Review of Shot Peening and Shot Peening Parameters for Different Alloys to Improve Fatigue Life of the Components

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Abstract - Shot peening is most often used for increasing fatigue strength of machine elements and components. It increases compressive residual strength and hence the resistance to detrimental effects of tensile residual stresses develop at the time of manufacture. Various researchers worked on shot peening, shot peening parameters and its effects on the fatigue properties of the material. The variation in the shot peening parameters like shot size, Angle of incidence, coverage, distance between nozzle and work piece can express the optimised solution to improve fatigue properties of material by using Grey Relational Analysis, Taguchi, Principal Component Analysis, ANN, Data Mining etc. The controlled shot peening is most cost effective and practical method of inducing surface residual compressive stresses which enhance the performance and extend the life of critical components so, it could be used for various precise manufacturing.

Key Words: shot peening, controlled shot peening, shot size, nozzle, ANN, GRA, Data Mining.

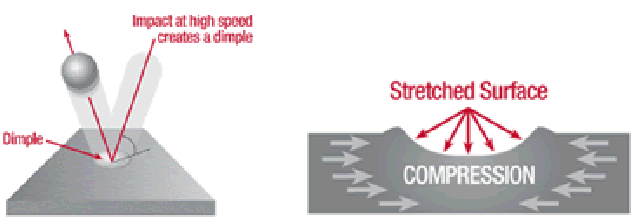
I. INTRODUCTION

Engineering components and structures are regularly subjected to alternating loads ,which made them prone to fatigue failures. It is well known fact that almost all fatigue cracks form at surface due to variety of surface stress concentration features, including grain boundaries, machining marks, surface breaking inclusions. Fatigue performance of metallic parts depends on three factors: Metallurgical, surface geometry and residual stress. Performance can also been affected by damages during process manufacturing or in service. Shot peening is a cold working process improving the mechanical properties such as fatigue (Drechsler et al, 1999), stress corrosion cracking (Kirk & Render, 1999) and so on (watanabe et al, 1999). Shot peening has potentially positive and sometimes negative effects on all these factors. Creation of compressive residual stress, work hardening, surface roughness and tribological properties modification, delay of micro grain propagation in service. Numerous investigations in the past have shown that shot peening can improve the fatigue performance of structural materials such as steels and aluminium alloys. Therefore in shot peening different parameters used and that are controlled depending upon experimentation made by different experimentation techniques .There are no of shot peening input parameters are used such as Shot nature, shot size, shot hardness, Almen intensity, shot angle, coverage, distance between blower and work piece, nozzle diameter , shot material , type of shot peening machine , material of specimen, density of shots, composition of shots, peening medium, pressure of compressed air.

The control of residual stress is crucial in ensuring the integrity of engineering components and shot peening can be used to good effect to introduce the beneficial compressive residual stress levels required. Therefore to have good results from shot peening the ideal conditions required for the performance of controlled shot peening.

II. CONTROLLED SHOT SHOT PEENING AN OVERVIEW

Controlled shot peening process is the most cost effective and practical method of inducing surface residual compressive stresses which enhance the performance and extend the life of critical components. Component failure is often related to residual tensile stress induced during manufacturing.



Subsequent sever working or unexpected conditions can eventually lead to premature failure are: (1) Metal fatigue, (2) Corrosion fatigue, (3) Stress corrosion cracking (4) Intergranular corrosion, (5) Fretting, (6) Galling,(7) Spalling (8) Wear etc.

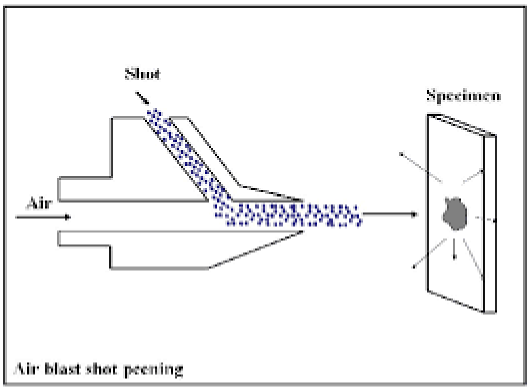
Controlled shot peening is the bombardment of a surface with small high quality spherical media called shot in a technically defined and controlled way. The shot can be made by steel, glass or ceramic etc.

