

VARIATION OF SURFACE RESIDUAL STRESS MEASURED BY SEVERAL X-RAY PROJECTION AREA FOR PEENED SURFACE

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ABSTRACT

The purpose of this study is to clarify the influence of X-ray projection area on the residual stress value. Shot peening was performed for plain carbon steel under several conditions (shot material: cast steel, shot size: 0.28-2.2 mm, velocity: 35 m/s, full coverage time). At first, residual stress on the peened surface were measured with several X-ray projection area (0.15 - 2 mm), and then on machined and ground surfaces to compare with the peened surface. The results obtained are as follows: (1)The less the projection area of X-ray, the more the amount of scatter, and the small area shows 20 % larger averaged value than the large area. (2)Over 1 mm of the diameter of the projection area, the value of residual stress become constant.

KEYWORDS

Shot peening, surface residual stress, X-ray projection area.

INTRODUCTION

It is widely known that residual stress affects on mechanical properties such as fatigue strength and stress corrosion cracking, but the quantitative influence of residual stress on their properties are not clarified yet. Almost all the measurements of residual stress are performed by X-ray diffractometer, but the residual stress value is changed by X-ray projection area.

In order to clarify the influence of X-ray projection area on the residual stress value, shot peening was performed for plain carbon steel under several conditions. At first, residual stresses on the peened surfaces were measured with several X-ray projection areas, and then on machined and ground surfaces to compare with the peened surface.

EXPERIMENTAL PROCEDURES

Experimental conditions are shown on work material and shot peening in Table 1, and on machining, grinding and residual stress measurement in Table 2.

Table 1 Work material and shot peening

Specimen	Material (S45C)	Plain carbon steel (0.45 %C) 180 HV		
	Size	Shot peening	25×25×12 mm	
		Machining	φ 45 mm	
		Grinding	25×25×12 mm	
Shot peening	Equipment	Direct pressure type		
		Nozzle diameter: 5 mm		
		Centrifugal type		
	Shot	Material: cast steel		
		D mm	0.28 (P1)	
			0.55 (P2)	
0.92 (P3)				
2.2 (P4)				
Peening time	T _r : full coverage time			
Impact angle	Normal to the peening surface			

Table 2 Machining, grinding and residual stress measurement

Machining	Tip: WC (STi20, P20)	Geometry: 0.5, 11.6, 30, 0, 0.8
	Cutting speed: 142 m/min	Feed rate: 0.15 mm/rev
	Lubrication : Dry	Depth of cut: 2 mm
Grinding	Wheel: WA, 60, K, 6, V	
	Grinding speed: 21.5 m/s	Feed rate: 0.7 mm/str
	Lubrication: Emulsion type	Depth of cut: 10 μm
Residual stress measurement	X-ray diffraction, (220) plane. sin ² ψ method Iso-inclination method	

EXPERIMENTAL RESULTS

Residual stress on the peened surface:

Figure 1 shows the results on the residual stresses on the peened surface (P3), and they were measured by three different projection areas. The difference of residual stress between the values of maximum and the minimum increases with the decrease of the projection area, its value is affected by the surface roughness and microscopic residual stress distribution.

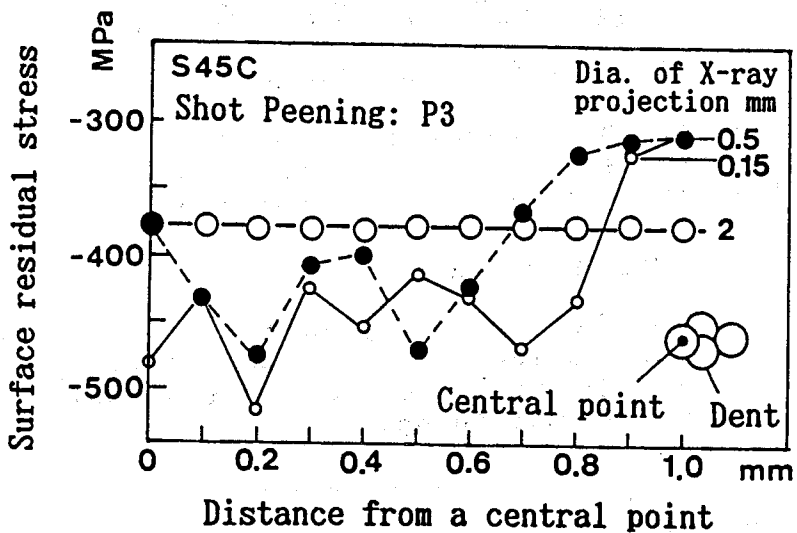


Fig.1 Influence of projection area on the surface residual stress produced by shot peening (shot peening: P3)

Residual stress on the machined surface:

Residual stresses on the machined surface are different on parallel and on perpendicular to the cutting direction. Figure 2 shows the surface residual stresses parallel to the cutting direction, measured by the same conditions as shown in Fig.1. These differences of surface residual stress also increase with the decrease of the projection area, but the differences are smaller than the results of shot peening shown in Fig.1. The reason why the machining is smaller is that the machined surface roughness is uniform compared with shot peening.

