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PEENING CHARACTERISTICS OF CEMENTED CARBIDE PEENING SHOT & LIFE IMPROVEMENT OF COLD FORGING DIE

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ABSTRACT

Shot peening is a technology having being extensively used chiefly for improvement of fatigue strength of automobile parts, air craft parts, and various forging dies. The common peening shots having being used are steel shot, glass beads, and ceramic shot. Recently, cemented carbide shot which features high hardness (1400HV) and high specific gravity (14) also came into use. Since it generates a large plastic deformation to the surface of work piece., it subsequently provides a greater compressive residual stress to and near the surface more than the common peening shots. The application of it to cold forging die showed an extension of its life up to max. 6 times. (Steel peening shot showed max. 3 times).

It indicates the cemented carbide shot provides a highly compressive residual stress to and near the surface which subsequently retard the occurrence of fatigue cracks or the growth of cracks, resulting in a greater extension of life of the die.

KEY WORDS

Shot peening, residual stress, residual stress distribution, fatigue crack, fatigue life

INTRODUCTION

Shot peening is widely used for a purpose of improving fatigue strength of automobile parts such as springs, gears, etc. as well as various aircraft parts.

As for automobile parts in particular, a process called Hard Shot Peening is used to cope with materials of high intensity and hardness owing to the intended objectives of improving fuel efficiency, increasing high power output, reducing the weight of parts and making them small. However, the common peening shot (such as steel, glass, ceramic, etc.) can hardly satisfy the demands of highly hard parts owing to lack of hardness, and shorter life. To fulfill the demands, recently, three companies, namely, Sintokogio, Toshiba Tungaloy and Sintobrator, have jointly developed the cemented carbide peening shot which is of sphere, featuring hardness HV1400 and specific gravity 14. The use of it for peening process generates a large plastic deformation to the surface of work piece which subsequently provides a large compressive residual stress, in comparison with common peening shots. It was learned the effect becomes greater as the hardness of work piece increases. [1) 2)]

What is called hard work pieces include automobile parts such as spring, gears, various punches and dies, tools, etc. In these years, a new application of shot peening on such hard work pieces for a purpose of extending the life has drawn a great deal of attention. Due to the peening characteristics, the cemented carbide shot is highly expected to display its effects in extending the fatigue life of the hard work pieces.

This study introduces characteristics of the cemented carbide peening shot and, in addition, presents results on the improvement of fatigue life obtained through applications for the cold forging punch.

CEMENTED CARBIDE PEENING SHOT

PROPERTIES OF VARIOUS SHOTS

Table 1 compares materialistic properties of the cemented carbide shot and conventional shots. The latter is about 1.9 greater in specific gravity and 1.6 in hardness than the former.

Table 1. Comparison of various shots

Shots	Specific gravity	Vickers Hardness
Steel shot	7.5	-850
Aluminum shot	2.7	-120
Zinc shot	7.1	40-55
Zirconia beads	6.0	-1300
Glass beads	2.5	500 - 550
Cemented carbide shot	14.0	1400

RESIDUAL STRESS DISTRIBUTION

Residual stress distributions obtained through shot peening by cemented carbide shot and steel shot are shown in Fig. 1 and 2. Table 2 indicates the peening conditions.

Table 2. Peening conditions

Peening machine		Ervin life tester
Test piece	Material	SKH57
	Dimension	19 x 76x 6 mm
	Hardness	HRC 65
Peening shots		Cemented carbide 0.1, 0.2mm Steel 0.1, 0.2, 0.3mm
Shot velocity		25 - 90 m/s
Coverage		150%

Fig. 1 shows the effects of shot sizes on residual stress distribution. The peak values and peak positions of compressive residual stress value of both cemented carbide shot and steel shot tend to become high and deep as the sizes increase respectively. However, compressive residual stress values of cemented carbide shot are about 300MPa higher than those of steel shot at the peak value.

