Effect of Heat Treatment on Crack Initiation & Propagation of Stainless Steel (Ss-304)

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Abstract

Cyclic loading is common experimental practice for investigations of large structures like vehicles. Numerical analysis of cyclic loading conditions is also a well-established field of research and application. Theoretical and practical support is rare for evaluating growth of fatigue cracks under cyclic loading conditions. Cracks can occur naturally in engineered components due to combination of environmental effects and materials and geometric properties. In this study, the effects of heat treatment on crack initiation propagation of stainless steel (SS-304) are investigated. The specimens are subjected to different cyclic load. The crack initiation propagation and final fracture behavior are observed microscopically. The specimens are kept in the furnace at 500°C at a constant time 1 hour where cooling medium is used as air for heat treatment the effects of heat treatment are investigated. The fatigue life of the tested specimen at 400MPa stress before after heat treatment are 54900 cycles 61000 cycles respectively. So, a better fatigue life is found after heat treatment.

Index terms— heat treatment, fatigue crack. fatigue crack growth, fatigue life.

Introduction ltra-fine grained metals are becoming promising for engineering applications due to the recent progress in technology. Therefore, for envisaged structural applications of Ultra-fine grained metals, attention has been paid to fatigue performance, such as cyclic properties, S-N characteristics, the formation of shear bands (SBs) and persistent slip band (PSBs) [1] .

Authors ? ? ?: Department of Mechanical Engineering, Rajshahi e-mail: rusho_moran@yahoo.com influence on the fatigue life under the same strain range. Therefore, the fatigue damage can be correlated to the crack size. It is possible to measure the fatigue damage components, or if no crack is found, it can be confirmed that damage has not been accumulated yet **??**3] . The fatigue life can be divided into two phases: the number of cycles to crack initiation (hereafter called initiation life) and the remaining life until the failure of the specimen (hereafter called growth life) [4] .

In this study crack initiation and propagation behaviour are observed before and after heat treatment.

Cyclic loading is a common phenomenon for different structures. When cyclic loading is applied on metallic structures a common incidence occur called fatigue failure. Fatigue failure is a continuous process which starts with a small crack. The crack propagates up to failure of the structure. Sometimes it is seen then there are more than one cracks initiate and propagate, but their initiation time is not same for all, and the propagation is not homogenous for all of them. Some cracks propagate up to certain cyclic loading and then remain unchanged. They are not directly responsible for the failure of structure, although they weaken the structure and cause more cracks to initiate. Even the crack initiation and propagation nature of cracks are not same before and after the heat treatment. From this study it is found that, crack propagation time is greater after heat treatment i.e. fatigue life is better after heat treatment.

II.

1 Test Material & Experimental Procedure a) Material Properties

The material used for the fatigue test was Type 304 austenitic stainless steel, which was provided in a cylindrical bar shape. Its chemical composition (in mass %) was: C, 0.07; Si, 1.0; Mn, 2.0; P, 0.05; S, 0.02; Ni, 10.5; Cr, 19.5 and balance Fe. The ultimate tensile strength, yield tensile strength is 600MPa and 300MPa respectively. The material had an approximately equiaxial grain structure.

2 b) Procedure

The working procedure of this study is shown below——? ? The required metal (ss-304) was collected.

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In order to quantify the fatigue damage, it is important to understand what kind of change is brought about by cyclic loading, and to know the critical conditions for fatigue life. Using carbon steel (S45C) specimens, Murakami and Miller showed that crack initiation and growth could be regarded as the damage caused by fatigue loading and that fatigue life was almost equivalent to the number of cycles for the initiated cracks growing to the critical size **??**2] . Kamaya had done a research based on observation of Fatigue Crack Initiation and Growth in Stainless Steel **??**3] . The fatigue loading causes various microstructural changes such as an increased number of dislocations, formation of cell structures, and alternation of deformation properties. However, these changes have minor© 2014 Global Journals Inc. (US)

? ? The metal was assured by determining ultimate and yield strength by using universal testing machine. ? ? The suitable shape was given to the metal according to the requirement. ? By using various grades of emery paper such as P320C, 600AW, P1000C, P1200C, C1500CW, C2000CW specimen surface were polished smoothly.

