Design And Analysis of Connecting Rod Using Beryllium Material

S.Aravind[1], T.K.Ajith Kumar[2],R.Dhanesh Raj[3], D.Kalaimani[4], P.Pandiyarajan[5], A.Jayaveeran[6]

[1, 2, 3, 4] Dept Of Mechanical Engineering
[5]Assistant Professor, Dept Of Mechanical Engineering
[6]Associate Professor, Dept Of Mechanical Engineering
[1, 2, 3, 4, 5, 6] T.J.S Engineering College

Abstract- Connecting Rods are used practically generally used in all varieties of automobile engines acting as an intermediate link between the piston and the crankshaft of an engine of an automobile. It is responsible for transmission the up and down motion of the piston to the crankshaft of the engine, by converting the reciprocating motion of the piston to the rotary motion of cranksha ft. While the one end, small end the connecting rod is connecting to the piston of the engine by the means of piston pin, the other end, the bigger end being connected to the crankshaft with lower end big end bearing by generally two bolts. Generally connecting rods are being made up of stainless steel and aluminium alloy through the forging process, as this method provides high productivity and that too with a lower production cost. Forces generated on the connected rod are generally by weight and combustion of fuel inside cylinder acts upon piston and then on the connecting rod, which results in both the bending and axial stresses. The present paper attempts to design and analyze the connecting rod used in a diesel engine in context of the lateral bending forces acting along its length during cycle of it The lateral bending stress are commonly called as whipping stress and this whipping stress forms the base of evaluation of performance of various materials that can be used for manufacturing of connecting rod. The conventional material used is steel which is designe using CAD toolwhich is CATIA V5 and subsequentlyanalysed for bending stress acting on it in the arena of finite element analysis using ANSYS workbench 14.5 and this procedure is followed for different material which are aluminium 7075 , aluminium 6061 and High Strength Carbon.

Keywords- Connecting Rod, Analysis, FEA

I. INTRODUCTION

The conversion of heat energy into mechanical energy is achieved by device called as internal combustion engine and connecting rod forms an integral part of this engine. The function of connecting rod is to transmit the gas pressure available at piston end to crank end for efficient conversion of heat energy into mechanical energy. During this process of nergy conversion various forces and corresponding stresses are generated on the body of connecting rod and it forms the most stressed part of I. C engines. The two forces acting on connecting rod can be classified as buckling load due to gas pressure and lateral bending due to inertia forces.

The inertia forces cause bending of connecting rod which causes whipping stress acting on it. In this project the conventional material used for manufacturing of connecting that is steel is replaced by aluminium alloys such as 7075 and 6061 and High Strength carbon fiber. The lateral bending of connecting rod occurring on each materials are evaluated analytically and using FEA approach. Computers employing microelectronics technology are called for aiding the geometric modeling of connecting rod which would provide the model for subjecting it to various materials.

The calculation of whipping stress due to inertia is first calculated for each material using analytical approiach. Geometricallymodeled connecting rod in CATIA V5 is subjected to diffrent materials and the equivalent stress results are calculated by FEA software named as ANSYS which are compared with the equivalent stress acting on the conventional connecting rod material that is steel to provide a platform for evaluation and validation of design.

II. LITERATURE SURVEY

The following research papers are consulted for obtaining an in-depth understanding of various aspects of the project:-

Suraj Pal et al. [1] "Design Evaluation and Optimization of Connecting Rod Parameters Using FEM" In this paper Finite element analysis of single cylinder four stroke petrol engines is taken for the study; Structural systems of Connecting rod can be easily analyzed using Finite Element techniques. So firstly a proper Finite Element Model is developed using Cad software Pro/E Wildfire 4.0.Then static analysis is done to determine the von Misses stress, shear stress, elastic strain, total deformation in the present design connect ing rod for the

given loading conditions using Finite Element Analysis Software ANSYS .In the first part of the study, the static loads acting on the connecting rod, After that the work is carried out for safe design.

