Fatigue Behavior and Monotonic Properties

For

AISI 16MnCr5 Steel
Four Point Bending

Iteration 187

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Summary

The required strain-life fatigue data for AISI Iteration 187 have been obtained using bending tests. The American Iron and Steel Institute (AISI) provided the material in the form of metal bars. These bars were machined into bending fatigue specimens. The Rockwell C hardness (RC) was determined as the average of nine measurements. Constant-amplitude tests under bending were conducted in the laboratory at room temperature to establish the strain-life curve.

Introduction

This report presents the results of fatigue tests performed on a group of 16MnCr5 Steel specimens (Iteration 187). The American Iron and Steel Institute provided the material. The objective of this investigation is to obtain the strain-life curve of the material under a four point bending cyclic test.

Experimental Procedure

Specimen Preparation

The material for this study was received in the form of bars. Bending fatigue specimens, shown in Figure 1, were machined from the metal bars. Before testing, the specimens had a final polish in the loading direction in the gauge sections using 240, 400, 500, and 600 emery paper and a thin band of M-coat D acrylic coating was applied along the central gauge section. The purpose of the M-coat D application was to prevent scratching of the smooth surface by the knife-edges of the strain extensometer, thus reducing the incidence of knife-edge failures.

Test Equipment and Procedure

Hardness tests were performed on the surface of three fatigue specimens using a "Rockwell C" scale. The hardness measurements were repeated three times for each specimen and the average value was recorded. All fatigue tests were carried out in a laboratory environment at approximately 25^{o}C using an MTS servo-controlled closed loop electro hydraulic testing machine. A bending rig was installed in the hydraulic testing machine as shown in Figure 2. An extensometer was installed on the bending specimen to measure the strain as shown in Figure 3.

A process control computer, controlled by FLEX software [1] was used to output constant stroke amplitudes.

Results

Chemical Composition

The chemical composition as provided by Gerdau corporation is shown in Table 1.

Constant Amplitude Fatigue Data

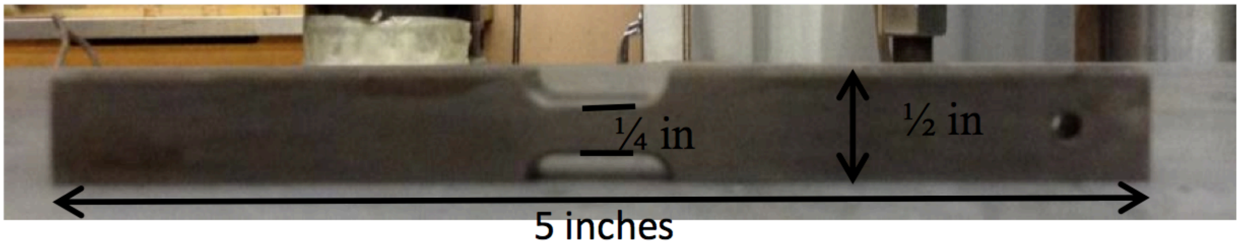
Constant strain amplitude, fully reversed (R=-1) stroke-controlled fatigue tests were performed on bending specimens. The tests were run under stroke control and the corresponding strain measurements were recorded. The load-strain limits for each specimen were recorded at logarithmic intervals throughout the test via a peak reading oscilloscope. Failure of a specimen was defined as a 50 percent drop in the tensile peak load from the peak load observed at one half the expected specimen life. The loading frequency varied from 0.5 Hz to 25 Hz. Constant amplitude fatigue test data obtained in this investigation are given in Table 2. A constant strain-amplitude fatigue life curve for the steel is given in Figure 4.

