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THE RESIDUAL STRESS DISTRIBUTION IN SHOT PEENED CARBURIZED STEEL UNDER FATIGUE

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ABSTRACT

Shot peening increased the fatigue strength of various machine parts. This effect consists of the compressive residual stress and work hardening in surface layer. But it is reported that on annealed 0.45% carbon steel the residual stress induced by shot peening was relaxed in fatigue process[1)2)]. So, in this study carburized steel was tested. Residual stress distribution of carburized steel differs from annealed 0.45% steel. The maximum compressive residual stress of carburized steel is larger than that of annealed 0.45% steel. The distribution of shot peened carburized steel was not changed in fatigue process.

KEY WORDS

Shot peening, Carburized steel, residual stress, half width, fatigue stress

1. SPECIMEN AND CONDITION OF EXPERIMENT

Fig. 1 shows geometry of specimen and heat treatment. After carburizing specimen were shot peened with three condition as shown in Table 1. Table 2 shows condition of experiment.

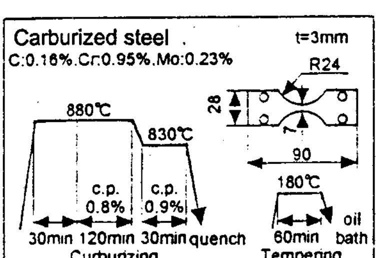

Fig. 1. Geometry of Specimen and Carburizing Condition

TABLE 1. Shot peening Parameter

	shot media		arc hight [mmA]
	dia. [mm]	HV	
SP.L(st.)	0.92	550 cast steel	0.72
SP.S(st.)	0.39		0.31
SP.S(wc)	0.39	1500 cemented carbide	0.24

TABLE 2. Condition of experiment

Shot peening SP.L(st) SP.S(st)	direct pressure type 3.0 kgf/cm^2 full coverage distance from nozzle to specimen 200 mm
Shot peening Sp.S(wc)	suction type 6.0 kgf/cm^2 full coverage distance from nozzle to specimen 60 mm
Fatigue test	plain bending R – 1 frequency 25 Hz
Vickers hardness test	weight 100 gf time 30 s
X-ray stress measurement	X-ray Cr – K α diffraction Fe - α (211) $\sin^2\psi$ method window ϕ 4 mm

2. RESULTS OF EXPERIMENT

2.1. Fatigue Test

Fig. 2 shows S-N curves after fatigue test. The fatigue limit at 10^7 cycles was increased for all shot peened specimen.

Fatigue limit of SP.L(st.) was the most increased 28%.

2.2. Residual Stress Distribution

Fig.3 shows the distribution of the residual stress, half width and hardness. The maximum residual stress was – 900 Mpa to – 1400 Mpa below surface.

Residual stress of unpeened specimen was compressive – 300 Mpa induced only by carburizing.

The more large shot size the more deep compressive residual stress induce, but the maximum residual stress is decreasing. The difference between SP.S(st) and SP.S(wc) was little in this experiment.

The distribution of hardness was not increased by shot peening. Work hardening is occurred by plastic deformation. Fig. 4 shows the surface roughness produced by shot peening and the maximum is 1.3 μm, then small plastic deformation. Fig. 4. Shows the surface roughness produced by shot peening and the maximum is 1.3 μm, then small plastic deformation was occurred at surface. But this plastic deformation was too little to increase the hardness.

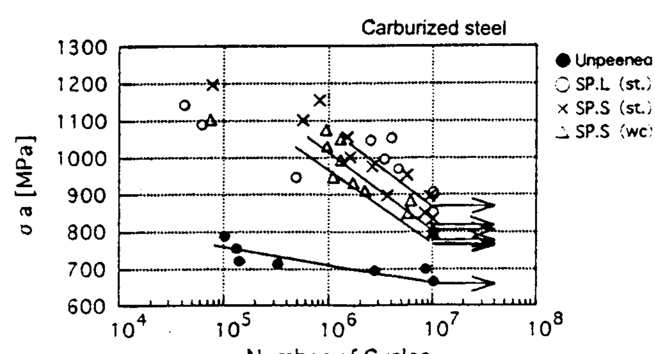

Fig. 2. S-N Curve

It was known that metal working as cutting or shot peening increases the half width value at surface[3)]. But the distribution of half width in Fig. 3 decreased by shot peening.

Generally half width increase with hardness. But in Fig. 3 the half width had no relation to the hardness as for the carburized steel.

2.3. Before and after fatigue test distributions of residual stress, hardness and half width

Fig. 5 and Fig. 6 show the influence of fatigue test for the residual stress, hardness and half width. The distribution before and after fatigue test (after 10^7 cycle) was compared.

The stress amplitude in these graphs was fatigue limit, therefore, under these stress amplitude specimen is not broken after 10^7 cycles.

