Fatigue Behavior For AISI 4120 Modified Steel Simulated Core 1900F Four Point Bending Test Iteration 199

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Prepared for:
The AISI Bar Steel Applications Group

June 8, 2018

Contents

List of Figures

List of Tables

Summary

The required strain-life fatigue data for AISI Iteration 199 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, polished and then tested. 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 4120 modified simulated core specimens heat treated at 1900F (Iteration 199). The American Iron and Steel Institute provided the material. The objective of this investigation is to obtain a constant amplitude strain-life curve of the material under a four-point bending cyclic test.

Experimental Procedure

Specimen Preparation

Bending fatigue specimens, shown in 1 and 2, were machined from the metal bars and polished with a small 500 grit wheel that was spinning in the same direction as the beam length. The specimens were heat treated to simulate the thermal history of a core in a carburized specimen by the AISI group and returned for fatigue testing. Before testing, the specimens had a final polish in the loading direction in the gauge sections using 600 emery paper.

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 in Table 2. All fatigue tests were carried out in a laboratory environment at approximately 25°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 3. An extensometer was installed on the bending specimen to measure the strain as shown in Figure 3. Epoxy was applied to attach the extensometer onto the specimen to prevent slipping.

A process control computer, controlled by FLEX software [1] was used to output constant stroke amplitudes for Iteration 199.

After failure was indicated by the 50% load drop specified by ASTM, the specimens were often only partially cracked. In order to observe the fracture surface, these specimens were placed at one end in a vice and then struck with a hammer on the other end after failure.

In order to conform with the AISI database structure Tables 1 also report a “bending stress” that assumes no plasticity in the beam. The stress is the bending moment, M, multiplied by the half height, c, of the beam section and divided by the moment of Inertia I as per Stress = M*c/I. Similarly the "Modulus" reported in the tables is simply the calculated Stress Amplitude divided by the Strain Amplitude.

Results

Chemical Composition

The chemical composition information is currently unavailable.

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 15 Hz. Constant amplitude fatigue test data obtained in this investigation are given in Table 1. A constant strain- amplitude fatigue life curve for the steel is given in Figure 4.
No "Fisheye" or subsurface crack initiation site was observed on the fractured surface. Some typical fracture surfaces were photographed and shown in figure 5 and 6. Note that the fast fracture darker regions are created by opening the crack.