? After polishing by the emery papers, Aluminum oxide (AL 2 O 3) powder was used for fine polishing and ethanol was used to remove the black spots from the specimen.

? ? A load was chosen for which the stress was produced on the tested specimen lies between the ultimate (600MPa) and yield strength (300MPa). ? By using this selected load the fatigue life (the number of cycle at which the structure fully fractured) of the tested specimen was determined with the help of fatigue testing machine.

? By selecting 10% of the fatigue life the specimen was examined with the help of fatigue testing machine.

The predicted space of the specimen was inspected microscopically to observe the crack initiation. ? The previous two steps were followed until the final crack of the tested specimen was occurred. ? Every times crack propagation of the tested specimen was observed microscopically. ? The above steps were performed after heat treatment of the tested specimen.

III.

4 Results and Discussion

5 a) Observation of Crack Initiation & Propagation

Cyclic loading is one of the main reasons for crack initiation and propagation. Crack is microscopic in nature. For stainless steel (SS-304) the change of length of PSBs due to fatigue is observed by using Metallurgical Microscope. In optical microscopic image, it is shown that the PSBs length is increased with increasing cyclic load after starting the crack growth.

Figure 1:

Figure 2:

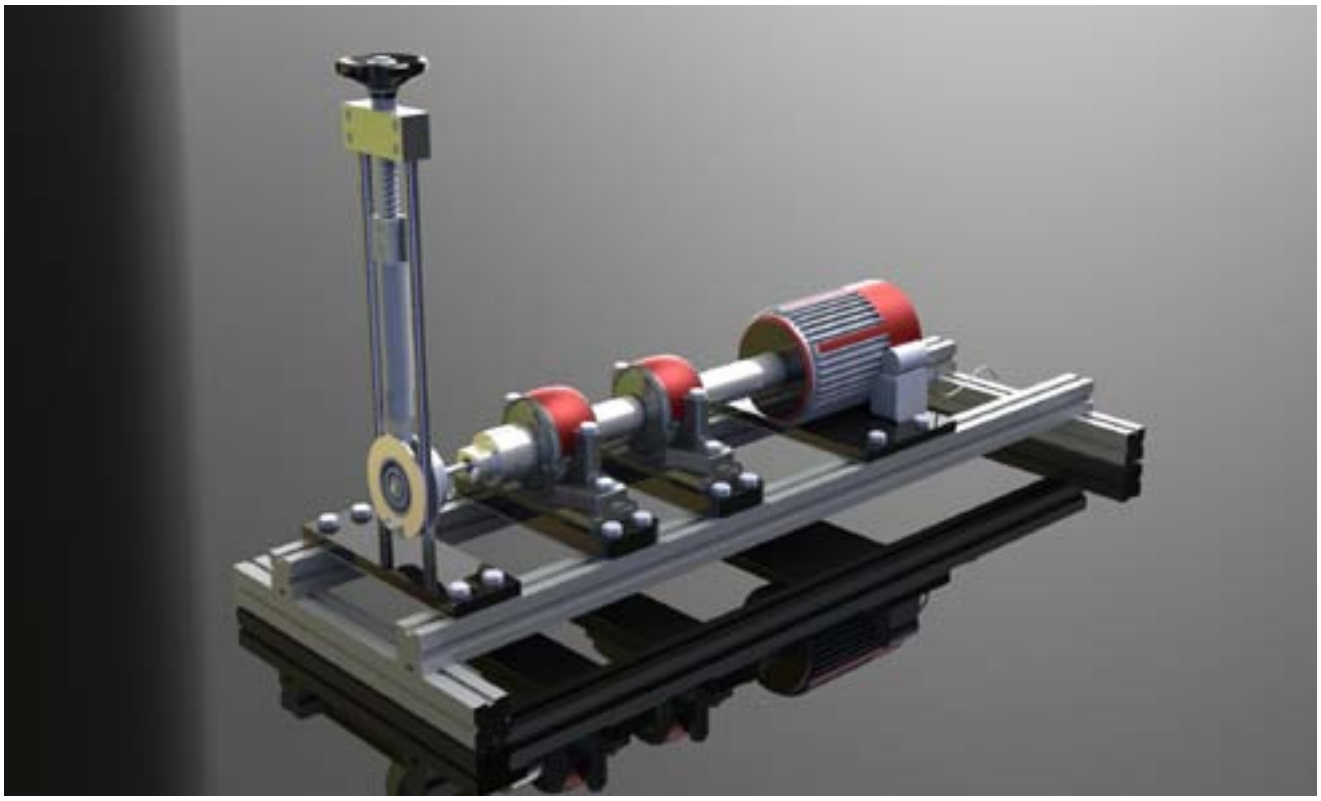

Figure 3:

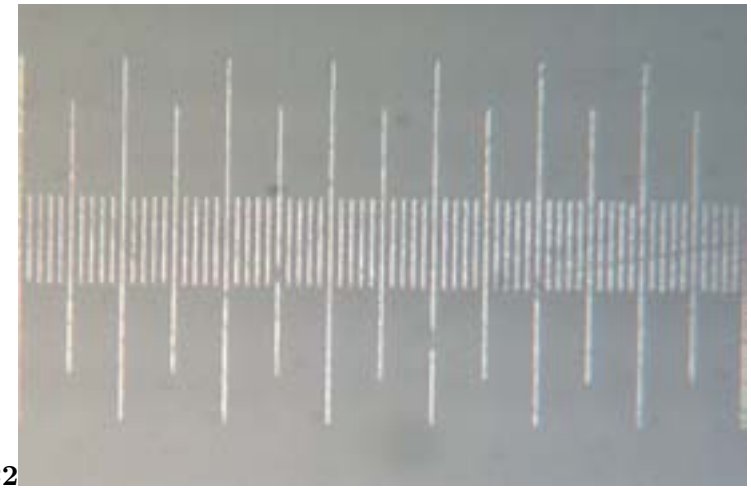

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Figure 4: Figure 2 . 2 :

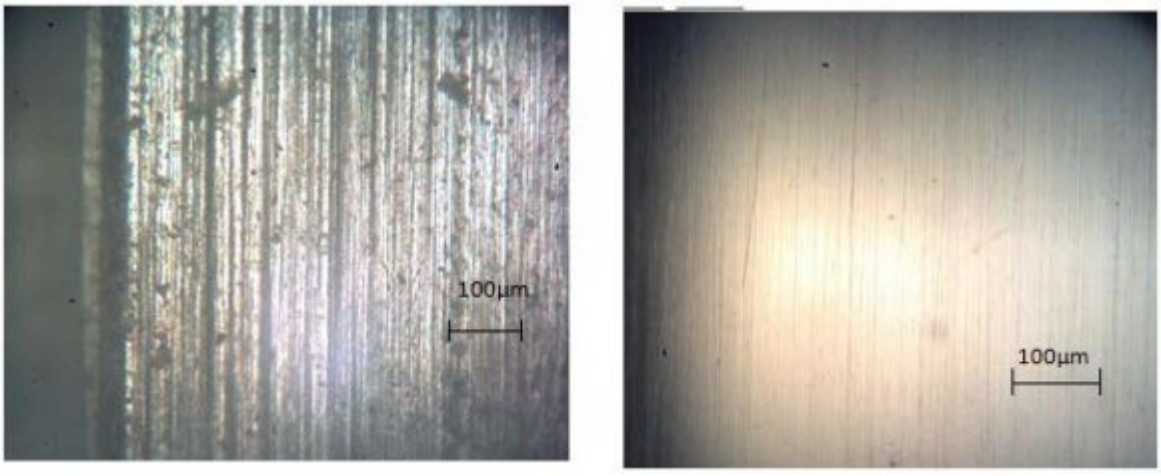

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Figure 5: Figure 3 . 4 :

