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Introduction to Structural Analysis of Shot Peening on Aluminium Alloy Plates

Miss V. A. Padekar¹, Hredey Mishra²,

¹PG Scholar, Jaihind COE, ²Assistant Professor, JCOE, Kuran.

Abstract: Shot peening allows metal parts to accept higher loads 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, North western Poly technical 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 field resulting from the shot-peening process. In this dynamic elasto-plastic analysis, single and twin spherical indentations were examined using the finite element 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 first is concerned with the effect 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 parts from 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 Bhuvarghana et al. Studied; 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. The material responses include residual stresses, cold work, surface roughness, micro-cracks and micro-structure changes. To obtain the maximum fatigue strength, the designer needs to consider both favourable 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 strength 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 shot peening (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 un peened 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 residual stress relaxation was observed in samples tested to a load level corresponding to the fatigue endurance at 5×10^6 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. COMMENTS ON REVIEWED PAPERS

A. From The Study Of Literature Review It Is Observed That

To summarize the literature studied it must be said that 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 chapter reviews literature relevant to the 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.

IV. GAPS IDENTIFIED FROM LITERATURE SURVEY

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. The research will allow us to justify uses of finite element tools for this kind of applications.

V. DIFFERENCE BETWEEN SHOT PEENING AND SHOT BLASTING

The distinct difference between Shot peening & Shot blasting - Most of them gets confused the difference between Shot Peening & Shot Blasting

	Shot Blasting	Shot Peening
Definition	Shot blasting or blast cleaning is a process in which an abrasive material is accelerated through a pressurized nozzle or centrifugal wheel and directed at the surface of a part to clean or otherwise prepare the part surface for further treatment.	Shot peening is a cold working process, which uses the mass and velocity of a shot stream to produce residual compressive stress at the surface of the part. It is a precisely controlled process relying on careful selection and control of media, intensity, coverage and equipment. At the time of shot impact, the metal surface yields in tension due to localized stretching that occurs, while the near surface layer is left in a residual compressive state due to the material’s attempt to restore the surface to its original shape
Media used	Blasting media includes sand; steel shot; cut wire shot; chilled iron; garnet, a sharp hard abrasive glass beads used to polish rather than remove surface coatings on soft metals and plastics.	Peening media must remain predominately round and uniform in diameter to avoid surface damage upon impact and to maintain a uniform compressive stress layer.
Applications	Shot blasting can be used on castings, forgings, and stampings to produce a uniform surface texture and for descaling, debarring, and deflating. Shot blasting is used in a wide variety of industries including automotive, marine, mining, and medical applications.	A variety of different metallic based materials are currently shot peened including: high strength steels, carburized and decarburized steels, cast and austempered ductile iron, and nonferrous alloys of aluminum, titanium and magnesium. Powder metal parts also benefit from shot peening. Connecting rods, crankshafts, compression springs, torsion and anti-sway bars and metal implants.

Table no.1 difference between shot peening and shot blasting



VI. CONCLUSION

In this review numbers of research papers were studied. The present study includes opinion of different authors on the research. The ultimate purpose of the project has been achieved with developing techniques of the finite element analysis of shot peening on aluminium alloy plate. In this project FEA Analysis & deal with Von-mises Stress and Fatigue sensitivity by considering shot peening pressure aluminium alloy plate. Fatigue analysis of aluminium alloy plate subjected to shot peening. The experiments have been validated by using ANSYS software. Hence, Explicit Dynamics can be used to stimulate shot peening stress. Experimentation will be the proposed work for the Shot peening on Aluminum Alloy Plate.

VII. ACKNOWLEDGEMENT

Department of Mechanical Engineering, here knowledge is considered as the liable asset and it is proved that the power of mind is like a ray of sun; and when strenuous they illumine.

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