Each shot striking the metal acts as a tiny peening hammer imparting a small indentation or dimple into the surface

2. Shot peening parameters

2.1 Angle of peening

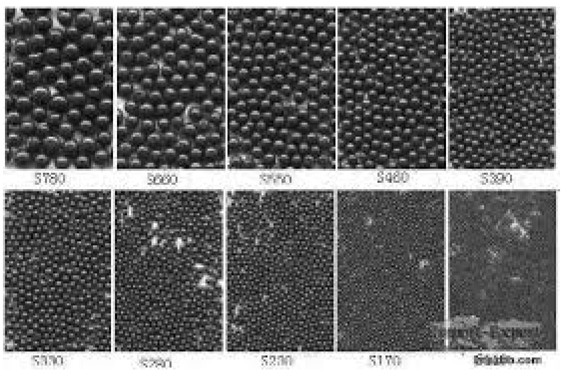
Amplitude of compressive residual stress is maximum (about 60/70% of yield strength after cold working) when the shot direction is perpendicular to the surface of the part, and amplitude will decrease when angle will increase. This aspect characterise the quality of the process: strike impact direction badly oriented, or badly controlled during the process, will induce poor amplitude of compressive residual stress compared to the potential of the material. (Olivier Higounenc).



Angle of the impact is too important in the controlled shot peening because it decides the amplitude of the shot striked on the component. In shot peening the as angle increases from 0 to 90 the effect of the shot peening improves and at 90 deg angle the maximum amplitude of impact is attained

2.2 Shot size

Shot peening can eliminate or soften the damaging effect of surface defects, if the shot size is correctly adapted to the surface topography. If shot size is too big it can't remove tool marks and shot peening performance is poor. The different types of shots used in shot peening i. e The material of shots, shape of shots, size(dia) of the shots etc.



These are some variations in the shots. Shot plays an important role in the shot peening

2.3 Coverage

Coverage is the percentage of area that has been impacted by the shots during the shot peening. In this process the shots (balls) of circular shape strikes on the surface of the component and that makes the indentation on the surface of the component. It is closely analogous to the spraying on the surface. The percentage of coverage is calculated by the Avrami's equation $C=100(1-\exp(-\pi^2 R.t))$

Where r is the impression ,R is the rate of creation of impressions, t is the time during which the impressions created.

III. EXPERIMETATION COMPARISONS

(Frack petit & Renaud) selected the shot peening parameters as Shot density, Hardness and size of the shot, Nozzle characteristics (diameter, deflection angle, length), Air pressure, Impact angle, Distance from nozzle to work piece, Exposure time, number of passes, Linear and rotational speed of work piece relative to nozzle. To specify all the parameter it require more time so, the Almen intensity process can give the standard parameters, only shot type & size and peening coverage has to specify.

The specimen taken is test specimen of 17CrNiMo6 of size 10*10*100mm. Six parameters was tested at three different levels (low,medium,high). 108 set-ups were randomly allocated and total experimental sites was 132. Each experimental site was procssed with required conditions and X-ray measurement to determine residual stress profile.

Profiles were obtained to find the key values

1. The maximum compressive stress (RSM in Mpa)
2. The depth at which the maximum compressive stress occurs (DRSM, in µm)
3. The depth of shot peened outer layer (SPOL, in µm)
4. The surface residual stress before peening (RSSi,in Mpa)
5. The surface residual stress after peening (RSSF, in MPa)

To carry out statistical analysis five responses were investigated

1. RSM,in MPa
2. DSRM, in µm
3. SPOL, in µm
4. RSSf, in Mpa
5. RSSf-RSSi,in MPa

Using these statistical calculations the optimum residual stressprofile could created.

(D.Lassithiotkis,et.al.)conducted the experiment to find the optimised parameters.material was SAE8620(Ni,Cr,Mo, steel) which was carburised, shot peening was carried out using ATX peening cabinet and S230H conditioned steel shot, residual stresses were measured by X-ray diffraction using Stresstech XSTRESS 3000residual stress analysers. From the work of (Petit & Renaud) the parameters are selected as peening time,pressure, mass, distance, angle. Two experimentations were carried out one by using taguchi for two levels and another is using Central Composite (CCDi) for five levels. The results were obtained from both the experiments. From first experiment it was observed that the angle of impact and mass flow rate is having most impact on surface residual stress and pressure have the most influence on maximum residual stress. The pressure and distance from the object are also significant for surface residual stress and depth but not for maximum residual stress.