G. Naga MalleshwaraRao et al. [2] "Design Optimization and Analysis of a Connecting Rod using ANSYS" The main Objective of this work is to explore weight reduction opportunities in the connecting rod of an I.C. engine by examining various materials such as Genetic Steel, Aluminium, Titanium and Cast Iron. This was entailed by performing a detailed load analysis.

K. Sudershan Kumar et al. [3] "Modelling and Analysis of Two Wheeler Connecting Rod" This paper describes modelling and analysis of connecting rod. In this project connecting rod is replaced by Aluminium reinforced with Boron carbide for SuzukiGS150R motorbike. A 2D drawing is drafted from the calculations. A parametric model of connecting rod is modelled using PRO-E 4.0 software. Analysis is carried out by using ANSYS software.

B. Anusha, C.VijayaBhaskar Reddy et al. [4] "Modelling and Analysis of Two-wheeler Connecting Rod by Using Ansys" In this paper a static analysis is conducted on a connecting rod of a single cylinder 4-stroke petrol engine. The model is developed using Solid modelling software i.e. PRO/E (creo-parametric). Further finite element analysis is done to determine the von-misses stresses shear stress and strains for the given loading conditions.

B. Anusha, Dr. C. VijayaBhaskar Reddy et al. [5] "Comparison Of Materials For Two- Wheeler Connecting Rod Using Ansys" The modelled connecting rod imported to the analysis software i.e. ANSYS. Static analysis is done to determine von-misses stresses, strain, shear stress and total deformation for the given loading conditions using analysis software i.e. ANSYS. In this analysis two materials are selected and analyzed. The software results of two materials are compared and utilized for designing the connecting rod.

Mr. H. B. Ramani et al. [6] "Analysis of Connecting Rod under Different Loading Condition Using Ansys Software" In this study, detailed load analysis was performed on connecting rod, followed by finite element method in Ansys-13 medium. 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 modelled, meshed and loaded in Ansyssoftware. The maximum stresses in different parts of connecting rod were determined by Analysis. The maximum pressure stress was between pin end and rod linkages and between bearing cup and connecting rod linkage. The

maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkage. It is suggested that the results obtained can be useful to bring about modification in Design of connecting rod.
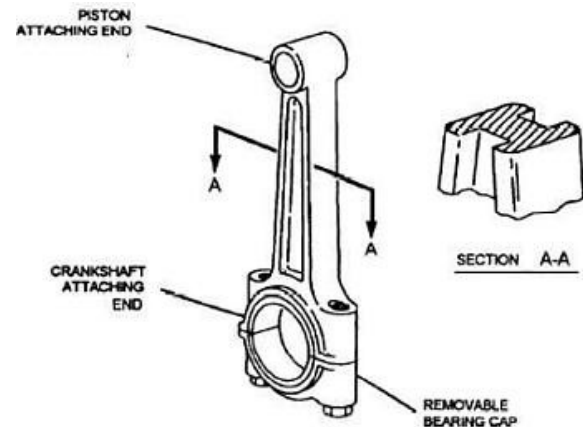
III. MATERIAL FOR CONNECTING ROD

Fig 1 Connecting Rod assembly

The most common type of production methods is casting, forging, and powdered metallurgy. Connecting rod must withstand a complex state of loading. It need to undergo high cyclic loads of the order of 10^8 to 10^9 cycles, which range from high compressive loads due to combustion, to high tensileloads due to inertia. Therefore, durability of this component is vital. Due to these factors, automotive connecting rods have been the topic of research for different aspects such as production technology materials, performance, simulation, fatigue, etc. In modern automotive cylinder engines, the connecting rods are most usually made of forged steel for production engines. Connecting rods for automotiveapplications are typically manufactured by forging from either forged. They could also be cast. Between the forging processes, powder forged or drop forged, each process has its own advantages and disadvantages. Powder metalmanufactured blanks have the advantage of near net shape and saving materials. However, the cost of the blank is high due to the high material cost and sophisticated manufacturing techniques. With steel forging,the material is cheap and the drop forging manufacturing process is cost effective..Due to its large volume production, it is only logical that optimization of the connecting rod for its weight or volume will result in large- scale savings. It can also achieve the objective of reducing the weight of the engine component, thus reducing inertia loads, reducing engine weight and improving engine performance and fuel economy

