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CORROSION FATIGUE AND FRACTURE BEHAVIOUR OF SHOT PEENED CARBON STEELS

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ABSTRACT

The influence of shot peening over corrosion, stress corrosion, corrosion fatigue and fracture behaviour of carbon steel has been studied. A laboratory equipment for stress corrossion testing was designed and fabricated (vertical type). Further, it was modified into `horizontal type' for easier loading and unloading of the test specimen. Test specimens were peened manually. The controlled peening showed that there was reduction in loss of weight, improvement in stress corrosion resistance and corrosion fatigue resistance when combined with carburising treatment. Shot peening alone did not show any appreciable improvement in corrosion fatigue resistance. It was also observed that shot peening delayed rate of crack propagation for notched specimens.

KEYWORDS

Shot peening, Stress corrosion, Corrosion Fatigue, Fracture

1. INTRODUCTION

Almost all metals and alloys are subjected to the action of atmospheric air or other surrounding media. (for example, sea water, soil, acid and alkali solutions etc.) and are gradually destroyed beginning from the surface. This progressive destruction of metal surface due to the chemical or electrochemical reaction is called corrosion to oxide or other compound form. In some cases, the compound will form a protective layer which reduces and prevents further corrosion, but in some cases this is not so, and further corrosion is not inhibited.

Stress corrosion is a combined action of corrosion and tensile stress, where corrosion is more severe. Most of the components of machines and structures are under stress corrosion. Hig strength alluminium alloys, magnesium, Titanium, Copper, steel and stainless steel are susceptible to stress corrosion (Pascoe, 1991).

Similarly, fatigue under corrosion environment is also important and more severe. Shot peening is a cold working process in which spherical steel shots or glass beads of suitable material and size are allowed to impings with relatively high velocity on the surface of metal parts. It is only commercially used for improving fatigue life of components but also equally good for delaying stress corrosion cracking (Paul, 1984). For peening fatigue and stress corrosion notched samples controlled peening could be used where peening intensity is decided on the basis of local peening considerations (Sharma and Mubeen, 1983; Sharma, 1987).

2. EXPERIMENTAL WORK

The pneumatic type shot peening equipment used for this investigation has been reported earlier (Sharma and Mubeen 1983). The corrodent used was 3N - NaCl solution. For studying effect of shot peening on corrosion, the virgin specimen and the shot peened specimen of same material were kept immersed under corrodent and the loss of weight was measured. This was carried out under two different conditions, corrodent is still and agitated state.

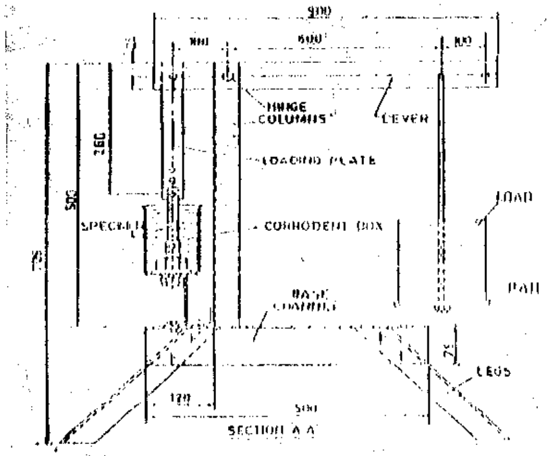

Fig. 1. Stress corrosion set up vertical type

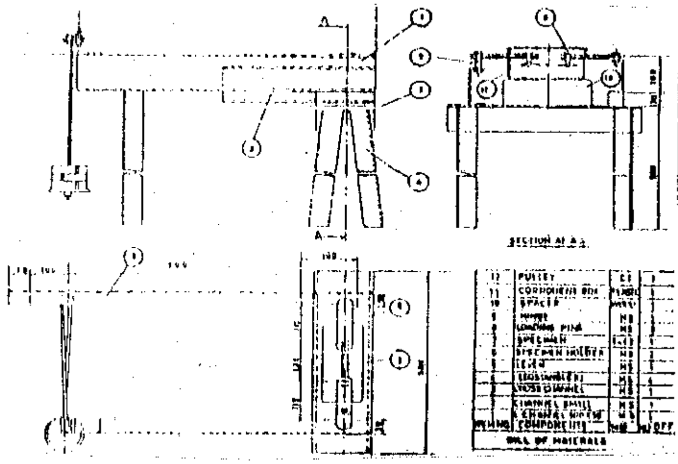

Fig. 2. Three views of stress corrosion set up, horizontal type.

