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Design and analysis of connecting rod with composites

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The research work main objective is to focuson modelling and analysis of connecting rod by varying material with same geometry. Many works are carried out by using alloys in the analysis of connecting rod such as aluminium, forged steel and titanium. The material for the connecting rod using here is Aluminium Reinforced with Boron Carbide Metal matrix composite. The solid model of connecting rod are created in CATIA V5.The static and dynamic analysis are performed by FEA software to determine the parameters for connecting rod like vonmises stress, deformation, natural frequency’s. The weight of the Connecting rod is to be optimized i.e., by changing the material. The simulation results are validated with the theoretical results.From the results, it is concluded that weight, stress and deformation of the connecting rod is reduced by 37.123%, 8.40%, and 50.03% by using the composite material. From the analysis compared to the conventional material, Aluminium Reinforced with Boron carbide MMC connecting rod have less weight, stress and deformation. Aluminium Reinforced with Boron Carbide Metal matrix composite material is selected as the most suitable material for Connecting rod

***Keywords*:** Connecting rod, Metal Matrix Composites, FEA

1. Introduction

In automotive engines connecting rods are well known components which are used for the convert linear, reciprocating motion of the piston into rotating motion of the crank shaft. In a connecting rod, the axial tension forces occur at the time of exhaust stroke, compression forces occur at the power stroke, bending stresses which are caused by the thrust, piston pulling and the centrifugal force generated by rotating crankshaft. In designing point of view, I-section of the connecting rod is designed to provide minimum weight with maximum rigidity. In case of high speed engines to keep the inertia forces as low as possible, I-section of the connecting rod is used and it can also withstand high gas pressure.

1.1 Connecting rod materials

The connecting rods are manufactured by different modern processes; there are sand cast, wrought forged, and powder metallurgy. The materials used for connecting rods are mild steels (having 0.35 to 0.45 percent carbon), alloy steels (chromium-nickel or chromium-molybdenum steels) and different alloys like aluminium alloys, magnesium alloys, titanium alloys and polymeric materials. These alloys are used for different applications depending upon the ultimate tensile strength required for the particular application. Till now, vast research is going on in the field of metallurgy and resulted in large number of newly developed materials are available to select materials and its particular applications. Inconel 718 is a nickel based super alloy that is well suited for applications requiring high strength in temperature ranges from cryogenic up to 1400°F. Inconel 718 also exhibits excellent tensile and impact strength. High strength. Excellent corrosion resistance. Outstanding weldability with resistance to post-weld cracking. Excellent creep-rupture strength at temperatures up to 700◦C (1300◦F).

2. Experimental Analysis of connecting rod

The experimental work is carried out by using co-co 80 FFT 12 analyser, it is advanced vibration measuring instrument it consists of impact hammer, accelerometer sensor and EDM software. FFT analyser convert signals from time or space domain function to frequency domain function. Coco is a plat form that can run in either Dynamic Signal Analyser or Vibration Data Collector mode. This is widely used in industries to measure the vibrations and check the balancing, looseness and misalignment problems.

2.1 NFT test of connecting rod

The experimental setup of NFT test, in this setup one is impact hammer and another one is accelerometer these two are connected to channel 1 and channel 2 respectively. Using bench wise fix, the connecting rod big end surface and Place the Accelerometer on the length of the connecting rod.

2.2 Mass of the connecting rod

Fig.1 Mass of the connecting rod from the experimental analysis

From the Experimental analysis, the mass of the connecting rod is 106 grams in Fig 1.

3. MODELLING OF CONNECTING ROD

The finite element model of the connecting rod is designed by using CATIA V5 R20 as per the specifications. Fig-2 shows the finite element model of the Connecting rod.

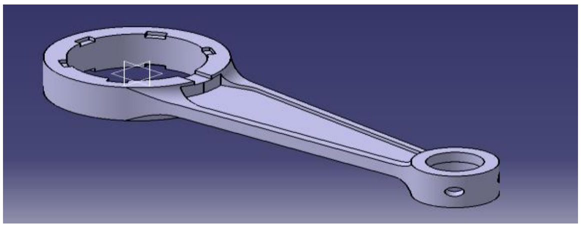

Fig.2 Connecting Rod

Table 1 Dimensions of connecting rod I-section

Parts	Units (mm)
Thickness of flange and web of the section T	3
Width of the section B	5.4
Width of the big end B1	14.72
Width of the small end B2	14
Height of the section H	12

Area of the section A $(mm)^2$	99
Length of the connecting rod L	92.27
Radius of crank r	27.2
Inner diameter of the small end d1	12
Outer diameter of the small end	1.14
Inner diameter of the big end d2	29
Outer diameter of the big end	38.44

