International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014

Finite Element Analysis of a Diesel Generator Cylinder

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***Abstract*— This paper analyses a catastrophic cylinder failure of a four stroke 14v diesel generator of an electrical power plant when running to nominal speed of 600rpm.the rated power of the engine was 7.5MW and before failure had accumulated 80,000h in service operating mainly of full load. as result the piston and liner of cylinder were broken, the crank case main crank shaft bearings next to this cylinder were also damaged the mechanical properties of cylinder (aluminum alloy) including tensile properties and brinel hardness were evaluated . no signs of fatigue failure were identify in piston .a finite element model of the cylinder has shown that the most heavy loaded areas match the fractured zones**

I. INTRODUCTION

Internal combustion engine failures due to cylinder anomalies are very destructive and hamper the failure diagnosis .once that failure has taken place ,usually liner, piston ,connecting rod and some times engine head are seriously damaged most failure of these elements are due to fatigue combined with another issue. Liner failure due to fatigue aggravated in wet type design by corrosion and hence stress corrosion and corrosion fatigue .another example is cylinder sleeve failure due to stress concentration cavities which appear during the manufacturing process, which contributes to reducing the resistance of the component, creating crack nucleation spots .in this case, bad cooling conditions during manufacturing could produce internal differences in the microstructer,providing another failure mechanism due to material fatigue failure in connecting rods to grooves at their small end, which are related to machining or assembling process, are also reported as crack origins bad design of the thread root radius, which produces stress concentration ,or forming laps which frequently occurs due to symmetrical metal flow during forming ,also contribute to accelerating connecting rod fatigue failure, in the case of piston failure, the faults are usually present in different piston parts :crown, ring grooves pin holes and skirt. The damage mechanism can have different origins but are mainly related to wear, high temperature and thermal, thermal mechanical fatigue piston – pin fatigue failure due to a defective piston-pin carburization, which decrease the fatigue strength a lot, has also been highlighted as a possible failure cause all these failure make it highly advisable to develop a methodology for cylinder failure diagnosis. in this work root cause analysis protocol is followed to analyze the cylinder failure of a 14v diesel generator of 7.5MW nominal power running at 600 rpm

II. DESCRIPTION

In this work static and thermal analysis of the diesel generator cylinder is carried out. in the static analysis, the parameters such as the internal pressure .in the thermal analysis uniform temperature load is applied .in the designe,we need to design the generator cylinder in such way that it should withstand for pressure as well as temperature load conditions. both thickness and the material are studied for this designe.the present generator cylinders that being used in the four cylinder engines is having lower efficiency so the

III. MODEL DEVELOPMENT USING CATIA

Material Properties aluminum alloy

The material used to manufacture above Diesel generator cylinder is aluminum alloy and its properties used for design and analysismodified designed engine cylinder is somewhat more efficient.

Table 1: Material Properties

Material	Aluminum alloy
Young's Modulus	7×10^4MPa
Poison's Ratio	0.34
Thermal expansion	33×10^{-6}
Density	2.7×10^{-6}Kg/mm^3

A. MODELLING AND MESHING

The chosen problem is considered as 3-D solid model .with the dimensional parameters the structure is model in cattie v5 modeling software as shown in fig.1.the model meshed for further analysis using a meshing package hyper mesh 10 with hex mesh .the model consists of 33440 elements. Fig.2.shows the solid 45 element considered for meshing .fee model of the engine cylinder is shown in fig .3.appropriate boundary conditions are incorporated in the analysis. the solid 45 is defined by ten nodes having three degrees of freedom **(**UX

UY and UZ)at each node translation in the nodal x,y and z directions .the element has Plasticity ,Creep Swelling, elasticity, Stress stiffing Large deflection, large strain, Adaptive descent Initial stress import capabilities.