IV. RESEARCH PROBLEM DEFINITION

The present work provides an insight of bending stress acting along the body of connecting rod due to inertia forces acting on the connecting rod which are known by name of whipping stress. The bending moment is dependent on material selected for connecting rod and is used to evaluate the bending stress acting on steel, Al7075, Al6061 and high strength carbon fiber. The comparative study of bending stress parameter provides the best material to be selected for connecting rod of diesel engine.

V. METHODOLOGY

1. To design the connecting rod for a diesel engine so as to determine the section thickness of connecting rod.
2. To geometrically model the connecting rod as per the dimensions generated from the process of design procedure followed.
3. Toanalyse the whipping load which is bending stress due to inertia forces acting on each material of connecting rod
4. Toanalyse the bending stress usin FEA approach on each material selected for study.
5. To plot the results for bending stress acting on Al7075, Al6061 and high strength carbon fiber and comparing this with bending stress acting on conventional material.

VI. GEOMETRIC MODELLING IN CATIA V5

The various components for the assembly of connecting rod are designed as per the rating of a diesel engine used in TATA Sumo four wheeler. The dimensions are determined from above process and various components are modeled and subsequently assembled as final product that can be illustrated here.The first component to be modeled is the connecting rod with a section thicknes of 7.3 mm and height of 36.5mm which can be shown below
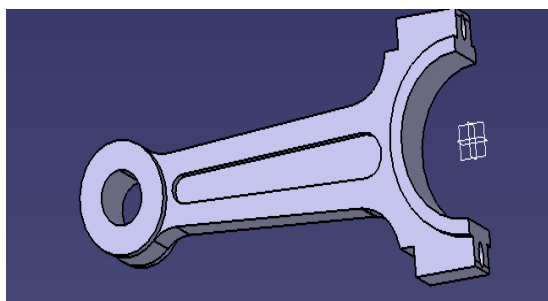

Fig.2. Geometric Modeling of connecting rod

The next part modeling deals with geometrically designing the upper cap of connecting rod which is used for fixing the crank end of connecting rod .the dimensions of this

components are same as upper section of connecting rod and can be depicted as follows
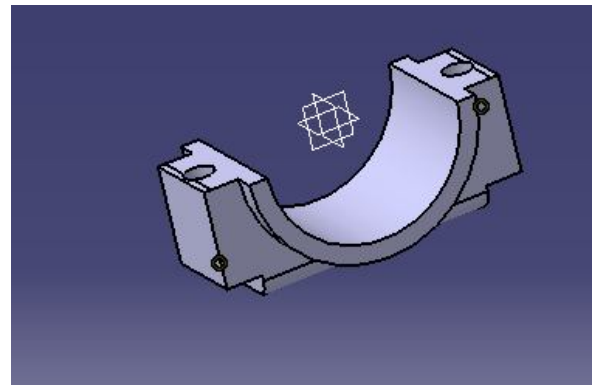

Fig.3. Geometric modeling of Upper cap of crank end

The last component is a bolt of 12 mm which is metric in standard and is used for clamping of crank end to assemble the complete connecting rod
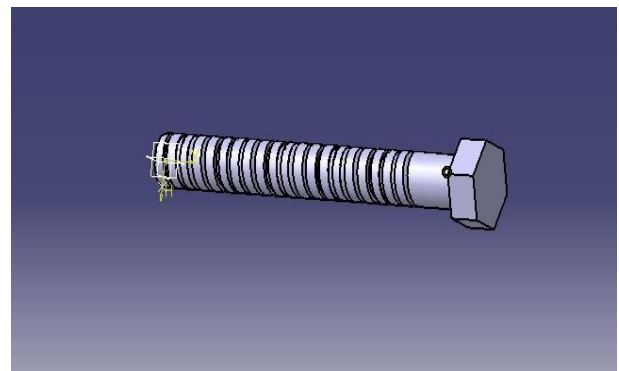