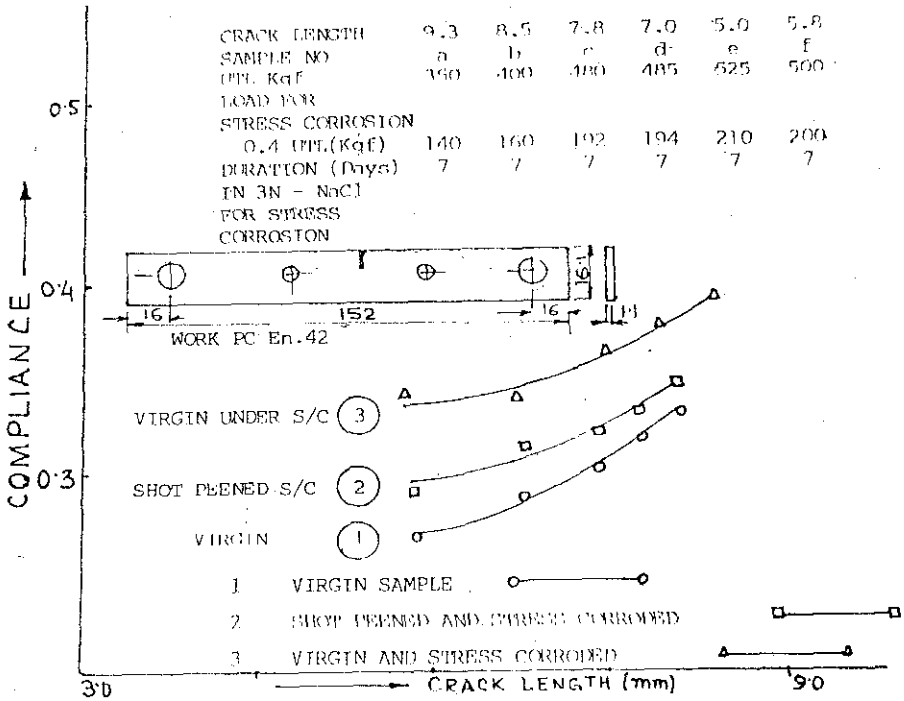

Fig. 3. Plot for compliance vs. crack length for three different conditions

For studying stress - corrosion behaviour the stress corrosion set up for vertical and horizontal loadings were designed and fabricated (Sharma, 1988). Fig.1, shows the vertical type set up. The test specimen is in the form of notched strip with holes at the two ends for loading. Loading can be done with a simple lever hinged on two vertical angles. One end of the lever carries loading plates which the other load pan. The test piece was pinned on a bolt while is fixed in the bottom of corrodent box (beaker) over the flange of a channel. The lower flange of this channel is bolted with the base channel. For replacement of corrodent, the lower bolt is to be unscrewed, while the upper bolt carrying specimen is fixed with M seal on the base of the beaker such that corrodent may not leak from beaker. During the test for the measurement of crack propagation under stress corrosion, a dial gauge indicator was mounted on the rod end and was fixed on the base channel. For agitation of corrodent an air pump was used. Further the stress corrosion set up was modified to have convenient loading and unloading of the test piece. The test piece can be loaded in horizontal position, which facilitated the mounting of the clip gauges for measurement of displacement in the test piece, while it was not possible to do so on vertical set up, (Fig.2) where three views of the set up are shown. In this, loading of the job was done by the rope and pulley. The test piece was dipped in the corrodent box, which can be placed below the test piece very conveniently and then supported over a removable wooden spacer. This arrangement simplified the loading and unloading of the test piece, as well as plotting of load-displacement curves for notched specimens (within elastic limit). The shot peened specimen were put under stress corrosion and stressed for a value of 0.4 times of ultimate tensile stress for seven days. The graph showing compliance vs crack lengths was plotted for the load-displacement curves of virgin stress corroded for seven days, and shotpeened and stress corroded for seven days. Fig.3 shows plot for compliance vs crack length for three different conditions.

