Research Paper Engineering

Evaluating The Effect of Shot Peening on Fatigue Life of Piston by using LS DYNA

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ABSTRACT

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, not withstanding all these studies, there are a huge number of damaged pistons. Although, traditionally, piston damages are attributed to wear and lubrication sources, fatigue is responsible for a significant number of piston damages. Fatigue exists when cyclic stresses/deformations occur in an area on a component. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. High temperature fatigue (which includes creep) is also present in some damaged pistons. Also thermal mechanical fatigue is present in other damaged pistons. Fatigue is an important parameter to be considered in the behavior of piston. Fatigue resistance of piston can be improved by using the shot pining. This project work focuses on the shot peening process and optimization of the different shot peening parameters with the help of LS Dyna. Project work also focuses on the material responses due to the shot peening process.

KEYWORDS Fatigue, shot peening, residual stresses, LS Dyna

1. INTRODUCTION:

One of the known ways to improve fatigue resistance is by using the shot pining process to induce a compressive residual stress in the surface layers of the material. Shot peening makes the nucleation and propagation of fatigue cracks more difficult. The shot peening results depend on various parameters. Peening rate can vary with shot size, shot hardness, shot speed, quantity of shot thrown per second and angle of impact.

2. FINITE ELEMENT MODELLING:

Model Geometry and Boundary Conditions:

The model used for the shot- peening analysis is realized in LS Dyna and consists of a steel plate. Shot hits target normal to surface under initial velocity. Outer side of target is constrained in all direction. Considering target fixed along the periphery.

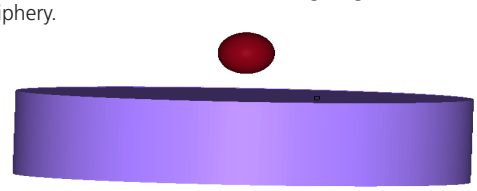


Fig 1 3D Model of target and shot

Mesh Model: Target mesh model consist of Aluminum sheet of thickness 4 mm and radius 8 mm. The boundary conditions on the target's base fix the model in z- direction. The mesh consists of full integration elements to control hourglass effect. Global element length ranges from 0.1 mm to 0.2 mm.

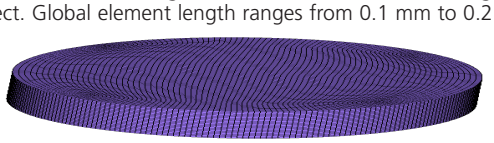


Fig 2 Target mesh model

Cast steel spherical rigid surface of diameter 1 mm is used to model the shot. Mass is equally applied to all nodes.

Material Properties: Aluminum is modeled as a target plate with a mass density 2070 kg/m³. Tensile strength of target material is 180 N/mm². Modulus of elasticity of the target is 73 × 10³ N/mm². Poisson's ratio, σ = 0.35 is used.

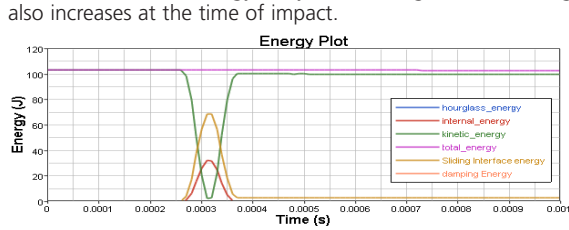
The cast steel shot is modeled as a rigid body with a mass density of 7200 Kg/m³. The value for modulus of Elasticity E=210× 10³ N/mm² is taken. Poisson's ratio σ = 0.265 is used.

Gravity loading:

Preloading due to gravity can be accomplished via gravity load. Gravity loading is applied in Z direction so that shot travels in vertical direction..

Quality of Analysis:

Figure shows Energy vs. Time plot. It is observed from graph that Kinetic energy drops down at the time of impact with increase in internal energy of system. Sliding interface energy also increases at the time of impact.



Graph1 Energy (J) Vs Time(S)

Input Parameters:

Shot peening analysis is carried out by varying different inputs parameters. Effect of the variation on residual stresses and deflection, generated in target plate are studied. Following input conditions are selected for analyzing the effect.

Shot size: Size of shot is selected as 1mm, 0.85 mm and 0.60mm.

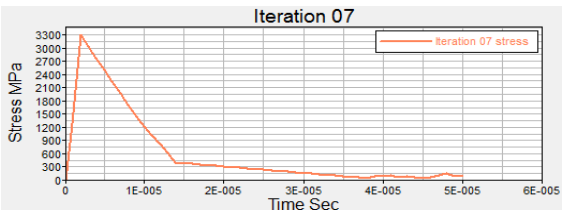
Shot velocity: Shot velocity is selected as 10,15, 20, 25,30,40,45,50,60,70 m/sec.

Shot angle: Shot angles are varied from 10, 20, and 30,40,50,60,70,80,90 Deg

Distance between shot & Target: Input parameters for distance between shot nozzle and target plate is selected as 70, 80, 100, 120, 140, 160, 180, 200, 230 mm

RESULT & DISCUSSIONS:

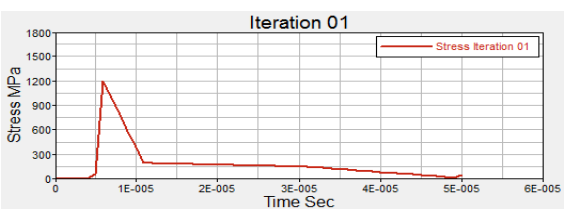
1. For variation in shot velocity : It is observed that as shot velocity increases from 10m/s to 55m/s, the residual stress value rises from 370MPa and surface deflection occurs from 0.006mm to 0.023mm. Graph for residual stresse Vs Time for shot velocity of 55m/s are as below



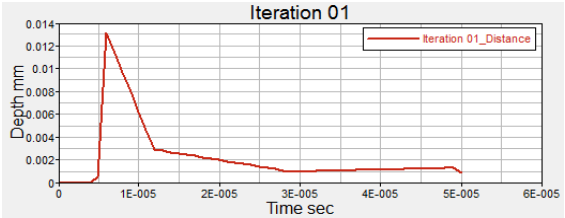
Graph 2 Residual stress (MPa) Vs Time (Sec)

2. Variation in distance between nozzle and target: Vaiation in distance between nozzle and target does not have significant effect on residual stresse and surface deflection. As distance increases from 80mm to 200mm, residual stresses maintain constant value of 2100MPa whereas surface deflection changes from 0.017mm to 0.0165mm.

3. Variation in shot size: As shot size decreases from 0.85 mm to 0.65 mm, residual stresses decreases from 1200MPa to 1000MPa. But surface deflection increases from 0.013mm to 0.015mm. Graphs shows residual stresses and surface deflection for 0.85mm shot size.

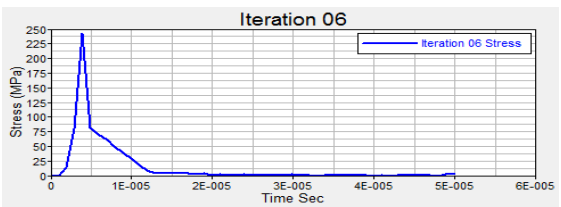


Graph 3 Residual stress (MPa) Vs Time (Sec)



Graph 4 Deflection (mm) Vs Time (Sec)

4. Variation in shot angle: As angle of shot increases from 15 deg to 80 deg, residual stresses decreases from 2500MPa to 240Mpa. Deflection also decreases from 0.019mm to 0.00225mm.



Graph 5 Residual stress (MPa) Vs Time (Sec)

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