THE LIMITEDCOMPONENTSTUDY FOR SHOT PEENING METHOD OF 40 BALLS

[1]JITHIN AMBARAYIL JOY, [2]HAO-YU, [3]DONG WON JUNG

Department of Mechanical Engineering, Jeju National University, Jeju, Republic of Korea
E-mail: [1]jithinjoy30jan@gmail.com, [3]jungdw77@naver.com

Abstract - Shot peening process is widely used to improve the mechanical strength, wear resistance, fatigue resistance and corrosion resistance of the parts. And also used to surface extinction, to scale, and eliminate the residual stress of casting, forging, welding, etc. The process consists of impacting the surface of the parts by multiple high-velocity shots which induce a layer of the plastic deformation near the surface and work-harden the near surface material. And there has a wide variety of the parameters which are known to influence the effectiveness of the shot peening process which can be principally categorized as shot, target and flow parameters. In practice, however, shot peening process is not described by each of the single mentioned process parameters, but principally by coverage percentage ([1], [2], [3]) Almen intensity and type of the used peening media. These are the key parameters for industrial calibration of shot peening process.

Keywords - Shot peening, work-harden, Finite element analysis, high-velocity, Balls.

I. INTRODUCTION

In this paper, we will use the finite element analysis software (ABAQUS) to do the simulation for the shot peening process. ABAQUS is robust finite analysis software for engineering simulation which can solve the problems from the relatively simple linear analysis to many complex non-linear problems ([4], [5], [6], [7], [8], [9]). From the simulation in ABAQUS, we can get the residual stress near the surface of the plate, and based on the distribution and value to guide the actual production.

II. THE THEORY OF SHOT PEENING STRENGTHENING

The shot peening strengthening is the process which balls of the high speed continuously flow to the workpiece's surface.

The flow of the balls looks like so many small hammers hit the metal surface which can produce a very strong plastic deformation near the surface of the workpiece. That means to produce the cold hardening layer which is called the surface strengthened layer. Fig.1 shows the change between before and after of the shot peening process.

From the point of the stress state, the high residual stress is produced in the strengthened layer. In terms of the structure of the organization, there are so many extremely dense dislocations in the strengthened layer, and the shape of dislocations will become polygons which are a regular arrangement under the action of the alternating stress and temperature.

And so the more tiny grains will be developed in the strengthened layer ([10], [11], [12]).

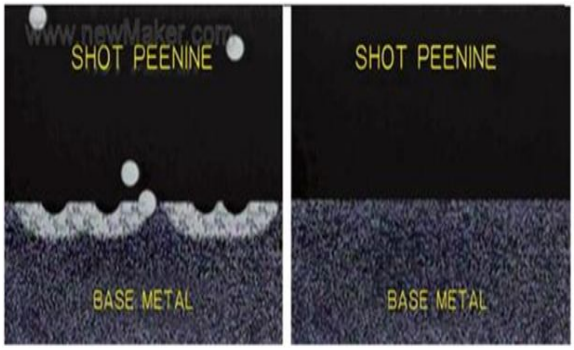


Fig.1:shows the change between before and after of the shot peening process.

III. THE PURPOSE OF THIS PAPER

In order to avoid the time and money consuming process of trial and error, computational mechanics have been applied to study the mechanical phenomena involved in shot peening process. During in this paper, we will use the finite element analysis to do the simulation based on the ABAQUS. Using the finite element analysis we want to get the value of residual stress of the surface strengthened layer ([12], [13]), and guide the shot peening process in a factory to get better quality.

The better quality of the production is closely related to value and distribution of the residual stress. After finishing the simulation we will export the value of the residual stress of the different depth in the vertical direction.

But the random locations and sequences of the balls are difficult to realize in ABAQUS's inherent module. This paper will use the Python language to write a unique script which can make the random locations and sequences of the balls true ([14], [15], [16]).

IV. THE REQUIREMENTS (BOUNDARY CONDITIONS)OF THE SHOT PEENING PROCESS AND THE LIMITATION OF THE BOUNDARY CONDITIONS IN ABAQUS

When using the finite element analysis purpose of the simulation must follow the actual. The shot peening process needs the steel balls continuously impact the surface of the plate, and the locations and sequences of the balls are random. The velocity of the balls is 40 mm/s ([17], [18], [19]). But the inherent module in ABAQUS is difficult to realize that random. Fig.2 shows the assembly model and the fixed locations and sequences of the balls before shooting.

