GENERAL ASPECTS OF SHOT PEENING CRITERIA OF PARAMETERS SELECTION

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ABSTRACT

Major groups of parameters affecting the shot peening process and quality of peened parts have been determined in the paper. These are as follows:

- shot peening equipment
- types and size of shot
- peening intensity
- surface coverage

Methods and frequency of inspection for the shot peening process as a function of type of machine elements to be peened have also been given.

KEY WORDS

Shot peening data, shot peening equipment, types and sizes of shot, peening intensity, surface coverage, destructive method of shot peening control, non-destructive method of shot peening control.

INTRODUCTION

Shot peening is one of the methods of cold working which is suitable for machine elements made of metals or plastics. The major applications of shot peening is related to improvement of fatigue life of parts. According to obtained results /Horowitz, 1973/, subject to a method of peening, the improvement can ranges from 15% to 200%. Such a great increase in fatigue life is possible due to coupling heat treatment to cold working represented by shot peening. Shot particles for peening should be made of cast iron /ball shot/ or cut steel wire /cylindrical shot/. Out of shots used for work hardening purposes are these made of cast iron, chilled iron shot, cast steel, glass, spring wire. The equipment used in shot peening can be mechanical, pneumatic combined with mechanical or pneumatic. In the mechanical equipment a revolving bladed wheel provide shot with kinetic energy while in case of a pneumatic equipment shot is accelerated by a continous stream of

compressed air. The choice of a suitable equipment depends first of all on:
- sizes and shape of parts
- rate of production

SELECTION OF SHOT PEENING PARAMETERS

General process charakterictic

The quality and effectiveness of peening depends on the following parameters:
- types and sizes of shot
- shot peening intensity
- surface coverage

For the purpose of obtaining the optimum results of shot peening above mentioned parameters may be governed by:
- number of rotors /mechanical propeller/
- number of nozzles and their diameters /pneumatic propeller/
- velocity and character of motion of parts or nozzles
- distance between peened parts and shot propelling wheels or nozzles
- exposure time

Type and Sizes of Shot

Selection of shot for work hardening depends largety on:
- required thickness of work hardened layer
- required roughness number

General requirements as to steel shot, cut steel wire shot and glass beads used in work hardening are given in Tables 1 and 2. Table 1 lists ranges of shot with the recommended groups of parts. The recommended sizes of cast shot and cut steel wire shot for the application to different parts are given in Table 2. Cut steel wire shot has to be conditioned to eliminate sharp edges.

TABLE 1 General Recommendations for Types and Sizes of Shot Used in Work Hardening

Types of parts	Globular cast steel shot /diam. in mm/	Cut steel vire shot /diam. in mm/	Glassbead /diam. in µm/
Spring leaves	0.30 - 0.75	0.40 - 0.60	175 - 300
Spiral springs	0.30 - 1.00	0.60 - 0.90	50 - 200
Gear wheels	0.30 - 1.00	0.40 - 0.90	50 - 200
Shafts	0.30 - 1.00	0.40 - 0.90	50 - 100

TABLE 2 Recommendations for Materials of Cut Wire Steel Shot and Globular Cast Steel Shot Used in Work Hardening

Types of parts	Cut wire steel shot			Globular cast steel shot	
	Designation and sizes of shot		Tensile strength for wire /MPa/	Designation and sizes of shot	
	SŁD-G 1/ /mm/	CW 2/ /10^{-3} in/		GS 1/ /mm/	CS 2/ /10^{-4} in/
Small parts	0.4; 0.6	20; 23		0.4; 0.6	170; 230
Large parts	0.7; 0.8; 0.9; 1.2; 1.4	28; 32; 35; 47; 54		0.6; 0.8; 1.0; 1.25; 1.6	280; 330; 390; 460; 550
Spring leaves	0.7; 0.8	28; 32	1961- - 2158	0.6; 0.8	280; 330
Spring leaves /heavy/	1.2; 1.4;	47; 54		1.25; 1.6	460; 550
Coil springs	0.8; 0.9	32; 35		0.8; 1.0	330; 390
Spiral springs	0.4	20		0.4	170; 230
Torsional shafts	0.4	20		0.4	170
Shafts /according to size/	0.4; 0.6; 0.9	20; 23; 35		0.4; 0.6; 2.0	170; 230; 390
Gear-wheels	0.6; 0.9	23; 25			230; 330; 390

1/ Designation in accordance with DIN 8201 part 2 /1977/and part 4 §1975/
2/ " " " " SAE J441 /1969/ and J827 /1969/

Delivered shot should in accordance with the obligatory standards be always given a sieve analysis.
Cast steel shot should conform to SAE J827 /1969/ and cut steel wire shot to SAE J441 /1969/.