References

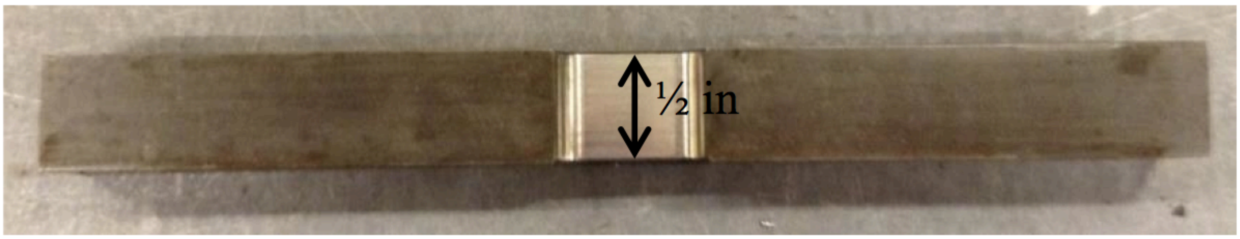
[1] M. Pompetzki, R. Saper, T. Topper, Software for rig frequency control of variable amplitude fatigue tests, Canadian Metallurgical Quarterly 25 (2) (1987) 181-194

Note:

Some specimen IDs, have a digital number with a letter “B”, such as 9B, it means this specimen (9) was tested at low strain amplitude without failure, then it was tested at high strain amplitude (9B).



