WORK-SOFTENING AND STRAIN-INDUCED TRANSFORMATION PRODUCED BY SHOT PEENING AND GRIT BLASTING FOR AUSTENITIC STAINLESS STEEL

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ABSTRACT

This paper describes on the characteristics of work softening and transformation produced by shot peening and grit blasting for austenitic stainless steel. Shot peening and grit blasting are performed by steel shot and grit with a centrifugal peening machine. Obtained factors are surface roughness, hardness distribution, half width, residual stress, diffraction intensity and retained austenite. Following results are obtained. (1)Strain-induced transformation is confirmed by compression, shot peening and grit blasting from X-ray diffraction. (2)Half width decreases in the work-softened zone. (3)Work-softening has no relation to residual stress distribution and retained austenite. (4)The maximum work-softening ratio was 8.3 % in this experiment.

KEYWORDS

Shot peening, grit blasting, work-softening, strain-induced transformation, retained austenite.

INTRODUCTION

Austenitic stainless steels are widely used in various industries such as mechanical, chemical, atomic, medical and processed food. But recently, SCC and corrosion fatigue of austenitic stainless steel are often reported as accidents. Although it is widely known that shot peening and grit blasting are very effective for them (1)(2)(3), the relation between these processes and the strain-induced transformation of crystal structure is not clear enough.

Work-softening phenomenon generally happens under combined heavy cold deformation for FCC or BCC metals such as steels, copper, aluminum and brass, and is completely different from Bauschinger effect. This phenomenon appears on the prestrained metals by shot peening as already reported (4)(5), and also reported recently as to the relations with the strain-induced transformation by shot peening and grit blasting (6).

In order to clarify the characteristics of work-softening and strain-induced transformation produced by shot peening and grit blasting for austenitic stainless steel. Shot peening and grit blasting were performed by steel shot and grit with centrifugal type blasting machine. Obtained factors are strain-induced transformation, surface roughness, hardness distribution accompanied work softening, half-width, retained austenite volume and residual stress.

EXPERIMENTAL PROCEDURES

Table 1 shows experimental conditions.

Table 1. Experimental conditions

Shot peening & Grit blasting	Equipment	Centrifugal type	
	Shot & Grit	Material: steel	
		P1, G1	D : 0.64 mm
		P2, G2	D : 0.92 mm
		P3, G3	D : 2.2 mm
	Velocity V	35 m/s	
	Peening time	T_f: full coverage time	
	Impact angle	Normal to the peening surface	
Prestrain	Compression	ε %	C1:10, C2:20, C3:35
Specimen	Material	SUS304: 18Cr, 8Ni, steel	
	Size	φ18×18 mm	
Residual stress measurement	X-ray diffraction, (220) plane, $\sin^2\psi$ method, Iso-inclination method		

Confirmation of strain-induced transformation was tried from the observation by etching with aqua regia and from the change in the X-ray diffraction pattern, In order to measure the residual stress distribution and to confirm strain-induced transformation in the affected layer, the window (4 × 4 mm) was made by electrolytic polishing. Residual stresses are calculated from the following equation.

$$\sigma_R = -\frac{E}{2(1+\nu)} \cot \theta_0 \frac{\partial 2\theta}{\partial \sin^2\psi}$$

Where E = 192 GPa and ν = 0.28.

In order to produce the work-softening by shot peening and grit blasting, compressive deformation was performed previously for specimens. Johnson wax #111 was used as the lubricant between the specimen and anvils. This lubricant was dried for 12 hours, and then the specimen was compressed very slowly to avoid the thermal influence.

EXPERIMENTAL RESULTS

Strain-induced transformation:

As reported in the previous paper(6), the peak of X-ray diffraction neighbored on 149° shows that the structure of the annealed specimen is clearly austenite. The height of this peak is decreased by compressive strain, and at the same time, another peak arises neighbored on 156° as strain-induced transformation, and this peak is (211) plain of alpha-Fe.

Hardness distribution:

Figure 1 shows the influences of shot peening and grit blasting on the hardness distributions for annealed and for prestrained specimens. The type of hardness distribution changes from work-hardening to work-softening with the increase of the prestrain. The maximum ratio of work-softening was 8.3 % on grit blasting and 7.1 % on shot peening.