Fig.4. Geometric modeling of Upper cap of crank en

All the components modeled previously are assembled as single product to provide the design of connecting rod. The constraint provided are geometrical constraint which are used to define the relation of various components with each other as shown below
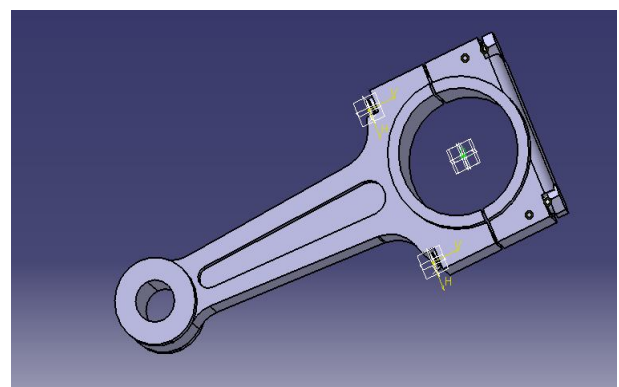

Fig.5. Assembly of connecting rod

VII. ANALYSIS OF SYSTEM

The term internal combustion engine refers to the engine in which working fluid is inside the work producing chamber and in most of IC engines this mixture in terms of air and fue is inducted during suction stroke. Further explosion of the mixture leads to generation of various gases and consequent pushing of piston in downward direction. This downwardmotion is transmitted to the crank shaft by means of connecting rod and thus the transmitting member i.e connecting rod must be a rigid link ideally. As rigidity cannot be achieved in practice, the deformation produced on connecting rod must be very small which can be evaluated by studying the type of forces acting on connecting. Connecting rod is subjected to gas pressure and inertia forces of which inertia force contributes to bending of connecting rod. This lateral bending leads to generation of bending stress known by name of whipping stress acting on connecting rod during it's cycle of operation. This bending stress is dependent on bending moment which acts on the length of connecting rod and is function of density of connecting rod used. Thus variation in material can produce certain results in terms of bending stress acting on the connecting rod and can help to optimize the material than can be used in application of connecting rods. From the domain of various materials that can be implied for construction of connecting rod following four materials are used for calculation of bending or whipping stress acting on them so as to choose the best material which would tend to reduce the whipping load and hence the vibrations of engine during its cycle of operation. The process of analytical analysis is initiated by calculating the maximum bending moment or which is termed as whipping load acting on connecting rod of each material and subsequently calculating the corresponding values of bending stress or whipping stress on connecting rod of each material. The mass of connecting rod per metre length is given by,

Is m_l= volume x density

= area x length x density Hence

m_l= A x1 x ρ

And m_l= A x ρ

Here ρ= density of material of connecting rod

As form design consideration we know that A= $11t^2$ Hence m_l = $11t^2$ x ρ

The value of Maximum bending moment can be shown as M_b = m x ω^2 x r x L / 9 x $3^{0.5}$

Here m = mass of connecting rod And r = crank radius

L= length of connecting rod

Substituting m = m_l x L in above expression M_b = m_l x ω^2 x r x L^2 / 9 x $3^{0.5}$

I_{xx}= 34.91 x t^4 and y = 2.5t Hence the bending stress

σ_b = (M_b x y) / I Thus above relation is used for calculating the bending stress or the value of whipping stress for different materials

Table.1. Bending moment acting on different materials

MATERIAL	Bending Moment N-m
Steel	5.716
Al7075	1.98
Al6061	1.914
High strength carbon fiber	1.17