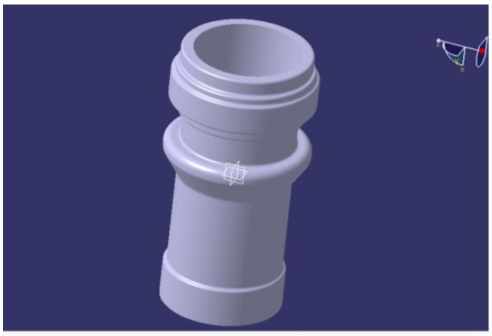

Fig.1 Solid model of diesel generator cylinder

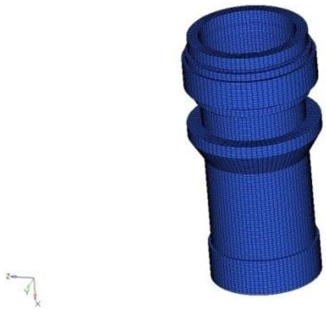

Fig 2: Finite Element model with boundary conditions diesel generator cylinder.

Table 1: Mesh is created in Hyper mesh with following quality parameters

Aspect Ratio	4
Length	5
Min. angle of hex	40
Max. angle of hex	150

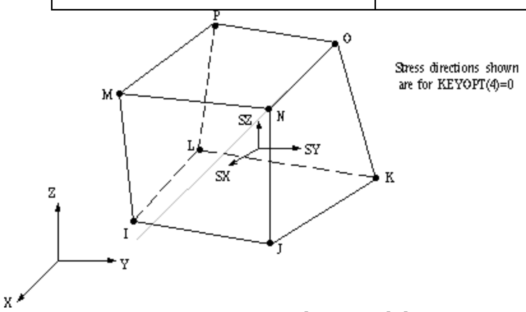

Fig 3. Element solid-45

IV. DIESEL GENARATOR CYLINDER

A. Static Analysis

Static analysis was carried out to know the strength of the generator cylinder by applying the internal pressure

B. Thermal Analysis

Thermal analysis was carried out to know the thermal stress of the generator cylinder by applying uniform temperature.

V. RESULTS & DISCUSSION

A. Static Analysis:

Static Analysis of Diesel generator cylinder made up with Aluminum alloy is performed. Displacements in X, Y and Z directions are shown in Fig.4, Fig.5 and Fig.6 respectively.Fig.7 shows stress in X direction. Stress in Y direction is shown in Fig 8. Fig.9 shows stress in Z direction and vanishes stress of the diesel generator cylinder shown in Fig.10.

Table 2: Static Analysis of aluminum alloy

Name	Results as per Analysis	Allowable stresses and deflection from the test results	Reference figure
Displacement in X-direction, mm	0.141186	7	4
Displacement in Y-direction, mm	0.667215	7	5
Displacement in Z-direction, mm	0.667215	7	6
Stress in X-direction, MPa	172.643	237	7
Stress in Y-direction, MPa	245.236	237	8
Stress in Z-direction, MPa	245.236	237	9
Von mises stress, MPa	232.242	237	10

