Inducing high residual stress through shot peening with high hardness conditioned cut wire

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Introduction

Currently, the automobile industry has adopted shot peening methods for automotive parts such as transmission gear, spring, and engine parts. As it is now, the shot peening method is used for almost all parts. Materials and heat-treatment for shot peening have evolved to apply static strength and fatigue strength. An effect required of shot peening is mainly fatigue strength improvement, and this effect depends on compression residual stress. Naturally, optimum shot and conditions should be selected by considering the mechanical properties of the product.

With social conditions changing, the automobile industry has been required to reduce the emission of CO_2 because of international efforts to reduce CO_2 [1]. It is an especially important issue. For that reason, the vacuum carburized furnace has been selected to replace the gas carburized furnace, because it has low CO_2 emission [2]. Normally, less than 700HV hardness shot media is used for gas carburized parts. On the other hand, the surface hardness of vacuum carburized parts is approximately 800HV. But the difference in hardness is not considered as a criteria for shot peening. In most cases, the same shot peening conditions are used as with vacuum carburized parts, but actually, shot media that is harder than the processing object should be used.

Therefore, high hardness conditioned cut wire has been developed for harder products like vacuum carburized parts. In this study, it is shown that high hardness conditioned cut wire can induce higher residual stress compared to existing conditioned cut wire.

Development of high hardness conditioned cut wire

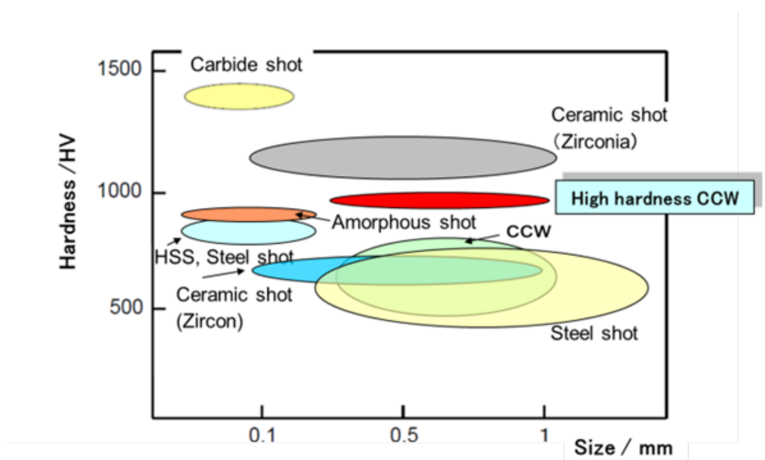

Fig.1 Distribution of shot used for peening.

Fig.1 shows shot distribution of the relationship between shot size and shot hardness used for shot peening. Typically, the surface hardness of vacuum carburized parts is approximately 800HV. The shot hardness needs to be higher than that to induce sufficient residual stress. Carbide shot and Amorphous shot have high hardness. However they do not have large size. Ceramic shot has high hardness and large size, but it cracks quickly so its lifetime is very short.

On the other hand, CCW and steel shot have a lineup of size but their hardness is low. Thus shot having hardness of HV900 or more and a size of Φ0.1 to 1.0 mm is required in the market.

Here we will explain the process for manufacturing high hardness conditioned cut wire.

Fig.2 shows the process for high hardness conditioned cut wire manufacturing. First, wire rod is annealed and drawn until it reaches the prescribed diameter. Then, that wire is cut to the same length as the diameter by a cutting machine and rounded to make spheres in the conditioning process. Subsequently, heat treatment is conducted. The quenching process gives it high hardness and the tempering process improves toughness by adjusting the metal structure and relieving stress. Finally, the work hardening process adjusts its hardness.

The above process is the manufacturing process of high hardness conditioned cut wire. Table 1 shows the observed values of high hardness conditioned cut wire.

Hardness measurement is that high hardness conditioned cut wire was buried by the resin and it was polished until the CCW were halved.That cross section was measured by a hardness tester. On the other hand, the sharpeness was visually counted the representative sample by using a microscope.

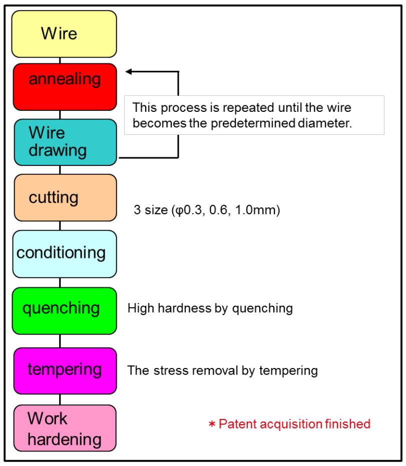

Fig.2 Manufacturing process.

