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Finite Element Analysis of I.C Engine Connecting Rod: A Review

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Abstract

The main objective of this paper is to proposed a weight reduction opportunities for a production cast iron connecting rod. We are taking different types of connecting rod made of cast iron and steel alloys materials and also compare their mechanical and geometrical properties. In recent time it is very necessary to reduce weight while increasing or maintaining strength of Connecting rod. This has entailed performing a detailed load, deformation, fatigue, stress and strain analysis. The connecting rod is a high volume production from automobile side. Every vehicle that uses an internal combustion engine requires at least one connecting rod. The major stress induced in the connecting rod is a combination of axial and bending stresses in operation. Connecting rod is subjected to more stress than other engine components. Failure and damage are also more in connecting rod, so stress analysis in connecting rod is very important.

Keywords: Connecting rod, Light-weight design, Stress analysis, Finite element simulation, Ansys software.

Introduction

An engine connecting rod is dynamic component of a vehicle, transmitting the axial cyclic motion of piston to the rotational motion of crankshaft. The connecting rod is therefore considered as a key component in terms of the structural durability and efficiency of an engine 4.The connecting rods subjected to a complex state of loading. It undergoes high cyclic loads of the order of 10^8 to 10^9 cycles, which range from high compressive loads due to combustion, to high tensile loads due to inertia. Therefore, durability of this component is of critical importance. Due to these factors, the connecting rod has been the topic of research for different aspects such as production technology, materials, performance simulation, and fatigue etc 12.One source of energy in automobile industry is internal combustion engine. IC engine converts chemical energy into mechanical energy in form of reciprocating

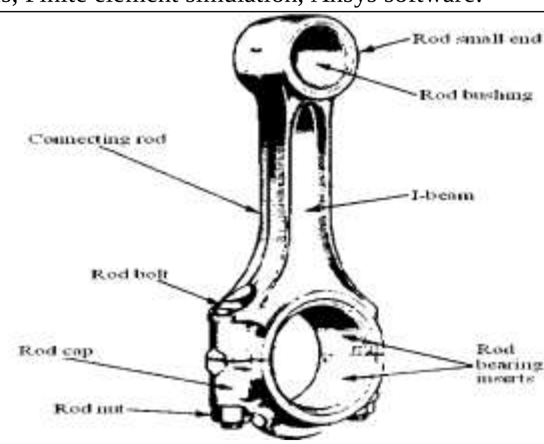

Fig.1 Connecting rod nomenclature 2.

Motion of piston. Crankshaft and connecting rod convert reciprocating motion into rotary motion 9. Connecting rods are widely used in variety of car engines. It consists of a pin-end, a shank section, and a crank-end. Pin-end and crank-end pin holes are machined to permit accurate fitting of bearings. One end of the connecting rod is connected to the piston by the piston pin. The other end revolves with the

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crankshaft and is split to permit it to be clamped around the crankshaft. The two parts are then attached by two bolts 5.

Literature review

Saharash Khare, O.P. Singh, K. Bapanna Dora, C. Sasun (2011) studied that, an analysis of the various components of the internal combustion engine was carried out. Subsurface cracks and pit marks were seen in the crank pin, roller bearings and big end surfaces of the connecting rod. It was found that high wear at the interface of these components was the main culprit. A laboratory test set-up was developed to correlate and reproduce the field failures. The loads and boundary conditions obtained from the experiments were used in the finite element model of the connecting rod assembly. Results show high interfacial pressure and stresses near the junction of web and flange of the connecting rod. The modified design of the connecting rod shows significant reduction in the extreme pressure in FEM resulting in the significant enhancement of durability life in laboratory test. A discussion of the spalling problem has been provided leading to the connection of pick pressure and spalling phenomena. The spalling of connecting rod, crank pin and roller bearing is attributed to the high-localized interfacial pressure that developed due to the design of the web and flange of the connecting rod 9.

S. Griza, F. Bertoni, G. Zanon, A. Reguly, T.R. Strohaecker (2008) studied that, it was verified with fatigue rupture of one of the fourth connecting rod bolt. Tensile tests were performed in four of the remaining connecting rod bolts. During this procedure, it was verified another bolt with fatigue crack propagation an indication that the first fatigued bolt did not have suffer torque relaxation. A finite element analysis was performed in connection with an analytical fracture mechanics approach aiming to evaluate the relation between tightening force and fatigue crack propagation in connecting rod bolts. The engine collapse occurred due to forming laps in the grooves of the bolt shank. Finally, some design improvements were suggested for avoid future failures: a gap in the groove length at the connecting rod cap interface, enough to avoid combination of forming laps and higher stress amplitude; increase of the bolt torque assembly to reduce stress amplitude 8.

Mr. H. B. Ramani, Mr. Neeraj Kumar, Mr. P. M. Kasundra (2012) 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 modeled, meshed and loaded in Ansys software. 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 5.

