Low velocity shot peening condition with using high hardness CCW

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Abstract
This paper shows the relationships that low velocity shot peening, energy etc.

Keywords Velocity, hardness, residual stress.

Introduction

It has been a long time since Shot Peening processing to automotive parts comes to be carried out. In this process, materials and heat-treatment evolved to be required static strength and fatigue strength. An effect required to Shot Peening is mainly fatigue strength improvement, and the effect is brought by the compression residual stress.The condition of Shot Peening has been changed with evolution of materials and heat treatment because compression residual stress is greatly affected by the mechanical property of materials before Shot Peening processing. Tendency of the evolution of materials and the heat-treatment is, of course, improvement of hardness and toughness. The high hardness media has been developed to provide enough residual stress to the hard work-piece.After The Great East Japan Earthquake, the electricity circumstance of Japan is at the crisis point under the influence of the generation stop of the nuclear power plant. Recently, there is an increment of fuel procurement cost by depreciation of the yen, and the power consumption reduction is an emergency problem for every manufacturer in Japan.
As mentioned previously, high hardness media had developed in consideration of Shot Peening for harder work-piece. However, it has been clear that enough compression residual stress distribution was provided by using more firm media at lower velocity. On the other hand, at the wheel-type Shot Peening device, it is possible to save power consumption of the motor by lowering projection velocity. Therefore, in this study, we checked whether low-speed Shot Peening using high hardness CCW (Conditioned Cut Wire) can contribute to the cost reduction by studying residual stress distribution and media's lifetime when performing Shot Peening at lower velocity.

About shot peening

Shot peening is a kind of cold work and is the surface modification technique. It can provide the various effects such as "Improvement of fatigue strength", "Improvement of lubricity", and "improvement of heat dissipation" by hitting spherical metal or ceramics ball (shot and media) that have 50μm~1mm diameters on metal parts. Here, the principle of shot peening is explained briefly. A shot media is first accelerated by compressed air (air type) or by rotated impeller (impeller type) then the shot media is made to project to the processed material surface at high speed. At that time, the processed surface exceeds a yield point, plastic deformation happens, many fine hollows appear, and work hardening happens by material distortion. Therefore, the residual stress of compression remains. (Fig1)

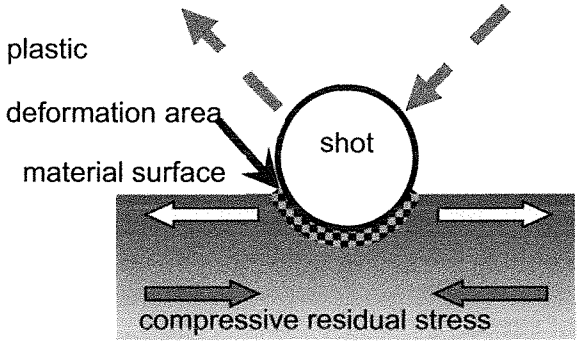

Fig.1. mechanism of residual stress

The compressive residual stress is effective in the fatigue strength improvement. Its purpose is to prevent the progress of the crack that occurs due to tiredness.

Experimental method

Two types of experimental method were employed: Shot Peening test in low velocity and media lifetime test. Shot Peening test in low velocity : Using spring steel SUP10 as a test piece, setting the surface hardness to 600HV by heat-treatment. Figure 2 and figure 3 show the hardness distribution of the depth direction of test materials, and the cross section. Comparing with 2 kinds of media, high hardness CCW, and commercial CCW. Table 1 shows specifications of the media. High hardness CCW is made in the following process;

-Cut the wire by same length as the diameter of wire.
-Process the wire by the conditioner to obtain the demanded roundness.
-Give quenching and tempering to the cut wire.
-Finally, process the heat-treated CCW by the conditioner for work hardening.

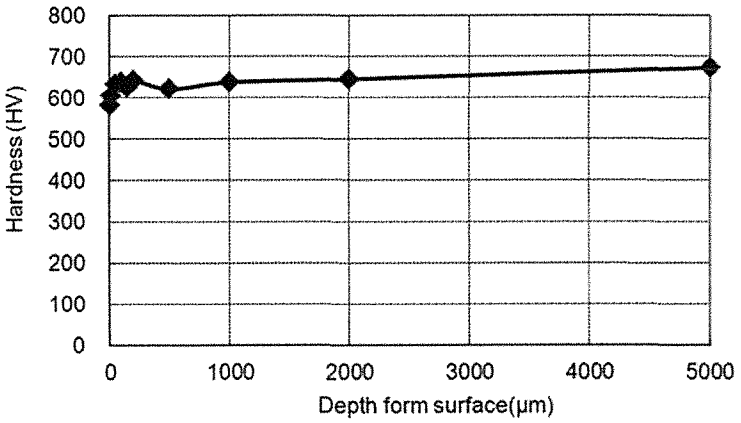

Fig.2. The hardness distribution of the depth direction of test materials

Perform Shot Peening on test piece at the various projection velocities, using wheel-type as a Shot Peening device.

