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THE TEMPERATURE CHANGE ON SURFACE OF WORKPIECE DURING PEENING

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ABSTRACT

A study has been made to investigate the temperature change on surface of specimen using a thermograph during shot peening. It was confirmed that the temperature change of annealed specimens is greater than that of carburized specimens, as well as an occurence of temperature ascent when peening with smaller shot. However, the softened smallest shot experienced only slight temperature changes. This change was caused mainly by abrasion.

Key words : Shot peening, Temperature, thermograph, abrasion

1 INTRODUCTION

Shot peening is widely recognized as a proven cost-effective process to enhance the fatigue life of metal parts, especially automotive parts[1]-[3]. By utilizing shot peening, engineers will be able to increase the life and the load on both new and existing designs, without increasing size or adding weight to critical components. The main reason to improve fatigue durability is to increase surface residual compressive stress and work hardening at surface layer. There are many studies to confirm the effect of shot conditions, shot peening time, velocity, shot hardness, and diameter, on a residual stress profile. However, there were few studies to investigate the temperature of a specimen during the shot peening treatment.

Temperature was measured using the thermograph against two types materials at several shot conditions. The volume of abrasion, hardness profile, residual stress distribution, and microphotograph were taken. It was confirmed that the ascent in temperature was observed for the softer material caused by abrasion.

2 EXPERIMENTAL PROCEDURES

2.1 Surface temperature

An infrared thermograph produced by JAPAN AVIONICS was used to measure temperature. This machine analyzed the profile of surface temperature by detecting the ultrared ray radiated from teh workpiece. Data of surface temperature was taken at each 15 second interval. In order to protect the scope, a protective film was placed in front of machine lens. Calibration was done before testing in order to remove the influence of the film. A target, that was heated to 250 ℃ and then cooled to room temperature gradually, was prepared. After measuring the target using a thermocouple sensor, the data measured by this testing device was compared to the thermocouple's data. The formula to calibrate temperature is as follow :

$$T = 1.307 \times T_0 - 0.048 \qquad (1)$$

Here, T_0 : Temperature measured by this testing device

2.2 Shot peening conditions

Table 1 shows shot peening conditions. Specimens were not rotated in order to catch concentrated injections. Shot media and specimen are shown in Table 2 and 3.

Table 1 Shot peening conditions

Injecting pressure (MPa)	0.49
Peening time (s)	60
Injecting volume (kg/min)	10
Distance (mm)	110

Table 2 Shot media

	Type	Hardness (HV)	Diameter (mm)
1	Rounded cut wire	820	0.62
2	Rounded cut wire	820	0.25
3	Steel beads	820	0.15
4	Stainless beads	220	0.15

Table 3 Material and heat treatment

Material	Diameter (mm)	Heat treatment	Hardness (HV)
JIS SCM420	10.0	910 ℃ carburizing 830 ℃ oil quenching 160 ℃ tempering	700
JIS S48C	24.3	600 ℃ annealing	220

3 RESULTS

3.1 Surface temperature

Fig.1 and Fig.2 show the change in temperature of both specimens. ΔT in figures is the difference between temperature before testing and maximum temperature during recording. In case of the measurement for SCM420, three types of shot, having hardness of HV820, were injected. It was confirmed that there was little change during treatment; 0.9 ℃ increase in 0.62mm and 0.25mm diameter shot, and 1.1 ℃ decrease in 0.15mm shot. SCM420 is case hardened steel and generally used for gear material. Recently after carburizing, this steel was shot peened by using shot having almost the same hardness as the specimen in order to enhance fatigue life. As shown in the results, there was no variation in temperature

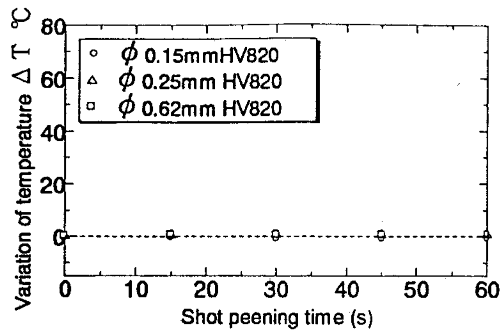

Fig.1 Variation of temperature (Material : JIS SCM420)

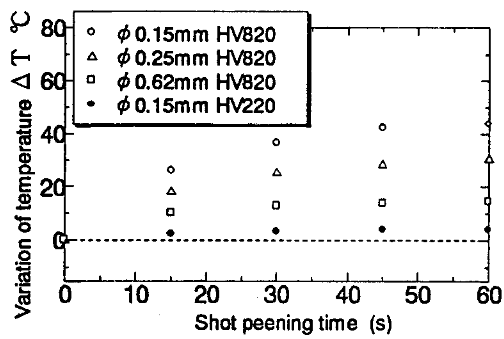

Fig.2 Variation of temperature (Material : JIS S48C)

