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Effect of Shot Peening on Fatigue Properties for Corroded and Uncorroded (CK35) Steel

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Abstract

The traction property is one of the important mechanical properties, especially the rotary parts which are subjected to constant and variable loads There are many methods used to improve this property, and the shoot peening by metal balls is considered the most critical one. the study focuses on this characteristic of steel CK35 used in many engineering applications as the rotating shafts and railway This study shows that the fatigue strength is improved by14% after shoot peening with metal balls. The study includs the rehabilitation of damaged samples as a result of fatigue corrosion. The standard solution adopted was 36% $MgCl_2$ with a 30 days immersion period. These samples has been improved by 6% after it decreased by18% due to immersion in the alkaline solution.

***Keywords**: Crevice corrosion, CK 35, fatigue strength, shot pining.*

1. Introduction

There are many methods for surface hardening; the-chemical methods, such as carburizing and nitriding. Physical methods showed a better interest with changing the chemical composition of treated alloys. One of these methods is shot peening with metal balls. The theory depends on the resist of nucleation and growth of cracks. Cracks and growth are with time working. This is required by many alloys subjected to continuous vibration and forces especially those used in bone fixation [1]. All the above listed methods increase surface hardness by producing compressive residual stresses. The surface plays a key role in the life of the metal parts, especially the fatigue age which is related to the formation and growth of cracks on the surface [2].

The shoot peening process depends on many variables, such as the speed of balls, the time spent on the process of solidification, and the dimensions of the balls used in the process of molding and shape [3].

In this study, used alloy steel (CK35) is used which resist vibration the presence of an auxiliary medium on corrosion leading to the acceleration of the process of the emergence of the crack and progress., The resistance of metal to the fatigue in the corrosion medium is less than in the non-helping to corrosion [4] in that the number of cycles necessary to break the corrosive medium which is less than the number of cycles required to obtain the fracture in the other medium when the same voltage value is applied to the alloy. [5,6].

The selection of shoot metal balls is as a method of surface hardening to obtain better properties of metal is to satisfy their requirements and efficiency. The shoot method of balls is applied to treat the damage caused by corrosion when the metal is exposed to hard corrosive media. The shoot of the balls leads to the closure of the pressure and some short cracks and impedes its progress, which improves the surface properties of the metal especially fatigue resistance. The objective of this research is to raise the efficiency of the metal chosen for studying as a common metal used in the engineering parts and improve its properties by increasing the hardness of the surface and to maintain a strong heart to withstand shocks

2. Experimental Work

2.1 Material

The alloy was in the form of rods with various lengths and diameters, which were machined by CNC to obtain accurate dimensions. Then, the samples surfaces were grinding and polished to avoid stress concentration areas. Fig 1 has showed the standard dimensions of the sample supplied with testing device used in rotational bending tests. The chemical composition and mechanical properties of CK35 illustrated in Tables 1 and 2, according to AISI1035.

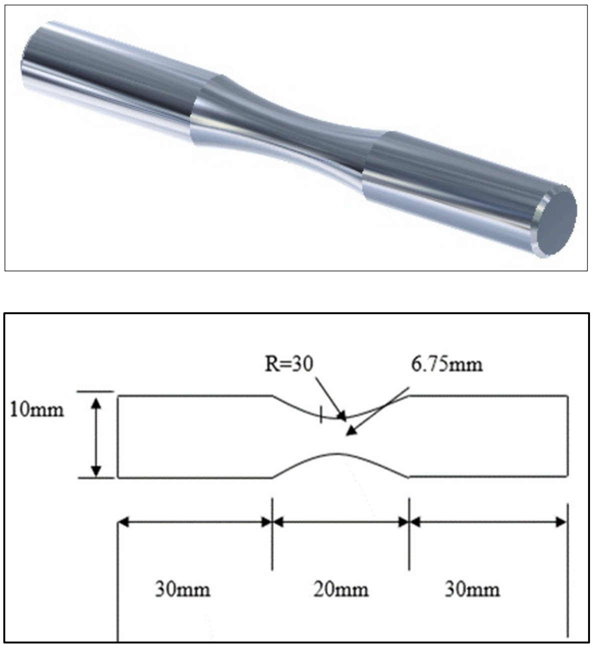

Fig. 1. standard fatigue sample (ISO 1143:2010 en)

Table 1,
chemical composition

Element	C	Si	Mn	Other	Fe
Standard	0.35	≤0.40	≤0.65	<1%	Rem
investigated	0.34	0.33	0.6	0.7%	Rem

Table 2,
Mechanical Properties according to AISI 1035

σ_{yield} (MPa)	$\sigma_{ult.}$ (MPa)	€%	Hardness(HB)
300	480-670	21	190

2.2 Machines and Instruments

2.2.1 Testing Machine

The HI-TECH Rotating Bending Fatigue Testing machine tester is used. The rotating speed of 5600 RPM where 1/3 million stress reversals occur per hour.