(1-a) Bending specimen side view



(1-b) Bending specimen top view

Figure 1: Bending Fatigue Specimen

Figure 2: Bending Rig in the testing frame

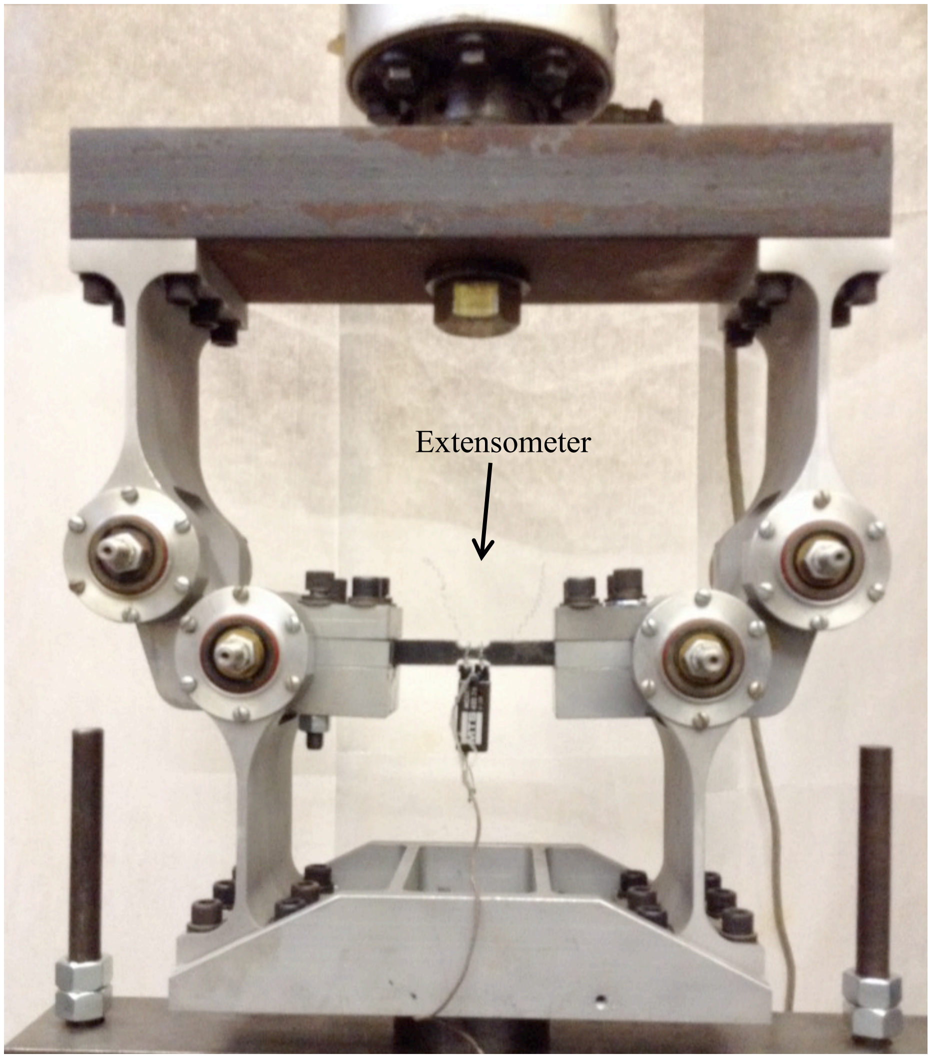


Figure 3: Extensometer installed on the bending specimen to measure the strain

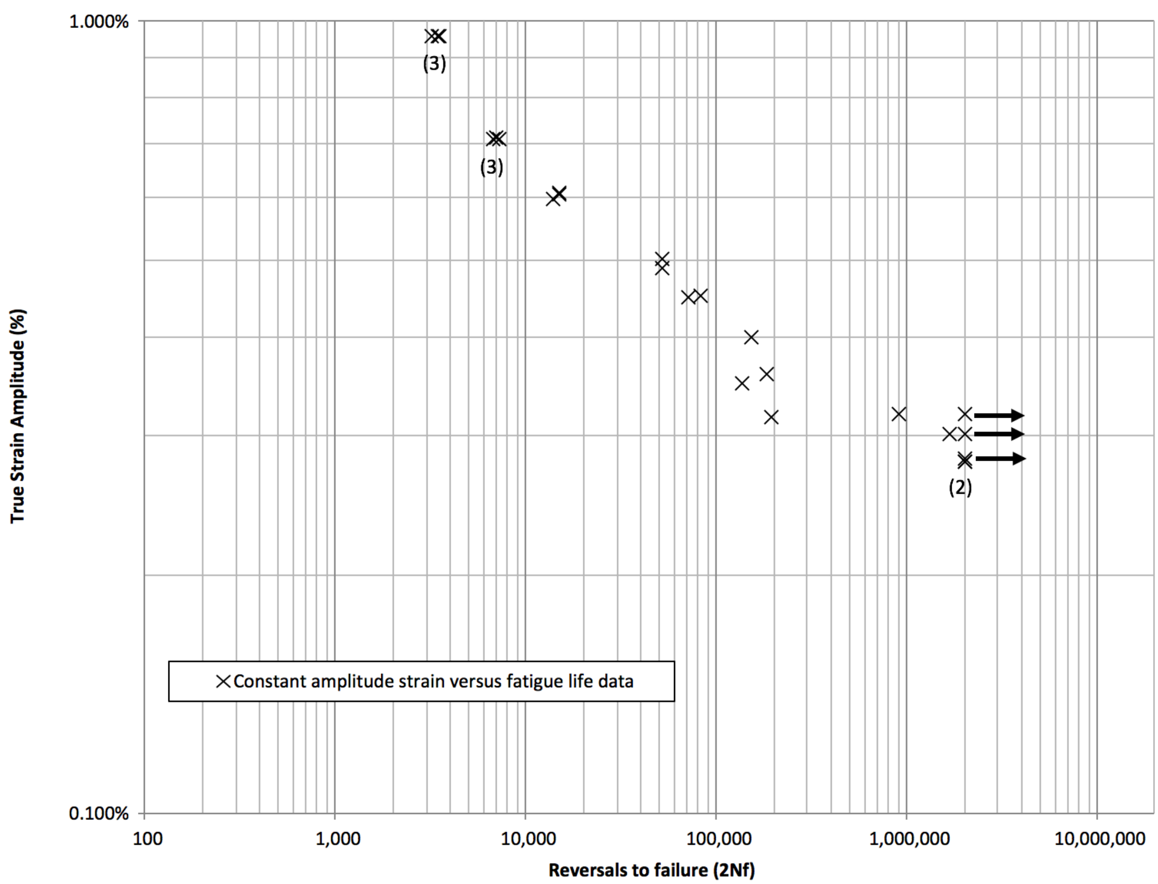


Figure 4: Strain-life fatigue curves for AISI 16MnCr5 (IT 187)

