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Analysis of Piston Rod Used In Aircraft Nose Landing Gear

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Abstract:

Aircraft is one of the most complex engineering systems that have been developed. Failure of an aircraft structural component can have catastrophic consequences, with resultant loss of life and of the aircraft. The investigation of defects and failures in aircraft structures is, thus, of vital importance in preventing further incidents. In general, failures occur when a component or structure is no longer able to withstand the stresses imposed on it during operation. Fatigue cracking is the most common cause of structural failure in aircraft. Landing gears are hydraulically operated. A hydraulic actuating cylinder is one of the most important parts of aircraft landing gears. They play a critical role in landing systems, control surfaces, such as flaps, speed brakes, and ailerons, stabilizers. Hydraulic actuating cylinders are generally subjected to dynamical stress. The present study deals with design and fatigue analysis of one such component called piston rod end which forms a part of hydraulic system. The fatigue analysis of piston rod end which is mainly used in hydraulic cylinders of Aircraft landing gear system. It is mainly involved in the calculation about equivalent stresses of piston rod and fatigue life calculation of piston rod under the dynamic condition of stresses by using ANSYS software. In this mainly verified the fatigue life with different geometry diameter of the piston rod and different special process like shot peened method to verify the fatigue life. In this paper, the 3D model of Piston rod is used in Aircraft nose landing gear is modeled in PRO-E Creo2-CAD and imported into ANSYS software to perform static and dynamic analysis to analyze strength and Fatigue analysis of Piston rod used in Aircraft nose landing gear.

Keywords:

Piston Rod, Aircraft, Fatigue Analysis, Gear, Speed Brakes, hydraulic actuating cylinder.

Introduction:

Fatigue failures start at the most vulnerable point in a dynamically stressed area particularly where there is a stress raiser. The stress raiser may be geometrical or metallurgical in nature, or sometimes a combination of the two. Geometrical stress raisers are non uniformities in the shape of the parts such as step changes in diameter, sharp corners and surface discontinuities like notches and machining marks etc. Metallurgical stress raisers may be quench cracks, corrosion pits, gross metallic inclusions, brittle second phase particles, etc. Also, the microstructure of the material plays a vital role not only in the initiation of fatigue failures but also during the progressive growth of the fatigue crack to cause failure of the component. Fatigue initiation frequently occurs near free surface, as nominal stresses are often higher there. Manufacturing and fabrication processes such as machining can introduce surface irregularities or discontinuities that act as points of stress concentration, facilitating fatigue crack initiation. The landing gear is a highly stressed structural part, and loss of integrity, such as fracture or cracking of the connections or attachment points can lead to serious consequences. Due to importance of the determination of the failure of landing gears, numerous researchers have studied in this area. Landing gears are hydraulically operated. A hydraulic actuating cylinder is one of the most important parts of aircraft landing gears. They play a critical role in landing systems, control surfaces, such as flaps, speed brakes, and ailerons, stabilizers. Hydraulic actuating cylinders are generally subjected to dynamical stress.

Thus, these components are susceptible to fatigue by the nature of their operation.

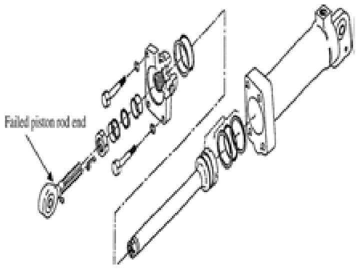


Fig 1. .Hydraulic actuating cylinder assembly.

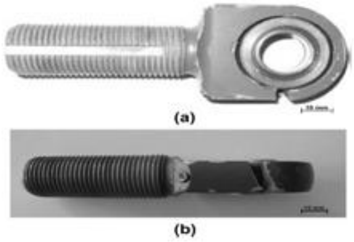


Fig.2.Failed piston rod end

LITERATURE SURVEY:

Literature 1:

A failure investigation has been conducted on a piston rod end used in a hydraulic actuating cylinder of an aircraft landing gear. The failed piston rod end was found to be broken. An evaluation of the failed piston rod end was undertaken to assess its integrity that included a visual examination, photo documentation, chemical analysis, hardness measurement, tensile testing, and metallographic examination. The failure zones were examined with the help of a scanning electron microscope (SEM) equipped with EDX facility. A stress analysis is also carried out by the finite element technique for the determination of highly stressed regions on the piston rod end. The results indicated that the piston rod end failed by fatigue with cracks initiated at the surface close to the mechanically damaged region due to high stress concentrations.