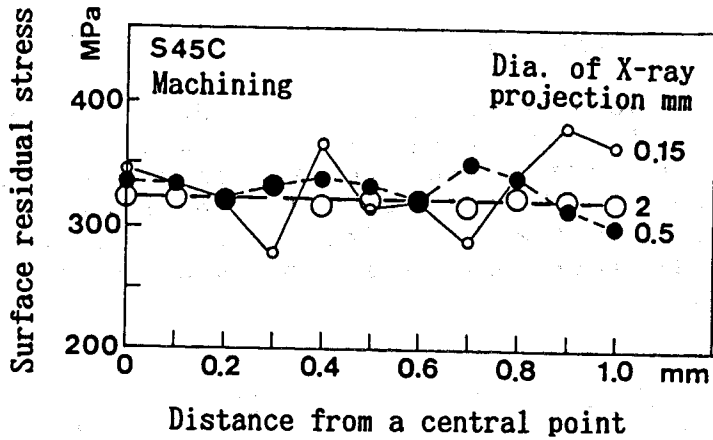


Fig.2 Influence of the projection area on the surface residual stress produced by machining. (Residual stress: parallel to cutting)

Residual stress on the ground surface:

Figure 3 shows the results on the ground surface measured parallel to grinding direction. The residual stress produced by grinding is similar to shot peening and the amplitude of stress is larger than the machining.

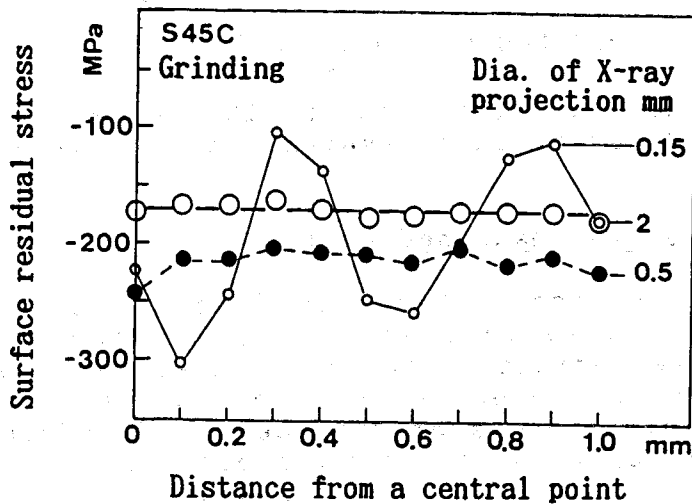


Fig.3 Influence of the projection area on the surface residual stress produced by grinding (Residual stress: parallel to grinding)

Influence of the projection area on the difference of surface residual stress:

Figure 4 shows the influences of projection area on the difference of surface residual stresses between the maximum and the minimum. The differences approach a zero and become negligible value where the diameter of projection area is above 1 mm.

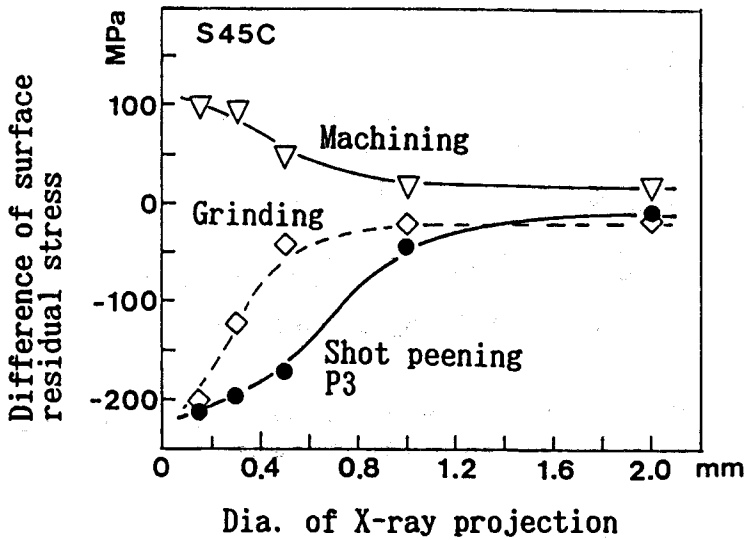


Fig. 4 Influence of the projection diameter on the difference of surface residual stress between the maximum and the minimum.