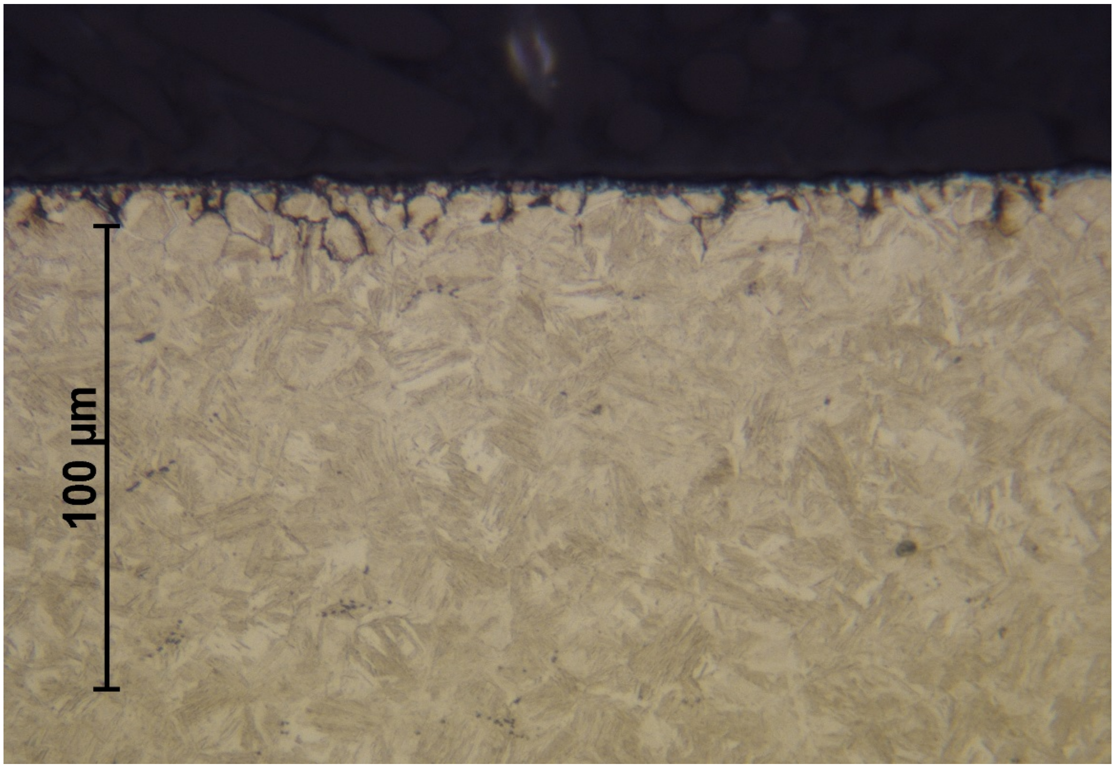


Figure 5: Microstructure of Iteration 187, surface.