Literature 2:

This paper analyses the rupture of a nose landing gear of a military transport aircraft collapsed during takeoff procedure. Examining the fracture surface, it was observed that the failure was due to growth of fatigue crack. Beach marks followed by a final fast fracture surface due to overload were observed.

Literature 3:

Very high cycle fatigue properties of various steels were studied using findings of previous research and laboratory fatigue testing. First, experimental data for more than 550 specimens covering 25 high and medium strength steels were used to investigate the relationships between the applied stress, number of failure cycles, size of defects or inclusions at fracture origins and stress intensity factors. Using the results of the investigation of these data, general conclusions were arrived at for steels as a whole. It was observed that the size of the failure origin can be predicted using strength properties of steels. Existing methods for estimating major parameters such as size of failure origins and stress intensity factors were reviewed, new methods were proposed and their accuracy was verified using experimental data. Also, the possibility of simplifying existing formulae with substitutions for the major parameters was reviewed. Employing these major parameters, new formulae for predicting fatigue strengths of both medium and high strength steels were proposed. Predictions of these proposed formulae were compared with existing well known formulae using experimental data and statistical methods highlighting the simplicity and importance of the proposed formulae. The ability of employing the proposed formulae for predicting, “fatigue strengths that are more close to the real values” as well as “fatigue strengths that are more safe and conservative” was reviewed. Secondly, fatigue properties and failure causes of medium strength – low carbon structural steels that are usually used in civil engineering structures were investigated. For this investigation, 35 smooth specimens of five steels were tested using a rotating bending fatigue tester. It was observed that fatigue failures occur up to around 107 cycles and that the failure originates from the surface.

It was found that the formulae proposed are able to predict failures of these medium strengths steels. Slopes of stress life curves in the very high cycle fatigue regions were well predicted by these proposed formulae while the predictions were fairly aligned with values suggested in previous research. Finally, recommendations were given for employing suitable prediction methods considering safety and importance of components and structures.

Literature 4:

Most of the existing methods for estimating εN parameters are based on a relatively limited amount of experimental data. In addition, sound statistical evaluation of the popular rules of thumb used in practice to estimate fatigue properties is scarce, if available. In this work, an extensive statistical evaluation of the existing Coffin–Manson parameter estimates is presented based on monotonic tensile and uniaxial fatigue properties of 845 different metals, including 724 steels, 81 aluminum alloys, and 15 titanium alloys. The studied Coffin–Manson estimates include the methods proposed by Muralidharan and Manson, Bäumel and Seeger, Roessle and Fatemi, Mitchell, Ong, Morrow, Raske, as well as Manson's universal slope and four-point correlation methods. From the collected data, it is shown that all correlations between the fatigue ductility coefficient ε′f and the monotonic tensile properties are very poor, and that it is statistically sounder to estimate ε′f based on constant values for each alloy family. Based on this result, a new estimation method which uses the medians of the individual parameters of the 845 materials is proposed. Existing System and its disadvantage The landing gear is a highly stressed structural part, and loss of integrity, such as fracture or cracking of the connections or attachment points can lead to serious consequences. Due to importance of the determination of the failure of landing gears, researchers [Refer 1] have studied in this area and correlated the fatigue failure of the piston rod with the results of the static stress analysis.

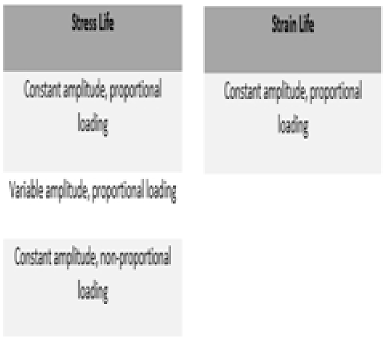
From the results of static stress analysis, fatigue life and fatigue damage factor of the piston rod could not be determined. Because in the modern engineering construction, analyse require not only standard strength analysis but also calculation of fatigue life. Proposed System and its advantage The main objective in the proposed system is to present results of strength and fatigue limit analysis applied to piston rod of the hydraulic cylinders by taking into account the advantages of application of the up-to-date digital chain of engineering analysis within which CAD tools are being used as well as strength and fatigue limit analysis. Further concentrates on modifications of the piston rod end design as well as its material and perform analysis which will help to recognize the best possible design of the piston rod end and material for higher fatigue life.