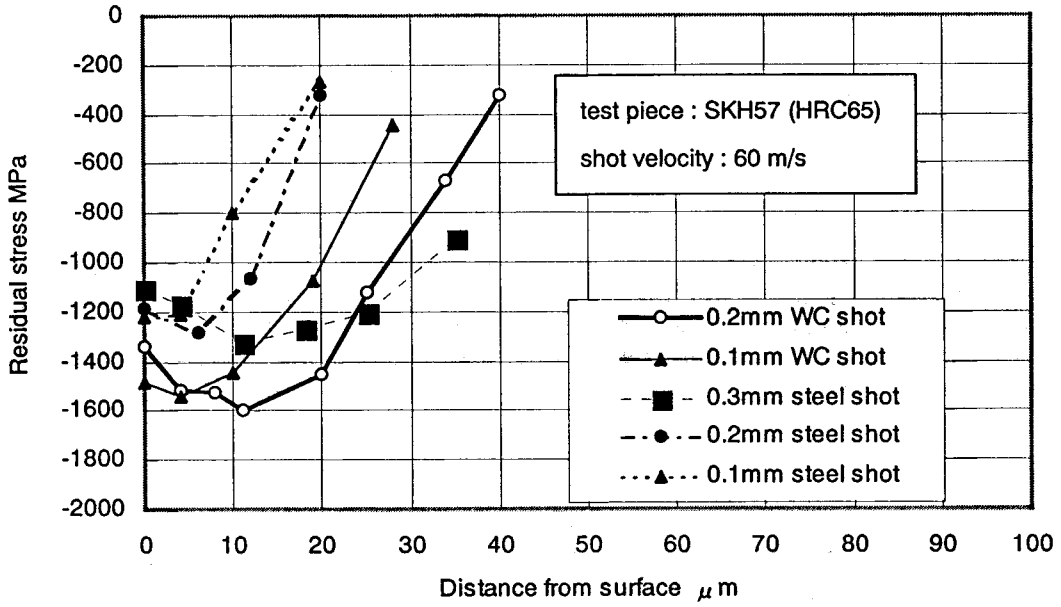

Fig. 1 Effects of Shot Sizes on Residual Stress Distribution [1)]

Fig. 2 shows the effects of shot velocity on residual stress distribution. Peak values of the cemented carbide shot are higher at every shot velocity than those of steel shot. It is to say that cemented carbide shot generates a high compressive residual stress even at a low shot velocity which steel shot can not. Cemented carbide shot, having characteristics of high hardness and high specific gravity, effectively generates blasting energy to work pieces due to the fact that it suffers little deformation when it collides with test pieces. It is considered that it subsequently generates a highly compressive residual stress to the test pieces.

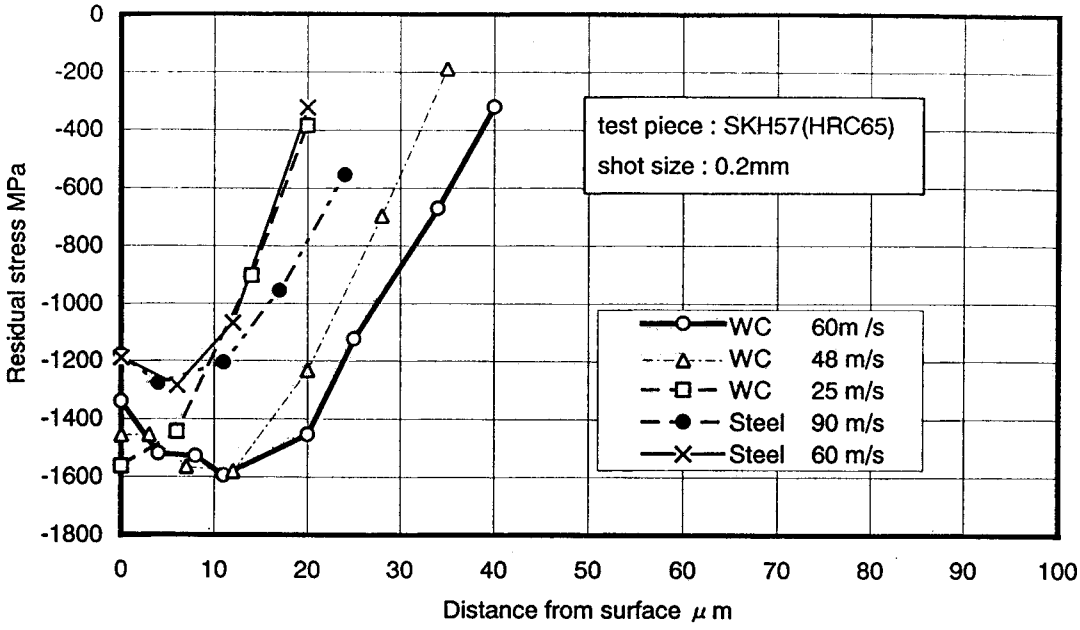

Fig. 2. Effects of shot velocity on Residual Stress Distribution [1)]

SURFACE ROUGHNESS

Table 3 shows the measuring results on surface roughness. Cemented carbide shot having characteristics of a high hardness and specific gravity causes the processed surfaces coarse more than the steel shot does when using the same shot size and processing at the same shot velocity. Nonetheless, it can fairly be improved by using smaller sizes and lowering shot velocity while generating a high compressive residual stress to the surfaces.