Results and Discussion

*4. N*umericalanalysis of connecting rod by using composite material

4.1 Static structural analysis of connecting rod

4.1.1 Mass of the connecting rod

From the numerical analysis, the mass of the connecting rod is

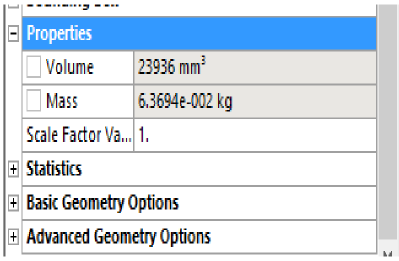

Fig.3 Mass of the Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod connecting rod

4.1.2 Meshing

Mesh process has been performed. The FEA model has 405679 nodes, 271672 elements. Figure.4 shows the meshed model of connecting rod

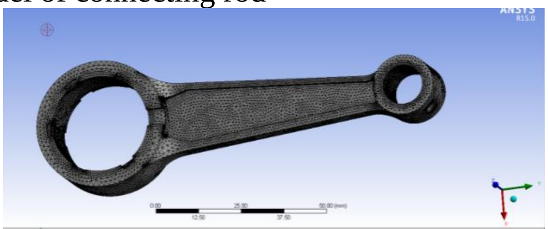

Fig.4 Meshed model of composite connecting rod

The pressure of 15.497MPa is applied in small end of the connecting rod and big end is fixed. Grid Convergence

4.1.3 Boundary conditions

The model is meshed by automatic mesh tool with an element type tetrahedral Fig-6.2. Fixed support type boundary conditions are considered for the analysis of the connecting rod. The pressure of 15.497MPa is applied in small end of the connecting rod and big end is fixed. Fig-14 shows that boundary conditions of connecting rod.

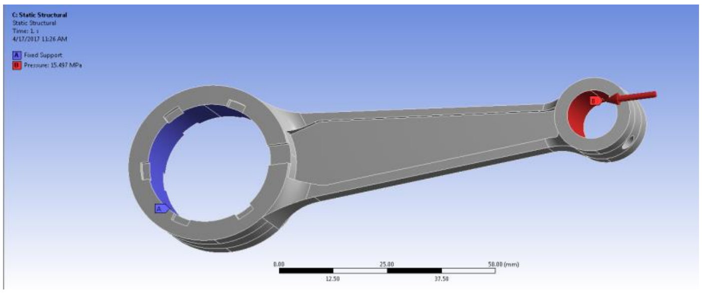

Fig.5 Boundary Conditions of composite Connecting rod

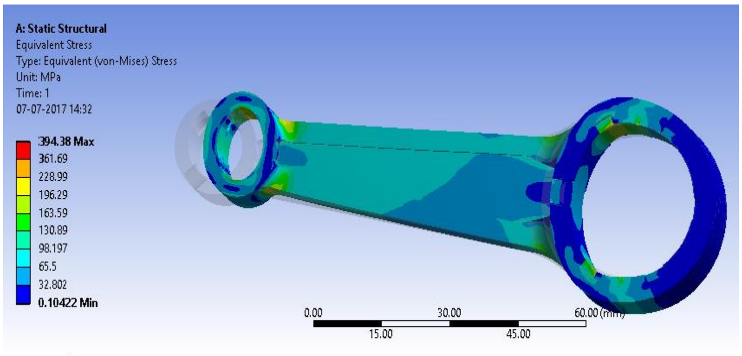

Fig.6 Equivalent stress in Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod

The figure-6 shows the static structure analysis of Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod and the maximum equivalent stress obtained is 394.38 MPa.

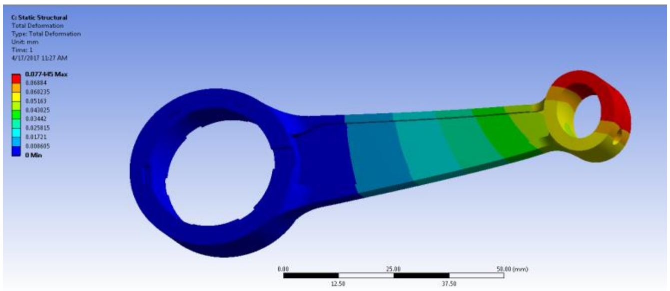

Fig.7 Total Deformation in Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod

The figure 7 shows the static structure analysis of Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod and the total deformation obtained is 0.077445mm.

6.2 Modal analysis

The main importance of Modal analysis is characterizing the dynamic properties of structure in terms of modal parameters, i.e. natural frequency, mode shape and damping. Modal analysis is a linear analysis in ANSYS family products and plasticity and contact elements are ignored if they defined.