Determination of Shot Peening Intensity

Shot peening intensity is determined by a measurement of one side peened test strip deflection. The strip is commonly referred to as the Alman test strip. In accordance with SAE J442 /1968/ the test strips should be made of material given in Table 3. The set of strips includes N, A and C strips. These strips are applied to low, middle and high peening intensity respectively. When middle intensity is involved, test strip A is preferably used. Deflection of the strip should range between 0.15 - 0.6 mm. For deflections lesser than 0.15 mm test strip N is recommended, for greater than 0.60- test strip C. To conform to recommendation /Kugelstrahlen-Shot Peening NO5154, 1977/ peening intensity should be determined with regard to cross section ot the part to be peened.

TABLE 3 Materials for the Almen Test Strips

Type of material	Components content /%/							Comments
	C	Mn	Si	P max	S max	Ni max	Cr max	
Cold rolled spring steel according to SAE 1070	0.65 0.75	0.6 0.9	-	0.040	0.050	-	-	Recommended standard: SAE J442, 1968
Cold rolled spring steel according to DIN 17222 C 75	0.75	0.7	0.4	0.045	0.045	-	-	Recommended standard: "Steyer-Daimler-Puch" N 05154
Vehicle spring steel according to PN-74/H-84032 65	0.62 0.70 0.65 0.70	0.5 0.80	0.17 0.37	0.040	0.040	0.25	0.35	
Vehicle spring steel according to PN-74/H-84032 75 or 75 select a to BN-76/0631-09	0.72 0.80 0.75 0.80	0.50 0.80	0.17 0.37	0.040	0.040	0.030	0.30	
Spring steel according to PN-74/H-84032 65G	0.60 0.70	0.90 1.20	0.15 0.40	0.040	0.040	0.30	0.30	

Table 4 indicates approximate recommendations for the peening intensity according to standard. The Almen strips are fastened to the test strip holder, and strips deflections measurements are made by a special dial gauge. For the purpose of determining optimum peening intensity test strips deflection exposure time relationship must be estabished, by way of experiment, a first. The curve in given in Fig. 1. This is a resultant curve out of three obtained for test strips of the some type. The value of strip deflection in point A indicates a desired peening intensity. Sphere above point A corresponds to little gain in the strip deflection with much increase in exposure time. Having regard to economy, it is undesirable to shot peen within long time of exposure /high costs of production/. On the other hand short time of exposure results in poor quality of the shot peening process. The time of exposure should be ordinarily determined so that strip deflection fall close to point A.

TABLE 4 Recommended Peening Intensity Regarding Thickness of Part to be Peened

Thickness of diameter of peened part /mm/	Test strip deflection /mm/	Type of the Almen strip
2	0.30	N
3	0.20	A
6	0.35	A
10	0.45	A
13	0.55	A
16	0.18	C
19	0.20	C
22	0.25	C

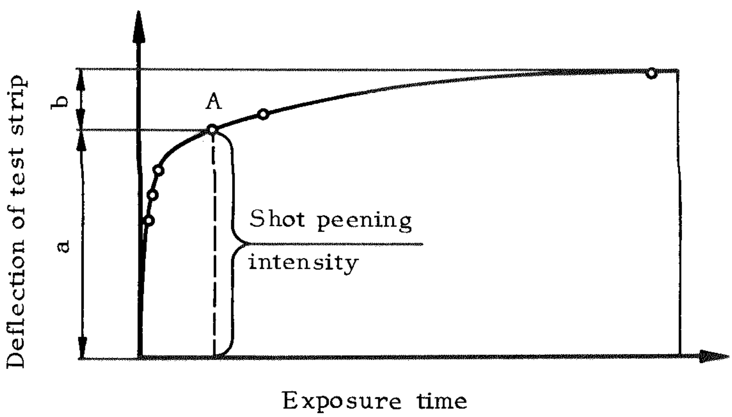

Fig. 1. Shot peening intensity curve

Surface Coverage

This is surface coverage which is tightly related to effect of shot peening on quality of the process. Surface coverage is a measure of how completely a surface has been hit by flux of impinging shot particles. Without adequate coverage, the improvement in fatigue characteristics normally produced by shot peening will not be obtained. As stated in SAE J443 /1968/, there is a definite and quantitative relationship between coverage and exposure time, which may be expressed as follows: $C = 1 - /1 - C_1/^n$ 1

where C = % coverage after n cycles
C_1 = % " " 1 cycle
n = number of cycles.

This relationship indicates that coverage approaches 100% is a limit and can be obtained after extremely long time. Becouse accurate measurement can be made up to 98% coverage, this value is arbitrarily chosen to represent full coverage, in accordance with /Horowitz 1976/. The importance of the formula /1/ is explained in Fig. 2. Fig. 3, shows appearance of 55% coverage surface /fig. 3a/ and 90% coverage /Fig. 3b/. These pictures correspond to points 1 and 2 in Fig. 2.