TABLE 3. Surface Roughness after Peening Process [1)]

Item \ Shot size (mm)		0.1			0.2					0.3
		Cemented carbide		Steel	Cemented carbide			Steel		Steel
Shot velocity m/s		60	25	60	60	48	25	90	60	60
Test piece hardness HRC		65.7	65.3	65.4	66.0	66.0	65.7	65.3	65.8	65.8
Ra μm		0.66	0.22	0.09	0.82	0.58	0.28	0.14	0.10	0.24
Rz μm		5.79	2.01	1.16	6.57	4.59	2.47	1.32	0.97	2.27
Residual stress	Peak position μm	abt.4	surface	surface	abt.15	abt.12	surface	abt.5	abt.6	abt.11
	Peak value MPa	-1550	-1560	-1220	-1600	-1580	-1560	-1290	-1280	-1330

LIFE IMPROVEMENT OF COLD FORGING DIE BY CEMENTED CARBIDE SHOT PEENING

TEST METHOD

Photo 1 shows the shape of a cold forging die used for the shot peening test. An air blasting machine was used for the test. Table. 4 shows the process conditions. Steel shot, in addition to cemented carbide shot, was used for a comparison purpose. The air pressure was varied in a range 0.1 - 0.5MPa. Nozzle diameters were 6mm (pressure tank type) and 8mm (suction type). The blasting distance was set at a 150mm and the angle at a 90° constant.

The peened cold forging die has been, after measuring surface roughness and surface residual stress, placed on field tests and life evaluation.

As for field tests, a 400 ton cold forging press machine (45 shots/min) was used. The life of die was evaluated based on numbers of hitting before a crack occurs at a R part of the die.

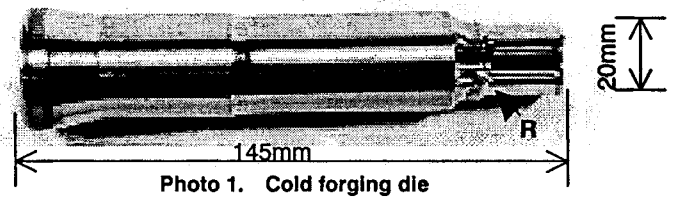

Photo 1. Cold forging die

TABLE 4. Peening conditions

Peening machine	Air blasting machine
Peening shots	WC 50 μ m (HV1400) Steel 50 μ m (HV 800)
Air pressure	Suction Type : 0.1 - 0.3 MPa Pressure Tank Type : 0.5 MPa
Blasting distance	150mm
Blasting angle	90°

TABLE 5. Test Results on the life of Cold Forging Die

	Peening conditions			Surface rough-ness (μ m)	Surface residual stress (MPa)	Test results Die life (Nos. of process)
	Peening shot	air pressure (Mpa)	Machine type			
1	Unprocessed parts			0.3 - 0.8	-670 - -940	Max. 5,000
2	Steel 50 μ m	0.5	Pressure Tank	2.81	-1257	10,000
3	Steel 50 μ m	0.5	Pressure Tank	1.91	-1198	14,000
4	Cemented carbide 50 μ m	0.2	Suction Type	3.38	-1457	20,500
5	1st step /cemented carbide 50 μ m	0.2	Suction Type	2.43	-1442	20,800
	2nd step / steel 50 μ m	0.3	Suction Type			
6	1st step /cemented carbide 50 μ m	0.2	Suction Type	2.59	-1591	32,300
	2nd step / steel 50 μ m	0.1	Suction Type			

RESULTS AND DISCUSSION

Table 5 shows the results of measurements on surface roughness and surface residual stress and life evaluation of the cold forging die after its peening process.