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

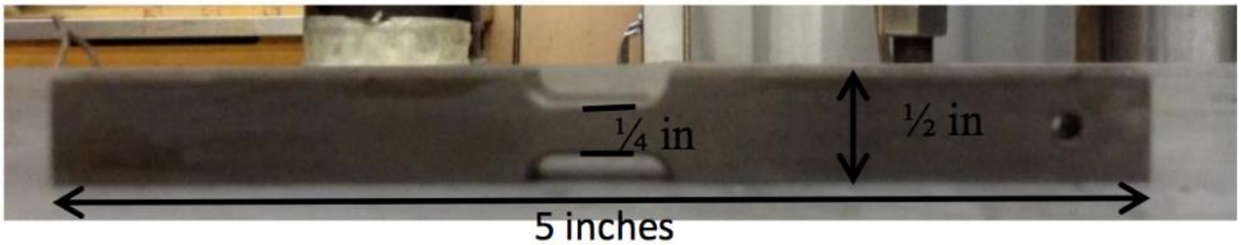

Figure 1: Bending specimen side view

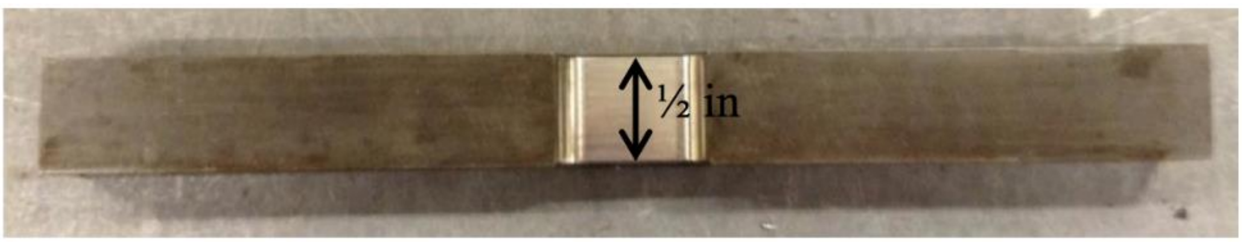

Figure 2: Bending specimen top view