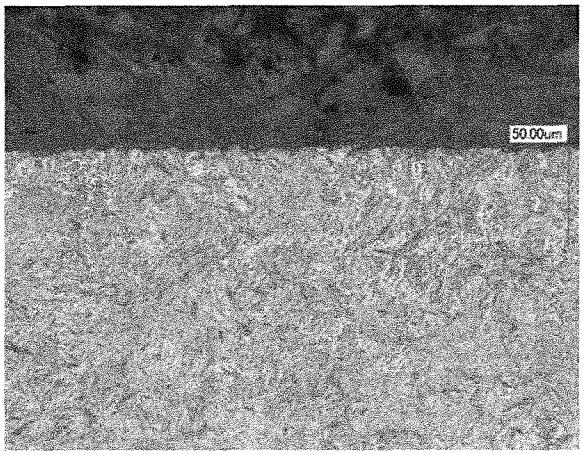

Fig.3. The photograph of test material (After heat-treatment)

Table1.Specifications of the test media

	Commercial CCW		High hardness CCW	
particle size (mm)	0.6	1.0	0.6	1.0
Hardness (HV)	606	620	924	938
roundness (%)	92	93	91	95

Media lifetime test : The wheel-type device for media lifetime evaluation called Ervin Life Tester is used for the measurement of the media lifetime. Definition of "lifetime" is same as the number of projection time that when the media bigger than specific grain diameter became half weight against initial media by wear. The upper limit of the projection velocity that can measure lifetime with concerning device is 60m/s. Tested commercial CCW at projection velocity of 60m/s, and tested high hardness CCW at various projection velocities and compared their lifetime.

Results and remarks

Comparison of the residual stress distribution : Figure 4 and figure 5 show the residual stress in each depth. Residual stress on material surface is the most important for Shot Peening. As we can know from the figures, the stress of high hardness CCW is larger than that of commercial CCW. Figure 6 shows the relation of projection velocity and the maximum residual stress against the CCW with diameter of 0.6mm. We can know that the maximum residual stress which is more or the same level as the maximum residual stress of commercial CCW is provided when testing at a projection speed that is faster than 25m/s with using high hardness CCW.

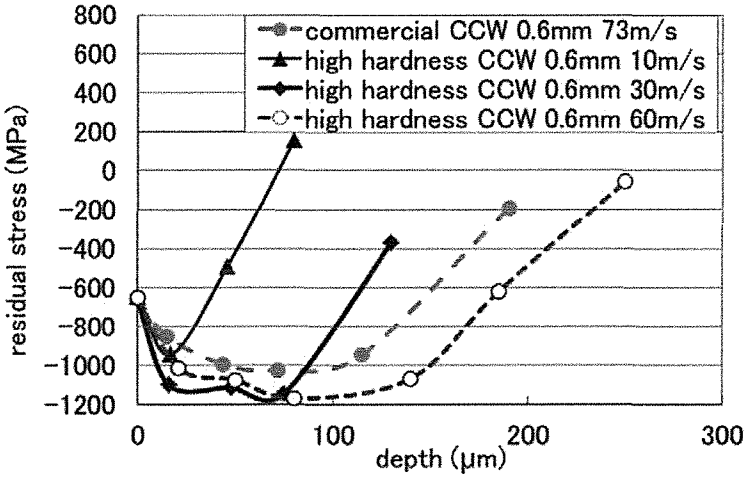

Fig.4. the residual stress in each depth (particle size 0.6mm)

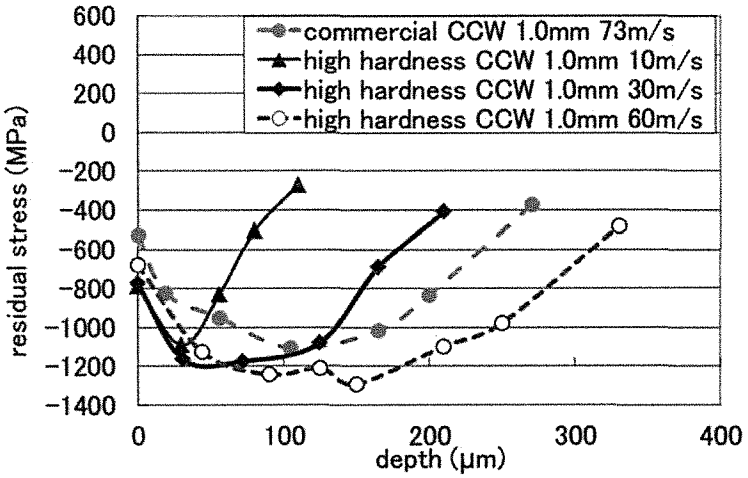

Fig.5. the residual stress in each depth (particle size 1.0mm)

