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Searching for the Most Suitable Condition and the Suggestion of Each Application in Ultrasonic Shot Peening

Kaneshi Hattori, Yoshihiro Watanabe, Mitsuru Handa
Tokyo Seiko, Japan
Jean-Michel Duchazeaubeneix
Sonats, France

1 Abstract

Ultrasonic shot peening, named Stressonic®, developed by SONATS, is being popularized among aeronautic industries for production parts and maintenance application because of its compact equipment that allows treatment partially and it can be integrated into production line.

However, Stressonic® has a big difference in processing method compared to that of classical shot peening. Therefore, the peening management, which influences the peening effect, needs to be renewed.

In this report, treatment conditions as amplitude, shot media (material, diameter), injecting distance, are set as Stressonic® management items. Then the most suitable Stressonic® condition is experimented by intensity and residual stress distribution obtained from the management above. Stressonic® application is also studied using parts, such as gears and springs, and confirmed its quality after Stressonic® process.

As a result of study and experiment, Stressonic® application has an outstanding peening effect.

Key words: ultrasonic shot peening, bearing ball, tungsten carbide ball

2 Introduction

Ultrasonic shot peening (USP) treatment has a lot of characteristics which are different from classical methods in principle and results. The outline of the principle is shown in Figure 1. A piezoelectric transducer emits ultrasonic waves at 20kHz. The waves are amplified when they travel through an acoustic booster. Finally by way of SONOTRODE, the kinetic energy is transmitted to shots. The dimension of the vibrating part, SONOTRODE, which contacts shots allows vibration amplitudes of 50 to 200 microns to be attained. In case the amplitude is 90 microns, the injection velocity of shots is approximately 10 to 20 m/sec. The shots strike the vibrating walls and are reflected off the surface. Then they collide with one another. The balls are scattered randomly throughout their encasing, like molecules of gas. A homogeneous treatment is obtained on the injected surface. At this study, the effects of shot amount and injection distance were examined.

Generally stainless balls, bearing balls or tungsten carbide balls which have high spherical accuracy and smooth surface are used as the shot media. The surface roughness after USP treatment becomes the smoothest that could never obtained in the classical methods

using high hardness shot to apply high compressive residual stress distribution. In USP treatment, combined (so-called multi) shot peening is not required because of the applied high compressive residual stress distribution and the smoothest surface. At this study, the housing for a carburized gear and a nitride valve spring are proposed, also the residual stress distribution and the surface condition are examined. Further the system to harden the bearing ball is introduced and the hardness distribution is measured.

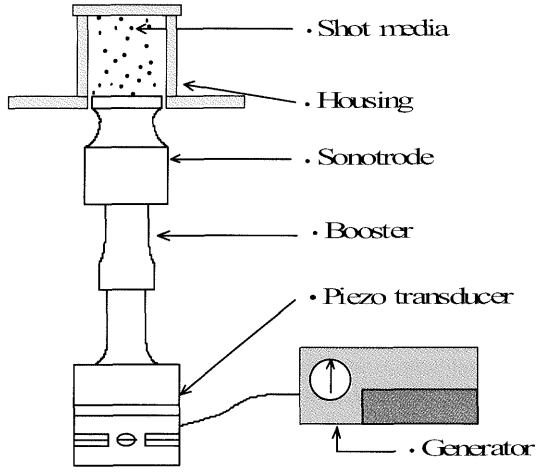

Figure 1. Principle of USP treatment

3 Experimental Procedures

First of all, the effect of the shot amount on the intensity was examined. The variation of coverage was observed by pressure sensor film. And the intensity was measured by almen

Table 1. Test (1) Conditions

SONOTRODE	Diameter	(mm)	70
	Amplitude	(μ m)	90
Shot	Material		SUS304
	Diameter	(mm)	0.6
	Hardness	(HV)	461
	Amount	(g)	2.5 , 5.0 , 10.0
	Possession rate	(%)	13 , 26 , 52
Injecting condition	Injecting time	(sec)	5
	Injecting distance	(mm)	30
Pressure sensor film	Measurable range	MPa	0.5 ~ 2.5

A-strip. The test conditions are shown in Table 1. Figure 2 and 3 show the shape of shots and an application to measure intensity.