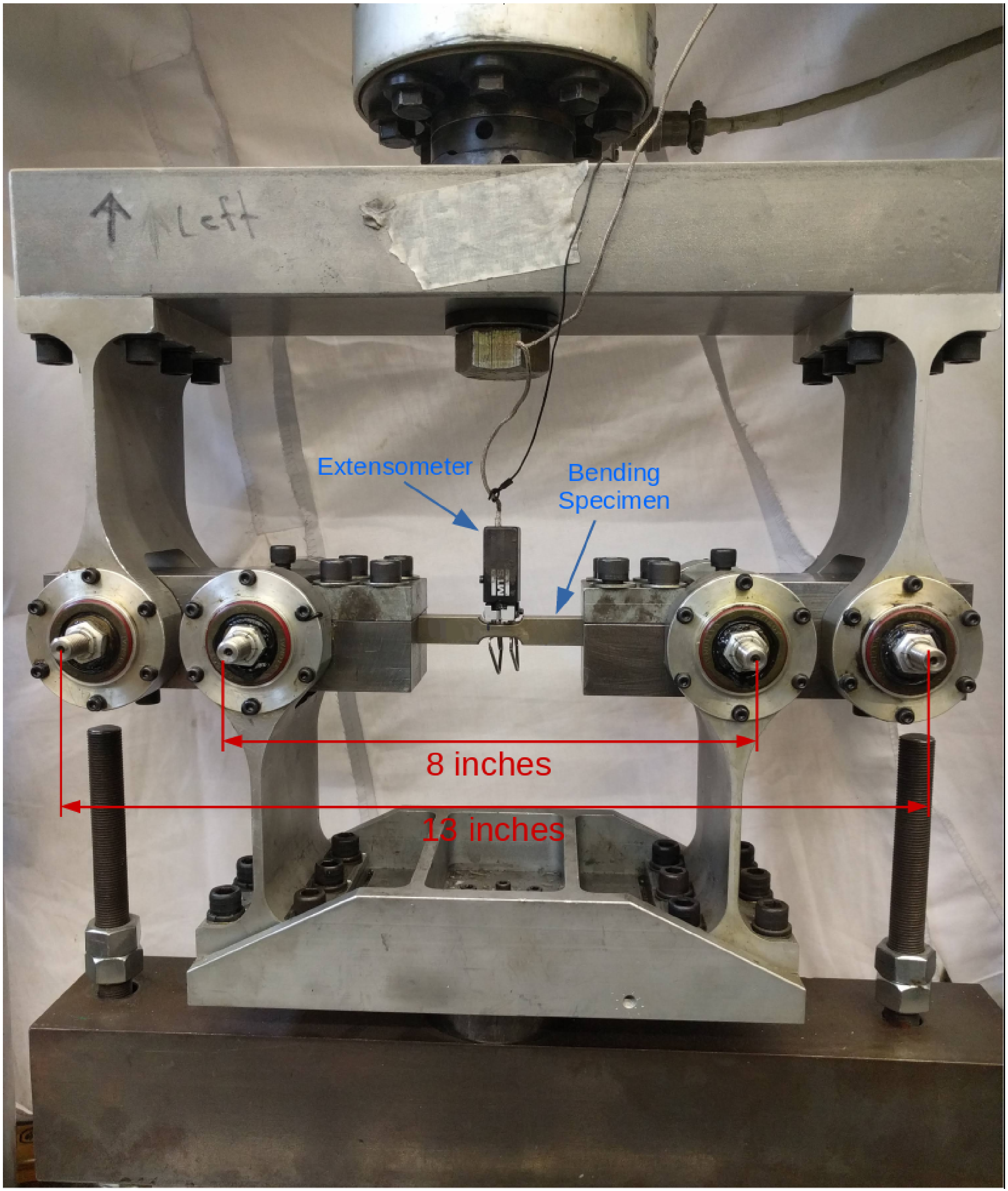

Figure 3: The Bending Rig and the Extensometer on the bending specimen

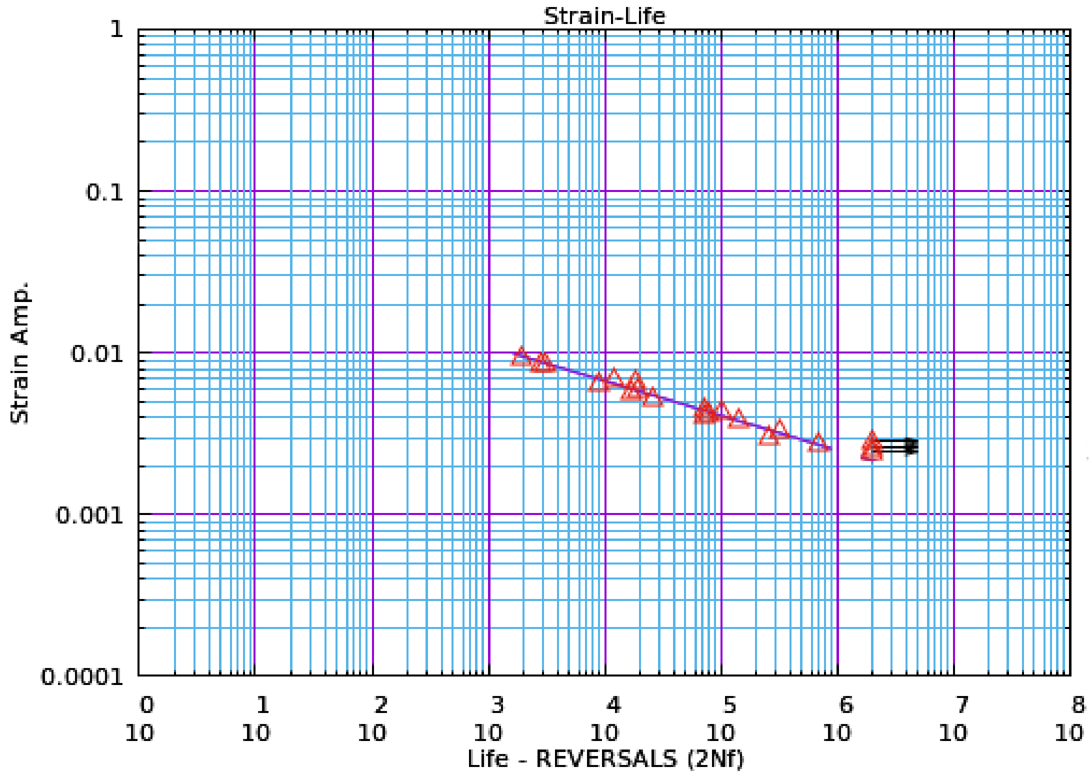

Figure 4: Strain-life fatigue curve for AISI 4120 modified simulated core 1900F (IT 199)

