Structural Analysis of Shot peening on Aluminum Alloy Plates

[1] Miss V A Padekar,[2] Mr Hredey Mishra,
[1] PG Scholar, Jaihind COE,[2] Assistant Professor, JaihindCOE, Kuran.

Abstract— **Shot Peening allows metal parts to accept higher oads or to endure a longer fatigue life in service without failure. In usual applications shot peening can be done without changing the part design or its material. If you strike a part surface with a rounded object at a velocity, sufficient to leave an impression and continue until you completely cover (cold work) the entire surface then you will have peened that part. The reasons for this improvement were not then understood. The round knob of the "ball peen" hammer was the smith's tool for applying this process to cold (not hot) parts. Shot peening is considered among the most-efficient techniques. The goal of this paper is, first to describe the mechanical characteristics due to shot peening, then to list the main parameters, in order Structural Analysis Of Shot Peening On Aluminum Alloy Plates, finally to summarize the effects of the loading parameters on the improvement level.**

Keywords— Aluminum Alloy Plates, Shot Peening, Structural Analysis.

I. INTRODUCTION

In order to achieve the final aircraft shape, some structural components are subject to forming processes, such as shot peening. Such a process introduces plastic deformation and residual stress inside the material. Benefits obtained by shot peening are the result of the effect of the compressive stresses and the cold working induced. Shot peening process increase fatigue life, and resistance to corrosion fatigue and cracking, fretting, etc. The balls are projected against the surface being peened, indenting the work surface causing plastic flow within the surface zone. In order to deform permanently the surface of the work-piece, the material must be yielded in tension, producing elastic stretching of the upper surface and local plastic deformation that manifests itself as a residual compressive stresses. Upon unloading, fibers placed below the indentation, try to restore their position to their original shape, but the surrounding material does not allow this to occur. But, regardless of the quality of the production, shot peening, properly applied, will be effective in reducing fatigue and therefore increasing the useful life of the component. The aim is to obtain high compressive residual stress as deeper as possible into the work-piece.If welded structures are subject to shot peening to achieve the final shape, the effect of welding-induced-changes will be lowered.

II. LITERATURE SURVEY

M. Meo et al. Studied, Shot peening is a manufacturing process intended to give aircraft structures the final shape and to introduce a compressive residual state of stress inside the material in order to increase fatigue life. This paper presents the modeling and simulation of the residual stress field resulting from the shot peening process. The results achieved show that a significant decrease of welding induced tensile residual stress magnitude can be obtained. Good agreement between experimental and numerical results was achieved [1].

Y. H. Yang et al. Studied, The Key Laboratory of Contemporary Design & Integrated Manufacturing Technology, Ministry of Education, Northwestern Polytechnical University, It is very significant to investigate the shot peening mechanism in ensuring a good resistance to fatigue and stress corrosion. This paper reviews the recent advancements in shot peening process. Emphasis is put on the application of numerical simulation techniques and finite element method in residual stress prediction during shot peening process. Different methods related to shot peening modelling and prediction of plastic deformation and surface integrity are reviewed. Some key issues such as algorithms and simulation procedures are discussed [2].

S.A. Meguid et al. Studied, Engineering Mechanics & Design Laboratory, Department of Mechanical and Industrial Engineering, University of Toronto,5 King+s College Road, Toronto, Ontario, M5S 3G8 Canada" Metal Improvement Company, 10 Forest Avenue, Paramus, New Jersey, 07652 USA This investigation is devoted to the modelling and simulation of the residual stress Held resulting from the shot-peening process. In this dynamic elasto-plastic analysis, single and twin spherical indentations were examined using the Þniteelement method. The contact between the shots and the target was modelled using contact elements of the penalty function type. Attention was devoted to three related issues. The Rust is concerned with the eject of the shot velocity, size and shape upon the plastic zone development and growth, and unloading residual stresses [3].

Andrew Levers et al. Studied, The shot peening process is largely used for the surface treatment of metallic components with the aim of increasing surface toughness and extending fatigue life. A secondary consequence of the process is that the residual stress distribution developed within the material may induce distortion of the component. This effect may therefore be used constructively in the straightening and forming of thin flexible metallic structures. In this paper, the various techniques available for modelling the effect of peening with finite elements are discussed. In particular, a method of simulating the effect of peening on large flexible panels is presented. Analyses are shown in which a novel loading is applied to finite element meshes in order to produce the desired residual stress distribution. Results from tests are compared to finite element analyses and preliminary results of large scale analyses are presented [4].