Figure 5 shows the influences of the projection area on the averaged value of surface residual stresses. The averaged value also approaches a constant value above 1 mm.

Influence of dent size on the surface residual stress:

The influence of the projection area is affected by the dent size produced by shot peening. The difference of surface roughness produced by the small size shot (P1) and the large size shot (P4) are shown respectively in Fig.6 and Fig.7. The more the dent size, the more the difference of the surface residual stress.

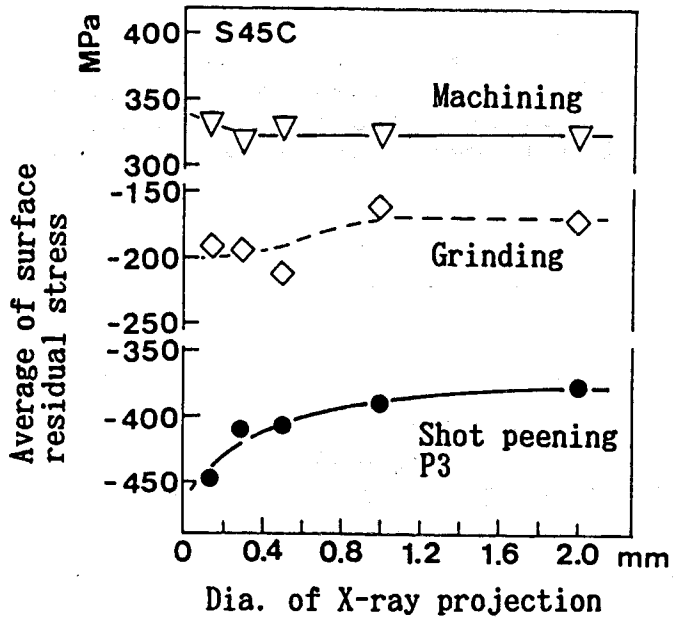


Fig.5 Influence of the projection area on the averaged value of surface residual stress.

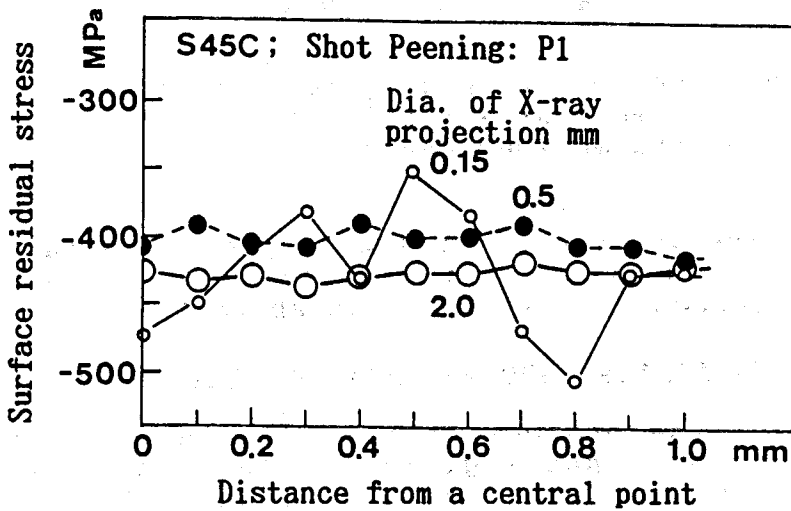


Fig.6 Influence of the projection area on the surface residual stress produced by shot peening (P1: small size dent)

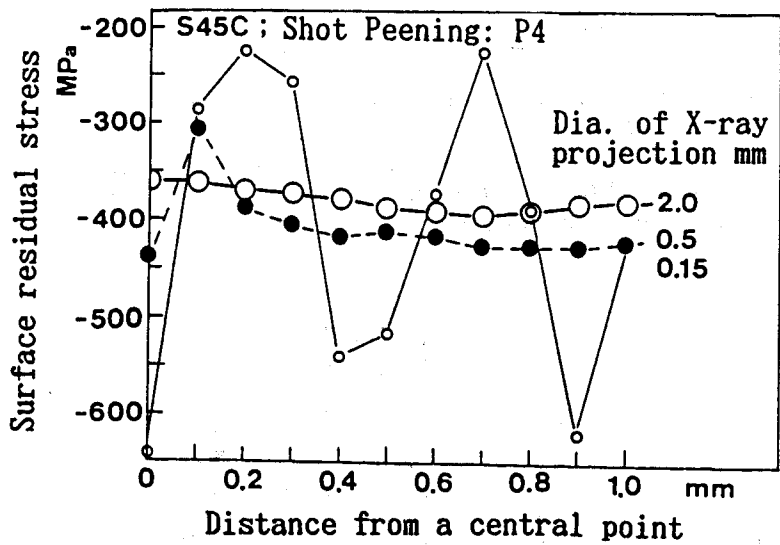


Fig.7 Influence of the projection area on the surface residual stress produced by shot peening. (P4: large size dent)

Figure 8 shows the influence of the projection area on the surface residual stress produced by shot peening (P1, P3, P4). The more the dent size, the more the difference.