The connecting rod geometries of different materials are subjected above bending moment acting on the connecting rods and corresponding values of bending stress which are the von mises stresses calculated for each material and this can be shown as follows.
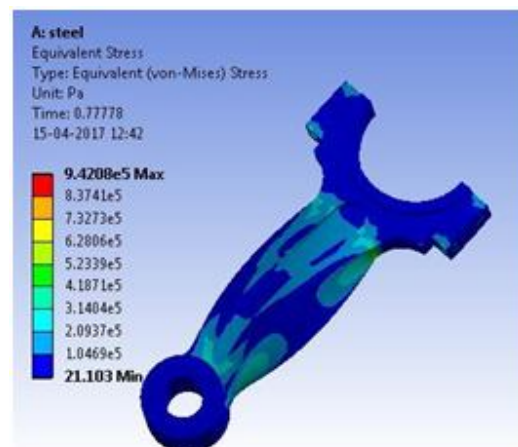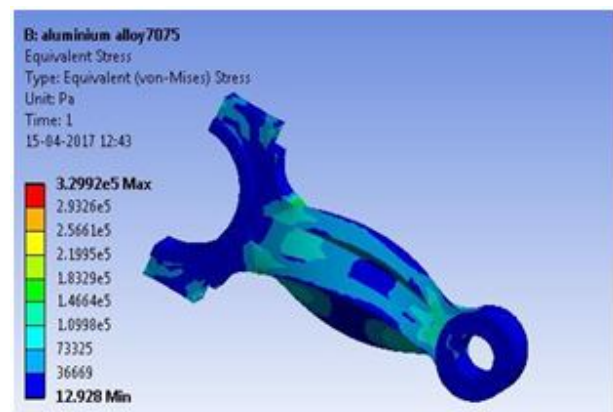

Fig.6. Bending stress on steel connecting rod

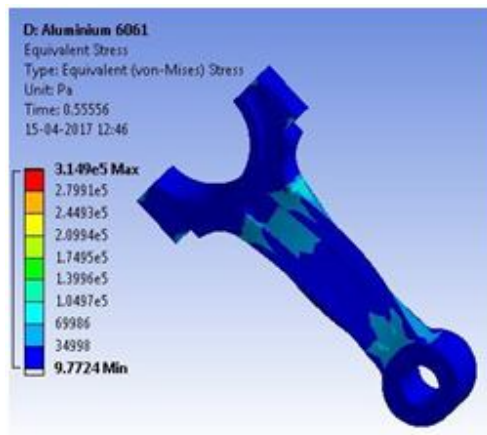Fig.7. Bending stress on Al7075 connecting rod

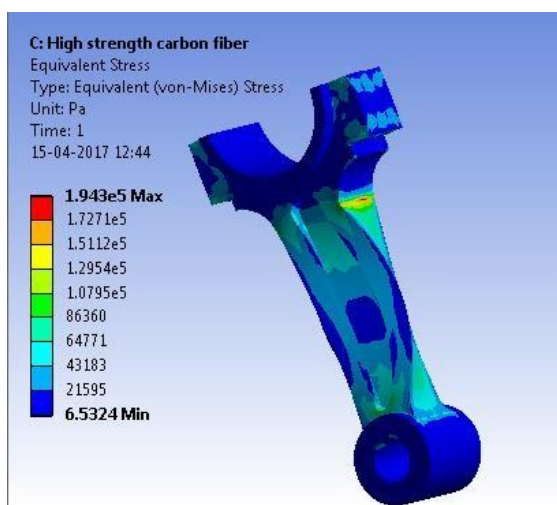Fig.8. Bending stress on Al6061 connecting rod

Fig 9. Bending stress on High strength carbon fiber connecting rod

VIII. RESULTS AND COMPARISON

The process of designing and analyzing the system with relevant parameters of study is followed by inferences generated by evaluation process of the data obtained during the process of analysis. The connecting rod of various material other than conventional material is subjected to various moment ratings which where analytical values employed for analysis of connecting rod and were used to study the behavior of the connecting rod with materials under consideration. The results calculated can be drawn on the lines of effect of Maximum bending moment which is bending stress in this case. The various input values which are used for connecting rod are presented and the variation in the effect due to material variation in the system can be presented as follows