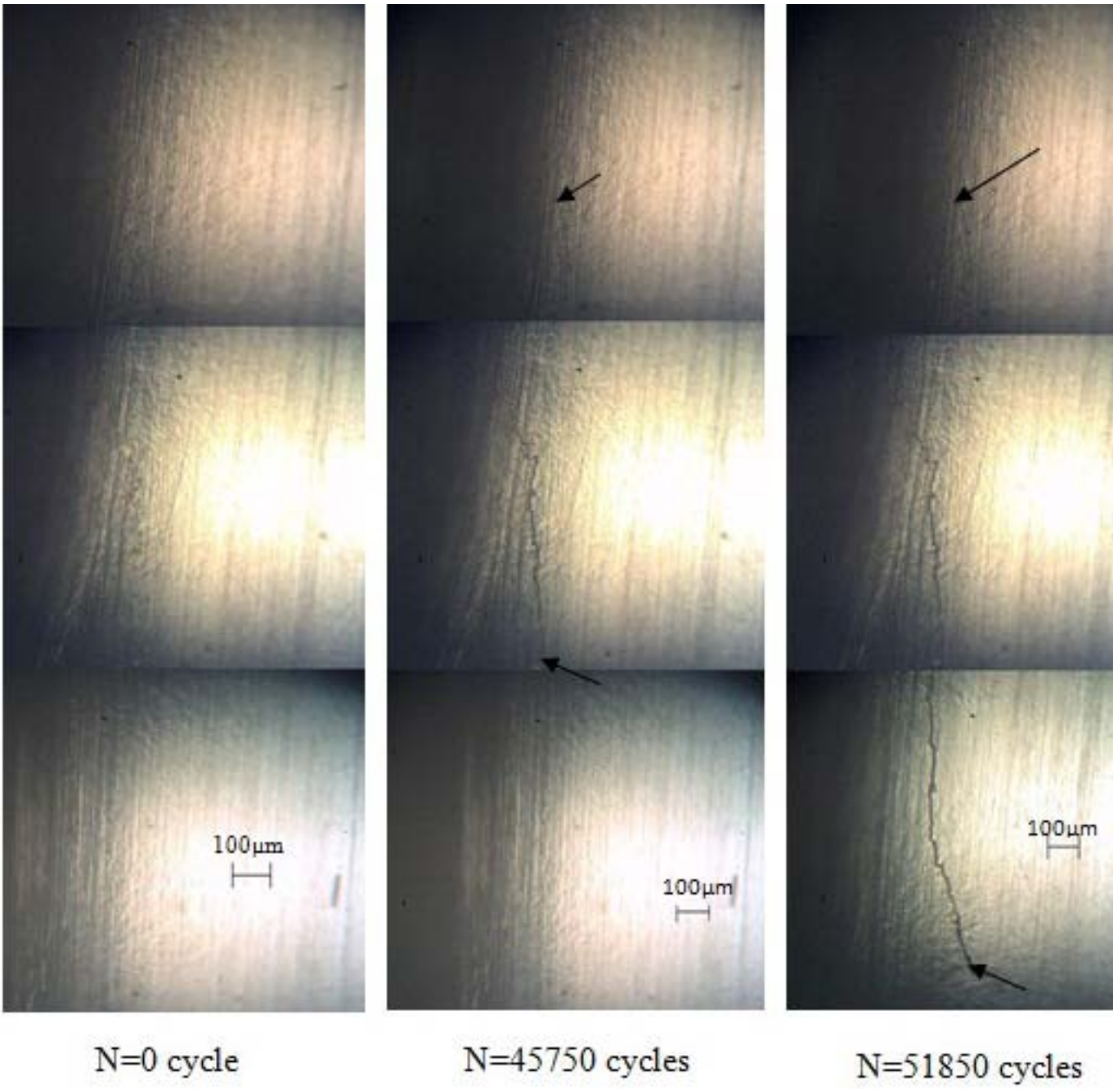

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Figure 6: Figure 3 . 5 :