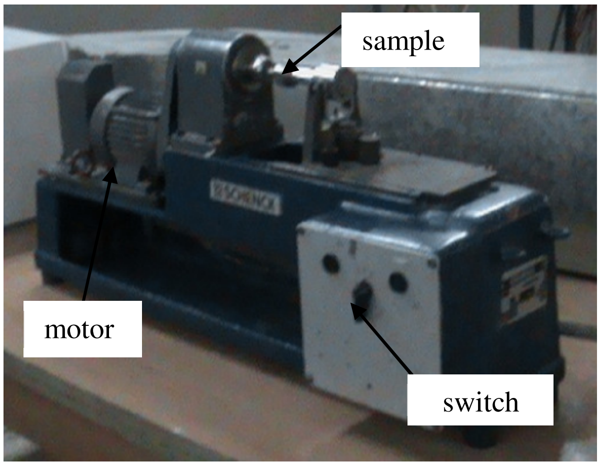

Fig. 2. Testing machine.

2.2.2 Shoot Peening Device

The shooting is performed using a shoot device where a ball bearing cast steel balls and the parameters as illustrated in table 3.

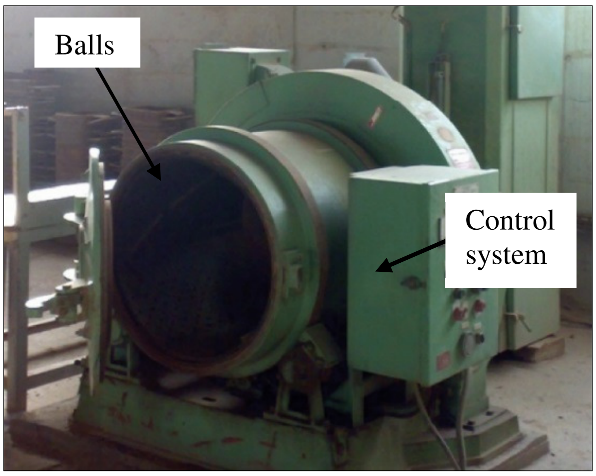

Fig. 3. Shoot Device.

Table 3,
Parameters of shot peening

Parameter	value
Diameter ball	0.6 mm
Hardness(HRC)	50
Pressure	12 bars
Speed	40 m/s
Distance between ball and machine	10 mm
Speed of lathe machine	20 rpm

2.2.3 Optical Microscope

Optical microscopic imaging has been used to investigate the fracture section surface fir both types of samples (Shoot Peening and Corrosion). The magnification for all samples was 500x)

2.2.4 High Precision Electronic Balance

Accuracy (10^{-5} gm)

2.3 Corrosion Test Medium

A standard corrosion test was selected to test for the resistance of fatigue, magnesium chloride at a concentration of 36% $MgCl_2$ (ASTM G36). This test solution was prepared by dissolving 360 g of high purity magnesium chloride per liter of distilled water. The PH of the solution daily was measured to keep the solution stable during testing time by adding more salt and water to corrosion cell.

2.4 Test Groups

Test groups were classified into four groups according to the type of mechanical and chemical treatment. Where 24 samples for each group have been machines by using Indexed turning machine. According to the standard specimen shown in Fig. 1.

Table 4,
Group of samples Coding

Group	Type of test
AS	As Received
SP	After Shot Peening
CR	After Corrosion
CRSP	After Corrosion and Shot peening

3. Results and Discussion

To draw the S – N curve which is illustrated in Fig (4), the titration test is performed on eight groups of samples. Each group consisted of three samples by casting a constant value of stress for each group and calculating the value of the number of cycles Failures for each sample to give more accuracy to the obtained results and to eliminate the random behavior of the samples. The same tests are repeated for the same number of samples with metal balls. The same tests is performed after the samples are immersed in salt solution. Then, the samples is cast with metal balls and the tests is carried out as shown in Fig (4)

Age-adjusted equations for the results is obtained in Fig (4) using a best curve fitting method and are as in Table (5)

Table 5,
Equation and fatigue limit

Samples Group	Fatigue equation	Fatigue limit	Enhance ment %
SP	$\sigma_f = 1184N_f^{-0.093}$	320	**14%**
AS	$\sigma_f = 1216N_f^{-0.102}$	280	
CRSP	$\sigma_f = 1259N_f^{-0.112}$	265	**6%**
CR	$\sigma_f = 11446N_f^{-0.11}$	250	

The fig (4) and table (5) show the increased fatigue limit and fatigue resistance of the alloy with the shooting of the metal balls compared with the test performed without shooting. This increase value is due to the exposure of the sample to a surface hardening process. The hardening of the surface leads to obstruction and even in the case the emergence of such cracks. The increase with shooting is about 14%.