For studying corrosion fatigue behaviours, the cantilever by PC rotating bending fatigue testing machine was used with a special arrangement for corrodent pumping over the specimen. Since it was observed that practically there was no survival of 0.3 carbon steel under 3N-NaCl environment, it was proposed to case carburise and then to shot peen the specimens for determining mean fatigue limit. Stair-case method was adopted for calculating mean fatigue limit (Mubeen, 1984).

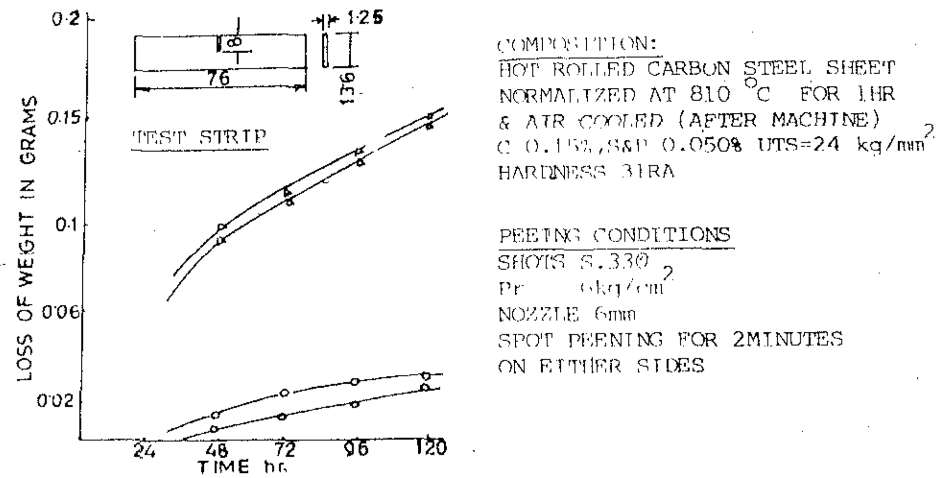

Fig. 4. Loss of weight of 0.15% steel in 3N-Nacl sol. with and without agitation for virgin and peened stress strips

3. RESULTS AND DISCUSSION

Loss of weight of shot peened specimens had shown reduction by 20% - 30% than that of virgin, when they corroded for seven days under 3N-Nacl in still state. (Fig.4 and 5). The corrodent in agitated state, had shown that the amount of material eaten away is more than previous case. Loss of weight due to corrosion on still state of corrodent shows, gradual increases and after certain period it is found reducing. This may be due to the formation of oxide layer. The test materials were low carbon steels.

