THE DEVELOPMENT OF NEW TYPE ALMEN STRIP FOR MEASUREMENT OF PEENING INTENSITY ON HARD SHOT PEENING

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Abstract

In the hard shot peening, it has been pointed out that Almen A type strip is not proper as an index of peening effect, because the arc height measured by Almen A strip is not in good correspondence to surface residual stress. Based on this background, the relation between residual stress and the arc height measured by conventional C strip and the high hard trial strip with hardness of HRC 60 was investigated. It was concluded that the arc height measured by high hard trail strip was in good agreement with the maximum compressive stress and the magnitude of stressed layer.

KEY WORDS: hard shot peening, residual stress, arc height, carburized gear

INTRODUCTION

As the fatigue strength of high hardness materials such as automotive power train components which have been demanded to withstand high load is mainly ruled by residual stress on surface layer, it is essential to give compressive residual stress on surface layer. To meet these requirements, shot peening of carburized gears is becoming popular as one of the methods to enhance the fatigue durability [1]-[2]. Furthermore, "Hard Shot Peening" characterized by its larger shot injecting energy with the arc height higher than 0.6 mmA leads to an increase in fatigue strength by 25% compared to conventional peening process [3]-[5].

On the other hand, the arc height indicating peening intensity is ordinary measured by Almen strip A type, the hardness of which is HRC 44 to 50. In hard shot peening, however, it has been pointed out that this strip is not proper as an index of peening effects, because the arc height measured by A strip is not in good correspondence to surface residual stress [6].

In this study, it was confirmed the limitation of the arc height measured by A strip as the index to estimate residual stress. To find the new type suitable strip for hard shot peening, conventional C type strips and the high hard trial strip with hardness of HRC 60 were studied. Using these two type strips, the relation between the arc height measured by these strips and the maximum residual stress of shot peened carburized specimen was studied.

EXPERIMENTAL PROCEDURES

Table 1 shows the shot peening conditions. Shot media is Rounded Cut Wire with 0.8 mm diameter, having hardness of HV 550 and HV 730. Shot peening was carried out by centrifugal type peening machine with changing shot velocity from 40 m/s to 82 m/s.

To clarify the relation between arc height and residual stress, carburized plate specimens made of JIS SCM420, 19 mm width 76 mm length and 7 mm thickness, were prepared. Table 2 shows vickers hardness of the specimens after carburizing. The surface residual stress of specimens after hard shot peening was measured by X-ray diffractmeter with 2θ-$\sin^2\psi$ method. Stress distribution was obtained by repeating the X-ray measurement and electrochemical polishing successively.

Table 1: Shot peening conditions

Shot media	Rounded Cut Wire
Shot diameter	0.8 mm
Shot hardness	HV 550 and HV 730
Shot machine	Centrifugal type
Shot velocity	40 - 82 m/s
Peening time	420 s (coverage 300 %)
Table rotating cycle	3 cycles / 60 s

Table 2: Vickers hardness of carburized specimen

Surface (HV)	Core (HV)	Effective case depth (mm)
722	350	1.40

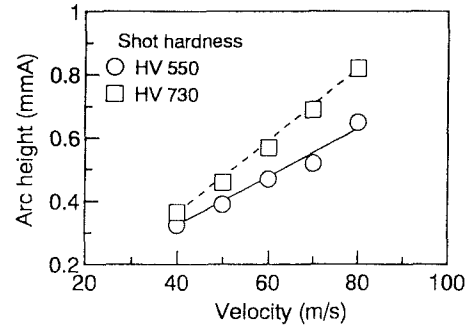

Fig. 1: The relation between shot velocity and arc height measured by A type strip

RESULTS

Figure 1 shows the relation between the arc height measured by Almen strip A type and shot velocity. At each shot hardness, the arc height increase with increasing shot velocity linearly. And at the same shot velocity, the arc height peened by HV 730 shot is higher than that by HV 550 shot. Here, the shot velocities required to obtain arc height 0.65 mmA are given from Fig. 1 as follows. The shot velocity for HV 550 shot is 82 m/sec, and 66 m/sec for HV 730 shot. Figure 2 shows the residual stress distribution of carburized plate specimens. It was confirmed that in spite of the same arc height, the maximum residual compressive stress and the magnitude of stressed layer peened with high hardness shot is higher and deeper than that peened with low hardness shot. Therefore, it is concluded that the arc height measured by Almen A strip is not in good correspondence to residual distribution, the maximum value and the magnitude of stressed layer, in case of peened with different hardness shot.