Royston et al. Studied, Shot peen forming is a production process used to create curved metal partsfiom sheet. It is commercially important despite the fact that its mechanisms are not fully understood; peen forming programmes are currently generated using experience and trial and error. The purpose of this work is to increase the predictability and range of application of the process by advancing its understanding.Finite element analysis proved to be a satisfactory procedure for studying shot peen forming. The stress distribution in a sheet arising from multiple indentations, as occur in shot peen forming, was modelled. [5].

Chang Feng Yao et al. Studied, to study the effect of different milled surfaces on shot peening surface integrity (roughness, residual stress, hardness, and microstructure), research on the change of surface integrity is carried out using the same shot peening process for different milling surfaces of 7055-T77 aluminum alloy. Surface integrity measurements, fatigue fracture analysis, and fatigue life tests are conducted to reveal the effect of surface integrity on crack initiation and fatigue life. The results show that shot peening can reduce the dispersion and instability of surface integrity brought by milling processing, although it increases the surface roughness; the maximum residual compressive stress and depth of residual stress layer increase significantly after shot peening, and the residual stress and hardening distribution are very good; larger surface roughness and irregular surface scratches of milling samples before shot peening easily lead to cracks and gouges produced on shot peening surface [6].

Baskaran Bhuvaraghana et al. Studied; Imparting residual compressive stresses in the surface layers of metallic components is one of the ways to improve theirfatigue strength characteristics. Shot peening is employed for imparting residual stresses by means of cold work. Shotpeening is a complex random process with many input variables. The material responses include residual stresses, coldwork, surface roughness, micro-cracks and micro-structure changes. To obtain the maximum fatigue strength, the designer needs to consider both favorable and detrimental aspects of these responses together. The prediction of the responses from the input parameters involves many methods spanning across multiple-disciplines such as plasticity, fracture, optimization etc. The paper presents an overview of the studies that predict the various material responses and suggests a method based on continuum mechanics in order to optimize the fatigue 7strength of any material [7].

Grum, J. Uros et al. Studied, The objective of the present study was to investigate the effect of surface hardening by shotpeening(SP) on fatigue properties of high-strength aluminium alloy 7075-T651. The paper describes the effects of SP treatment by presenting analyses of surface roughness measurement, microhardness profiles, microstructure changes, residual stresses and material bending fatigue resistance. The obtained results show a favourable influence of SP treatment on fatigue properties as induced compressive residual stresses and hardened surface layer retarded the initiation of fatigue cracks. SP treatment nearly doubled the cycles to failure at the higher applied stresses when compared to the untreated specimens. The fatigue limit of the SP-treated specimens increased to 218 MPa at 107 cycles. The experimental data confirmed an increase of fatigue strength after SP treatment due to the compressive residual stress ability to influence fatigue crack nucleation. Increased resistance to plastic deformation and the residual stress profiles provided a corresponding fatigue crack closure [8].

M. Benedetti et al. Studied, The effect of different shot-peening treatments on the reverse and pulsating bending fatigue behaviour of Al 7075 T651 was studied. The fatigue improvements with respect to the unpeened condition and the influence of the peening intensity on fatigue were discussed accounting for the effects of surface modifications and residual stresses. In particular, the extent of the residual stress redistribution during loading was investigated by means of X-ray diffraction (XRD) measurements. No significant residualstress relaxation was observed in samples tested to a load level corresponding to the fatigue endurance at 5□106 cycles. Residual stress relaxation was observed only when the material plastic flow stress was achieved during the compressive part of the fatigue load cycle. Accordingly, shot peened samples with deep sub-superficial compressive residual stress peak showed a reversed fatigue endurance level corresponding to the condition of incipient plastic flow. This phenomenon was also accompanied by sub superficial fatigue crack initiation. On the contrary, samples tested at shorter fatigue lives or under pulsating loading conditions showed crack initiation close to the surface. The initial and the stabilised residual stress profiles were considered for discussing the improvement in the fatigue behaviour due to peening. For this purpose, a multiaxial fatigue criterion was adopted to account for the biaxial residual stress field. The fatigue life was quite accurately predicted as long as fatigue initiation occurs on the surface [9]

III] PROBLEM STATEMENT

Fatigue cracks originate mostly from the surface, as the stresses due to loads (such as bending and torsion) are generally high at the surface compared to the inside material. The fatigue resistance of sub-surface material is also higher (approximately by 1.4 times) than that of the surface (Peige et al., 1996). The fatigue strength can be enhanced by the use of controlled cold working methods. Shot peening (SP) is one such process which induces residual compressive stresses (RCS). The RCS reduces the tensile mean stresses due to the applied loads and manufacturing thereby it increases the fatigue strength. Besides, the development of RCS is always accompanied by cold work, micro cracks, surface roughness and the microstructure changes.