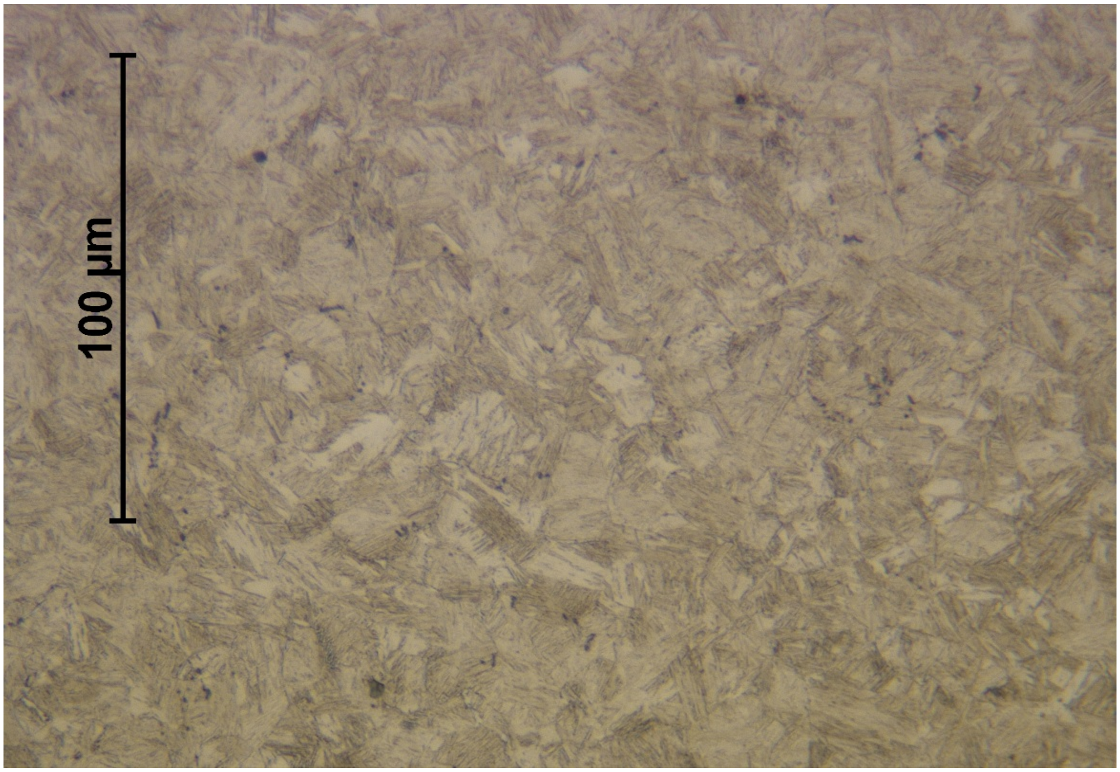


Figure 6: Microstructure of Iteration 187, core.

Table 1: Chemical Analysis (Bar Average) for AISI 16MnCr5 Steel (Iterations 187)

C	**0.16**
Mn	**1.22**
P	**0.018**
S	**0.034**
Si	**0.07**
Ni	**0.11**
Cr	**1.06**
Mo	**0.04**
Cu	**0.23**
Sn	**0.010**
Al	**0.020**
V	**0.002**
Nb	**0.002**

Table 2: Constant Strain Amplitude Data for AISI 16MnCr5 Steel (IT 187)

Specimen ID	Strain amplitude (%)	Load amplitude (lb)	Reversals to Failure (2Nf)	Hardness (HRC)
2	0.605	900.2	14,882	
3	0.487	732.9	52,372	
4	0.448	686.7	70,890	40.1
6	0.713	1038.8	6,960	40.7
7	0.398	606.8	151,726	41.8
8	0.348	536.9	135,370	
9	0.359	541.9	183,318	
10	0.317	475.7	192,448	
11	0.301	453.2	1,666,812	
12	0.278	427.0	2,000,000	
12B	0.608	895.2	14,940	
13	0.280	423.3	2,000,000	
13B	0.710	1035.0	6,706	
14	0.301	457.0	2,000,000	
14B	0.710	1032.6	7,288	
15	0.500	739.1	52,374	
16	0.320	480.7	2,000,000	
17	0.320	481.9	913,794	
18	0.598	897.7	13,966	
19	0.451	681.7	82,314	
20	0.278	420.8	2,000,000	
21	0.960	1148.7	1,587	
22	0.960	1182.4	1,710	
23	0.960	1183.6	1,763	

**Hardness obtained as average of three readings*