FATIGUE ANALYSIS OF THE PISTON ROD END IN ANSYS WORKBENCH ANSYS:

Fatigue Tool is capable of simulating a diverse range of load cases which may be classed into two main categories of fatigue loading:

Stress life: Applicable to High Cycle Fatigue (HCF) with greater than 10^5 cycles.

Strain life: Used for Low Cycle Fatigue (LCF) which does not exceed 10^5 cycles.



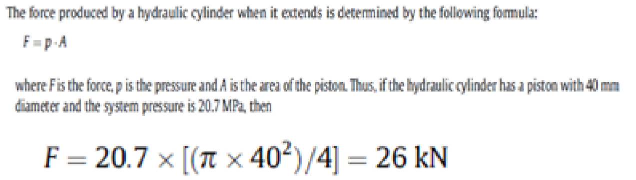
Advanced Fatigue Analysis:

Post-Processing Direct incorporation of the Fatigue Tool into the proven ANSYS Mechanical user interface results in simple yet powerful solution data analysis using the familiar Results component system.

Variables available for fatigue analysis through contours, vectors, tabulated data and charts include:

- Fatigue life
- Fatigue damage at specified design life
- Fatigue factor of safety at specified design life
- Stress biaxiality
- Fatigue sensitivity chart
- Rain flow and damage matrix outputs

Design formulas:



The force produced by a hydraulic cylinder when it extends is determined by the following formula:

$F = p \cdot A$

where F is the force, p is the pressure and A is the area of the piston. Thus, if the hydraulic cylinder has a piston with 40 mm diameter and the system pressure is 20.7 MPa, then

$$F = 20.7 \times [(\pi \times 40^2)/4] = 26 \text{ kN}$$

ANSYS FATIGUE ANALYSIS
PISTON ROD – 4340 STEEL

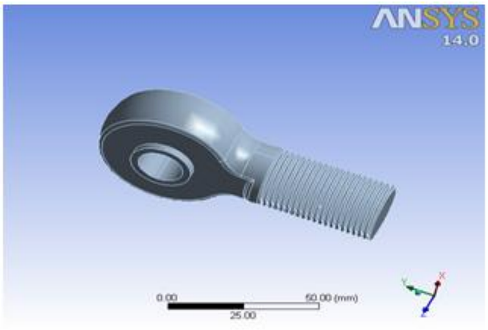


Fig.3. Piston rod view

Fatigue behaviour of the piston rod at Load = 32000 N
4340 Piston Rod Shot Peened