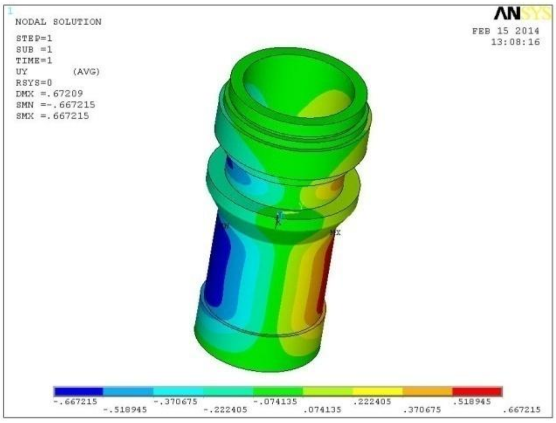

Fig.4 Displacement in y-direction

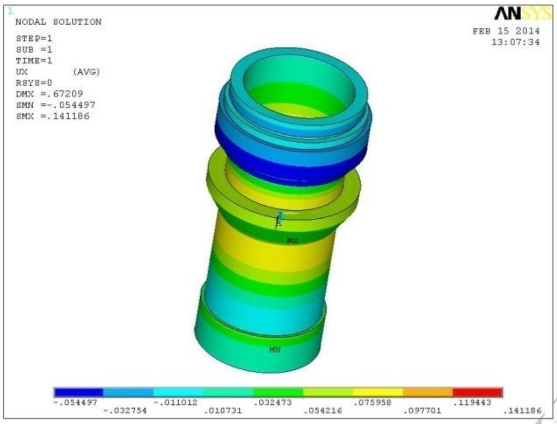

Fig.5 Displacement in x-direction

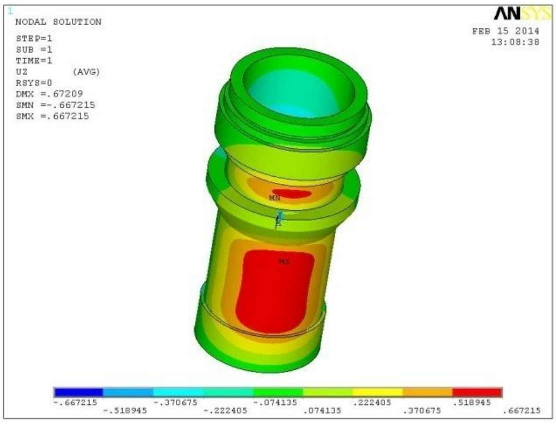

Fig.6 Displacement in z-direction

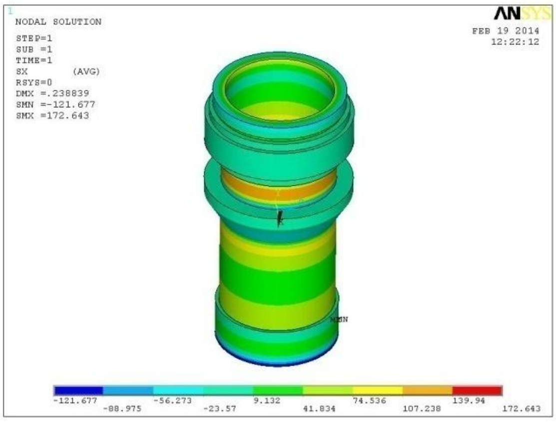

Fig.7 Stress in x-direction

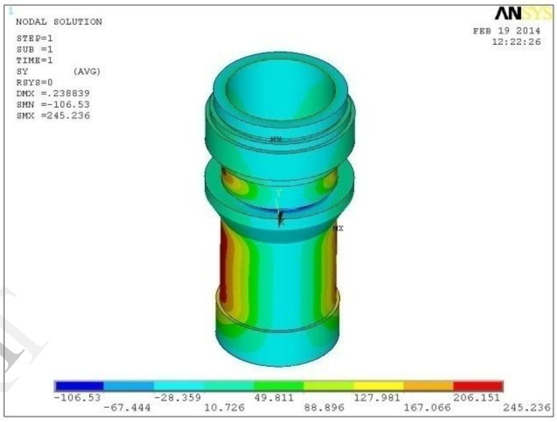

Fig.8 Stress in y-direction

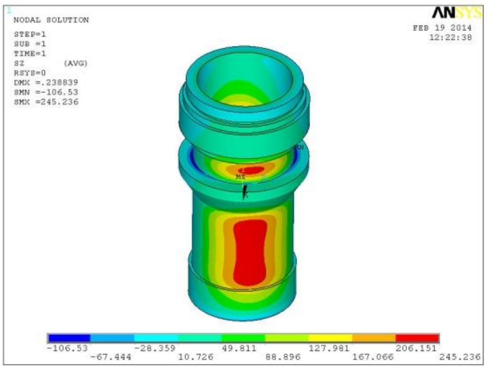

Fig.9 Stress in z-direction

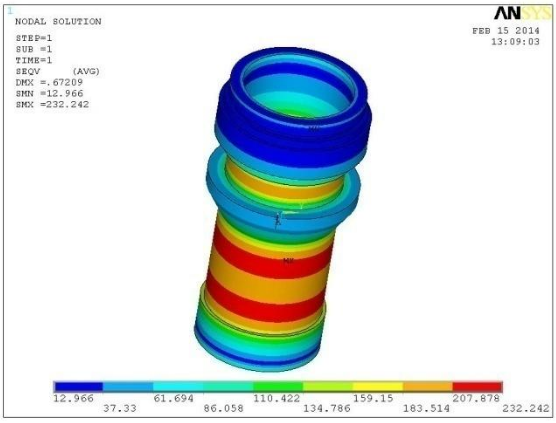

Fig.10 Vonmises stress

Table 3: Thermal Analysis of Aluminum alloy

Name	Results as per Analysis	Allowable stresses and deflection from the test results	Reference figure
Displacement in X-direction, mm	0.24267	7	11
Displacement in Y-direction, mm	0.37182	7	12
Displacement in Z-direction, mm	0.37182	7	13
Stress in X-direction, MPa	674.414	710	14
Stress in Y-direction, MPa	589.621	710	15
Stress in Z-direction, MPa	589.621	710	16
Von mises stress, MPa	517.483	710	17

