© 2014 IJEDR | Volume 2, Issue 1 | ISSN: 2321-9939

Role of Finite Element Modeling in Shot Peening Process

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***Abstract* - Shot peening is a process which is used to improve the fatigue life of component. In this present era where we are dealing with low weight requirements which requires low weight alloys having low fatigue strength, shot peening is emerged as a solution for improving the fatigue life. But selection of wrong parameters will lead to reducing the fatigue life rather than improving it. Finite Element Modeling is used as an effective technique for prediction of residual stresses in shot peening process. FEM will lead to saving the cost, time and efforts related to shot peening experimentation. This paper is focused on review of Role of FEM in shot peening.**

***Index Terms* - Shot Peening, Residual Stresses, FEM, Shot Peening Parameters.**

I. INTRODUCTION

Engineering components and structures are regularly subjected to cyclic loading and they are consequently prone to fatigue damage. In most cases, fatigue damage will initiate at the surface due to localized stress concentrations caused by machining marks, exposed inclusions or even due to the contrasting movement of dislocations. Evidently, control over the initiation and early propagation of surface cracks is paramount for prolonging the fatigue life of components. Shot peening is extensively used for the above purpose as it produces near surface plastic deformation leading to the development of work-hardening and high magnitude compressive residual stresses.

In principle when on rebound of the shot, the balanced system of residual stresses are trapped in the target, the plastically deformed zone recovers only some part of the elastic portion of its total strain. The resulting trapped compressive stresses assume their positions in a thin subsurface layer with tensile residual stresses distributed throughout the lower region.[2]Hardening is expected to increase the flow resistance of the material and thus reduce crack tip plasticity, while, the residual stresses can act as: a) mean stress modulators in the case of the onset of crack propagation or b) closure stress in the case of crack growth. [1,2]

II. SHOT PEENING & RESIDUAL STRESSES

I. Shot peening

Shot peening is viewed as a process involving multiple and progressively repeated impact. In this process, the result is accomplished by bombarding relatively hard particles, usually spherical chilled shots (0.25 to 1 mm diameter) having impact velocities ranging from 20 to 150 m/s. They are projected against the surface being peened with sufficient velocities to indent the surface. Fig. 1 shows schematic diagram of shot peening

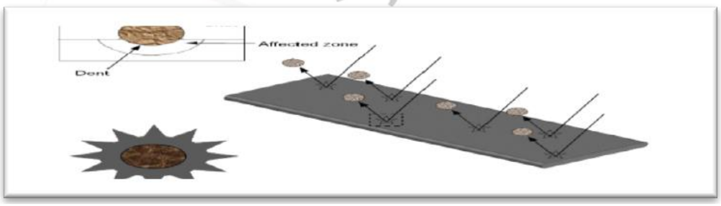

Fig 1: Schematic Diagram of Shot Peening

II. Residual Stresses in Shot Peening:

Shot peening is an effective method of improving the fatigue strength of components and structures. A series of effects are induced by shot peening, which have great influence on the fatigue strength of machine parts. These effects are: structure change within the surface layer the formation of a residual stress field (RSF) and the change of surface roughness.[3] Fig 2 represents residual stress distribution after shot peening.

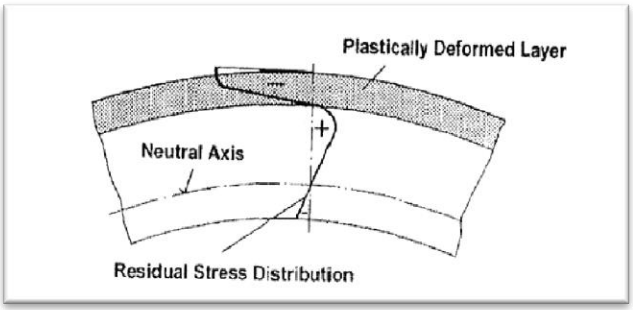

Fig 2: Residual Stress distribution

III. REVIEW OF FEM IN SHOT PEENING

Table 1 shows the review of work of researchers in the shot peening.

Table 1: Review of FEM in shot peening

Researcher	Parameters					Approach Used			
	Size	*Dist.*	*Vel.*	*Angle*	*Time*	*FEM*	*Expt.*	*Analytical*	*Meta.*
Wang et.al.[3]	√	√	√		√		√		
Romero et.al.[4]	√	√	√	√	√		√		
Curtis et.al.[5]	√				√		√		
Renaud et.al.[6]	√	√	√	√	√		√		
Rodopoulos et.al.[1]	√	√					DOE		
Ludian et.al.[7]	√		√		√		√		√
Rehman et.al.[8]	√		√			√			
Mehmood et.al.[9]	√	√	√	√	√		√		
Inoue et.al.[10]	√		√				√		
Uros et.al.[11]	√		√	√	√		√		
Wang et.al.[12]		√	√	√	√	√	√		
Hirai et.al.[13]	√	√	√			√			
Liu et.al[14]	Gave 3 models for residual stress prediction					√			
Miao et.al.[15]	√				√			√	
Bhuvaraghan et.al[16]	√		√	√	√	√			
Gangraj et.al.[17]	√		√		√	√			
Bagherifard et.al.[18]	√	√				√			
Gariepy et.al.[19]	√	√	√	√	√	√	√		

Vel.-Shot Velocity, Expt.-Experimental, Meta.-Metallurgical

I. Findings From Review:

- Considerable amount of experimental work is carried out on shot peening of Al 2024 alloy for fatigue life.
- Less work is reported on shot peening optimization parameters.
- Many researchers have used shot peening method successfully to improve fatigue life.
- Most relevant parameters are shot velocity, shot dia., exposure time, shot distance and shot distance.
- Experimental work can be efficiently used for fatigue life prediction.
- Finite element model can be used to predict residual stresses after shot peening.

IV. CONCLUSION AND RESEARCH ISSUES

Based on above review following conclusion can be made:

- Shot peening has beneficial effects on the different grades of aluminum alloys. But over peening may damage the surfaces and less peening will not improve fatigue life in desired amount.
- Majority of the researchers have carried out experimental work for analyzing the effect of shot peening on fatigue life of aluminum. Also there are substantial differences between the findings of the various experiments in the fatigue life prediction of for peened components. This need to be investigated.
- The shot peening process involves number of parameters such as shot size, shot material, shot quality, pressure/velocity, exposure time, peening distance etc, that need to be controlled. Shot peening process heavily depends upon condition or peening parameters. But it remains unclear how these parameters affect the peening quality and what are the optimum peening conditions for aluminum alloys.
- Experimental optimization of process parameters is expensive. Finite element modeling of the process can reduce the experimental expenses and number of iterations requited for optimization.

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