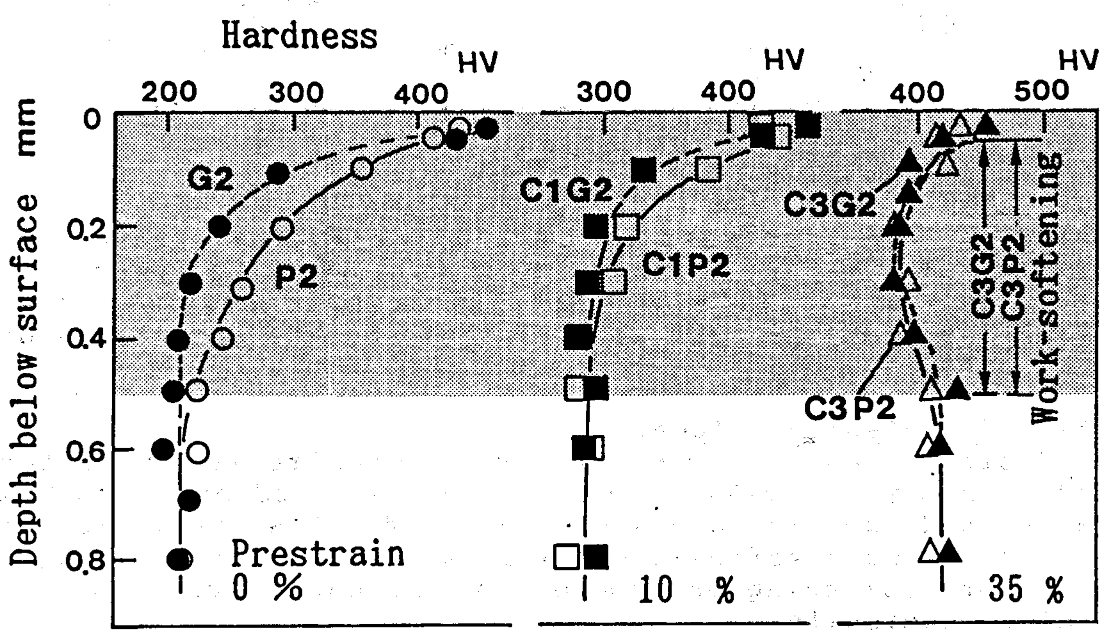

Fig.1 Hardness distributions (P2 and G2).

Half width distribution:

Half width means the micro strain of the crystals and appears similar to the hardness distribution. The distributions of half width by shot peening and grit blasting are shown in Fig.2. Because the half width of the work-softened zone decreases, the work-softening phenomenon produced by shot peening or grit blasting means the relaxation of micro strain of the crystals. Dark layer in Fig.2, Fig.3 and Fig.4 is work-softening zone.

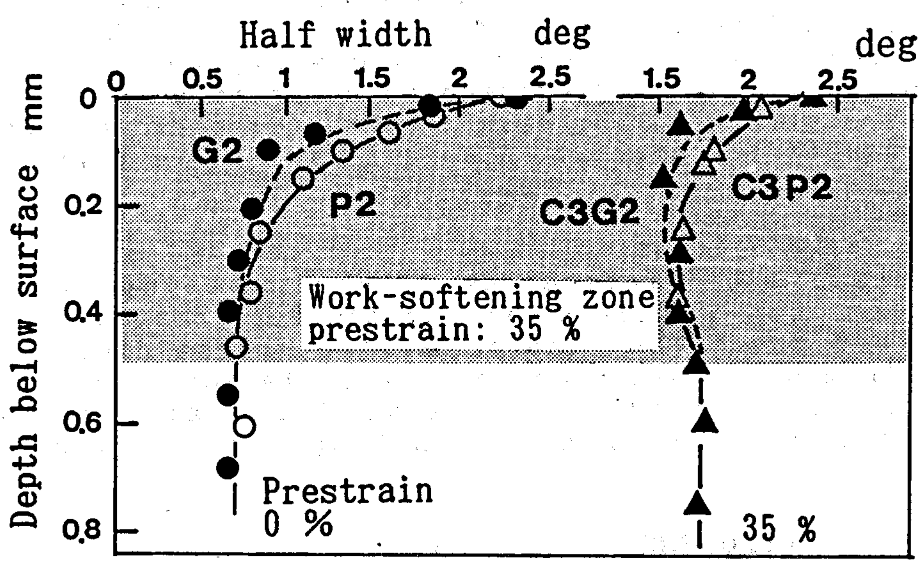

Fig.2 Half width distribution (P2 and G2)

Residual stress distribution:

The residual stress distributions after shot peening and grit blasting for annealed and for 35 % prestrained specimen are shown in Fig.3. Their residual stress distributions are similar, but not concerned the phenomenon of work-softening.

Retained austenite volume:

The distributions of the ratio of austenite volume after shot peening and grit blasting for annealed and for 35 % prestrained specimen are shown in Fig.4. This result is not similar for work softened results as shown in Fig.1. Therefore, work-softening phenomenon is not concerned with the retained austenite.