Table 5 indicates that the die life has improved over about 2 times due to peening process. Amongst the peening shots, cemented carbide shot extended the die life about 4 to 6 times even at a low shot velocity. Fig. 3 represents the relation between the die life and surface residual stress. The figure shows a close relation that the die life increases as the surface residual stress rises. It also indicates that when a high compressive residual stress is generated near the surface, the die life significantly extended due to retarding the occurrence of fatigue cracks or the growth speed of cracks.

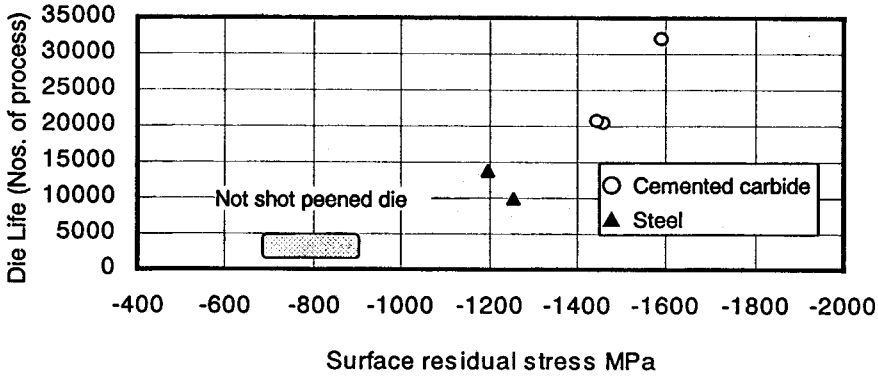

Fig. 3. Relation between die life and surface residual stress value

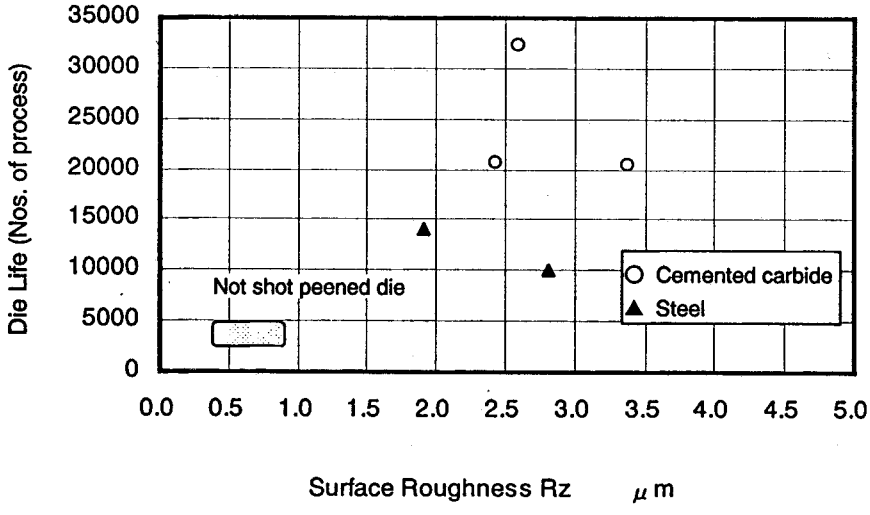

Fig. 4. Relation between die life and surface roughness

Fig. 4 show relations between the die life and surface roughness. The test results did not show a close relation between the two. In general, as the surface roughness becomes greater, notch effect increases which in turn becomes a start point of destruction under the existence of fatigue stress and causes the die life short.

However, it is likely that in the tests the effect to the die life was little within the surface roughness (-304um) after the peening process owing to the effects by a large compressive residual stress.

CONCLUSION

Lately, a process aiming at improving the life of dies, tools, etc. has drawn a wide attention as a new shot peening application. The cemented carbide shot is considered suitable for those hard materials because of its greater effect on improving the fatigue life. Thus, tests focused on the cold forging die have been conducted to clarify the peening performance of the cemented carbide shot. Its summary is as follows. :

1) The cemented carbide shot, owing to its high hardness and high specific gravity, generated a highly compressive residual stress to and near the surface of work pieces even at a low air pressure.

2) Field test results on the cold forging die showed a close relation between the die life and the surface residual stress. That is to say, when compressive residual stress was generated to the surface of work piece by peening process, the die life increased over about 2 times. When, particularly, it was cemented carbide shot, the die life increased over about 4 to 6 times owing to a high compressive residual stress.

3) The relation between the punch life and surface roughness was not revealed.

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