IX. CONCLUSION

Thus it can be inferred that this paper projects a work to determine the best material that can be used formanufacturing of connecting rods. The geometric modelgenerated with the aid of specification of design procedure is consequently analysed for bending stress which is caused by bending moment due to ineria of connecting rod The FEA approach helps to evaluate the approximate values of bending stress acting on different material such as Al 7075, Al6061 and High strength carbon fiber which are used to compare with the conventional material employed which is steel. The connecting rod of high strength carbon fiber suffers lesser in context of bending due to inertia and thus can be best suited for connecting rod of diesel engine.

REFERENCES

[1] International Journal of Science and Research (IJSR), India Online ISSN: 2319- 7064 Volume 2 Issue 7, July 2013 www.ijsr.net "Design Optimization and Analysis of a Connecting Rod using ANSYS" G. Naga MalleshwaraRao International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol.2, Issue.5, Sep-Oct. 2012 pp- 3367-3371 "Modelling and Analysis of Two Wheeler Connecting Rod "K. Sudershn Kumar1, Dr. K. Tirupathi Reddy, Syed AltafHussain

[2] International Journal of Engineering and Management Research, Vol.-2, Issue-6, December 2012 ISSN No.: 2250- 0758 "Design Evaluation and Optimization of Connecting Rod Parameters Using FEM" Suraj Pal, Sunilkumar 1P.G. student,Y.C.O. Engg. Talwandisabo, Department of MechanicalEngg. Senior Assistant Professor Y.C.O. Engg. Talwandisabo, Department of Mechanical Engg.

[3] IOSR Journal of M echanical and Civil Engineering (IOSR- JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 6,Issue 5 (May. - Jun. 2013), PP 83- 87 www.iosrjournals." Modelling and Analysis of Two Wheeler ConnectingRod by Using Ansys " B. Anusha, C.VijayaBhaskar Reddy

[4] International Journal of Engineering Trends and Technology (IJETT) – Volume Issue 9- Sep 2013 " Comparision Of Materials For Two-Wheeler Connecting Rod Using Ansys" B. Anusha#1, Dr.C.VijayaBhaskar Reddy.

[5] International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 9, November- 2012 ISSN: 2278-0181 "Analysis of Connecting Rodunder Different Loading Condition Using Ansys Software" Mr. H. B. Ramani, 2 Mr.Neeraj Kumar, 3 Mr. P. M. KasundraW. Li, D. Li and J. Ni, Diagnosis of tapping

process using spindle motor current International Journal of machine Tools &Manufacturing,ELSEVIER, 43, 2003, 73-79

[6] International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013 2081 ISSN 2229-5518 IJSER ©2013 http://www.ijser.org "DesignAnd Analysis of Connecting Rod Using Forged steel" Leela Krishna Vegi, VenuGopalVegi

[7] IOSR Journal of Mechanical and Civil Engineering (IOSR- JMCE) e-ISSN: 2278-1684 Volume 6, Issue 1 (Mar. - Apr. 2013), PP 117-125 58 www.iosrjournals.org "Stress analysis of connecting rod by FEM Photoelasticity" Prof. Vivek C. Pathade1 ,Dr.Dilip S. Ingole.

[8] ."Optimization of Connecting Rod Parameters using CAE Tools" Anil kumar Student, Mechanical Engineering GJUS&T,HisarKamaldeep Grover Assistant Professor, Mechanical Engineering Department GJUS&T, HisarBalvinderBudania Assistant Professor, Mechanical Engineering Department OITM, Hisar.

[9] "Optimization of steel connecting rod by aluminium connecting rod using finite element analysis" 1Tukaram S. Sarkate, 2Sachin P. Washimkar, 3SachinS. Dhulekar 1, 2, 3 B.E., BabasahebNaik College of Engineering, Pusad