Fig.4. Loading and Boundary conditions

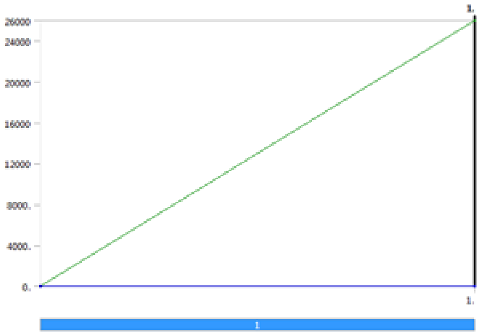


Fig5. : load acting on the piston rod

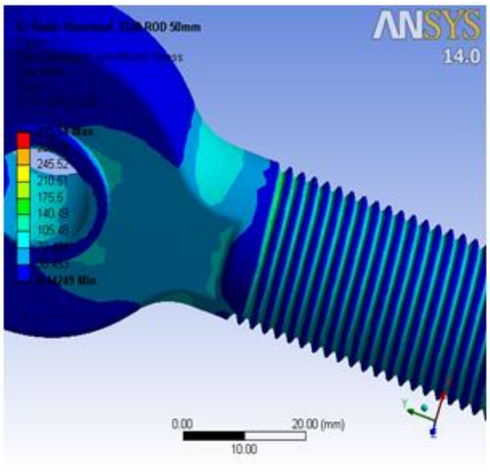


Fig 6. : Equvivalent stress at 32000N

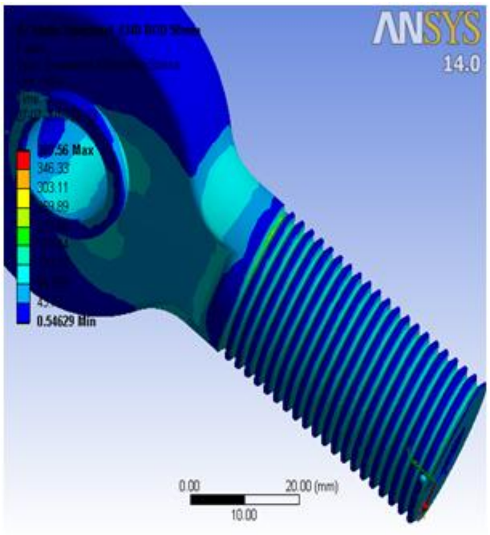


Fig. 7 Equivalent Alternating Stress

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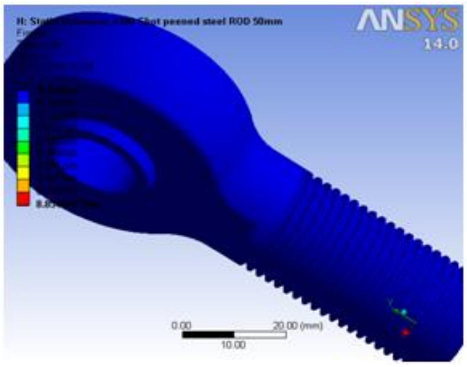

Fig 8. . Fatigue life at 32000 N

4340 Piston Rod:

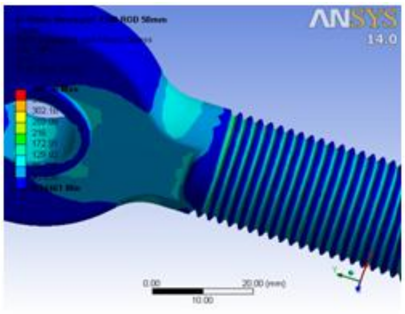

Fig.9. Equivalent Stress at 32000 N

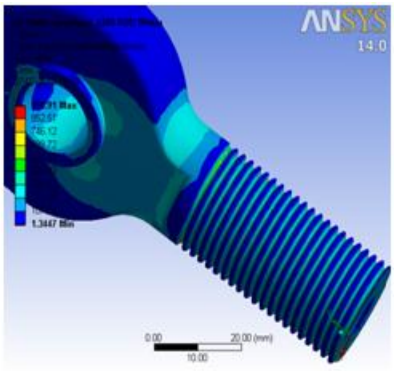

Fig.10. Alternating Stress at 32000 N

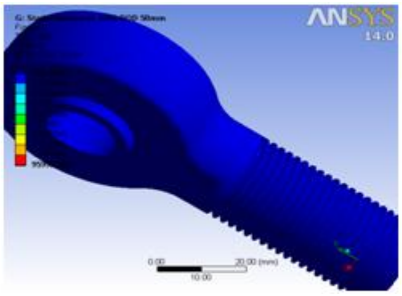

Fig 10. Fatigue life at 32000 N

CONCLUSION:

[A] AT LOAD 26000 N

Material of the piston rod end	Fatigue Life
Piston rod 4340	1000000 Cycles
Piston rod peened steel shots	1000000 cycles

From the above table, at load 26000 N, rod made off with 4340 and 4340 shot peened with stand the fatigue load and have got the fatigue life of 1000000 cycles.

[B] AT LOAD 28500 N

Material of the piston rod end	Fatigue Life
Piston rod 4340	9.6 E 5Cycles
Piston rod peened steel shots	1000000 cycles

From the above table, at load 28500 N, the rod made off with 4340 experienced fatigue life and got the fatigue life of 9.6 E5 cycles. But even at this higher load 28500 N, the 4340 shot peened rod still has a fatigue life of 1000000 cycles. So fatigue load at which 4340 rod fails is 28500 N and passed at 26000N fatigue life cycle.

[C] AT LOAD 28500 N:

Material of the piston rod end	Fatigue Life
Piston rod 4340	95992 Cycles
Piston rod peened steel shots	8.85 E 5 Cycles

From the above table 3, at load 32000 N, the rod made off with 4340 experienced fatigue life and got the fatigue life of 95992 cycles and the 4340 shot peened rod as well fail at this load with a fatigue life of 8.85 E

5 cycles. So fatigue load at which 4340 shot peened rod fails is 32000 N. It is concluded from the above results that if the piston rod is made by 4340 peened with steel shots, its fatigue strength is improved and offers high resistance to fracture against fatigue loads.