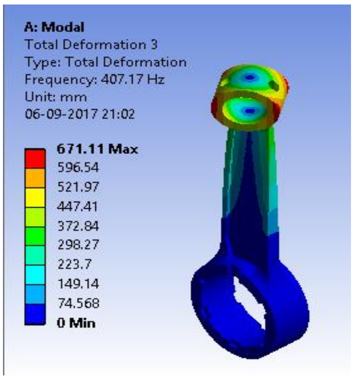

Fig.8 Max deformation at third mode

Fig.8 shows that the maximum deformation at mode-3 of connecting rod. From the figure, it is observed that natural frequency at mode-3 is 407.17Hz, and table.6.1 show that natural frequencies at six modes.

Table 3 Natural frequencies of connecting rod

s.no	mode	Frequency (Hz)
1	1	76.857
2	2	369.26
3	3	407.17
4	4	555.73
5	5	1552.1
6	6	1745.2

6.3 Harmonic analysis

A harmonic or frequency-response analysis considers loading at one frequency only. Loads may be out-of-phase with one another, but the excitation is at a known frequency. This procedure is not used for an arbitrary transient load.

– One should always run a free vibration analysis prior to a harmonic analysis to obtain an understanding of the dynamic characteristics of the model.

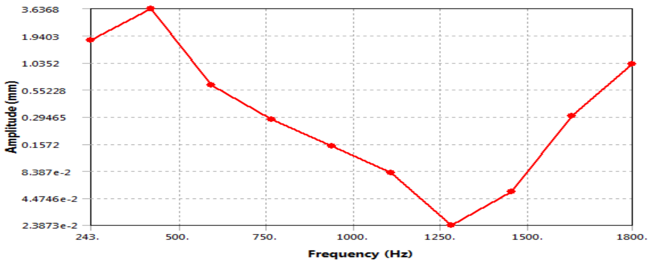

Fig 9 Frequency Response of connecting rod

Fig.9 shows that Frequency Response of connecting rod is obtained maximum amplitude of 3.6368 at 416Hz frequency.

6.4 Results of experimental NFT test using FFT analyser

Experimental NFT test is carried out by using FFT analyzer with impact hammer and piezo electric sensor data was saved in it that saved data performed to using of EDM software frequencies are recorded. Natural frequency experimentally obtained as 381.25Hz.

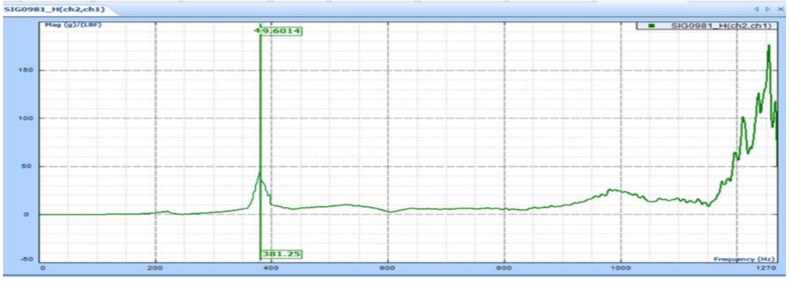

Fig.10 Natural Frequency Spectrum

Table 4 shows the comparison of frequency obtained from the FFT analyzer and Numerical analysis using ANSYS. From the results observed that the first natural frequency is at 396.52 Hz from ANSYS and 381.25 Hz from FFT analyzer.

From the results, it is observed that error between the FFT analyzer results and ANSYS results is 3.851%. It shows that good agreement between the FFT analyzer and ANSYS Results.

Table 4 Natural Frequency Comparison

S.No	Frequency (Hz) from FFT analyzer	Frequency (Hz) from Numerical Analysis	%Error
1	381.25	396.52	3.851

The table 5 shows the structural analysis results of two materials of connecting rodfrom the table it is observed that ALB4C composite connecting rod shows better results as compared to other at same working conditions.

Table 5 Comparison of Structural Analysis Results

S No		20CrMo alloy steel	ALB4C composite
1	Mass (grams)	101.3	63.64
2	Equivalent stress (MPa)	430.56	394.38
3	Total deformation (mm)	0.15501	0.077445

CONCLUSIONS

1. Natural frequency test is carried out experimentally by using impact hammer and FFT analyser instrument and found the natural frequency of existing connecting rod as 381.25Hz.
2. The analytical and experimental results of modal analysis are 381.25Hz and 396.25Hz are compared and found that there is a good agreement.
3. From the static structural analysis, it is observed that Von misses Stress and deformation for 20CrMo was found to be 430.56N/mm², 0.15501mm which is greater than Aluminium Reinforced with Boron Carbide Metal matrix composite connecting rod i.e. 394.38 N/mm², 0.077445 mm. Weight, stress and deformation of the connecting rod is reduced by 37.123%, 8.40%, 50.03% by using the composite material.
4. Finally, it is concluded that compared to the conventional material, Aluminium Reinforced with Boron carbide MMC connecting rod have less stress and less weight and is selected as the most suitable material for Connecting rod

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