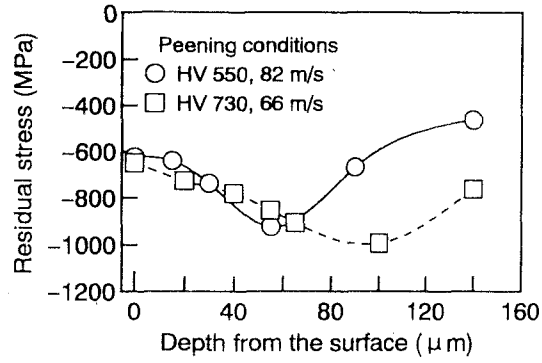

Fig. 2: Residual stress distribution at the condition of arc height 0.65 mmA

DISCUSSION

Considering the results shown, new strips are required which show the good agreement between its arc height and the residual stress profile even peened with different hardness shot. When peened by different hardness shot with the same shot velocity, for example, there should be distinct difference in arc height depending on shot hardness. In Fig. 1, however, no difference can be found between higher and lower hardness shot in the lower velocity region.

Therefore, in the development of new type strips suitable for hard shot peening, conventional C type strip and the high hard trial one of HRC 60 with the same dimension as that of Almen A strip were prepared. The strips were quenched in oil after holding at 1143K for 0.5h. Tempering was carried out at 473K for 1 h.

Figure 3 shows the relation between shot velocity and the arc height measured by conventional C type strips. Independent of shot velocity, arc heights obtained by two different hardness shots were almost the same. Consequently, it is concluded that the arc height measured by C strip is in worse agreement with residual stress than that by A strip. The relation between shot velocity and the arc height measured by high hard trial strip is shown in Fig. 4. The data on Almen A strip are shown for comparison. The arc height by trial strips is lower than that by A strips over the whole test velocity, and the difference in arc height is more prominent than in A type strips.

As a next step, to confirm its suitability for an index to estimate residual stress distribution, the relation between arc height measured by the high hard trial strips and residual stress was studied.

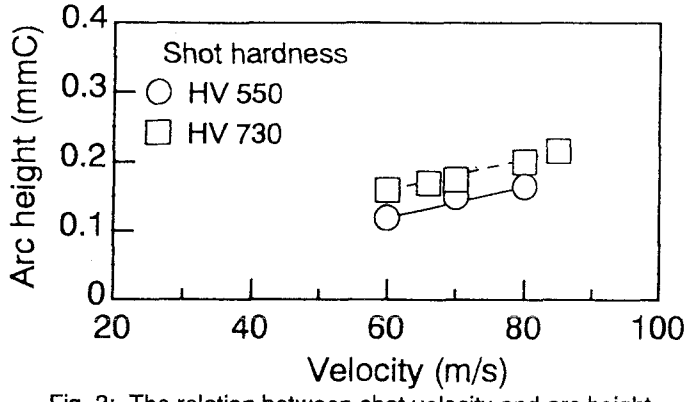

Fig. 3: The relation between shot velocity and arc height measured by C type strip

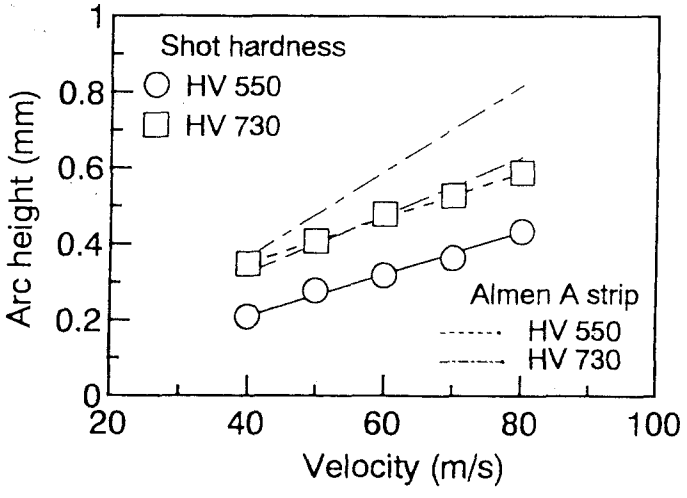

Fig. 4: The relation between shot velocity and arc height measured by high hard trial strip

Figure 5 shows the surface residual stress distributions of carburized plate specimens peened by optional conditions using two different hardness shots. Figure 6 shows the relation between the arc height measured by A strip and the maximum residual stress.

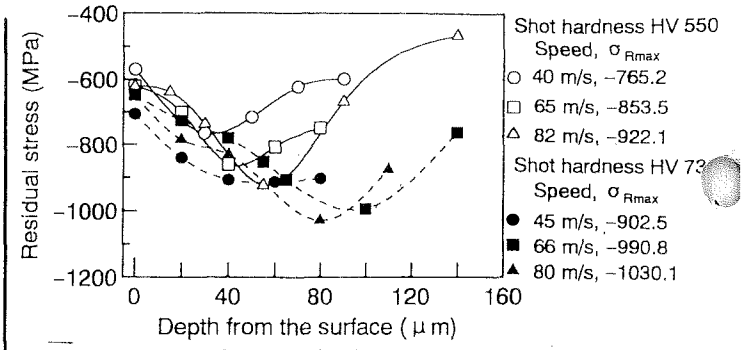

Fig. 5: Residual stress distribution at the optional conditions

As mentioned above, in case of the same arc height measured by A strip, the maximum compressive residual stress by the shot of HV 730 was higher than that by the shot of HV 550. Consequently, it is impossible to indicate peening intensity by the arc height measured with A strip.