Future Scope:

There is a scope of experimental validation of the numerical results got it from Ansys by testing the piston rod under different static and fatigue loads in order to predict the fatigue life experimentally. In the present study, the piston rod is treated with the process of shot peening of steel balls and the study is performed under the corresponding endurance limit. But there is a scope of shot peening with different materials balls which may have higher endurance limit that the shot peened with steel balls, which further widens the area of present work.

References:

1. Osman Asi, ÖnderYesil, “Failure analysis of an aircraft nose landing gear piston rod end”, Engineering Failure Analysis 32 (2013) 283–29.

2. L.A.L. Franco, N.J. Lourenço, M.L.A. Graça, O.M.M. Silva, P.P. de Campos, C.F.A. von Dollinger, “Fatigue fracture of a nose landing gear in a military transport aircraft”, Engineering Failure AnalysisVolume 13, Issue 3, April 2006, Pages 474–479.

3. Chaminda S. Bandara, Sudath C. Siriwardane, Udaya I. Dissanayake, RanjithDissanayake, “Fatigue failure predictions for steels in the very high cycle region” – A review and recommendations, Engineering Failure Analysis, Volume 45, October 2014, Pages 421-435.

4. Meggiolaro MA, Castro JTP. “Statistical evaluation of strain-life fatigue crack initiation predictions”. Int J Fatigue 2004;26:463–76.

5. Govindasamy, V.; Durairaj, P.; Joy, T.N. , “Redesign of solid piston rod of horizontally mounted, free rod end type oil hydraulic cylinder used in fuel handling equipments in nuclear system application”.Frontiers in Automobile and Mechanical Engineering (FAME), 2010.

6. Sheng Xiaoming; Si Guangju; Li Xin, “Reconfigurable Hydraulic-Mechanical Combined Drive Devices Based on Multi-functional Piston-Rod Built-in Hydraulic Cylinder”. Digital Manufacturing and Automation (ICDMA), 2010 International Conference n Year: 2010, Volume: 2 .

7. Yongfeng Liu; Hongsen Tian; Xiaoliang Ding; Lianda Liu; Tao Qiu, “Research on 3-D Design for the Group of Piston Crankshaft Connecting Rod”. Measuring Technology and Mechatronics Automation (ICMTMA), Year: 2010, Volume: 3 .

8. Ning Haiqiang; Yu Shilin; Wang Shuxin, “The ameliorative design of diesel engine connecting rod assembly using FEM”. Electric Information and Control Engineering (ICEICE), Year: 2011.

9. Quan Long; Yang Yang; Hou Xuwei, “Simulation and experimental research on the axial piston pump with series three-windows in valve plate”. Fluid Power and Mechatronics (FPM), Year: 2011 .

10. Gangwani, D.G.; Metkar, R.M. , “Computer Aided Modelling and Finite Element Analysis of Connecting Rod Fouling on Camshaft of DI Engine of Mahindra and Mahindra Tractor”. Emerging Trends in Engineering and Technology (ICETET), Year: 2009 .

11. Zhiwei Tong; Fengxia Zhu; Hao Liu, “Dynamic Simulation for Crank-Connecting Rod Mechanism of Mud Pump Based on Virtual Prototyping Technology” . Intelligent Computation Technology and Automation, 2009. ICICTA '09.Year: 2009, Volume: 2 .

12. Zhang Yong; Li Wei-Shan; Liu Xuan, “Numerical simulation study of diesel engine based on new type of crankshaft connecting rod mechanism”. Electric Information and Control Engineering (ICEICE), Year: 2011.

13. Wang Cheng-gang; Xie Xiao-heng; Xiao Jian; Yu Jiu-yang; Gai Chao-hui, “Development and experimental research of new impact pneumatic cylinder. System Science”, Engineering Design and Manufacturing Informatization (ICSEM), Year: 2012, Volume: 2 .

14. Juan Chen; Bohong Liu; Xiaoye Qi; Deyi Wang, “Analysis of failure mechanism and stress influence on cylinder”. Electronic and Mechanical Engineering and Information Technology (EMEIT), Year: 2011, Volume: 7 .

15. Shichun Zhao; Weimin Cui; Tianxiang Yu; Bifeng Song, “Landing gear torque arm position analysis and the optimization design”. Quality, Reliability, Risk, Maintenance, and Safety Engineering (ICQR2MSE), Year: 2011.