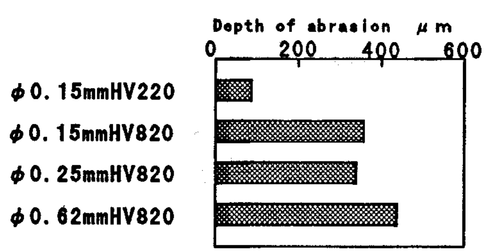

Fig.3 Depth of abrasion (Material : JIS S48C)

regardness high shot hardness.
On the other hand, with S48C, there is a remarkable difference in temperature, depending on the three types of diameter. The ascent in temperature increases as adiameter of shot decreases, and the hardness of shot increases.
Fig.3 shows the depth of abrasion after shot peening. In the case of SCM420, there was little abrasion. However, the depth on carbon steel was a hundred times deeper than that of case hardened steel. It is considered that themain reason of increased temperature is abrasion. The changing rate of surface temperature is not related to the cause of abrasion.

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3.2 Residual stress profile and hardness profile

In order to confirm the effect of shot peening, the surface residual stress and hardness profile were measured.

The surface residual stress of specimens after shot peening was measured by an X-ray diffractmeter with the 2θ-$\sin^2\psi$ method. Stress distribution was obtained by repeating the X-ray measurement and electrochemical polishing successively.

Fig.4 and Fig.5 show the residual stress profile for both materials, and Fig.6 and 7 show the hardness profile. At the results for S48C, residual stress profiles were almost the same dispite shot diameter and hardness being extremely different. However, workhardening was remarkably high in case of using the 0.62mm shot. There was no mutual relation between result of stress and the that of hardness. Neverthless, as size of shot increase an increasing proportional relationship in residual stress and hardness was observed (see Fig.4 and 6).

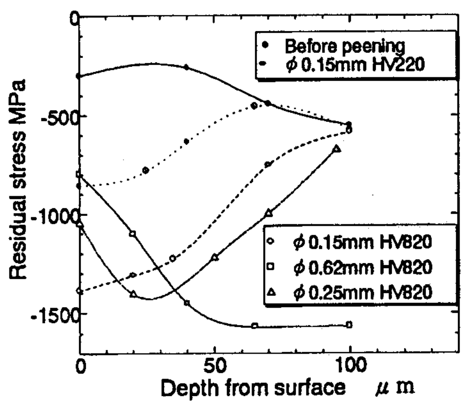

Fig.4 Residual stress distribution
(Material : JIS SCM420)

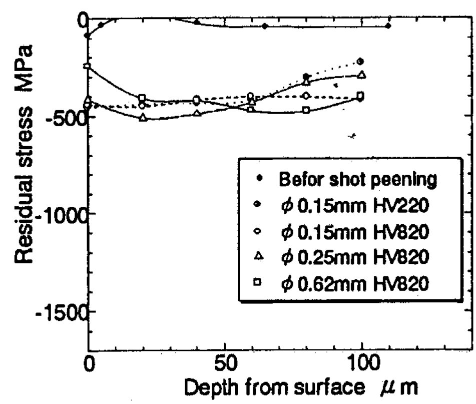

Fig.5 Residual stress distribution
(Material : JIS S48C)

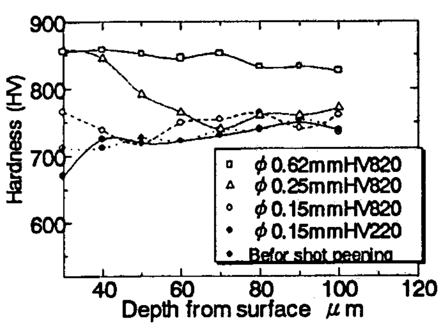

Fig.6 Hardness profile
(Material : JIS SCM420)

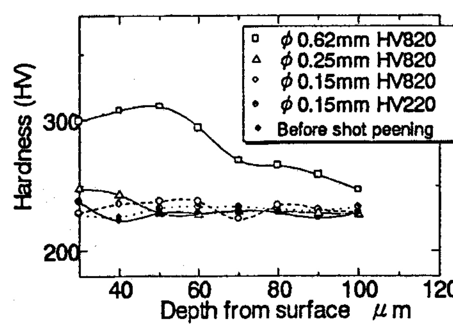

Fig.7 Hardness profile
(Material : JIS S48C)

4 DISCUSSION

4.1 The resistance for abrasion

As mentioned above, the depth of abrasion was 90 micrometers even if hardness between shot and material was identical same when using the 150 micrometer shot. However, abrasion was not observed at SCM420 despite using a harder shot compared with material. The mechanism of abrasion is considered that a yield at surface layer is occurred at first stage of abrasion, secondary yield layer will have brittle properties, and finally brittle regions are removed[4].