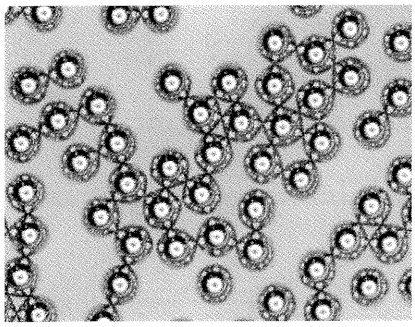

Figure 2. ϕ 0.6mm shot

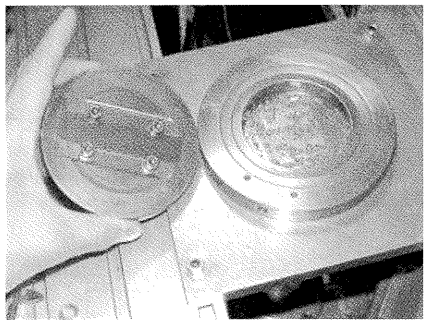

Figure 3. Intensity measuring application

(2) Relation between amount of shot and intensity, and 100% coverage time were measured minutely. Also the influence of injecting distance were investigated. Test conditions are shown in Table 2.

Table 2. Test (2) Conditions

SONOTRODE	Diameter	(mm)	70	
	Amplitude	(μ m)	90	
Shot	Material		SUJ2	Tungsten carbide
	Diameter	(mm)	1.2	0.86
	Hardness	(HV)	850	1,500
Injecting condition	Distance	(mm)	10, 20, 30	

4 Results

The result of test (1) is shown in Figure 4. The uniform color developed in peened area (70mm diameter) of each condition show that Ultrasonic shot peening was treated homogeneously. Also both of the coverage and the intensity show a constant tendency to decrease when the shot volume is increased. It seems that there is interference among the shots themselves.

The result of test (2) is shown in Figure 5. Figure 5a and 5b show there are the best conditions which can satisfy both of the higher intensity and the shortest full-coverage time. Figure 5c shows that the distance is an important factor in USP, because doubled (tripled) distance requires treatment time of the same ratio (doubled or tripled).

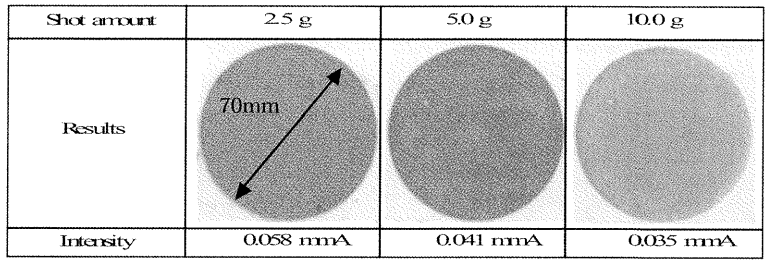

Figure 4. Intensity and result of pressure sensor film

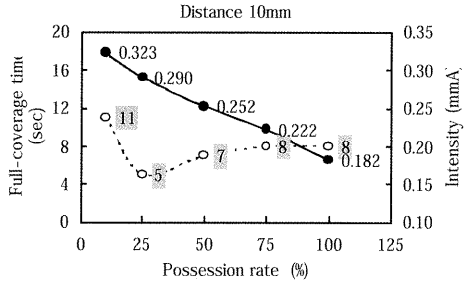

Figure 5a. Effect of shot amount (SUJ2 1.2mm)

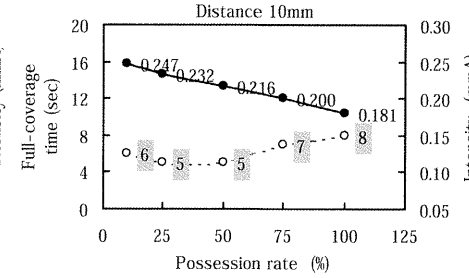

Figure 5b. Effect of shot amount (Tungsten carbide 0.86mm)

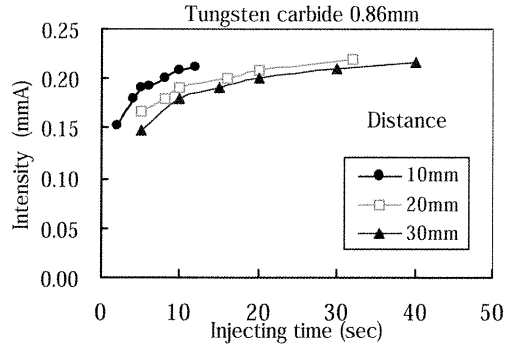

Figure 5c. Effect of injecting distance

5 Suggestions

In this section, some applications for a gear and a spring are proposed. And the qualities (residual stress distribution and surface condition) after USP treatment are reported. Also the circulation system to harden the bearing ball is introduced which developed in TOYO SEIKO and the distribution of hardness is also reported. The image how to shot-peen gear in USP treatment is shown in Figure 6.