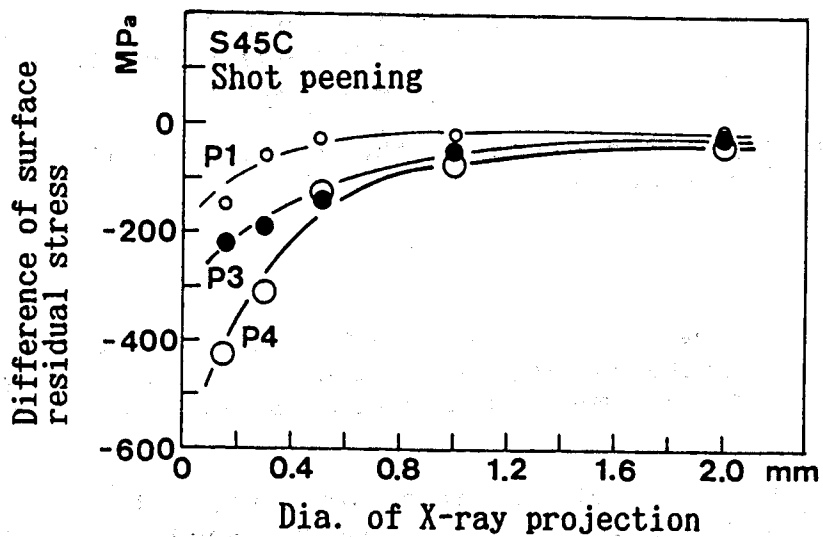
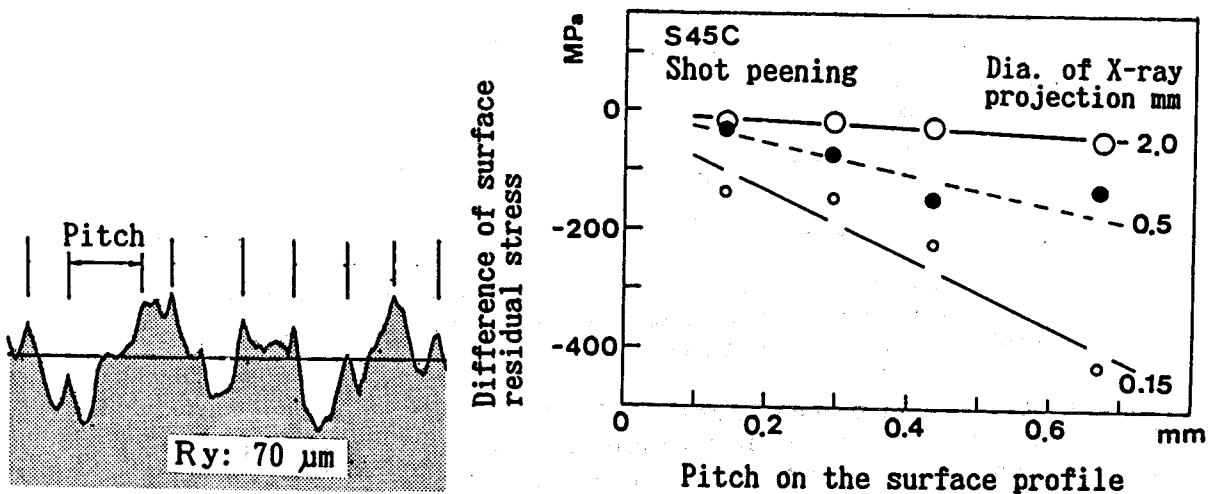


Fig.8 Influence of the projection area on the surface residual stress produced by shot peening.

Influence of pitch on the surface profile:

Pitch of surface profile was measured as shown in Fig.9 (a), and the relation between the pitch and surface residual stress produced by shot peening are shown in Fig.9 (b). These result means that the difference of the surface residual stress increases with the pitch.



(a) Pitch on the surface profile (P4)

(b) Relation between pitch and difference of surface residual stress

Fig.9 Influence of the pitch on the difference of surface residual stress produced by shot peening.

CONCLUSIONS

In order to clarify the influence of X-ray projection area on the residual stress values, shot peening, machining and grinding were performed. The results obtained are as follows:

- (1) The less the projection area of X-ray, the more the amount of scatter, and the maximum averaged value of scatter is 20 % in this study.
- (2) Over 1 mm of the diameter of the projection area, the value of residual stress become constant.