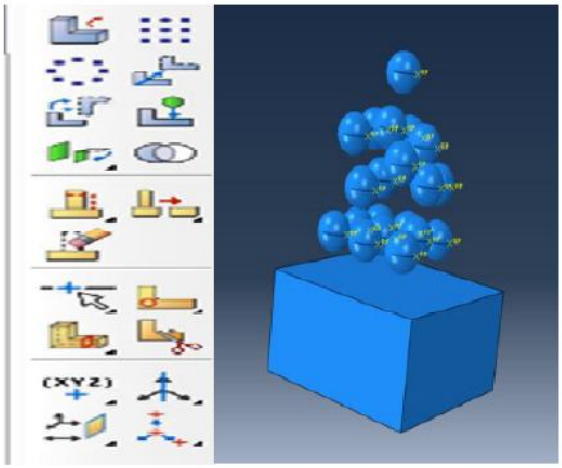


Fig.2: The assembly model in ABAQUS and fixed locations and sequences of the balls before shooting.

V. THE PRINCIPLE OF PYTHON SCRIPT TO REALIZE THE RANDOM LOCATIONS AND SEQUENCES OF THE BALLS

To achieve this goal, a new script has been developed in Python, which chooses a random position in the impact zone for the first shot; then, it simply subtracts the effective dimple area from the impact zone considering new borders for the impact area; thus for the next shot, it chooses a random position in the new impact zone. This approach does not let the distance between two impact centers to be less than the radius of dimple diameter. The procedure continues till the impact zone is completely covered by the effective indentations ([20], [21]). Fig.3 shows the first three steps of the procedure for choosing the impact centers in an attempt to simulate full coverage ([22]).

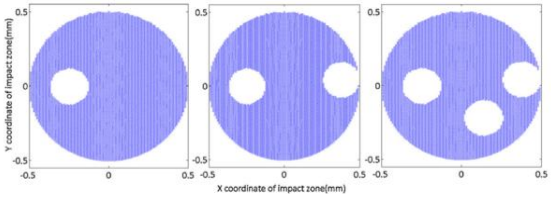


Fig.3:Impact pattern generated by the first three successive impacts by a Python script.

VI. THE SECOND SIMULATION OF 40 BALLS SEQUENCES DIFFERENT TIMES BYPYTHON SCRIPT

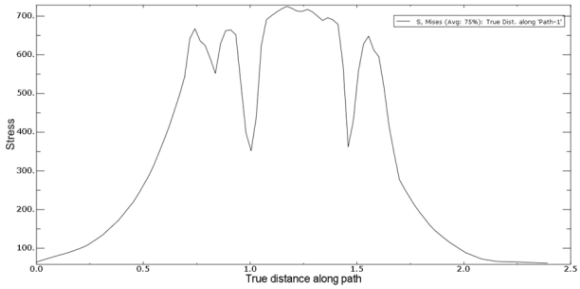


Fig.4: The residual stress curve of the horizontal path first time of 40 balls.

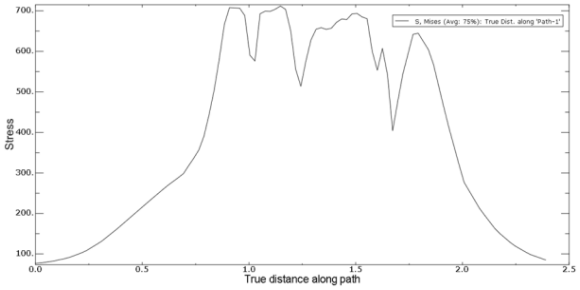


Fig.5: The residual stress curve of the horizontal path second time of 40 balls.

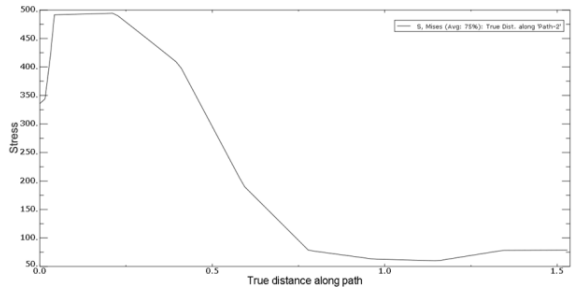


Fig.6: The residual stress curve of the vertical path first time of 40 balls.

