNECTING ROD

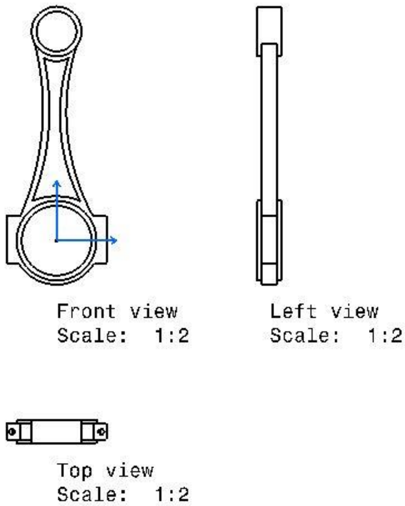


Figure.4. Connecting Rod

5. ANSYS

ANSYS is a general-purpose programme that engineers may use to model interactions across several fields of physics, including as structural, vibration, fluid dynamics, heat transport, and electromagnetics. As a result, ANSYS, which allows you to simulate testing or working settings, allows you to test in a virtual environment before making product prototypes. Furthermore, 3D simulations in a virtual environment may be used to identify and improve weak areas, compute life, and predict potential issues.

ANSYS IMAGES

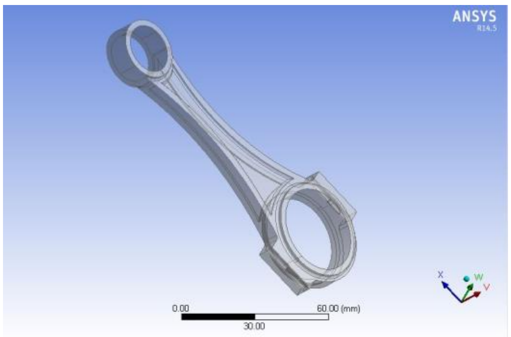


Figure.5. Ansys Image

6. RESULT AND DISCUSSION

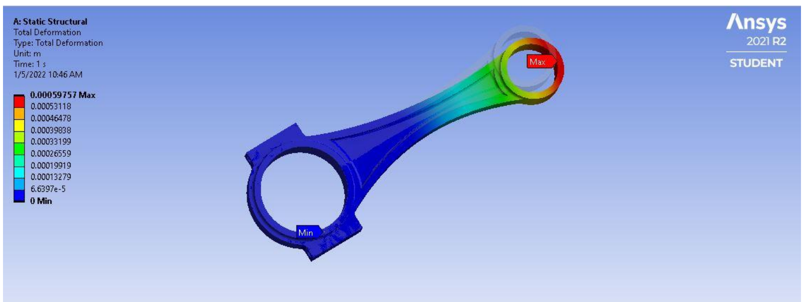


Figure.6. Total deformation of connecting rod using steel

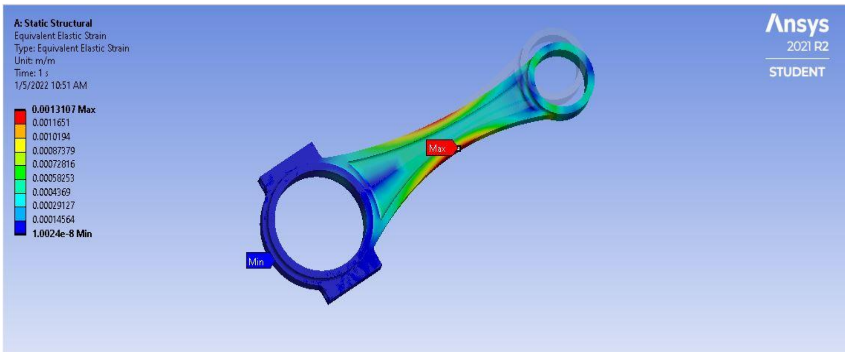


Figure.7.Equivalent elastic strain of connecting rod using steel

Table.2. Comparision of connecting rods with three different materials

Materials	Structural steel	Al+si ca
Total deformation	0 to 0.0005975	0 to 0.0001474
Equivalent stress	1.002e-8 to 0.00131	2.83e-9 to 0.0003235
Equivalent elastic strain	611.44 to 2.621e8	745.23 to 2.6205e8
Max principle elastic strain	2.07e-7 to 0.001295	6.2172e-10 to 0.00031983

7. CONCLUSION

The study's findings show that the connecting rod may be built and optimised for a load range that includes compressive load as one extreme load and tensile load as another. The weight of the existing steel connecting rod may be lowered by switching to alloy materials. According to the results of the aforementioned analysis, the alloy material of Aluminum + Silicon carbide produces superior results than other alloy materials. The new optimised alloy-based connecting rods are much stiffer than the previous generation.

8. REFERENCES

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