RELAXATION OF RESIDUAL STRESS DISTRIBUTION PRODUCED BY SHOT PEENING UNDER FATIGUE TEST

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ABSTRACT

Residual stress distribution produced by shot peening was decreased in early time under fatigue test of plate bending method. Shot peening was performed by steel shot intensity
0.15A-0.74A to anneald medium carbon steel specimens. Residual stres was measured by Xray window process. The distributions of residual stress are all C type, which has the maximum stress at peened surface. Relaxation of residual stress distribution appeared exceedingly by small stress amplitude under fatigue test.

KEYWORDS

Residual stress, Residual stress distribution, Fatigue test, Shot peening.

1. Introduction

It is already well known for shot peening to increase fatigue strength of machine elements and residual stress contribute mainly to such effect (1) (2) (3). Residual stress distribution produced by shot peening has two types, the one is C type and the other is S type, the former is induced in annealed steel or rather soft metals, the latter is induced in hard metals such as carburized or quenched steels. In this study, the distribution is all C type.

2. Experiment

Peening conditions, specimen and fatigue test conditions are as follows.

Peening conditions

1) shot: cast steel
2) machine: air pressure type
3) sign, shot size, intensity, surface residual stress:
   SP1 0.18mm 0.15A -466MPa
   SP2 0.39mm 0.26A -369MPa
   SP3 0.65mm 0.46A -410MPa
   SP4 0.92mm 0.74A -419MPa
4) coverage:100%

Specimen

1) material: 0.45% carbon steel
2) treatment: 900°C 1hr annealed
3) form: as shown in Fig.1

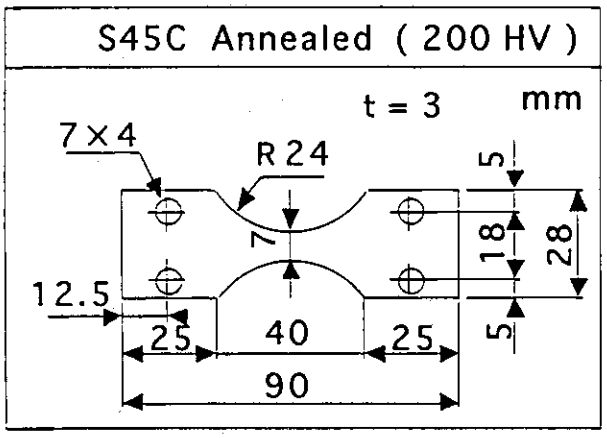


Figure 1 Specimen

Fatigue test conditions

1) machine: alternating plate bending
2) stress ratio: R=-1
3) endurance limit stress: at 10^7 times

3. Results

Fig.2, shows various distributions produced by shot peening. Residusl stress distribution (a) shows that the most deeply spread one induce from the most strong intensity SP4 and the most shallow one induce from the most weak intensity SP1. Half width (b) and hardness(c) are similler distribution.

Fig. 3. Shows S-N diagram of fatigue test. The difference of fatigue strength between anneald and peened is clear and SP2, SP3 and SP4 are similler.

Fig.4, shows the distribution of residual stress after fatigue tese at 10^5 times and each stress amplitudes are 1%, 10% and 80% of fatigu limit strength respectively from the results of fatigue test as shown in Fig.3. The more the stress amplitude increase, the less the residual stress distribution decrease.

The shallow distribution SP1 is rapedly vanished under small stress amplitude but on the other hand the deeply spread distribution SP4 is decreased slowly without vanishing.