Q. Wang, F. He (2004) has studied the connecting rod is among the most important parts used widely in various engines. With the increasing demands from the automotive and motorcycle industries for geometrical dimensional accuracy and internal quality, new precision forging technologies and equipment have been introduced recently to China to improve the production of connecting rods. Based on the experience of the development of several forging lines in recent years, the authors sketch new progress in the precision forging of connecting rods in China: this includes automatic billet feeding and a temperature control system, 3D-CAD/CAM applications in cross-rolling and reducer rolling for performs and precision forging equipment, as well as a compound die combining trimming, punching and calibrating operations 6.

Bai-yan He, Guang-da Shi, Ji-bing Sun, Si-zhuan Chen, Rui Nie (2013) studied that, This paper presents the failure analysis of a connecting rod used in a diesel generator set on an offshore platform. To determine the failure mechanism, material characterization and numerical analyses are performed on the connecting rod. The macro and micro structures are analyzed by scanning electron microscope (SEM) and optical microscope. The chemical composition and metallographic structure investigation are conducted to study the characteristics of the material. Hardness and tensile tests are performed to verify the mechanical properties of the connecting rod. A nonlinear finite element (FE) analysis with the bolted assembly is performed to evaluate the local stress near the mating faces, and the results shows that the crack position is consistent with the high stress spots. As a result, lower yield strength of the material and high

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stress level or high stress concentration are concluded as the main reasons of failure of the connecting rod 1.

Xianghui Meng, YoubaiXie (2011) studied, a new numerical analysis for the piston skirt is conducted to consider the effects of the connecting rod inertia on the piston skirt–liner system lubrication. The piston dynamics, the oil film and the friction loss of the system are analyzed and compared with one earlier model that has been adopted widely. The results on a gasoline engine show that the connecting rod inertia does have some influence on the system lubrication as well as the piston dynamics, especially when engine runs at high speeds. A new dynamics model of the piston in reciprocating engines is presented to consider the effects of the connecting rod inertia on the lubrication performance of the piston skirt–liner system. From the numerical analysis on a four-stroke gasoline engine 12.

Vivek. C. Pathade, Bhumeshwar Patle, Ajay N. Ingale (2012) studied have every vehicle that uses an internal combustion engine requires at least one connecting rod. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight. The major stress induced in the connecting rod is a combination of axial and bending stresses in operation. The axial stresses are produced due to cylinder gas pressure (compressive only) and the inertia force arising in account of reciprocating action (both tensile as well as compressive), where as bending stresses are caused due to the centrifugal effects. The result of which is, the maximum stresses are developed at the fillet section of the big and the small end. Hence, the paper deals with the stress analysis of connecting rod by Finite Element Method using Pro/E Wildfire 4.0 and ANSYS, WORKBENCH 11.0 Software 12.

Liming Zheng, ShuqingKou, ShenhuaYang, LiliLi, FeiLi (2010) this paper reports on the laser notching technology in C70S6 steel for fracture splitting connecting rod using a Nd: YAG pulsed laser. The effects of process parameters on starting notch (SN) dimension and morphology were investigated by both finite element method (FEM) simulations and physical experiments for various process parameters. Optical microscopy and the scanning electron microscope (SEM) were used for the measurement of SN dimension and the observation of SN morphology in the experiment. The results were compared with the predictions. It was found that the FEM simulations results showed good consistency with the experiments, which indicates that the finite element model is feasible and reliable. Based on the principal findings from the two methods, optimum ranges of process parameters for different fracture splitting connecting rods were predicted, which area flexibly adjusting notch depth, a curvature radius less than 0.08 mm and an opening angle within the range 18–261. The results indicate that the predicting ranges are suitable for making good SNs, which has also been proved by the fracture splitting experiments. Through systematical experimental research on laser notching of C70S6 for fracture splitting connecting rod, the effects of the processing parameters on SN dimension and morphology are studied, and the optimum range of the processing parameters is obtained 3.

Teruie Takemasu, victor Vazquez, Brett painter, Taylan (1996) studied that, in conventional hot forging of connecting rods, the material wasted to the flash accounts approximately 20 to 40% of the original workpiece. In order to reduce the cost of forged products, the forging must be performed in a closed cavity to obtain near-net or net shape parts. In flashless forging, the volume distribution of the preform must be accurately controlled to avoid overloading the dies and to fill the cavity. These studied deals with the design of the optimum preform to forge a connecting rod without flash. The initial perform design was obtained from physical modeling experiments. The optimization of this perform was found through 3D FEM process simulations. The advantage of performing simulation is that no tooling has to be built and the number of experimental tryouts can be significantly reduced. A preform optimization methodology was derived for this investigation 11.