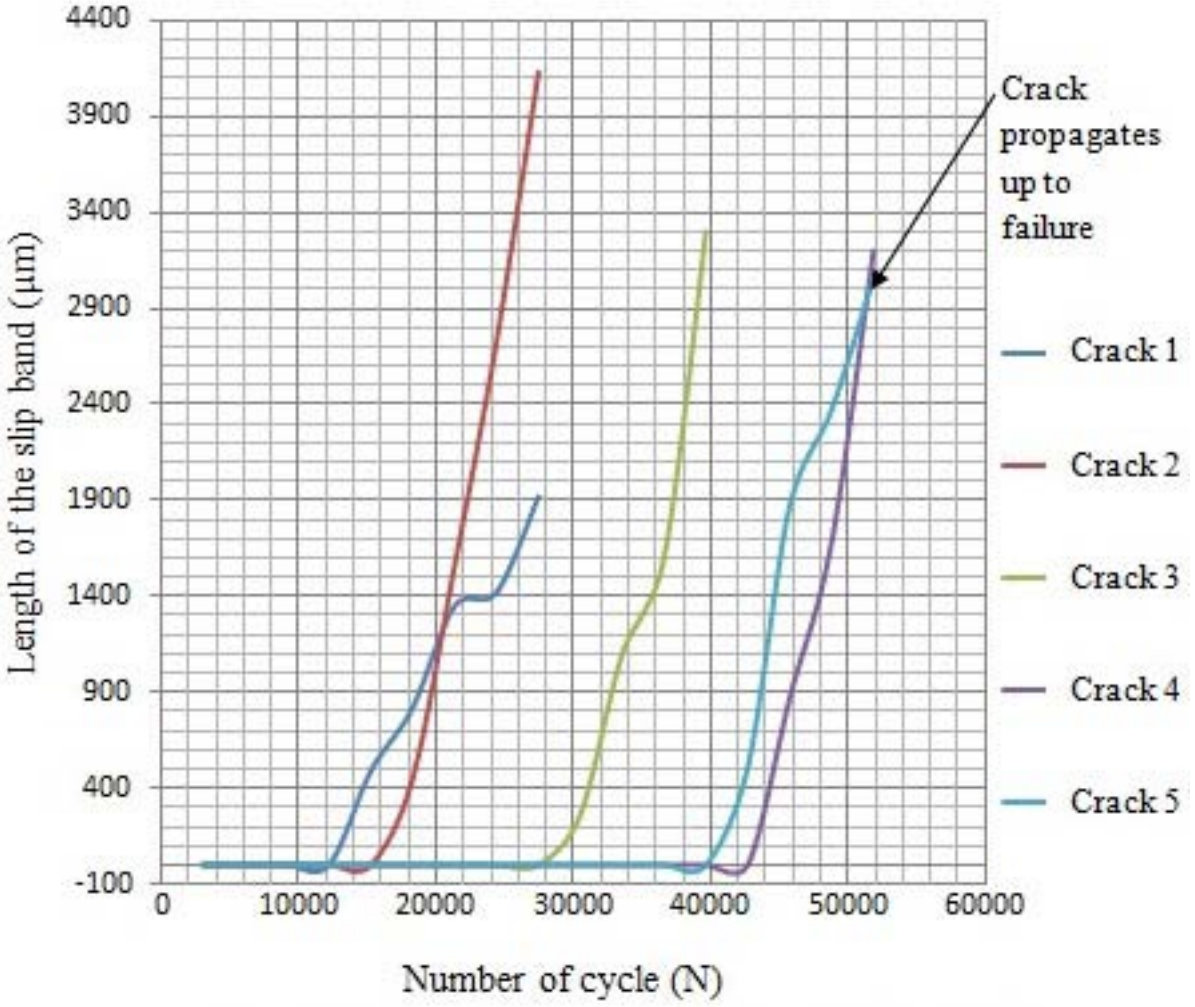

Figure 6.12: Number of Cycle Vs length of the slip

Figure 7: Figure

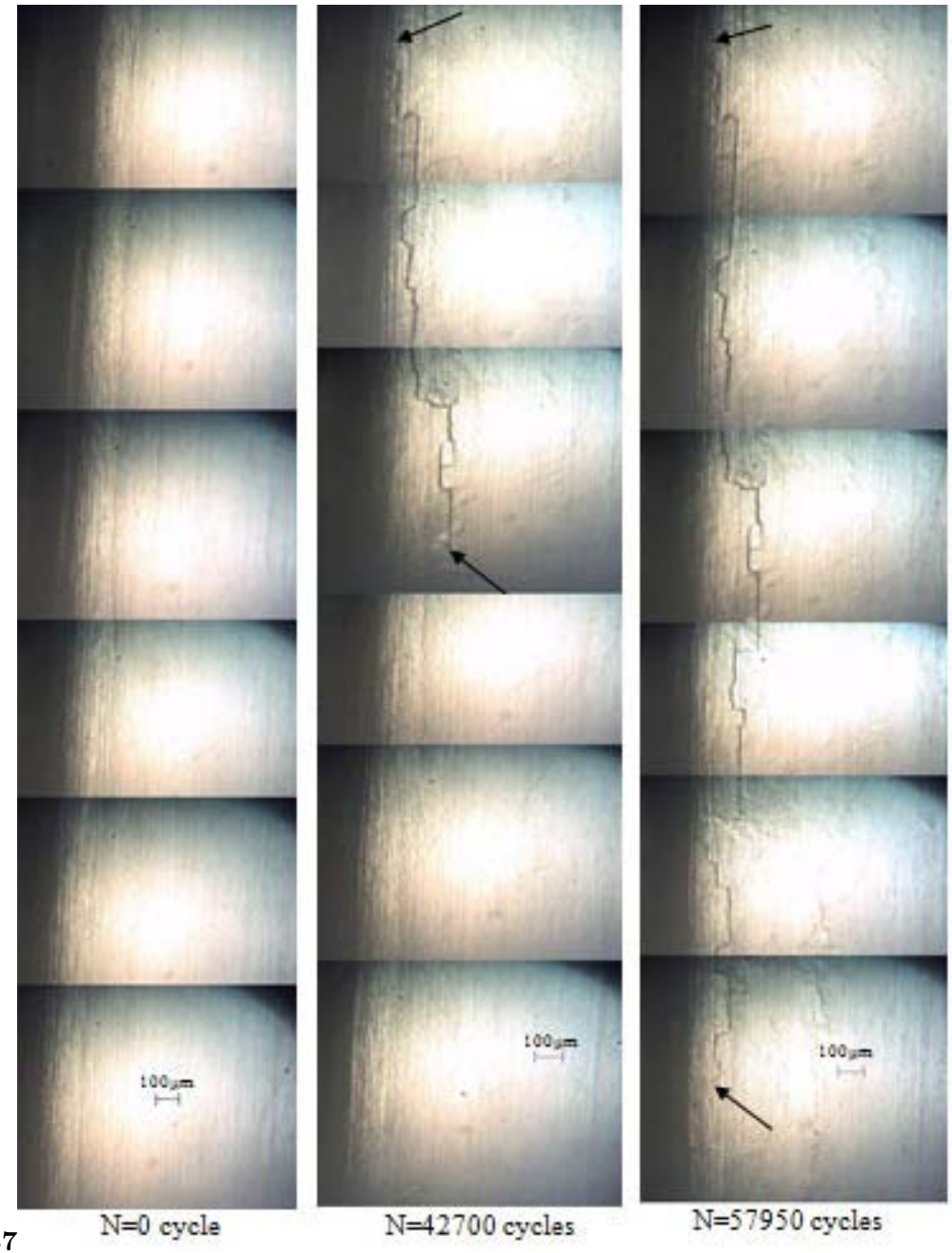

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Figure 8: Figure 3 . 7 :

.1 Appendix A

[Low-Cycle Fatigue Damage for Plant Maintenance E-Journal of Advanced Maintenance ()] 'Low-Cycle Fatigue Damage for Plant Maintenance'. *E-Journal of Advanced Maintenance* 2013. 5 p. .

[Chopra (2002)] 'Mechanisms and Estimation of Fatigue Crack Initiation in Austenitic Stainless Steel in LWR Environments'. O K Chopra . ANL- 01/25. *NUREG/CR-6787*, Aug 2002.

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