When test in solution (36% $MgCl_2$) according to ASTM G36, the sample – typically U-bend – is immersed in a boiling MgCl2-solution. The time to cracking is an indication of the resistance to stress corrosion cracking.

This test causes a decrease in the weight of the alloy comparing to the test conducted under dry conditions. This decrease is due to the immersion of these samples in the salt solution which influenced efficiency on the samples. Clicking on the surface and thus cracks develop faster because of the combined effect of stress and corrosion. The continued effect of this medium causes more pits and the formation of many cracks and makes these cracks faster [8]. The decrease in the value of the threshold was about 18%.

The shooting of the specimens led to the termination and closure of the pits caused by the salt solution and the creation of compressive stresses on the surface hardening the progress of the crevices. The increase in properties unreturned samples to their original state due to the corrosive effect of the salt solution, the value of the increase was 6%. The corrosion rates of the tested samples are presented in Table (6).

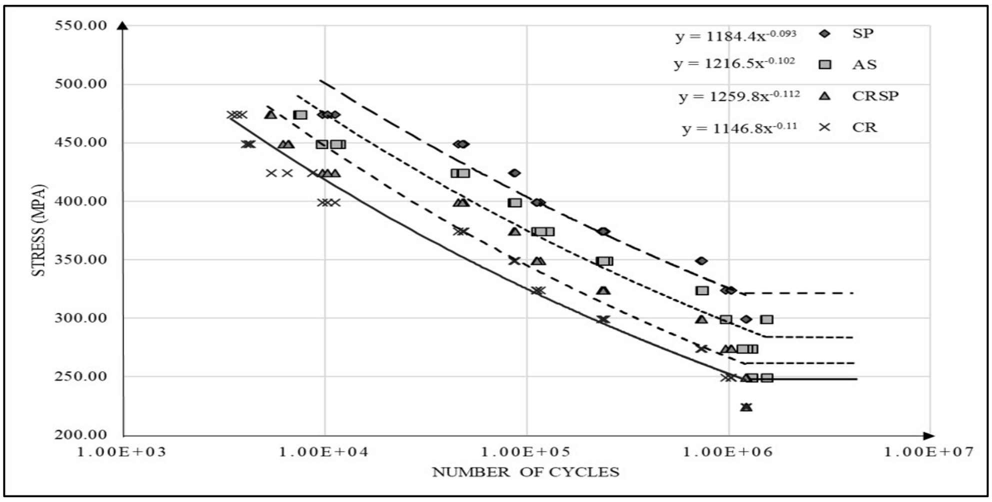

Fig. 4. (S – N) curve for test specimens.

Table 6,
Corrosion rates of samples

Type of test	AS	SP	CR	CRSP
Weight loss (g)	0.0530	0.0355	0.0815	0.0670

It is noted that the weight loss due to corrosion decreased with shoot metal balls while this rate increased when immersed in salt solution and decreased again when the cast of metal balls has been shoot. This is in line with the results of the tests presented previously.

The fracture sections as shown in Fig 5 has reveled a finer cracking in the shot samples, in addition to stress cracking has been avoided in the shot samples after corrosion.

4. Conclusions

Shot peening increases the fatigue resistance for the un corroded samples with 6% meanwhile the fatigue resistance has a better enhancement with the uncorroded samples with 14%.

The weight loss due to corrosion of shot samples overcomes the cervices corrosion.

The fatigue resistance can be enhanced and maintained perfectly even after corrosion.