The compressive residual stress was not decreased by fatigue tests. This was different to the case of annealed 0.45% c steel.

The hardness and half width was also not changed before and after fatigue test. The fact that hardness and of half width was not changed during fatigue test are the same to the case annealed 0.45% c steel.

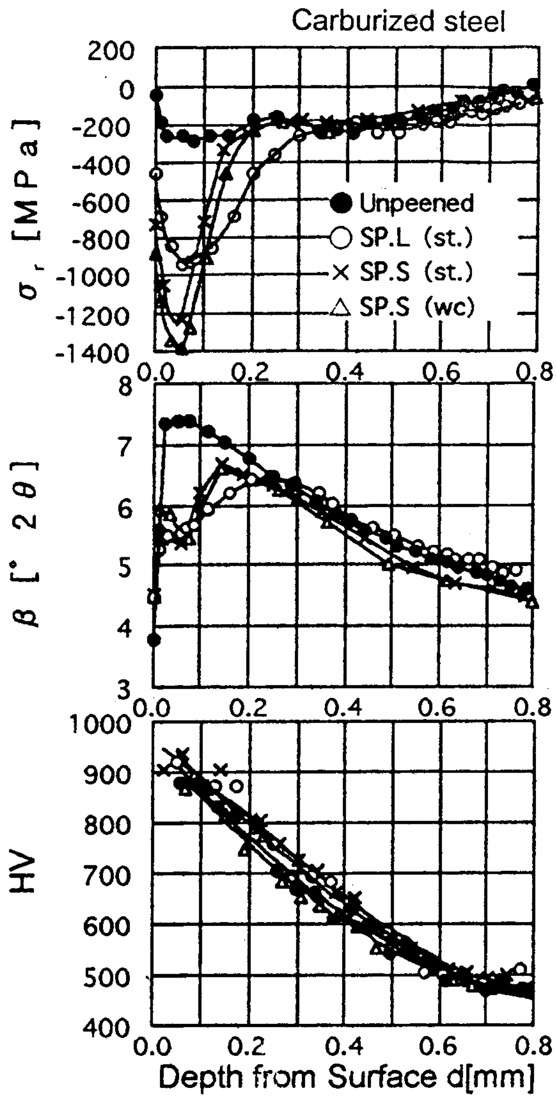

Fig.3 Distribution of residual stress, half width and hardness

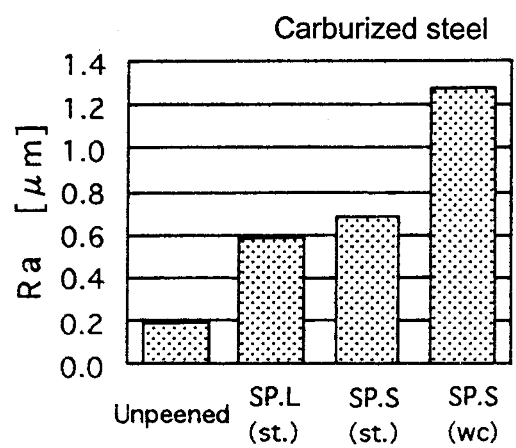

Fig.4 Surface roughness

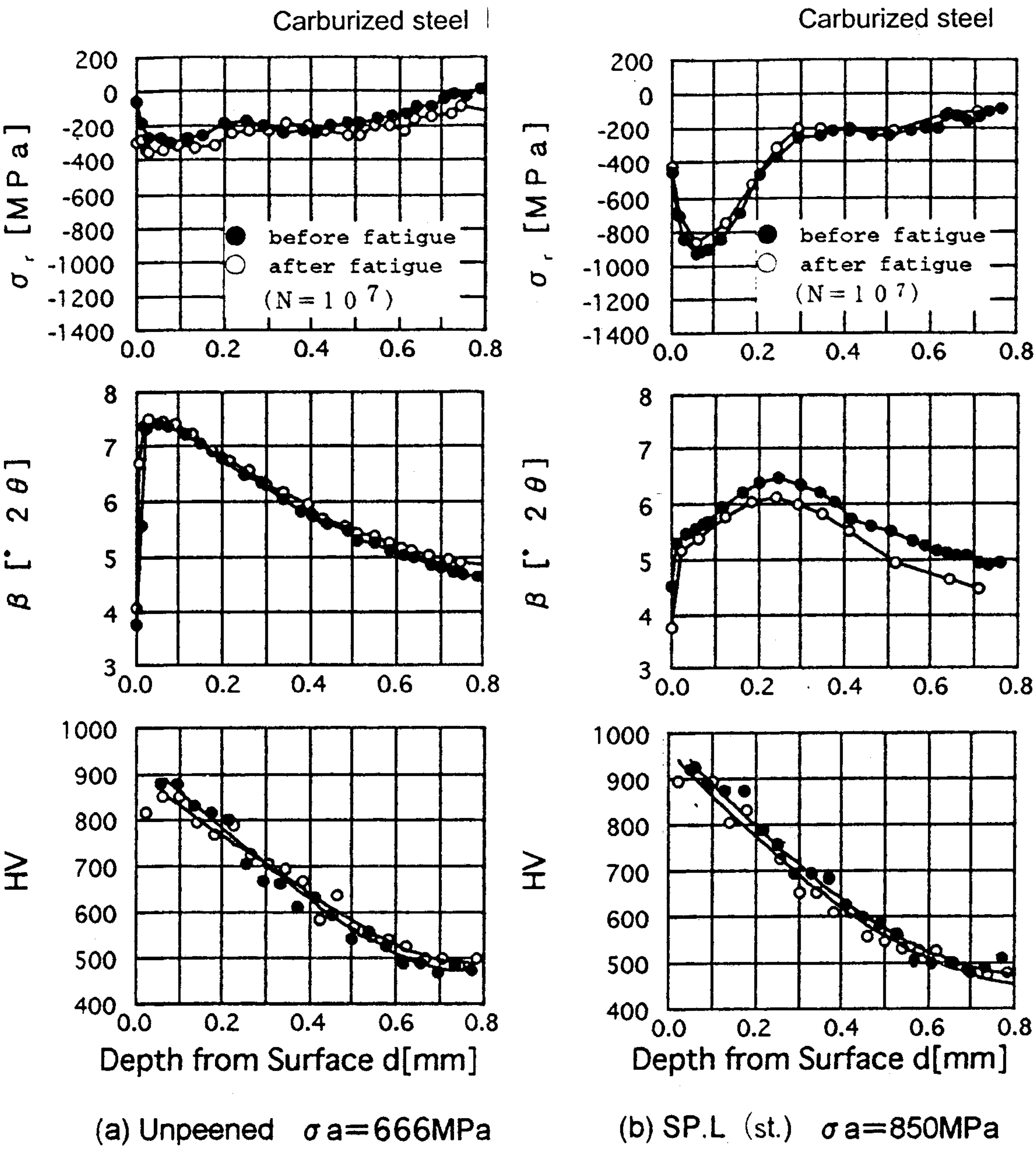

Fig.5 Before and after 10^7 fatigue test distribution of residual stress, half width and hardness.

