EFFECT OF SHOT PEENING CONDITIONS ON FATIGUE STRENGTH OF CARBURIZED STEELS

Hiroji Aoki and Etuichi Nagashima, SINTOKOGIO LTD.,
and
Takashi Miura, SUZUKA COLLEGE of TECHNOLOGY, JAPAN

ABSTRACT

We investigated the effect of different shot peening conditions on the fatigue strength of carburized steels.
The results of investigation indicate that the shot peening is exceedingly effective in improvingthe fatigue strength with carburized steel specimens but its effectiveness is greatly affected by its conditions.
In applying the shot peening, therefore, it is important to select the conditions that can bring out its maximum effect.

Keywords

Carburized steel, shot peening, Fatigue strength, Projection density, Shot size, Shot hardness, Shot velocity

INTRODUCTION

Shot peening has such advantage that it can improve the fatigue strength of the materials at a relatively low cost and that its effect seldom depends on materials to be processed. Therefore, it has been usually used to improve the fatigue strength of various metal materials. There have already been reports on the effect of shot peening [1] [2], and recently there are reports on the hard shot peening [3]. Because of many factors on the peening effect, the most effective condition of shot peening is not cleared completely.
This paper concerns with the study of shot peening conditions which influence the carburized steel fatigue strength such as projection density or coverage, projection velocity, and hardness of shot, and shot size.
We carried out rotating bending fatigue tests with specimens after having being processed under various shot peening conditions to evaluate the optimum conditions for shot peening to improve the fatigue strength.

EXPERIMENTAL DETAILS

Carburized Cr steels (JIS SCr415, SCr420H) having chemical compositions as shown in Tab.1, were provided as specimens for our tests.

Tab. 1 Chemical composition of specimens (wt.%)

	C	Si	Mn	P	S	Cu	Ni	Cr
SCr415	0.16	0.20	0.71	0.017	0.013	0.001	0.002	1.02
SCr420H	0.22	0.26	0.85	0.015	0.014	0.02	0.03	1.17

Tab. 2 Shot Peening Condition

code	projection velocity (m/sec)	shot size	hardness of shot	projection density (kg/m^2)	material	note
A	–	–	–	–	SCr415	Non peening
AP1	73	SAE S230	HRC53	200		
AP2				400		
AP3				600		
AP4				1200		
APW	73+64	S230+S110	HRC53+HRC60	300+300		Double Shot peening
B	–	–	–	–	SCr420H	Non peening
BP1	73	SAE S110	HRC53	600		
BP2			HRC60			
BP3		SAE S230	HRC53			
BP4			HRC60			
BP5A	50	SAE S280	HRC53			
BP5B	73					
BP5C	90					
BP6	73		HRC60			
BPW	73+50	S280+S110	HRC53+HRC60	300+300		Double Shot peening

The specimens were machined in the shape shown in Fig. 1 and finished with a sand paper of 120 to 400 grit.
They were then heat-treated; first, they were carburized at 940°C for 300 minutes, kept at 850°C for 20 minutes, and then oil-quenched.
Further, they were tempered at 280°C for 210 minutes, and after that they were air-cooled.
The shot peening was done under the conditions as shown in Tab.2 with a centrifugal projection type shot peening machine.
The code number APW and BPW in Tab.2 were tested with two step peening that is to say double peening, using large size firstly and small size of shot nextly.
And in these cases, total projection density were same with that of single size shot.
The fatigue test was performed with the rotating bending fatigue tester with a maximum load capacity of 10 kg-m and 2400 rpm. And also, we measured the surface roughness and hardness of specimens at every 50μm deep from the surface using a micro-vickers hardness tester.

RESULTS

Projection density and fatigue strength

The S-N diagram is shown in Fig.2. It was obtained with various projection densities.
It shows that the fatigue limit for SCr415 was improved 1.41 times until 600 kg/m^2 of projection density as it increased compared with that of a specimen not shot peened.

Shot velocity and fatigue strength

The S-N diagram obtained from the varied shot projection velocity is shown in Fig.3.
The fatigue limit is improved as shot projection speed is increased and the fatigue limit for SCr420H material is improved 1.24 times as the result. Comparing the projection speed of 90m/sec. with that of 73m/sec., there was no significant difference in the improvement of the fatigue limit.

Double shot peening

We carried out double shot peening tests with shots of two different sizes; total projection density of the two is the same with single shot peening, but it improved the fatigue limit only a little compared with single shot peening.

Hardness of shot and fatigue strength

The S-N diagram obtained with the various shot hardness is shown in Fig.4.
When we performed shot peening tests on SCr420H with shots of three (3) different sizes;
It shows that the fatigue limit of SCr420H is improved as the shot hardness of each size of SAE, S110, S230 and S280 is increased.
In case of an average hardness of HRC53, the fatigue limit is improved 1.13 to 1.24 times and in case of HRC60, 1.27 to 1.35 times.
No significant difference in the fatigue limit caused by the difference of shot size was recognized.
The effect of surface roughness was not recognized clearly in these tests.