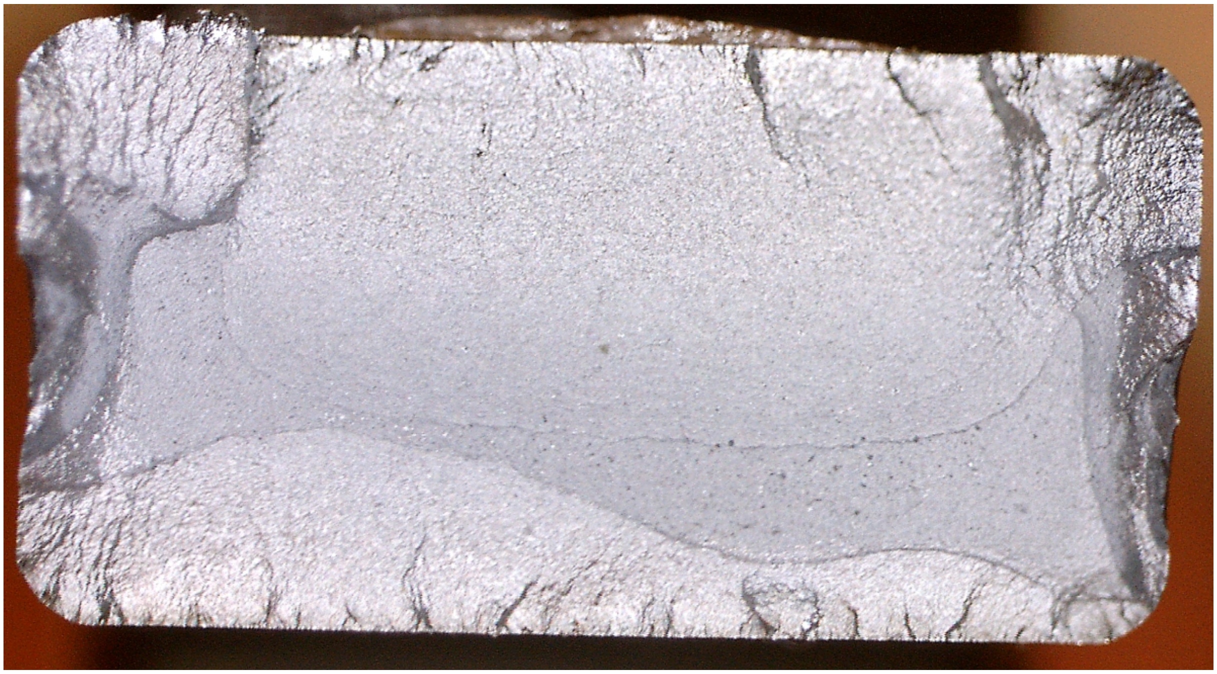

Figure 5: Fracture surface of specimen IT199-15b, 2Nf=3,070

Figure 6: Fracture surface of specimen IT199-4, 2Nf=77,700

Table 1: Constant Strain Amplitude Data for AISI 4120 modified simulated core 1900F Steel (IT199)

StrAmpl	2Nf	StressAmpl* Mpa	Mean Stress* Mpa	PlsStrAmp	Modulus** Mpa	Comments	Spec ID
0.009333	1934	1518	0.00	0	162667		27
0.008733	2818	1431	0.00	0	163895		30
0.008760	3070	1417	0.00	0	161743		15b
0.006467	8812	1177	0.00	0	182000		23
0.006915	11930	1129	0.00	0	163321		3
0.005733	16684	1071	0.00	0	186880		24
0.006740	18490	1034	0.00	0	153444		6
0.005900	19440	1009	0.00	0	171084		21
0.005315	25600	970	0.00	0	182520		1
0.004560	72350	815	0.00	0	178719		2
0.004100	73590	790	0.00	0	192717		5
0.004255	77700	805	0.00	0	189100		4
0.004410	100360	732	0.00	0	166037		8
0.003880	142170	660	0.00	0	170059		10
0.003020	256680	523	0.00	0	173282		13
0.003290	316262	573	0.00	0	174150		11
0.002737	702390	484	0.00	0	176862		19
0.002833	2000000	445	0.00	0	156957	#runout	25
0.002640	2000000	465	0.00	0	176286	#runout	15
0.002455	2000000	465	0.00	0	189571	#runout	18

* "Stress" implies Stress = M*c /I where M is bending moment, c is half height of beam, and I is moment of inertia

** Modulus = (StressAmpl. / StrainAmpl.)

Table 2: Rockwell C Hardness Test Data for AISI 4120 modified simulated core 1900F Steel

Specimen ID	Test 1	Test 2	Test 3	Average
6	42	41	43	42.00
2	42	43	41.5	42.17
4	41	41	41	41.00
Overall				41.72