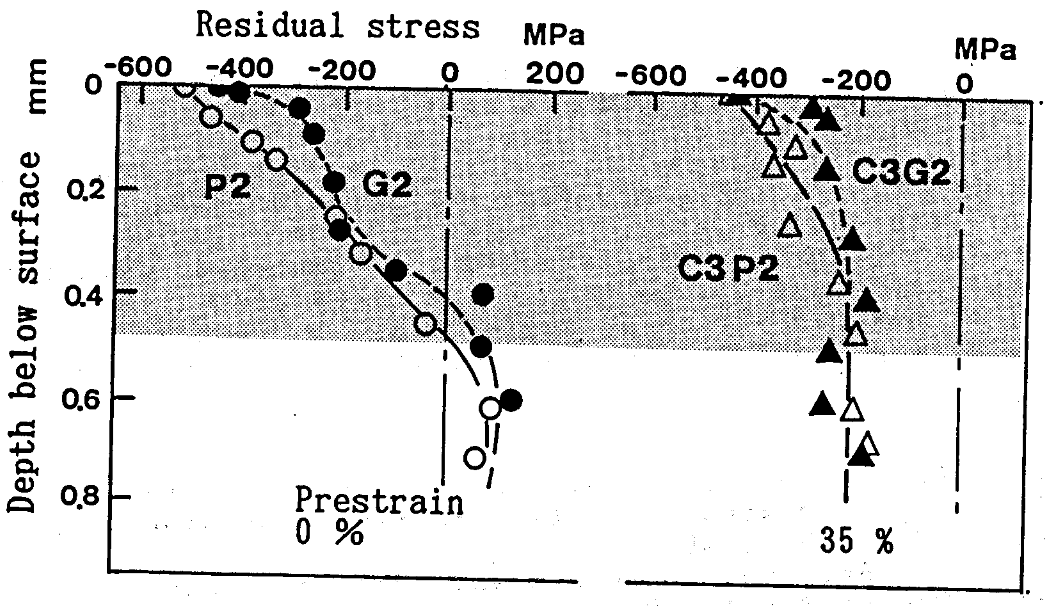

Fig.3 Residual stress distribution (P2 and G2)

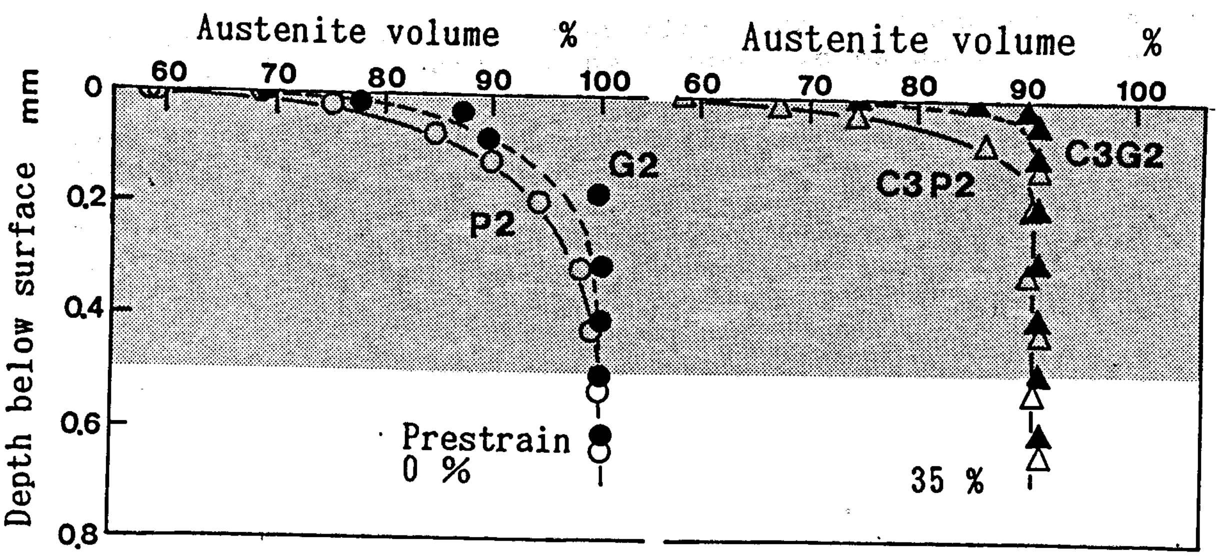

Fig.4 Retained austenite volume distribution (P2 and G2).

CONCLUSIONS

(1) Strain-induced transformation produced by shot peening and grit blasting is confirmed from X-ray diffraction.

(2) Hardness distribution shifts from work-hardening type to work-softening type by shot peening and grit blasting with previous compressive strain.
(3) Owing to decrease of half width in work-softened zone, the work-softening may induce the relaxation of microstructure of crystal.
(4) Work-softening phenomenon is not concerned with residual stress distribution and retained austenite.
(5) The maximum softening ratio is 8.3 % produced by grit blasting and 7.1 % by shot peening in this experiment.

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