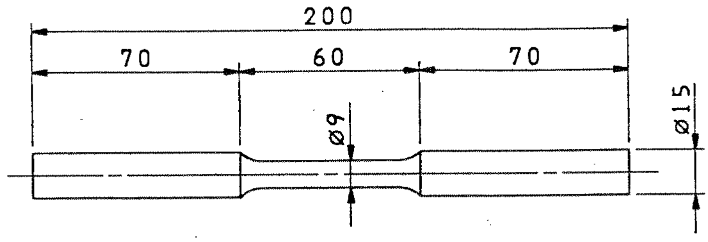

Fig.1 Configuration of fatigue specimen

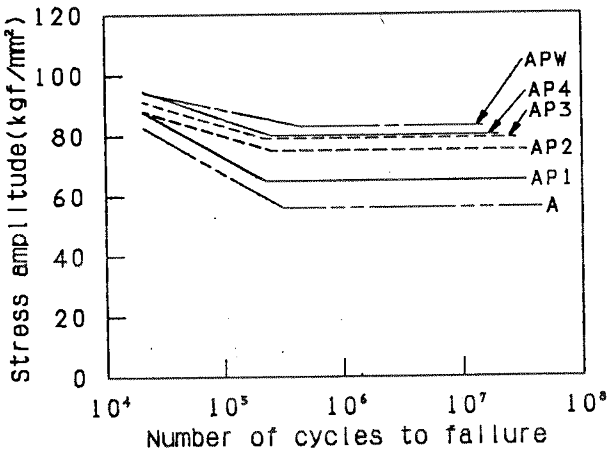

Fig.2 S-N diagram with shot peening
(Effect of projection density)

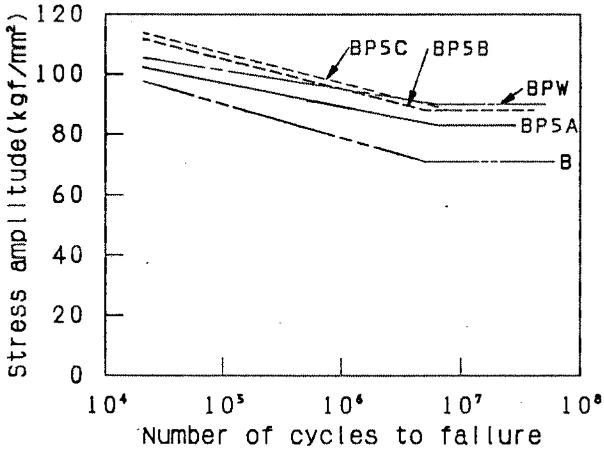

Fig.3 S-N diagram with shot peening
(Effect of shot projection velocity)

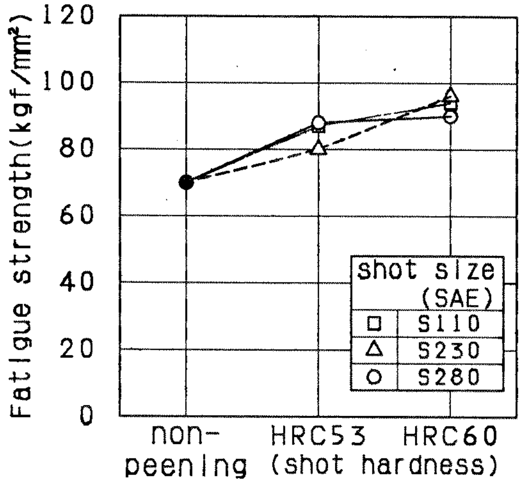

Fig. 4 The relation of shot hardness and fatigue strength

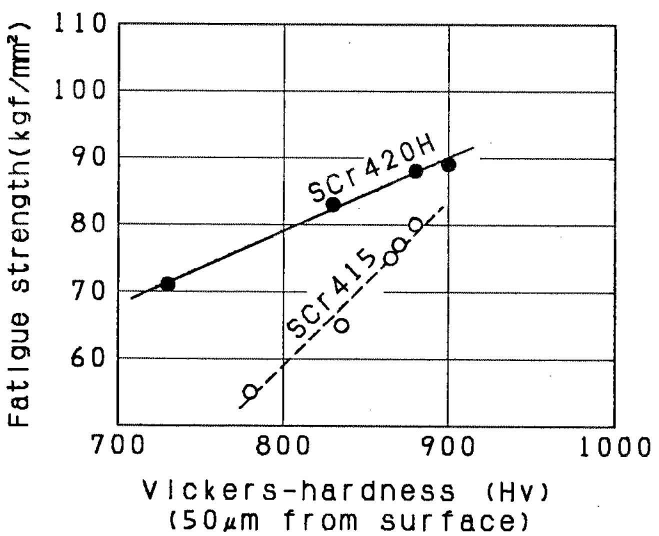

Fig. 5 The relation of hardness and fatigue strength

DISCUSSION

The results of fatigue tests indicate that the shot peening is exceedingly effective in improving the fatigue strength of carburized steels.
The results also indicate that there are various conditions affecting the effect of shot peening and that, among the conditions, projection density, shot projection velocity and shot hardness affect the fatigue strength effectively.
We investigated correlation between shot hardness and fatigue limit so as to know the factors affecting the fatigue strength.
In general, it is thought that the compressive residual stress is most effective to the fatigue strength among the factors in materials such as compressive residual stress, surface hardness and surface roughness affected by shot peening [3].
It was difficult to measure a residual stress distribution in the specimen used in this test. However, from the measuring of residual stress distribution on a flat plate, we noticed that the maximum residual stress was produced at a depth nearly 50 μm from the surface and it relates the hardness at 50 μm deep. Based on this fact, we investigated a correlation between the hardness at 50 μm deep and the fatigue limit.
The results, as shown in Fig. 5, indicate that the hardness at the point 50 μm deep is an effective parameter for carburized steels showing an improvement of the fatigue strength using shot peening.

CONCLUSIONS

As the results of fatigue tests on carburized steels (SCr steel), we have come to the following conclusions:

1. Shot peening is extremely effective in improving the fatigue strerngth; the fatigue strength increases with the increase of shot projection density, velocity and hardness.
2. With shot peening applied, the correlation between the hardness at a point of 50 μm deep from the surface and the fatigue limit is very close and that the hardness is effective as a parameter showing the fatigue strength.

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