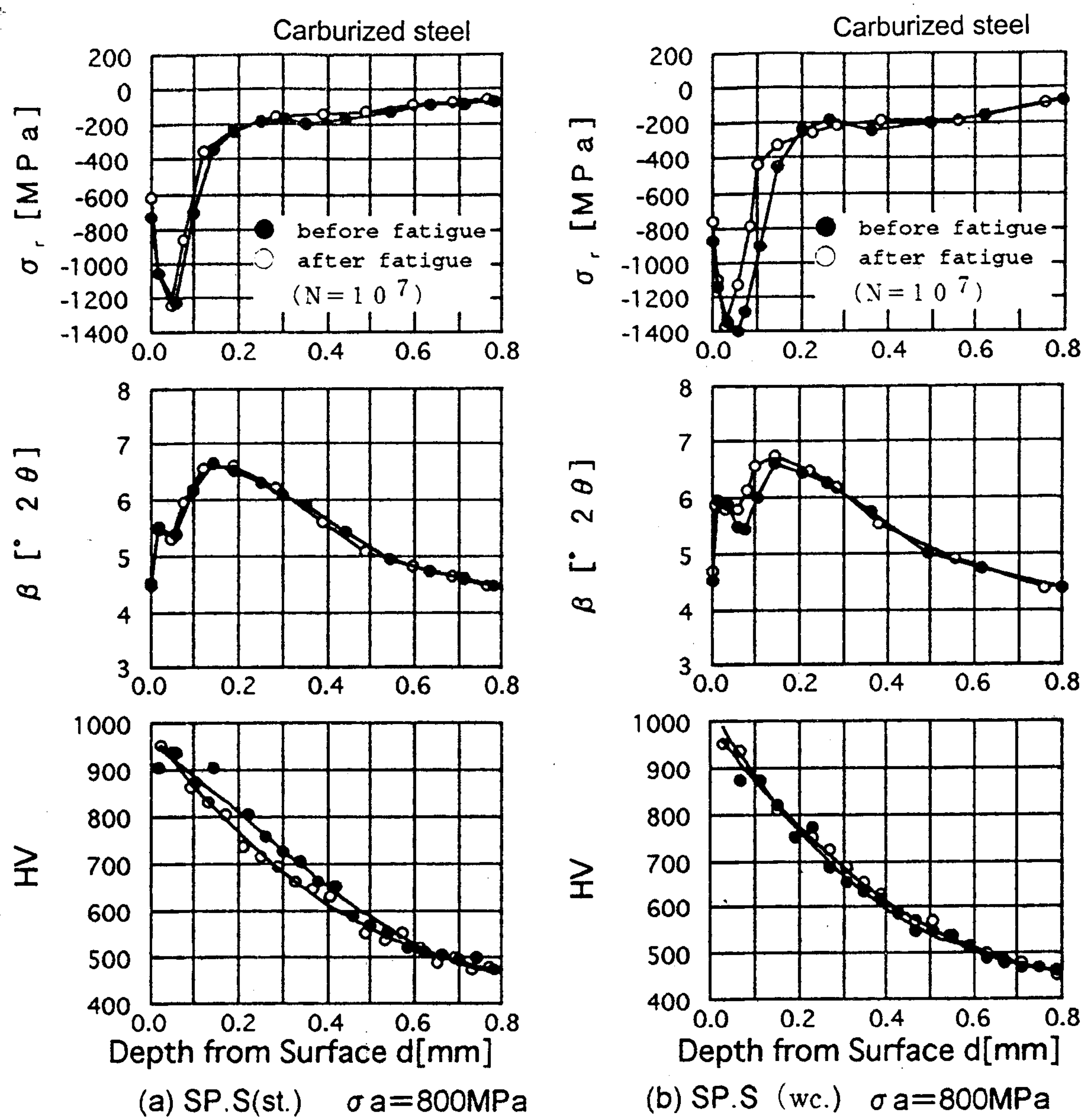

Fig.6 Before and after 10^7 fatigue test distributions of residual stress, half width and hardness.

2.4. Change of the residual stress, half width and hardness in fatigue test until breaking

Under more high stress amplitude which broke specimen at 10^6 cycle (alternating stress: 1150 Mpa) distribution of residual stress, hardness and half width was shown in Fig. 7, shot peening condition is SP.S(st).

Residual stresses, half width and hardness were also not decreased under fatigue tests. The brittle fracture of carburized steel was noticed from observation of the surface fracture.

3. CONCLUSIONS

The conclusions obtained from this test can be summarized as follows:

1. Shot peening improved the fatigue limit (25%) of carburized steel and induced S-type residual stress distribution.
2. In carburized steel work hardening was not observed in this shot peening condition.
3. Under fatigue process the residual stress distribution was not decreased. Hardness distribution and half width distribution were also not decreased.

4. REFERENCES

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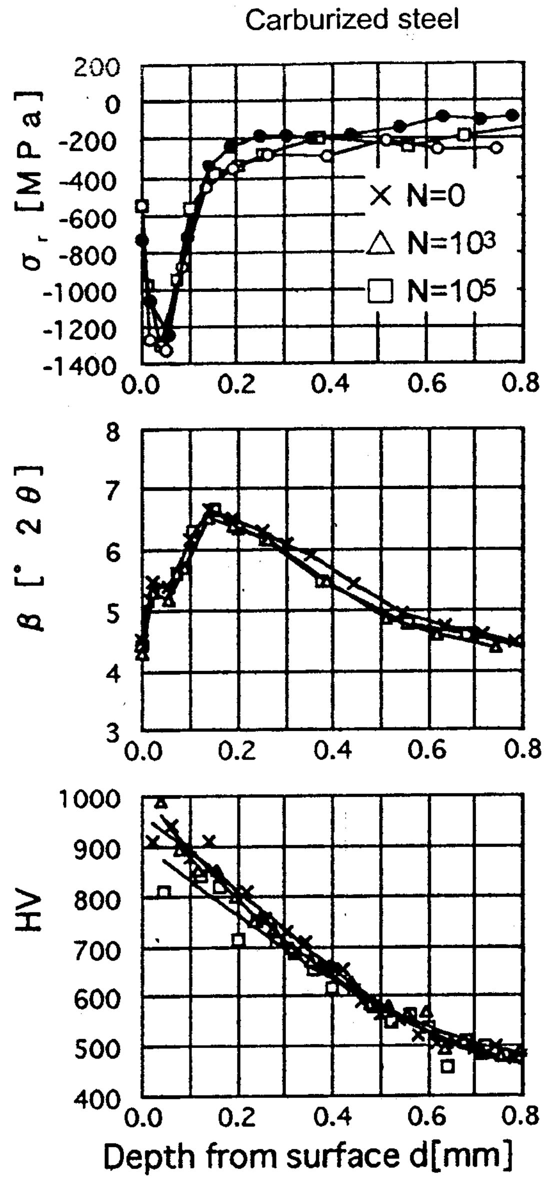

Fig.7 distributions of σr, β, HV until breaking (σa=1150MPa, SP.S (st.))