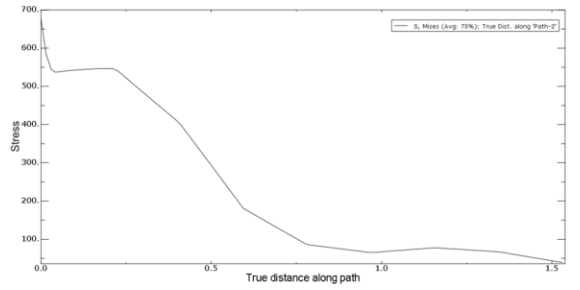


Fig.7: The residual stress curve of the vertical path second time of 40 balls.

Table1: The residual stress value of the horizontal path first time of 40 balls.

X/ True distance	Y/ Residual stress
0	64.2469
0.159513	90.382
0.319027	138.9
0.47854	241.721

0.638053	443.375
0.797399	615.241
0.954643	524.565
1.11281	707.68
1.27186	718.505
1.43087	572.622
1.58977	604.108
1.74925	224.982
1.90877	123.726
2.06828	74.2934
2.22779	64.3418
2.38731	61.3844

Table2: The residual stress value of the horizontal path second time of 40 balls.

X/ True distance	Y/ Residual stress
0	76.3346
0.15943	91.4433
0.318861	135.096
0.478291	205.71
0.637721	276.16
0.797123	407.042
0.956551	706.787
1.11494	702.251
1.27287	602.629
1.43206	680.077
1.59049	547.197
1.74924	609.316
1.90861	463.4
2.06804	219.994
2.22747	125.212
2.3869	85.041

Table3: The residual stress value of the vertical path second time of 40 balls.

X/ True distance	Y/ Residual stress
0	335.669
0.0757347	492.39
0.177918	494.097
0.280102	453.542
0.382285	403.576
0.484468	287.17
0.586652	180.444
0.688835	118.845
0.791019	75.4315
0.893202	67.0704
0.995385	62.1349
1.09757	60.5398
1.19975	66.672
1.30194	76.5955
1.40412	78.4111
1.5063	78.6298

Table4: The residual stress value of the vertical path first time of 40 balls.

X/ True distance	Y/ Residual stress
0	677.906
0.0765831	542.548
0.178894	546.296
0.281205	481.8
0.383516	405.056
0.485827	283.842
0.588139	172.583
0.69045	120.457
0.792761	82.1196
0.895072	70.6708
0.997383	68.4167
1.09969	75.3767
1.20201	73.8293
1.30432	68.0173
1.40663	54.2733
1.50894	38.94

SUMMARY AND CONCLUSIONS

The study reveals several multiple impacts at identical points that from one point of view correspond to the existing standard definitions, but on the other hand require high computational costs. From the finite element analysis in ABAQUS we can get the value of the residual stress in horizontal and vertical path. In this simulation we just done two times of the shot peening process, and output the value three points in horizontal and vertical path. Horizontal path: value of the first point (0.159) is 90.382 and 91.4433. Second points are 707.68 and 702.251. Third point is 74.293 and 219.994. Vertical path: residual stress value of the first point (0.17) is 494.097 and 546.296. Second point is 118.845 and 120.457. Third point (1.51) is 78.6298 and 38.94. For example we change the number of the balls and velocity, and also we can change the material of the

balls to get better quality of the shot peening process ([23]).

RESULTS

Every time every ball is random by the python script. Every time run the script we will get a different locations and sequences of the balls. That is mean that the residual stress of the strengthened layer. We get the value of the residual stress from different lines in the strengthened layer ([24], [25],[26]).

In post-processing two paths are defined to show the residual stress's value every time. The first path is (1368:976:-49, 40, 12313:12265:-1, 314, 3008, 3057, 3106, 3155, 3204, 3253, 3302, 3351, 3400) which is a middle line on the surface of the strengthened layer. And the second path is (12249, 12298, 12347, 38415, 38366, 38317, 38268, 9946) which is a line perpendicular to the surface.

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