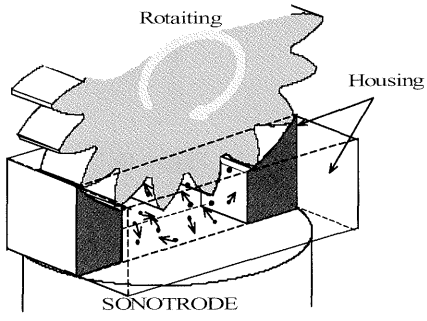

Figure 6. Application for gear

The residual stress distribution after USP treatment to carburized gear is shown in Figure 7. The result of SEM observation of the peened surface is also shown as Figure 8. There is few changes in the roughness value before and after.

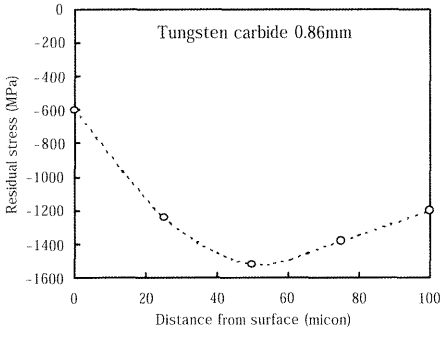

Figure 7. The residual distribution

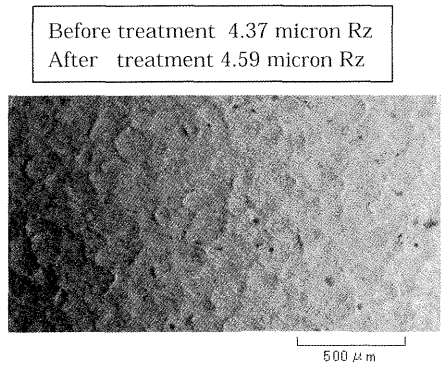

Figure 8. SEM observation of the surface after USP with tungsten balls 0.86mm

The image of the application for a valve spring is shown in Figure 9. The spring was pressured from both sides. In case of nitride spring, an endowed compressive residual stress value could exceed –2000MPa at the peak. The residual stress distribution after USP treatment to nitride spring is shown in Figure 10.

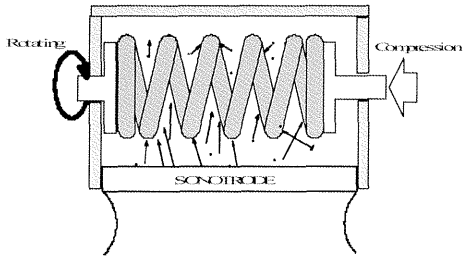

Figure 9. The application for a spring

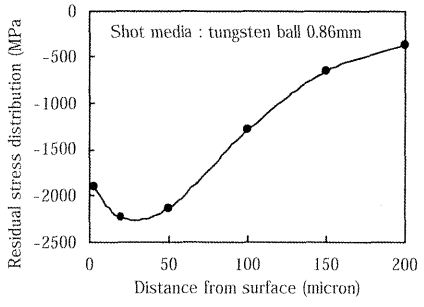

Figure 10. The residual stress distribution

Bearing balls were shot peened themselves at USP treatment. To manufacture more durable bearing balls, the circulation system for balls under 0.6mm diameter was developed. The result of hardness distribution before and after is shown in Figure 11. The work hardened layer are confirmed.

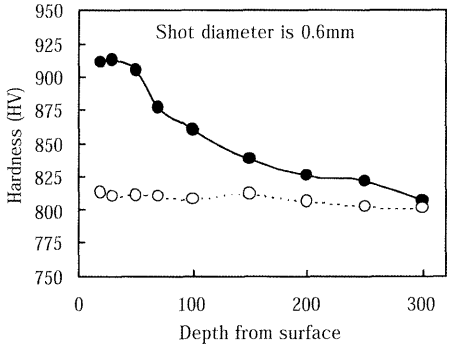

Figure 11. The distribution of hardness

6 Conclusions

Ultrasonic shot peening has unique characteristics summarized as below.

1) Shot amount, injecting distance are important factors to obtain the highest peening effect.
2) This is a suitable method to obtain a larger residual compressive stress distribution without a deterioration of surface condition.