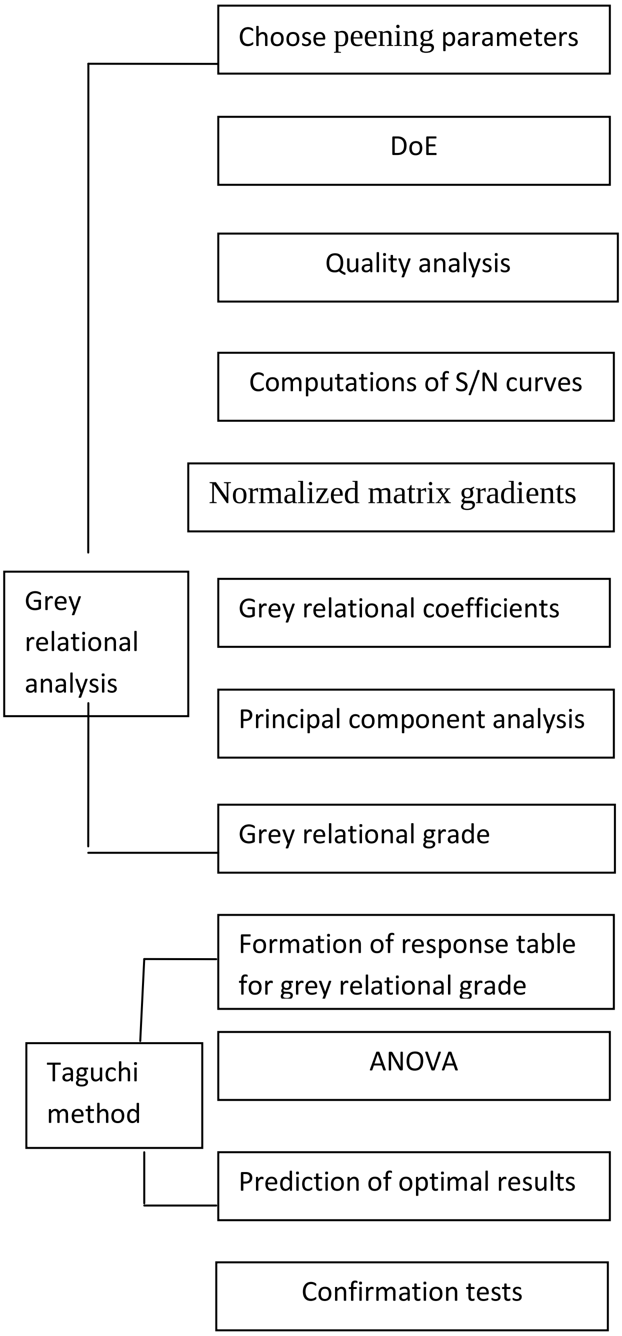
(Ludian & wagner) specify the Coverage is one of the important parameter of shot peening as it affect more for inducing residual stresses in the components.

To specify the effect of the civerage the experiment conducted by them in which the specications was material age-hardening aluminium alloy Al2024 was taken. Shot were SCCW14with average size

0.36mm.mass flow rate 45g/min, the distance between nozzle and workpiece surface 60mm, The Almen intensity was measured on conventional A-type and N-type Almen strips, Quantitative metallography (image C0 analysis was used to determine coverage degrees, the surface roughness was measured by a profilometer. Residual stresses induced were evaluated with the incremental hole drilling method using an oscillating drill with a 1.9 mm diameter driven by an air turbine with a rotational speed of about 200rpm.

The residual stresses induced are measured by strain guage rosetts at 10µm depth. The above experiment is performed for 4, 20, 80 seconds resulted in coverage 16 % (low coverage), 53 %(medium coverage), and 100 % (full coverage) respectively. The coverage percentage increase is shown in the graph by plotting coverage time Vs peening time. The residual stress at the different surface depths is studied by another graph. The above experiment is concluded that low coverage(16%) can induce the compressive residual stresses in less amount, the intermediate coverge(53%) start the development of compressive residual stresses for increasing the fstigue life of the component, and the peening with full coverage (100%) resulting in highest improving the fatiguelife of the component.

(J.Solis Romero, et.al.) had the experiment for optimising the shot peening process poarameters. The parametersare selected as shot-S230, Air pressure-60 psi, Stand off distance-6in, Duration(passes) AT saturation point-8 sec and 100% coverage, Nozzle size-0.25 inch., Almen intesity-17A. (Dr.Lakhwinder Singh, et.al) had developed flow chart for optimisation of shot peening



IV. RESIDUAL STRESS MEASUREMENT

There are various methods of measurement of residual stresses.

4.1 Mechanical methods

- Hole drilling method

- Deep hole method
- Sectioning technique
- Conour method

4.2 Diffraction Techniques

- X-ray diffraction method
- Neutron diffraction method

4.3 Other non-destructive techniques

- Barkhausen noise method
- Ultrasonic method

These are some of the important methods of residual stress measurement. X- ray diffraction is on of the popular and precise method getting used widely.

V. APPLICATION OF SHOT PEENING

The beneficial effect of the process of fatigue resistance of ferrous materials is well established, whereas for aluminium materials it is less clear (J. Solis Romero, et.al.).

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