IV] OBJECTIVES

1.Design and Measurement of stresses.
2.Development of finite element model using ANSYS software.
3.FEA Analysis & deal with Von-mises Stress and Fatigue sensitivity by considering shot peening pressure aluminium alloy plate.
4.Fatigue analysis of aluminium alloy plate subjected to shot peening.

V] METHODOLOGY

Imparting residual compressive stresses in the surface layers of metallic components is one of the ways to improve their fatigue strength characteristics. Shot peening is employed for imparting residual stresses by means of cold work. Shot peening is a complex random process with many input variables.

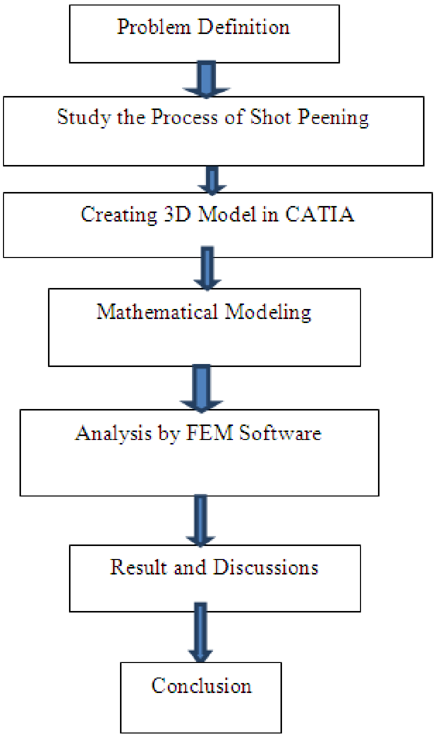

Figure No.1 Methodology Flowchart

This project work will relate to design of aluminium alloy plate, Optimization of stresses, and suggests a method based on continuum mechanics in order to optimize the fatigue strength of any material including:

1. Measurement of stress developed in aluminium alloy plate.
2. Development of finite element model using ANSYS software.
3. Fatigue analysis of aluminium alloy plate.

EXPLICIT DYNAMIC ANALYSIS OF PLATE

Modeling of Alluminium Alloy Plate Using CATIA:

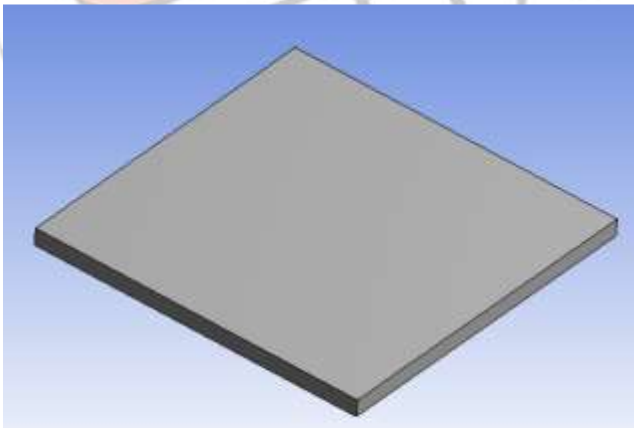

Figure No.2 Aluminium Plate

CATIA V5 is mechanical design software, addressing advanced process centric design requirements of the mechanical industry. With its feature based design solutions, CATIA proved to be highly productive for mechanical assemblies and drawing generation. CATIA V5 is totally compliant with windows presentation standards. CATIA V5 users' access the highest productivity for specific advanced processes with focused solutions like Sketcher, Part design, Assembly Design, Drafting.

Material for Aluminium Alloy Plate: A wrought plate of high-strength, precipitation hardened, aluminium alloy.
Aluminium Plate 100×100×5mm.

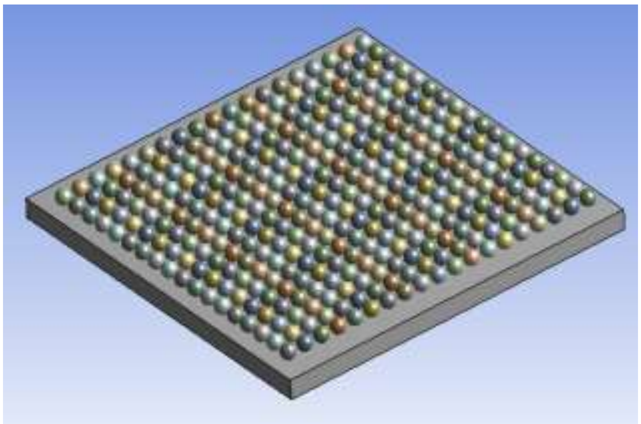

Figure No.3 Aluminium Plate with Steel balls

For above Figure No.3, Steel balls of 2mm Radius and around 342 numbers were impacted with velocity of 50 m/s.

