Technical journals online.com

Review Article

EVALUATING EFFECT OF SHOT PEENING OVER FATIGUE LIFE THRU CAE

[1]Satish Navnath Pawar, [2]Dr.Prof. M.M. Mulkutkar, [3]Swapnil S. Kulkarni

Address for Correspondence

[1]ME-Mech/Design- Appearing, [2]Professor, Department of Mechanical Engineering, Brahmdevdada Mane Institute of Technology, Belati, Solapur 413001, [3]Director-Able Technologies India Pvt. Ltd., Pune

ABSTRACT

Fatigue is the prominent mode of failure for components subjected to cyclic stresses. Although, traditionally, the damages are attributed to wear and lubrication sources, fatigue is responsible for a significant number of such applications. The cyclic stresses/ deformations have mainly two origins: load and temperature. High temperature fatigue (which includes creep) is also present in some damaged pistons. Also thermal mechanical fatigue is present in other damaged pistons. Shot peening is one of the process to enhance fatigue life of components & there is scope in study effect of shot peening on fatigue life of piston. Use of CAE software is being explored for determining the residual stresses and the plastic strain induced due to the impinging steel balls over the test component.

INTRODUCTION

Engine piston is one of the most complex components among all automotive or other industry field components. There are lots of research works proposing, for engine pistons, new geometries, materials and manufacturing techniques, notwithstanding all these studies, there are a huge number of damaged pistons. Damage mechanisms have different origins and are mainly wear, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role.

INDUSTRIAL RELEVANCE:

Fatigue is a major consideration in the design and performance evaluation of materials, components and structures since most of the all mechanical failures are attributed to fatigue fractures, especially in engine parts. The investigation emphasized that this cost could be significantly reduced by using proper and efficient design, manufacturing & various processes. Such studies are necessary to enhance the competitiveness of the vehicle components and their application in the automotive industry. Efficient design manufacturing methods help in enhance performance and efficient operation of the given component.

OBJECTIVES OF THE WORK

1. Study of impact of shot peening on fatigue life.
2. Development of FE model to predict residual stress profile.
3. To study of fatigue analysis by considering residual stress (prestress)
4. Assess the stress levels along the surface depth of the component and the corresponding effect of the same

PROPOSED WORK

1. Study of fatigue mechanism.
2. Study shot peening method in view of fatigue life.
3. Development of finite element model to simulate shot peening process for generating residual stress profile.
4. Shot peening on piston with optimized levels for factors (parameters).
5. Fatigue life prediction.
6. Result & discussion.

LITERATURE REVIEW

George Leghorn, presented that shot peening is a means of cold working the surface of metal parts by means of a hail or blast of round metal shot directed against the surface. It is equivalent to a myriad of small hammer blows impinged over the entire surface indenting the surface and causing plastic flow and work hardening of the surface metal. This work hardening of the surface metal increases its tensile strength and yield point. Machines for shot peening fall into two distinct categories. One is the wheel type machine wherein a bladed wheel rotating at high speed is gravity fed with peening shot. The air blast machines vary as to method of feeding the shot into the air blast. In some, the shot is sucked up by the vacuum caused by the aspirating action of the blast.

J. A. Horwath, presented that shot peening generates plastic deformation in the exposed surface layer and thus, induces compressive residual stresses in that layer. An improvement in the fatigue strength of shot peened components is commonly reported in his literature. Such an effect depends on the variables of the process, i.e. shot size, nozzle pressure, impingement angle, shot flow rate and nozzle distance from the specimen surface.

Hiroji Aoki & Etuichi Nagashima, investigated the effect of different shot peening condition on fatigue strength of carburized steel. Experiment is carried on SCr420H material. Peening is done on steel material by varying projection density, shot velocity, hardness & it is recorded that fatigue strength will vary between 113% to 141 % as compared to unpeened material.

John S. Eckersley, Buzz Ferrelli, presented how shot peening is useful to crankshafts and con-rods of huge reciprocating compressors and to the small valve reeds, only a few thousands of an inch thick, that are the heart of refrigeration and air conditioning sealed units. The paper reviews these and other applications for compressor engineers so that they will be able to increase the life and/or the loading on both new and existing designs, without increasing size or adding weight to critical components. The controlling parameters of the Shot peening process are also discussed.

David Breuer, presented application of shot peening for improvement of strength of powder metal component.This paper will focus on bending strength improvement of PM gearing by combining recent improvement inPM technology combined with established technologyof shot peening.Factoring in the significant cost saving of PM manufacturaring, PM gears with shot peening have the potential to replacing higher load application currently served by wrought gearing. This paper addresses gear

application limited by bending fatigue & discusses shot peening as way by which we can use low load application PM method for high load application.

P.S. Prevey, presented conventional wisdom that whether 100% coverage by shot peening is required to achieve full benefit in terms of compressive residual stress magnitude and depth as well as fatigue strength. Further in this work shot peening is studied with the various coverage. Coverage is defined in the shot peening literature in terms of the fraction of area impacted. After the shot peening specimens were thermally exposed at 519K (475F) for 24 hours. Residual stress and cold work determinations were then repeated to determine if thermally induced relaxation had occurred. A residual stress-depth distribution for various coverage levels & bending fatigue test is carried out for various coverage.