Rong-Fong Fung (1997) studied that, the time dependent boundary effect of the end, which moves reciprocally with slider along the horizontal guide, of the flexible connecting rod on the dynamic responses is studied in this paper. The constraint of elastic deformation at the joint between the connecting rod and the slider is theoretically derived but not assumed. The Hamilton's principle is employed to formulate the governing equations of the connecting rod. It is found that the simply-supported assumption at the end is extended and replaced by the time-dependent elastic deformation. The equations of motion are transformed into a set of ordinary differential equations by use of the specific variable transformation and Galerkin method. Finally, the Rungs-Kutta numerical method is applied to obtain the transient amplitudes. The results are compared for various ratios of the crank radius to the length of the connecting rod. Also, the dynamic responses are compared among Timoshenko and Euler beam theories and those of assuming the ends of connecting rod are simply-supported 7.

Method and software used

FEA

The finite element analysis (FEA) is a computing technique that is used to obtain approximate solution to the boundary value problem in engineering. It uses a numerical technique called the finite element method (FEM) to solve boundary value problems. FEA involves a computer model of a design that is loaded and analyzed for specific results. The FEM has become a powerful tool for the numerical solution. Application range from deformation and stress analysis of automotive, aircraft, building and bridge structure to field analysis of heat flux, fluid flow, magnetic flux and other flow problem with the advance in computer technology and CAD system 10.

ANSYS

ANSYS (Advanced numerical system simulation) is being used by designers across a broad spectrum of industries such as aerospace, automotive, manufacturing, nuclear, electronics, biomedical and many more. ANSYS provides simulation solution that enable designer to simulate design performance directly on desktop. In this way, it provides fast, efficient and cost- effective product development from design concept stage to performance validation stage of the product development cycle. ANSYS package help to accelerate and streamline the product development process by helping designer to resolve issues related to structural deformation, heat transfer, fluid flow, electromagnetic effects, a combination of these phenomenons acting together, and so on 10.

Conclusion

A connecting rod forms a basic element of an internal combustion (IC) engine, which performs the function of converting the reciprocating motion of the piston into angular effort of the crank. This research project investigated weight reduction and increasing strength opportunities that cast iron connecting rods offer. Design and analysis of light-weight connecting rod using cast iron alloys. In this study, a procedure of estimating load, deformation, fatigue and stress for a connecting rod was suggested by using FEA with actual loading and boundary conditions. The stresses induced in the small end of the connecting rod are greater than the stresses induced at the big end.Therefore, the chances of failure of the connecting rod may be at fillet section of both end.

References

1. Bai-yan He, Guang-da Shi, Ji-bing Sun, Si-zhuan Chen, Rui Nie. Crack analysis on the toothed mating surfaces of a diesel engine connecting rod. Engineering Failure Analysis 34 (2013) 443–450.
2. Christy V Vazhappilly, P.Sathiamurthi, International Journal of Scientific and Research Publications, Volume 3, Issue 2, February 2013 1 ISSN 2250-3153
3. Liming Zheng, ShuqingKou, ShenhuaYang, LiliLi, FeiLi. A study of process parameters during pulsed Nd: YAG laser notching of C70S6 fracture splitting connecting rods. Optics & Laser Technology 42 (2010) 985–993.
4. Moon Kyu Lee, Hyungyil Lee, Tae Soo Lee, Hoon Jang. Buckling sensitivity of a connecting rod to the shank sectional area reduction. Materials and Design 31 (2010) 2796–2803.
5. Mr. H. B. Ramani, Mr. Neeraj Kumar, Mr. P. M. Kasundra. Analysis of Connecting Rod under Different Loading Condition Using Ansys Software. Vol. 1 Issue 9, November-2012.
6. Q. Wang, F. He. A review of developments in the forging of connecting rods in China. Journal of Materials Processing Technology 151 (2004) 192–195.
7. Rong-Fong Fung. Dynamic responses of the flexible connecting rod of a slider- crank mechanism with time-dependent boundary effect. Compuwrs ct Sm~twcs Vol. 63, No. 1. pp. 79- 90. 1997.
8. S. Griza, F. Bertoni, G. Zanon, A. Reguly, T.R. Strohaecker. Fatigue in engine connecting rod bolt due to forming laps. Engineering Failure Analysis 16 (2009) 1542–1548.
9. Saharash Khare, O.P. Singh, K. Bapanna Dora, C. Sasun. Spalling investigation of connecting rod. Engineering Failure Analysis 19 (2012) 77–86.
10. Sham Tickoo, ANSYS 11.0 for Engineers and Designers 2011.

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(ISRA), Impact Factor: 1.852

11. Teruie Takemasu, victor Vazquez, Brett painter, Taylan. Investigation of metal flow and preform optimization in flashless forging of a connecting rod. Journal of material processing technology 59 (1996) 95-105.
12. Vivek. C. Pathade, Bhumeshwar Patle, Ajay N. Ingale. Stress Analysis of I.C.Engine Connecting Rod by FEM. Volume 1, Issue 3, March 2012**.**
13. Xianghui Meng, YoubaiXie. A new numerical analysis for piston skirt–liner system lubrication considering the effects of connecting rod inertia. Tribology International 47 (2012) 235–243.