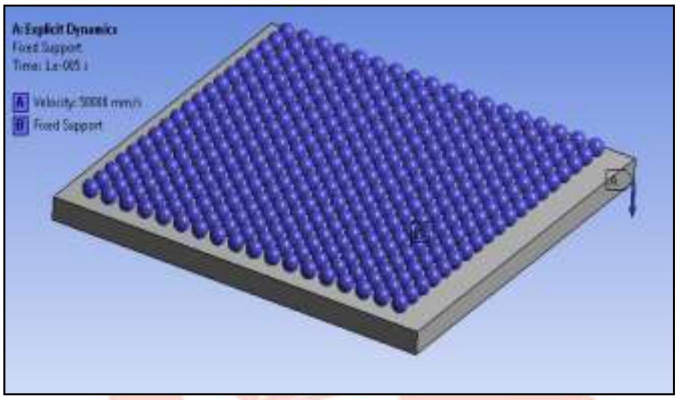

Figure No.4 Boundary Condition of Plate with Velocity and Base fixed support

For above Figure No.4, Velocity is 50m/s.

Explict Dynamics of Aluminium Plate:

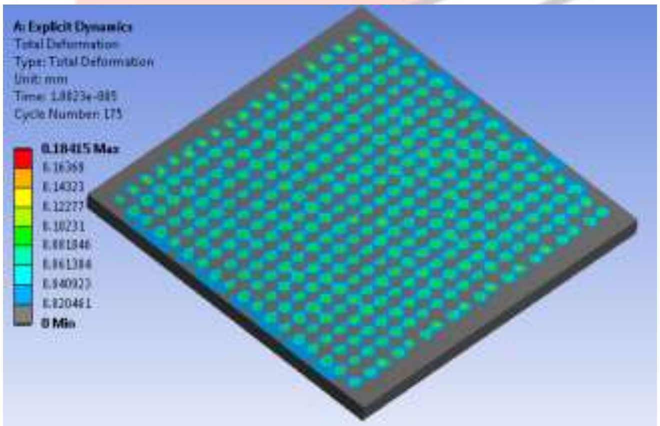

Figure No.5 Aluminium Plate with Deformation for Explict Dynamics

For Explict Dynamics of plate, total deformation is 0.1845 mm.

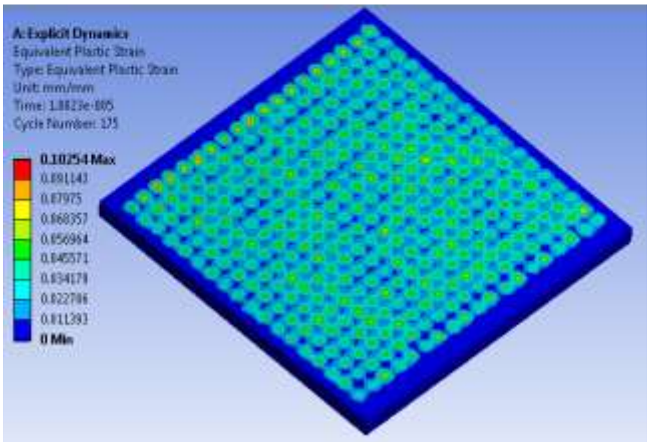

Figure No.6 Aluminium Plate with Equivalent Plastic Strain

For Explict Dynamics of plate, Equivalent Plastic Strain is 0.1025mm/mm.

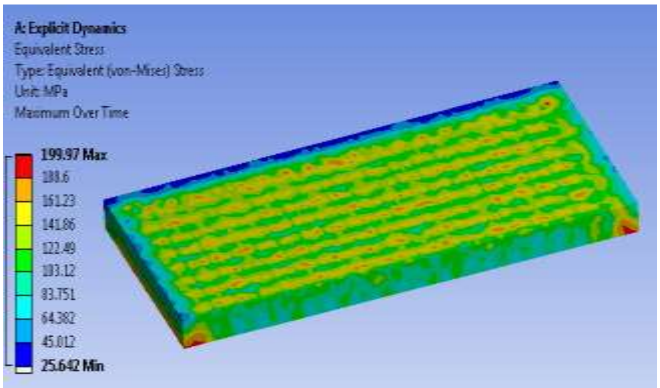

Figure No.7 Aluminium Plate with Equivalent Von-Mises (Residual) Stress

For above Figure No.7, Aluminium Plate with Equivalent Von-Mises Stress (Residual) is 199.97 MPa.