Fig.9 shows a microphotograph of the peened surface layer for S48C using, hardness of HV220 and diameter of 0.15mm shot. The microphotograph for SCM420, having been injected by HV820 and 0.15mm shot, is shown in Fig.9. In S48C, removing of brittle regions at surface layer was observed. No similar phenomenon was confirmed in SCM420 and a slightly plastic flow was observed.

4.2 Heating during abrasion

Ogawa[5] and Muller[6] suggested the velocity of shot media at air type peening device as follows:

$$V = K \cdot d^{-1/3} \cdot \rho^{-1/2} \cdot p^{x} \qquad (2)$$

Here, V : velocity , K and x : const. depending on machine and shape of nozzle, d : diameter ρ : density, p : pressure

In this study, velocity would be inversely proportional to diameter, because ρ and p are constant. Also, it is confirmed that ascent of temperature increases with increasing velocity. Fig.10 shows the relation between variation of temperature (Δ T) and $d^{-2/3}$. Here, Δ T is the difference between temperature at 60 seconds after injecting and initial temperature. As shown in this figure, the relation is linear.

$d^{-2/3}$ is like kinetic energy because the injecting volume is constant. Ascent of temperature by abrasion is mainly dependent upon the kinetic energy of shot media.

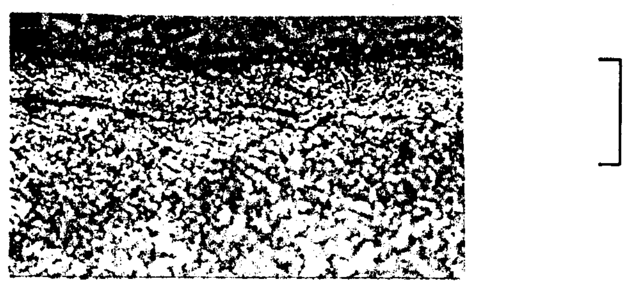

Fig. 8 Microphotograph (Material : JIS S48C)

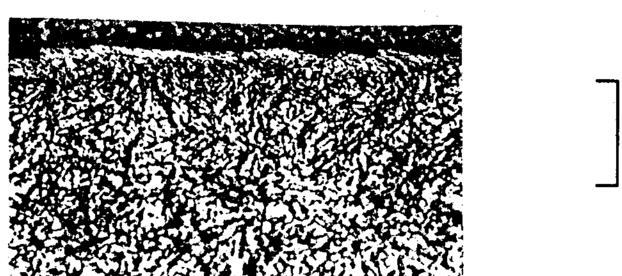

Fig. 9 Microphotograph (Material : JIS SCM420)

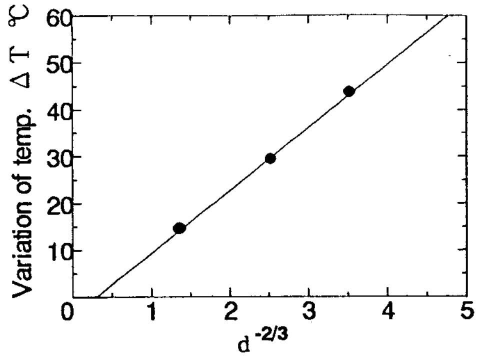

Fig.10 Relationbetween variationof temperature and $d^{-2/3}$

5 CONCLUSION

The variation of surface temperature by infrared thermograph for carbon steel S48C and case hardened steel SCM420 were measured. The results are summarized as follows;
At S48C, ascent of temperature was observed. A temperature increases with increased the difference in hardness between material and shot, decreases when using smaller shot. On the other hand, there was no ascent of temperature at carburized SCM420 steel during shot peening. It is considered that the main reason of this phenomenon is due to abrasion. This abrasion depends upon the kinetic energy of shot media.

REFERENCES

[1] S Hisamatsu, T Kanagawa, Proc. of Japan and China conference of Shot Peening, 1987

[2] Y Watanabe, N Hasegawa, K Namiki, A Hatano, Proc. of ICSP 4, 63, 1990

[3] C M Verpoot, C Gerdes, Shot Peening Theory and Application, 11, 1991

[4] K Tousha, Doctoral Thesis, 1995

[5] K Ogawa, T Asano, A Saito, K Kawamura, M Ogino, H Aihara, Proc. of JSME, 272,1990

[6] PP Muller, D Urffer, Proc. of ICSP 3, 49, 1987