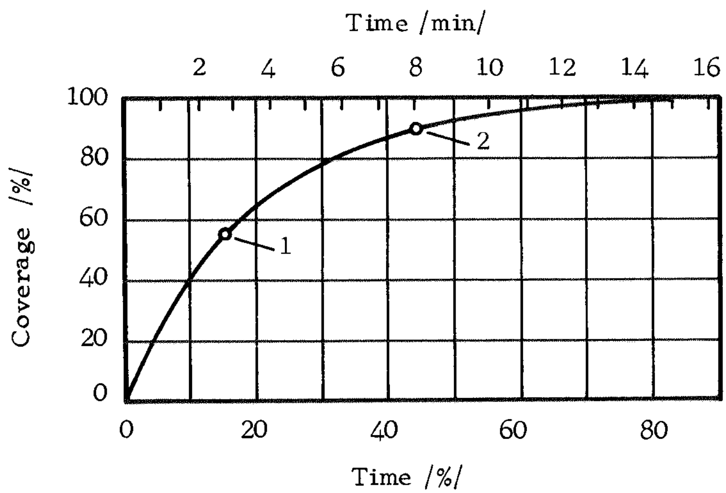

Fig. 2. Surface coverage as a function of time: 1 - exposure time corresponding to 55% coverage /determined by way of microscopy/, 2 - exposure time corresponding to 90% coverage /determined by way of microscopy/

SAE J443, 1968 provides procedures for determining and controlling surface coverage. Visual method for measuring coverage consists in examining the surface at a magnification of 50 diameters.

METHODS FOR THE CONTROL OF SHOT PEENING PARAMETERS

The resultant effect of: type and size of shot air pressure or rotational speed of a bladed wheel, nozzle diameter, nozzle - part distance, angle of impingement and exposure time on quality of peening depends on the control of each of these variables. There are some methods for controlling above mentioned parameters:
- direct observation during shot peening

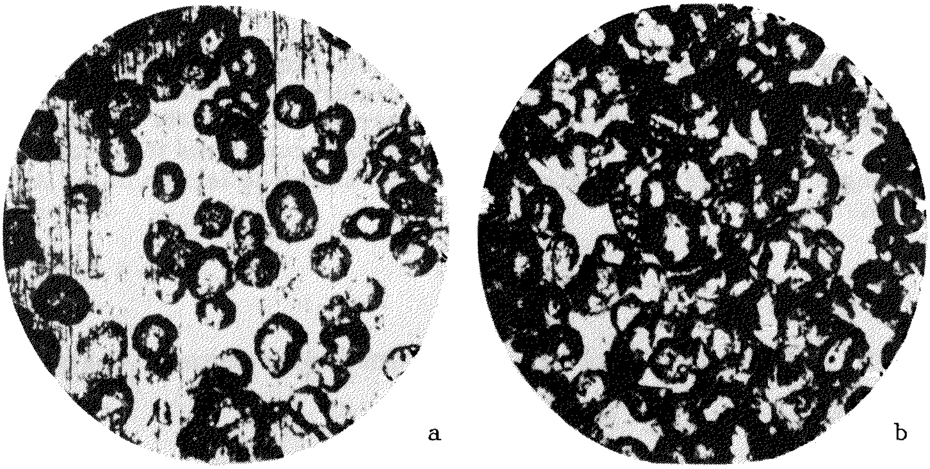

Fig. 3. Appearance of a peened surface: a - 55% coverage, b - 90% coverage

- measurement of deflection of Almen test strips and measurement of coverage
- distribution of hardness analysis
- metallographic analysis
- results of fatigue testing comparisons.

Table 5 provides procedure for current control of shot and shot peening parameters according to standard /BN-780/7002,1/.

TABLE 5 Specification for Control of Shot Composition and Shot Peening Parameters

Parameter /Desired properties/	Testing time: Peened parts	Testing time: Almen test strips	Testing time: Shot composition
Peening intensity	-	After 60 h time peening	-
Coverage	After 20 h time peening	a. b.	-
Sieve analysis: For shot	-	-	Just after delivery and after initial elimination of sharp edges for cut steel wire shot
Sieve analysis: For shot composition	-	-	After 60 h time peening
Fatigue test	For new production	-	-

CONCLUSIONS

The shot peening process requires an accurate selection of shot peening parameters. A correct selection of shot peening, parameters should be based on non-destructive testing of surface layer, having regard to an adequate criterion of mechanical properties, e.g. fatigue life. In practical conditions it is enough to meet peening intensity demands determined by measuring deflection of the Almen test strips.

REFERENCES

Horowitz, J. /1973/. Oberflächenbehandlung mittels Strahlmitteln. Oberfläche-Surface, 2, 38-42.

DIN 8201 /1977/.

SAE J441, /1969/.

SAE J827, /1969/.

SAE J442, /1968/.

Kugelstrahlen - shat Peening N O 5154, /1977/

SAE J443 /1968/

Horowitz, J. /1976/. Oberflachenbehandlung mittels Strahlmitteln. Oberflache-Surface 4, 1A - 16A.

Kulowanie, Wytyczne Obróbki. BN-80/1062-01 /1980/