S.A.Meguid, G.Shagal, presented measurement of residual stress, methods of measurement & difficulties include .The main focus of this paper is on the development on FE model for 3D analysis of shot peening. In this paper different symmetry cell models are developed to simulate shot peening process .Models are developed to increase coverage area. Also three dimensional elastopalstic FEA of the process was conducted using these symmetry cell models. Author suggested XRD & hole drilling method for validating the model.

Shengping Shen, S. N.Atluri, presented mathematical model by assuming that the shot peened part (target material) is a semi-finite body. A homogeneous residual stress field and associated plastic strain exist at any specified depth due to the assumption that a semi finite body has been uniformly loaded. To describe the maximum elastic loading, the impact of an elastic sphere on the surface of an elastic semi-finite body is analyzed. This can be considered as a particular application of Hertzian contact theory of between two elastic spheres. Thus, we can obtain the equivalent stress in the target material after impact.

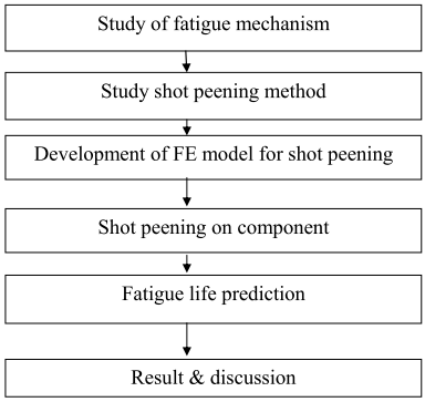
M. L. Aggarwal, V. P. Agrawal, R. A. Khan, presented procedure to calculate, fatigue strength of shot peened leaf springs from laboratory samples. The axial fatigue strength of EN45A spring steel specimen is evaluated experimentally as a function of shot peening in the conditions used for full-scale leaf springs testing in industries. Optimum shot peening condition for specimen is found and S/N curves of the specimens are correlated with leaf springs curve. A mathematical model has been developed which predicts the fatigue life of leaf springs for a given stress at varying shot peening conditions. Predictions from this model are compared with experimental data. The estimation of fatigue life and relaxation of compressive residual stress field are discussed.

F.S.Silva, discussed that the piston is one of the most stressed components of an entire vehicle pressures at the combustion chamber may reach about 180–200 bar speeds reach about 25 m/s and temperatures at the piston crown may reach about 400bar. Above mentioned pressure & temperature condition imparts fatigue. Fatigue exists when cyclic stresses/ deformations occur in an area on a component. The cyclic stresses/ deformations have mainly two origins: load and temperature. Traditional mechanical fatigue may be the main damaging mechanism in different parts of a piston depending on different factors. High temperature fatigue (which includes creep) is also present in some damaged pistons. Thermal fatigue and thermal mechanical fatigue are also present in other damaged pistons.

Akber J.A, Kyriacou S., El-Zafrany A.M, presented that Shot peening is a well-established cold working process, widely used in automotive and aircraft industries. The technique involves the impingement of a stream of spherical shots, directed at the metal surface at high velocity under controlled conditions. The process has useful applications in increasing fatigue strength, relieving tensile stresses.

J. A. Horwath, Jian,L., presented that Shot peening generates plastic deformation in the exposed surface layer and thus, induces compressive residual stresses in that layer. An improvement in the fatigue strength of shot peened components is commonly reported in his literature. Such an effect depends on the variables of the process, i.e. shot size, nozzle pressure, impingement angle, shot flow rate and nozzle distance from the specimen surface.

FLOW OF WORK



REFERENCES:

1. George Leghorn "The story of shot peening" A.S.N.E. Journal November 1957, pp 653- 666.
2. F.S. Silva "Fatigue on engine pistons – A compendium of case studies", Engineering failure analysis 13 (2006), pp-480-292
3. Arshad Mehmood , M.M.I.Hammouda, "Effect of shot peening on the fatigue life of 2024 aluminum alloy" Failure of engineering materials & structures (2007), code 02.
4. S.A.Meguid, G.Shagal, "Development & validation of novel FE model for 3D analysis of peening of strain rate sensitive materials." Journal of engineering materials & technology, April 2007, Vol. 129/283.
5. M.L. Aggarwal, V.P. Agrawal , R.A. Khan "A stress approach model for predictions of fatigue life by shot peening of EN45A spring steel.", International journal of fatigue 28, 2006, 1845-1853.
6. Shengping Shen, S. N.Atluri. "An analytical model for shot-peening Induced Residual Stresses",CMC, vol.4, no.2, pp75-85,2006.
7. S.B.Mahagaonkar,Dr.P.K.Brahmankar,C.Y.Seemikeri "Influence of shot peening parameters on fatigue life & surface hardnessof AISI 1045 materials" , IE journal-PR,Vol. 90, Sept.2009.
8. T. Hong , J.Y. Ooi , B.A. Shaw "A numerical study of the residual stress pattern from single shot impacting on a metallic component", Advances in Engineering Software 39 (2008) 743–756
9. P.S. Prevy, "The Effect of Shot Peening Coverage on Residual Stress, Cold Work and Fatigue in a Ni-Cr-Mo low alloy steel", Proceedings International Conference on Shot Peening Garmisch-Partenkirchen, Germany, Sept. 16-20, 2002.
10. Robert L. Barrie, Peter T. Kantzos , "Effectiveness of Shot Peening in Suppressing Fatigue Cracking at Non-Metallic Inclusions in Udimet® 720." NASA/TM—2005-213577.