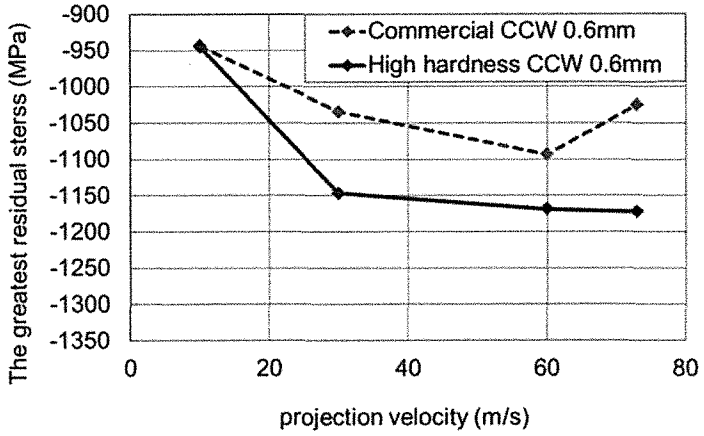

Fig.6. The relation of projection velocity and the maximum residual stress (particle size 0.6mm) Similarly, Fig 7 shows that for 1.0mm.

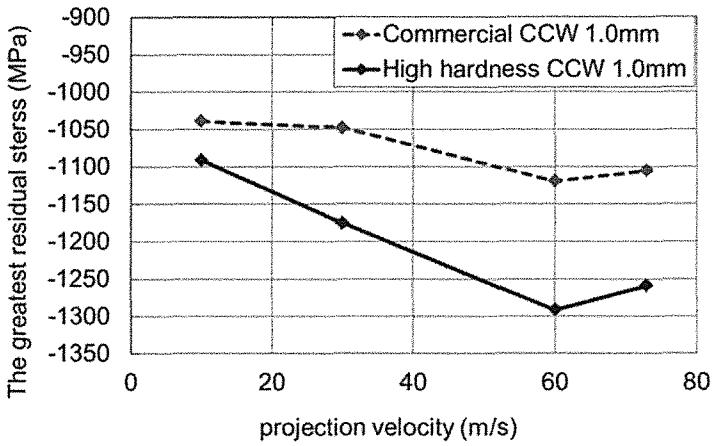

Fig.7. The relation of projection velocity and the maximum residual stress (particle size 1.0mm)

We can know that the maximum residual stress which is more or the same level as the maximum residual stress of commercial CCW is provided when testing at a projection speed that is faster than 15m/s with using high hardness CCW.

Comparison of media lifetime

Figure 8 shows the relation of projection velocity and lifetime. The lifetime of commercial CCW at projection velocity of 60m/s is approx. 4,000 times. High hardness CCW has lower lifetime than commercial CCW at the same velocity, that mean tenacity is low while the hardness is high. On the other hand, we can also know the lifetime of high hardness CCW exceeds the lifetime of commercial CCW at projection speed of 60m/s when projection speed of high hardness CCW is less than about 25m/s.

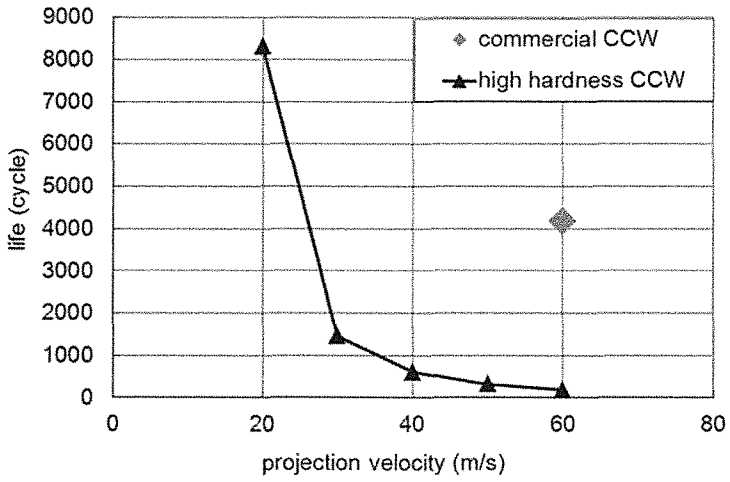

Fig.8. The relation of projection velocity and lifetime (0.6mm)

Conclusion

As the result of having performed Shot Peening on spring steel, we can know that the high hardness CCW can get more or the same residual stress as the commercial CCW even if it lowered projection velocity. The Shot Peening at low velocity using high hardness CCW can bring the media life cycle improvement, operation cost (and electricity cost) reduction of wheel-type Shot Peening device, and life cycle improvement of consumable parts such as the liner, and makes it possible to expect total operation cost reduction.