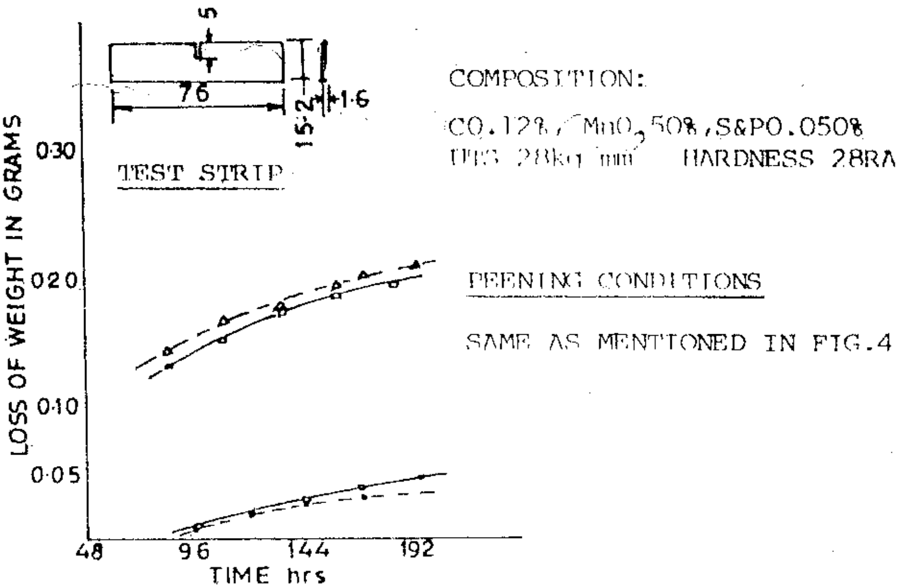

Fig. 5. Loss of weight of 0.12%C steel in 2N Nacl sol. with and without agitation for virgin and peened test strips

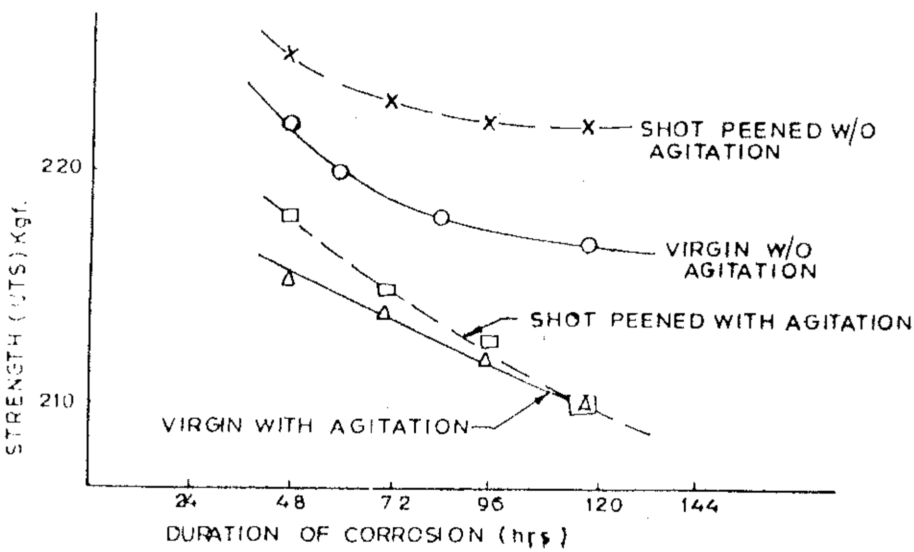

Fig. 6. Loss of strength of 0.12% C-Steel after corrosion in 2N Nacl sol. with and without agitation for virgin and peened test strips (76 x 15.6 x 1.25) mm

From the plot for compliance vs crack lengths, it is clear that rate of crack propogation was lowered in the case of shot peened specimens. The test material for this was En42 steel strips.

The experimentaql results of mean fatigue limit of 0.3% carbon steel are presented in Table 1. It showed that shot peening combined with case *carburising hardening and tempering* treatment was beneficial for increasing corrosion fatigue resistance.

Table 1. *Corrosion Fatigue Results*

Sl. No.	Material condition (0.3% carbon steel)	Mean fatigue limit, Kg/mm^2	% *improvement*
1.	Virgin in annealed condition	1925-	
2.	Shot peened	26.20	36.10
3.	Virgin under 3N - NaCl	No fatigue limit	—
4.	Shot peened, under 3N - NaCl corrodent	No fatigue limit	—
5.	Carburised, hardened and tempered	20.97	8.93
6.	Carburised, hardened tempered and shot peened	27.50	42.85
7.	Carburised, hardened and tempered, under 3N - NaCl corrodent	7.00	—
8.	Carburised, hardened tempered and shot peened under 3N NaCl corrodent	9.10	30% comp-red to condition No.7

The above figure shows that the strength of shot peened samples were higher under corrosive environment without agitation as well as under agitation. Thus shot peening may be considered to be beneficial in minimising corrosion effects.

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