Figure 7 shows the relation between the arc height measured by high hard trail strips and the maximum residual compressive stress. Independent of shot hardness, a linear relation is obtained. Namely, the maximum residual stress can be estimated by the arc height measured by high hard trial strips. This good agreement is considered due to the combination of the hardness of strip and shot media, especially the hardness of strip which simulate the surface of carburized components. Figure 8 shows the residual stress profiles of the carburized specimens peened with the same arc height 0.42 mm by trial strip. It is confirmed that the same residual stress profile, the maximum compressive stress and stressed depth, is obtained even with the different peening conditions.

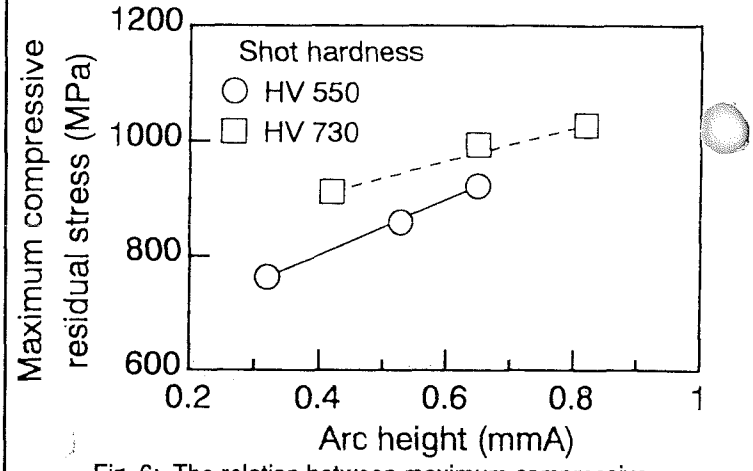

Fig. 6: The relation between maximum compressive residual stress and arc height measured by A strip

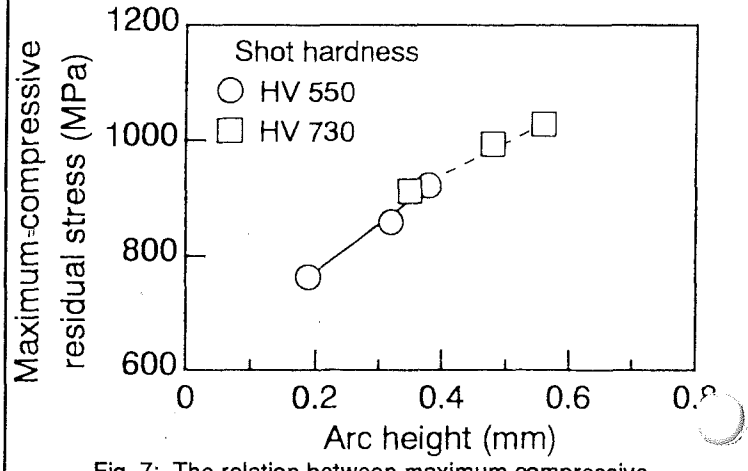

Fig. 7: The relation between maximum compressive residual stress and arc height measured by trial strip

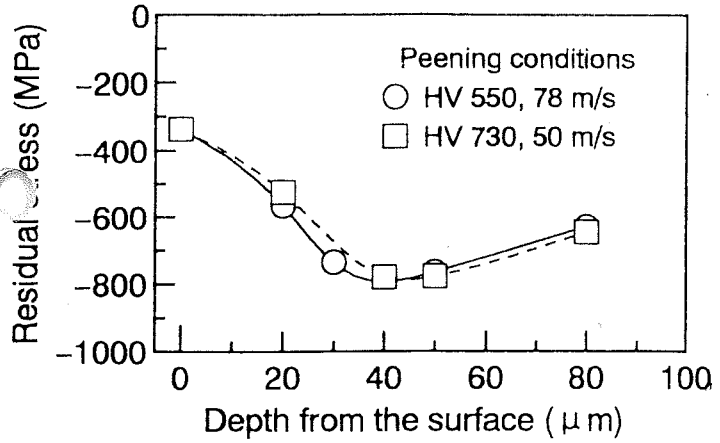

Fig. 8: Residual stress distribution at the condition of arc height 0.42 mm by trial strip

CONCLUSIONS

Test results are summarized as follows;
(1) When surface hardened components such as carburized gears are shot peened with the same arc height by Almen strip A, the residual compressive stress given by harder shot of HV 730 is higher and deeper than that by shot of HV 550. Accordingly, in hard shot peening, it is impossible to estimate peening intensity by the arc height measured by conventional A type Almen strips.
(2) The good relation was confirmed between the arc height measured by high hard trial strips and the residual stress profile, in terms of the maximum residual stress and the stressed depth. This good agreement is due to the combination of the hardness of the strips and shot media which enable to simulate the actual peening conditions.

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Contact The Shot Peener for information on the new harder Almen strip.