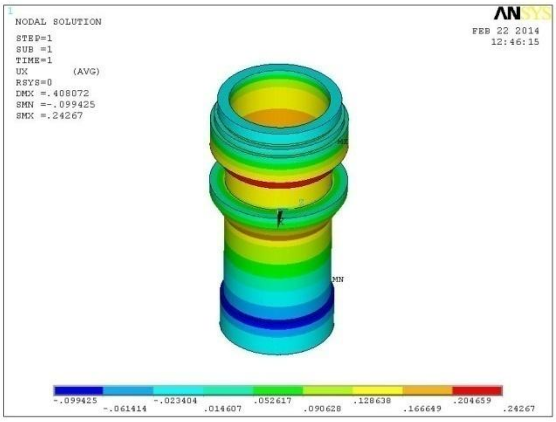

Fig.11 Displacement in x-direction

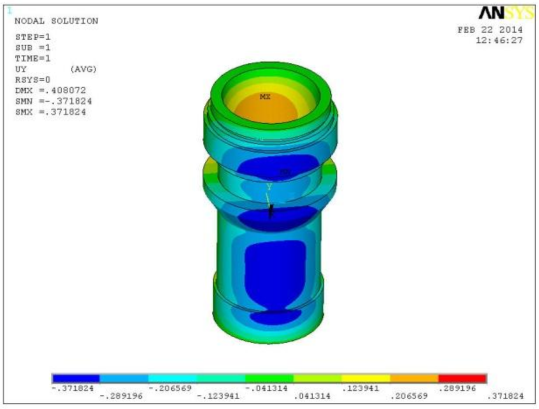

Fig.12 Displacement in y-direction

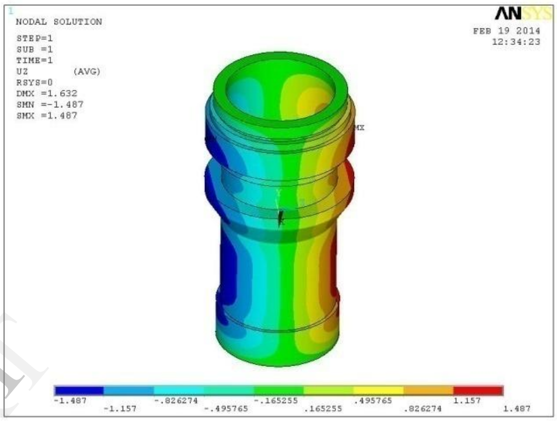

Fig.13 Displacement in z-direction

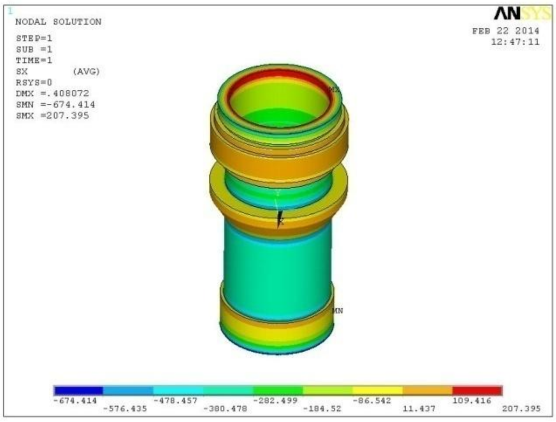

Fig. 14: Stress in x direction

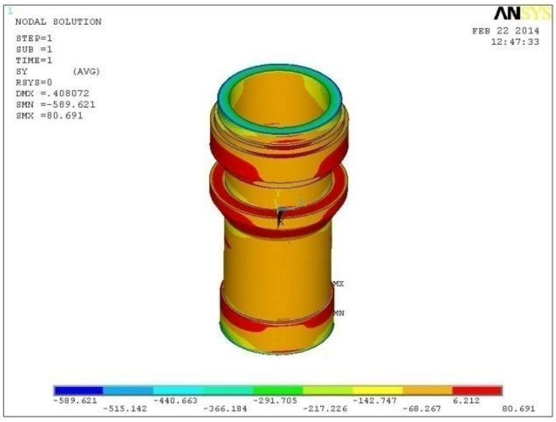

Fig.15 Stress in y-direction

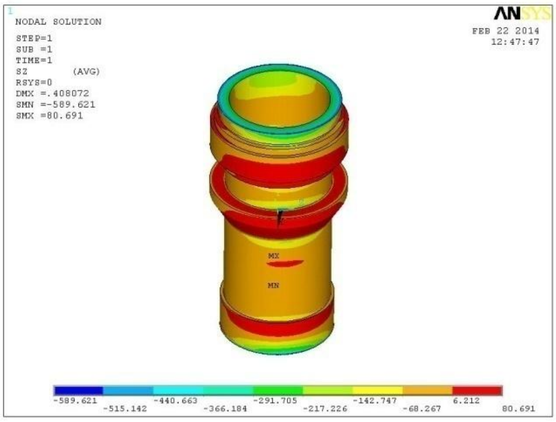

Fig.16: Stress in Z direction

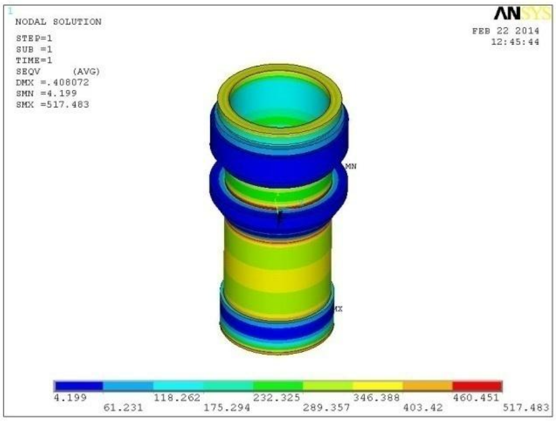

Fig.17 Vonmises stress

VI. CONCLUSION:

The following conclusions are drawn from the present work.

1. The maximum deflection induced 0.66721 mm under 14 MPa loads which is within the allowable limits i.e. < 7mm.

2. The maximum stress induced is 232.242 MPa which is less than allowable limits of 237 MPa. Hence the factor of safety is 1.0204.

3. The maximum deflection induced 0.37182 mm under uniform temperature of 140^0C load which is within the allowable limits i.e. < 7mm.

4. The maximum stress induced is 517.483MPa which is less than allowable limits of 700 MPa. Hence the factor of safety is 1.352.

REFERENCES

[1] Branco CM, Infante V, Sousa e Brito A, Martins RF. A failure analysis study of wet liners in maritime diesel engines. Eng Fail Anal 2002;9:403–21.