VI] CONCLUSION & DISCUSSIONS

1. Total deformation is 0.1845 mm.
2. Equivalent Plastic Strain is 0.1025mm/mm.
3. Equivalent Von-Mises (Residual) Stress is 199.97 MPa.

Hence, Explict Dynamics can be used to stimulate shot peening stress.
Experimentation will be the proposed work for the Shot peening on Aluminum Alloy Plate.

VII] ACKNOWLEDGMENT

It is of immense pleasure to me in expressing sincere and deep appreciation towards my guide Prof. Hredey Mishra., for priceless execution of steering this contribution all the way through this work with soft suggestions, embedded supervision and invariable advocacy. Special thanks to the principal and teaching staff of JCOE Kuran, for needful support and encouragement throughout the course.

.

REFERENCES

[1] S.A. Meguid, G. Shagal!, J.C. Stranart, J. Daly, "Engineering Mechanics & Design Laboratory, Department of Mechanical and Industrial Engineering, University of Toronto,5 King+s College Road, Toronto, Ontario, M5S 3G8 Canada" Metal Improvement Company, 10 Forest Avenue, Paramus, New Jersey, 07652 USA)

[2] Andrew Levers a, Alan Prior ba British Aerospace Airbus Ltd., Broughton, nr Chester, Clwyd CH4 0DR, UKb Hibbitt, Karlsson and Sorensen (UK) Ltd., Genesis Centre, Birchwood, Warrington, Cheshire WA3 7BH, UK

[3] Finite element modelling of shot peening process- A progress overviewY. H. Yang, M. Wan, W.H. Zhang 1 The Key Laboratory of Contemporary Design & Integrated Manufacturing Technology, Ministry of Education, Northwestern Polytechnical University

[4] Shot peen forming sheet metal: finite element prediction of deformed shapeL V Grasty, BSc, PhDLing Dynamic Systems Limited, Royston, HertfordshireC Andrew, MA, PhD, CEng, FIMechEManufacturing Engineering, Department of Engineering, University of Cambridge Three-dimensional dynamic Þnite element analysis of shot-peening induced residual stressesS.A. Meguid!, G. Shagal!, J.C. Stranart!, J. Daly"! Engineering Mechanics & Design Laboratory, Department of Mechanical and Industrial Engineering, University of Toronto,5 King+s College Road, Toronto, Ontario, M5S 3G8 Canada " Metal Improvement Company, 10 Forest Avenue, Paramus, New Jersey, 07652 USA

[5] S.A. Meguid, I.F. Collins, W. Johnson, The co-indentation of a layer by two ßat plane or spherical-headed rigidpunches, Int. J. Mech. Sci. 19 (1977) 1Ð9.

[6] S.A. Meguid, M.S. Klair, An examination of the relevance of co-indentation studies to incomplete coverage inshot-peening using the Þnite-element method, J. Mech. Working Technol. 11 (1985) 87Ð104. S.A. Meguid, M.S. Klair, Elasto-plastic co-indentation analysis of a bounded solid using Þnite element method, Int.J. Mech. Sci. 27 (3) (1985) 157Ð168.

[7] M.T. Khabou, L. Castex, G. Inglebert, E¤ect of material behaviour law on the theoretical shot peening results,European J. Mech. A/Solids 9 (6) (1990) 537Ð549. A.K. Li, M. Yao, D. Wang, R. Wang, Mechanical approach to the residual stress Þeld induced by shot-peening,Mater. Sci. Eng. A 147 (1991) 167Ð173.

[8] W. Johnson, Impact Strength of Materials, Arnold, London, 1972.

[9] R.Clausen,Ermittlungvon,Ein.ßussgrossenbeim,Kugelstralendurch,Einzelkornversuche, 1st Int. Conf. onShot-Peening, Paris, 1981, pp. 279Ð285.

[10] K. Iida, Dent and a¤ected layer produced by shot peening, 2nd Int. Conf. on Shot Peening, Chicago, USA, 1984,pp. 217Ð227.

[11] J. Edberg, L. Lindgren, K. Mori, Shot peening simulated by two di¤erentÞnite element formulations, in: Shen,Dawson (Eds.), Simulation of Materials Processing: Theory, Methods and Applications, Balkema, Rotterdam,1995, pp. 425Ð430.