Table 1 Observed values of high hardness CCW.

size	Φ0.3mm	Φ0.6mm	Φ1.0mm
Average hardness (HV)	933	924	938
Shape of grain (%)	95.2	91.1	95.5

Objectives

In this study, high residual stress that is induced by high hardness conditioned cut wire (high hardness CCW, 900HV) is compared with existing conditioned cut wire (existing CCW, 800HV).

Hereby, it shows whether high hardness CCW is effective for vacuum carburized parts, for both air type shot peening and wheel type shot peening.

In addition, this study investigates whether changing from air type shot peening with existing CCW to wheel type shot peening with high hardness CCW contributes to cost reduction.

Methodology

SCM420H is prepared for a specimen that is typical carburized steel which is standardized to Japanese standards (JIS). This test piece size is a Φ25mm×25mm cylinder. Fig.3 shows the hardness distribution of the depth direction of the test piece. As shown in Fig.3, the surface hardness of the test piece is 850HV and very hard.

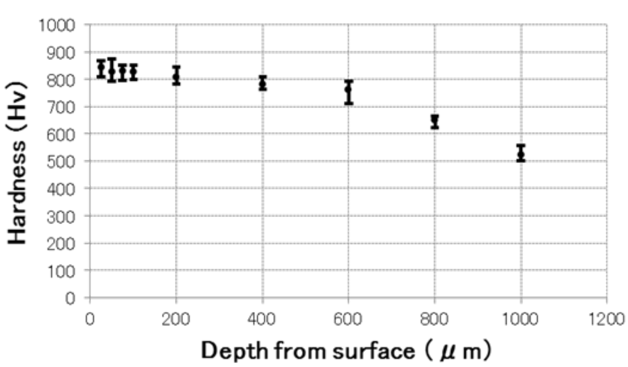

Fig.3 Hardness distribution of the depth direction of test piece.

The media is compared between high hardness CCW and existing CCW. Table 2 shows the specifications of these media. High hardness CCW is made through the manufacturing process described above.

High hardness CCW and existing CCW are used for shot peening by air type machine and wheel type machine. After shot peening, the residual stress is measured by X-ray stress measurement for each velocity and air pressure value.

Table 2 Specifications of the test media.

	High hardness CCW	Existing CCW
Diameter size (mm)	0.6	0.6
Hardness (HV)	917	770
Roundness (%)	93	94

Results and analysis

Effect of high hardness CCW on air type shot peening and wheel type shot peening.

Fig.4 and Fig.5 show the relationship between depth direction and residual stress. It is important that the surface of the test piece is given residual stress because of the improved strength it provides. As shown in the figures, high hardness CCW can induce higher residual stress compared to the existing CCW. In addition, high hardness CCW can induce high residual stress even at low velocity and low air pressure.

Existing CCW cannot induce residual stress to the outermost surface of the test piece. On the other hand, high hardness CCW can induce higher residual stress. The greatest residual stress with wheel type shot peening by existing CCW tends to decline in comparison with air type shot peening. However, with high hardness CCW, that is not so.

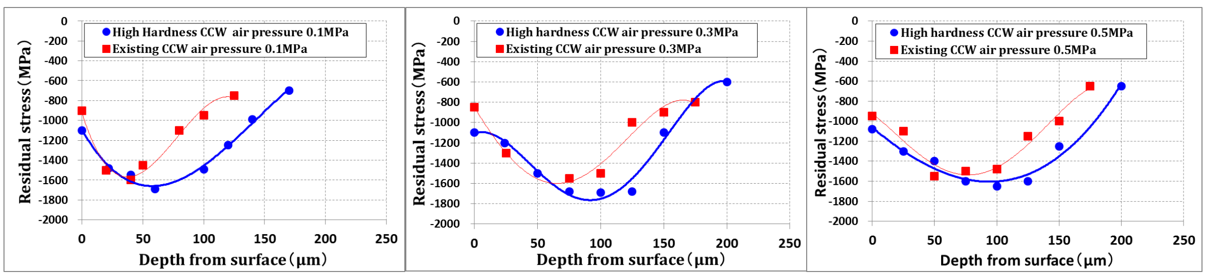

Fig.4 Residual stress at each depth with air type shot peening.