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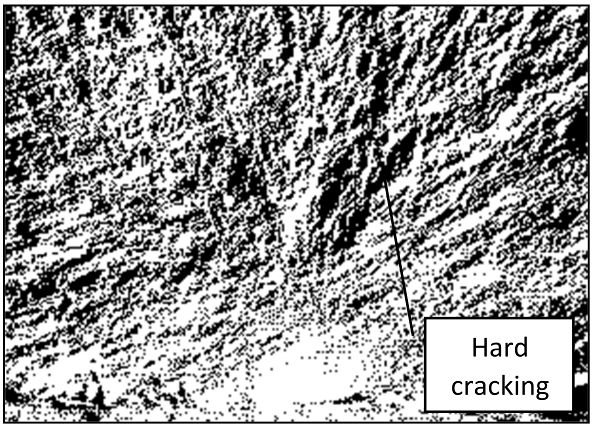
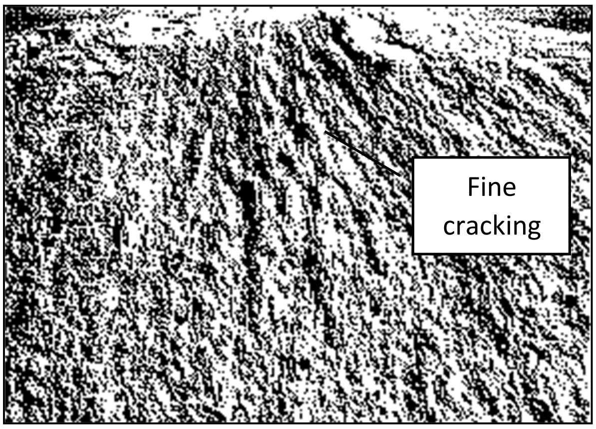
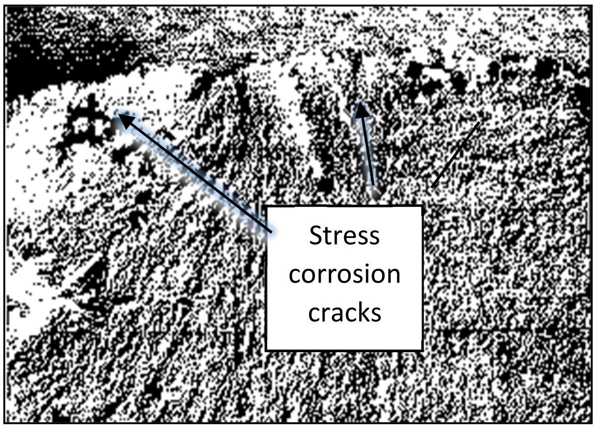


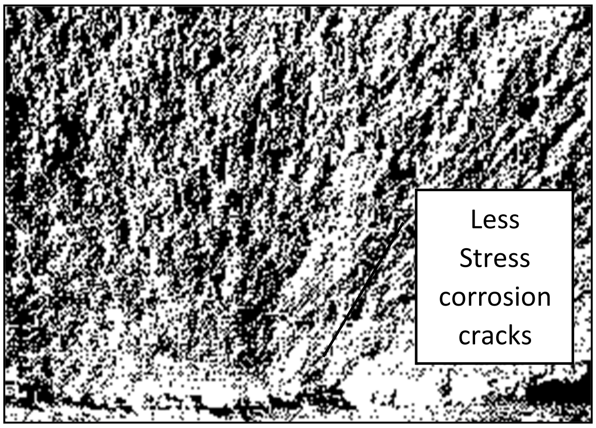
A: without shoot (200x)



B: with shoot (200x)



C: corrosion (200x)



D: corrosion + shoot (200x)

Fig. 5. Fracture surface of four cases.

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تأثير القذف بالكرات على خواص الكلال لعينات متآكلة وغير متآكلة للفولاذ CK35

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الخلاصة

تم في هذا البحث دراسة تحسين خواص الكلال للفولاذ (CK35). حيث تضمن البحث دراسة اربع حالات من خلال اختبار الكلال. الحالة الاولى للعينات كما أستلمت. والحالة الثانية تم فيها اختبار الكلال بعد اجراء بسمرة بالقذف بكرات حديدية. والحالة الثالثة كانت بأختبار الكلال لعينات مغمورة في محلو $MgCl_2$ بتركيز ٣٦% لمدة ٣٠ يوما. و الحالة الرابعة والاخيرة كانت باختبار العينات المغمورة بعد اجراء بسمرة القذف بكرات الحديد. حيث تحسنت مقاومة الكلال للعينات بعد بسمرة القذف بنسبة ١١%. بينما انخفضت خواص الكلال بالنسبة للعينات المغمورة بنسبة ١٨%. و بعد أجراء البسمرة بالقذف طرأ تحسن على خواص الكلال لتلك العينات بنسبة ١٤%. وعليه نجد ان القذف بالبسمرة من العوامل التي تعيد تأهيل العينات من ناحية مقاومة الكلال حتى بعد تعرضها للتآكل.