[2] Hormaza W, Mateus L, Maranon A. Failure analysis of a cylinder sleeve from a turbocharged diesel engine. Eng Fail Anal 2008. doi:10.1016/ j.engfailanal.2008.09.010.

[3] Xu XL, Yu ZW. Failure analysis of a diesel engine connecting rod. J Fail Anal Prevent 2007;7:316–20.

[4] Rabb R. Fatigue failure of a connecting rod. Eng Fail Anal 1996;3:13–28.

[5] Griza S, Bertoni F, Zanon G, Reguly A, Strohaecker TR. Fatigue in engine connecting rod bolt due to forming laps. Eng Fail Anal 2008. doi:10.1016/ j.engfailanal.2008.10.002.

[6] Silva FS. Fatigue on engine pistons – a compendium of case studies. Eng Fail Anal 2006;13:480–92.

[7] Yu Z, Xu X, Ding H. Failure analysis of a diesel engine piston-pin. Eng Fail Anal 2007;14:110–7.

[8] Heywood JB. Internal combustion engine fundamentals. Singapore: McGraw-Hill Book Company; 1998.

[9] Rezeka SF, Henein NH. A new approach to evaluate instantaneous friction and its components in internal combustion engines, SAE 840179; 1985.

[10] Abbasi HR, Bazdar M, Halvaee A. Effect of phosphorus as an alloying element on microstructure and mechanical properties of pearlitic gray cast iron.
Mater Sci Eng A 2007;444:314–7.