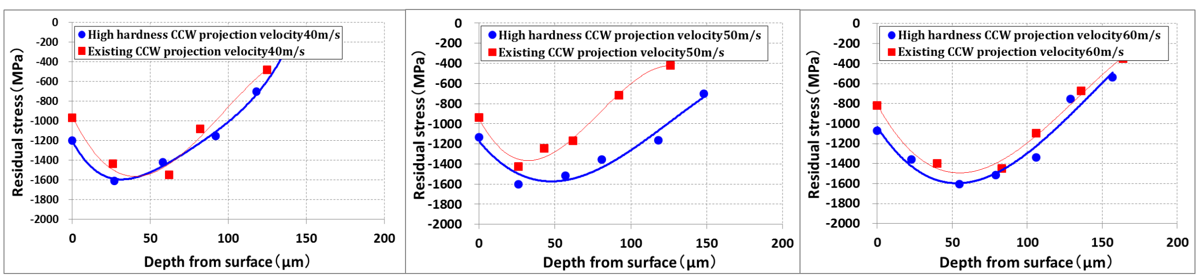

Fig.5 Residual stress at each depth with wheel type shot peening.

Here, the residual stress curves resulting from air type shot peening and wheel type shot peening were compared. Fig.6 shows an example of this relationship. The residual stress curve resulting from existing CCW at air pressure 0.3MPa equals the residual stress curve resulting from high hardness CCW at projection velocity 60m/s. Similarly, existing CCW at air pressure 0.1MPa equals high hardness CCW at projection velocity 40m/s. Moreover, existing CCW at air pressure 0.5MPa equals high hardness CCW at projection velocity 70m/s.

Thus, the residual stress from air type shot peening by existing CCW can be induced through wheel type shot peening by high hardness CCW.

A characteristic of wheel type shot peening is its ability to apply peening broadly. Therefore the residual stress at each point within the projection range needs to be investigated.

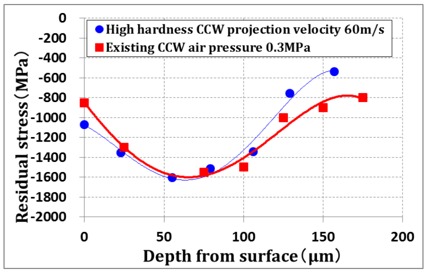

Fig.6 Residual stress comparison between air type shot peening and wheel type shot peening.

Effect of high hardness CCW at each point within projection range for wheel type shot peening.

The residual stress of the test piece is investigated at each point within the projection range of width 100mm×length 450mm. Set measurement points are width 50mm×length 25mm, 75mm, 150mm, 225mm, 300mm, 375mm. Fig.7 shows the residual stress curve at each measurement point by high hardness CCW at projection velocity 60m/s. Also Fig.7 shows as a comparison the residual stress curve for existing CCW at air pressure 0.3MPa. High hardness CCW for wheel type shot peening can induce equivalent residual stress at any set measurement point compared to existing CCW for air type shot peening. And we found that high residual stress of more than 1600MPa was obtained throughout the projection range. This means by using wheel type shot peening, peening applied to a wide range is possible. High hardness CCW has been found effective for obtaining high residual stress during the peening of vacuum carburized parts.

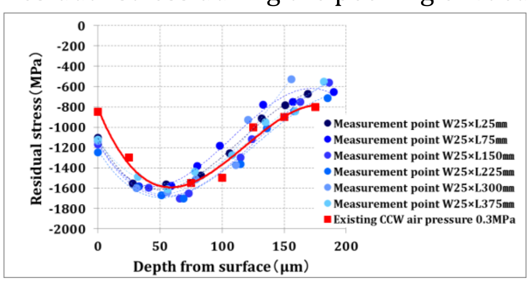

Fig.7 Residual stress curve at each measurement point.

We calculated the cost in this test to confirm whether high hardness CCW for wheel type shot peening is advantageous. Fig.8 shows the peening processing cost per test piece in this test and this figure shows comparison of cost between using air type device with existing CCW and using wheel type device with high hardness CCW. This was calculated based on the electricity cost and the CCW used when the test was actually carried out.Both the cost of electricity and the cost of abrasives decreased. As a whole, the cost was reduced by 26%. It is presumed that the cost would decrease in actual operation as well.

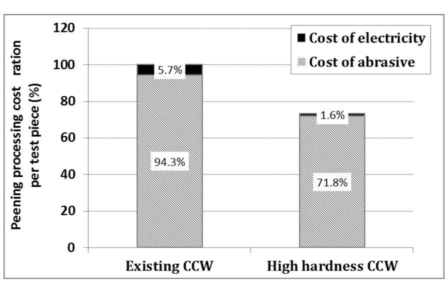

Fig.8 Calculated cost in this test.

Conclusions

As a result of this study, it has become clear that high hardness CCW can induce higher residual stress to vacuum carburized parts compared to existing CCW. In addition, it is effective for both air type shot peening and wheel type shot peening methods. By using high hardness CCW for wheel type shot peening, it is possible to obtain residual stress equivalent to using existing CCW for air type shot peening, and peening can be performed efficiently. Moreover, it is expected to reduce the total operation cost.

References

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