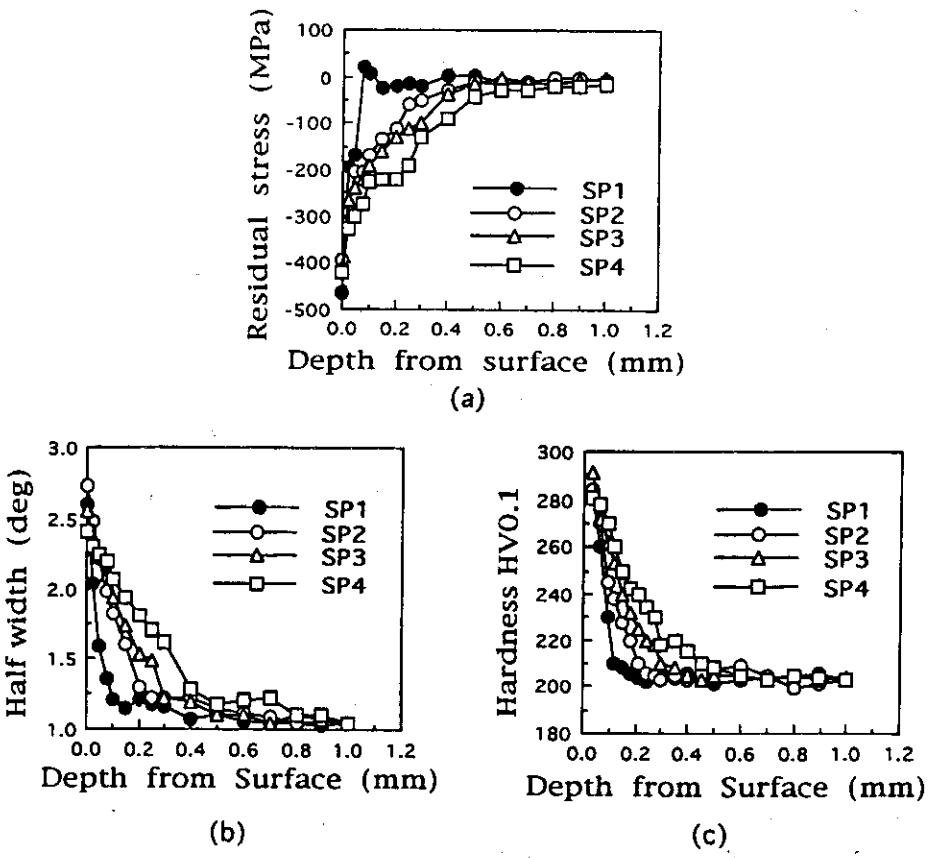


Figure 2 Distributions of residual stress, half width and hardness

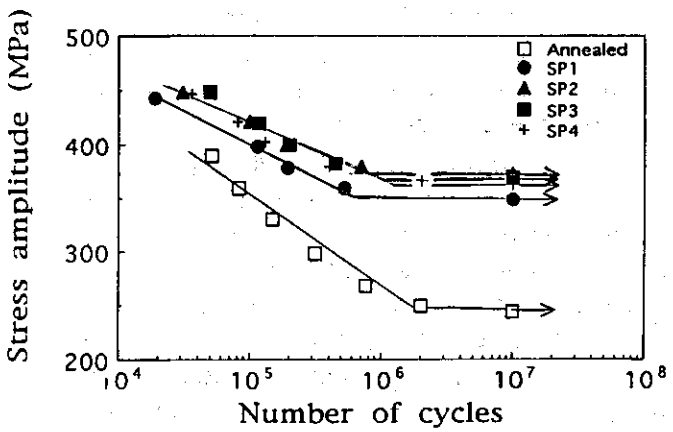


Figure 3 S-N Diagram

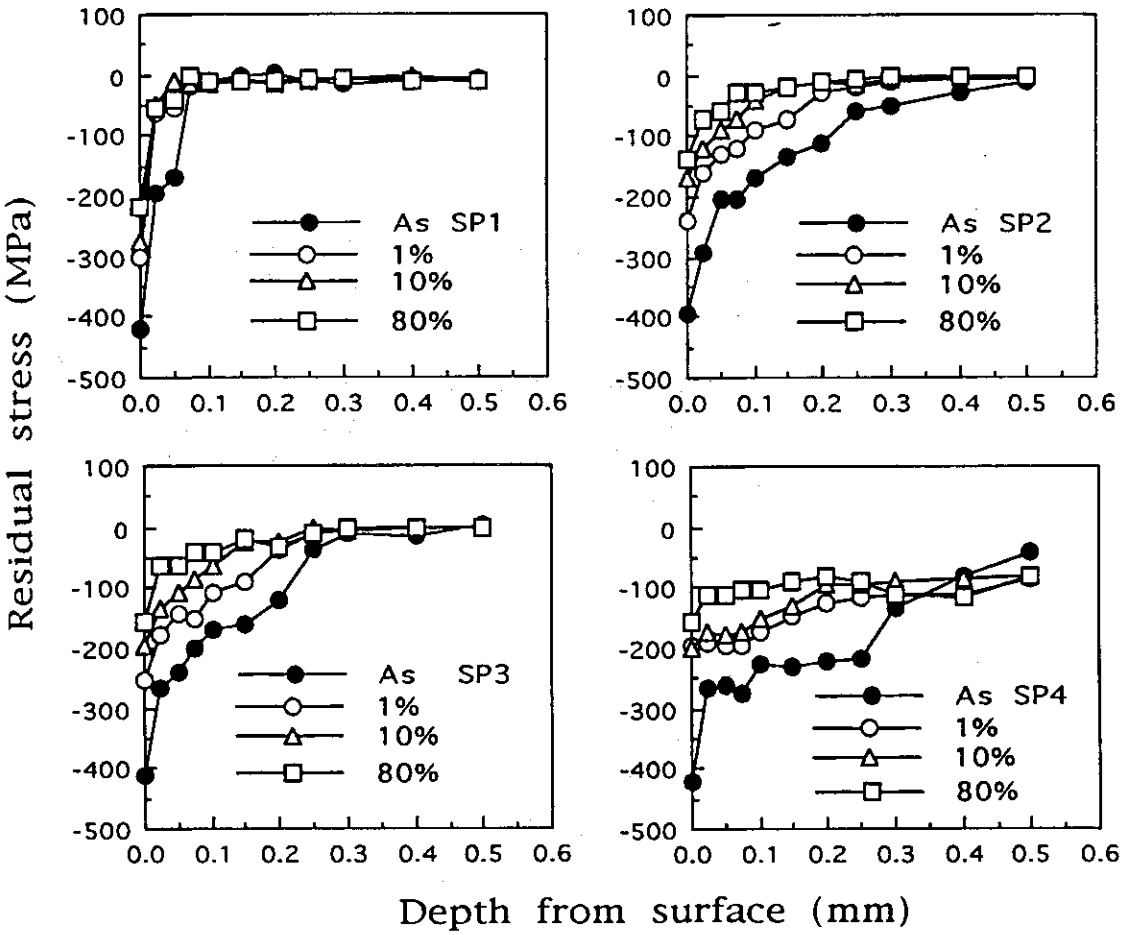
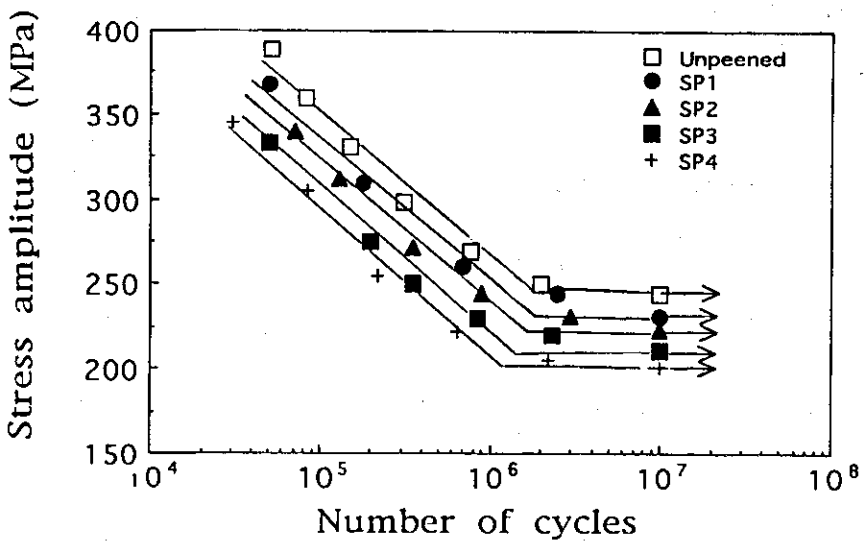


Figure 4 Residual stress distribution at 10^5 times under several stress amplitude

Relation between residual stress and fatigue strength is not always clear enough. Residual stress has several factors such as distribution, surface value, maximum value, C type or S type, depth of compressive residual stress, integrated value from surface and so on. These factors are related somwhat to fatigue strength but not yet clear. Fatigue strength is not related initial or remained residual stress in fatigue test.

Peened surface has three factors related to fatigue strength, the one is residual stress and the second is work hardened surface layer and the third is surface roughness. The 1st and the 2nd are effective to fatigue strength, but the 3rd is not effective. In this study, after shot peening, specimen was annealed removing the 1st and the 2nd factors,

and then fatigue test was performed. The result was shown in Fig. 5. The most hevy impacted specimen SP4 is the most weak one, and this result shown the relation such as the surface roughness affects in inverse propotion to fatigue strength, namely fatigue strengh decrease in proportion to the surface roughness. Fatigue strength of peened specimen is always affected these three additional or minus factors. Therefore, it is a difficult problem to obtain the pure effect of residual stress. In this study, the behavior of the residual stress distribution under fatigue test is not clear relations between fatigue strength and the distribution but shows rapidly decrease phenomenon of residual stress at surface and insiside. Residual stress don't keep initial destribution under various stress amplitude.



Figur 5 S-N Diagram of annealed specimen after shot peening

4. Conclusion

Relaxations of residual stress distribution under fatigue test are as follows.

1. Relaxation apears under small stress amplitud
2. Relaxation of shallow distributed residual stress is more than deep destributed one.
3. There is no direct relation between fatigue strength and relaxation of residual stress distribution of C type.
4. The remained surface residual stress at 10^7 times is the maximum-352 MPa and the minimum is -238 MPa in this experiment.

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