Fatigue Behavior and Monotonic Properties For AISI 9310 Steel Four Point Bending Iteration 177

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Summary

The required strain-life fatigue data for AISI Iteration 177 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 9310 Steel specimens (Iteration 177). 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 samples were then carburized and quenched in oil 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 3. 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 4. 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 177.

After failure was indicated by the 50% load drop specified by ASTM, the specimens were often only partially cracked. In order to conform with the AISI database structure Tables 2 also report a "bending stress" that assumes no plasticity in the beam. The stress is the initial 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 Initial Stress Amplitude divided by the Initial Strain Amplitude.

Results

Chemical Composition

The chemical composition as provided by Chrysler 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 20 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 5.

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

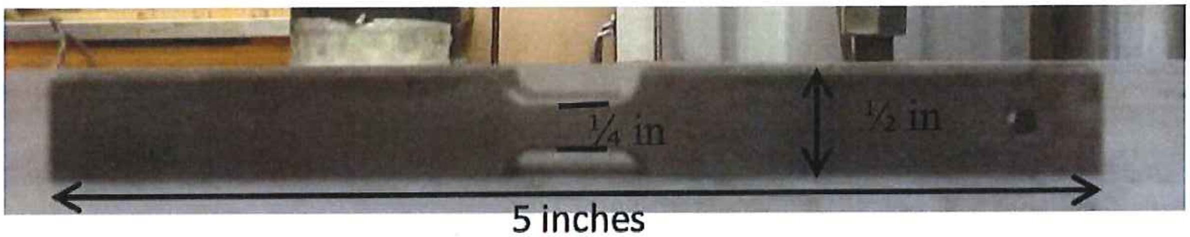

Figure 1: Bending specimen side view

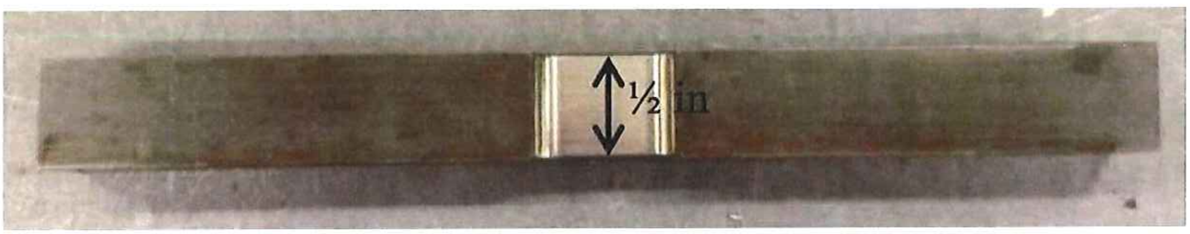

Figure 2: Bending specimen top view

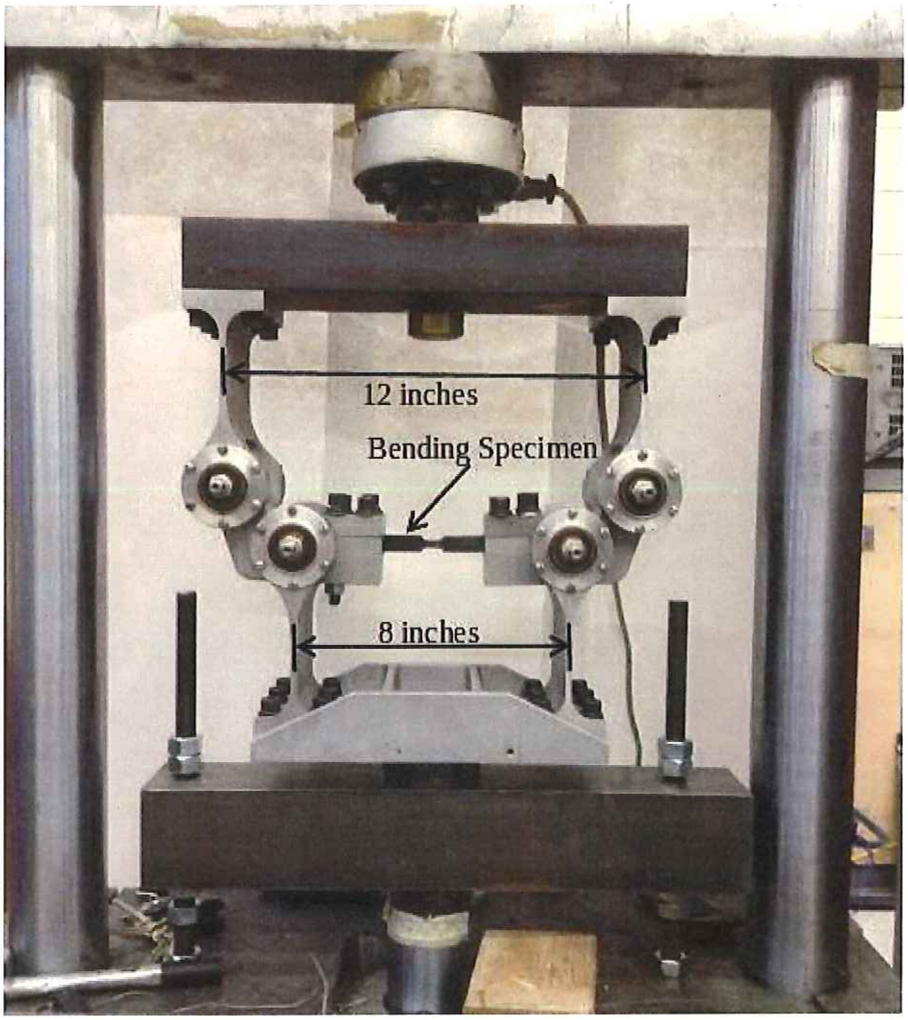

Figure 3: Bending Rig in the testing frame

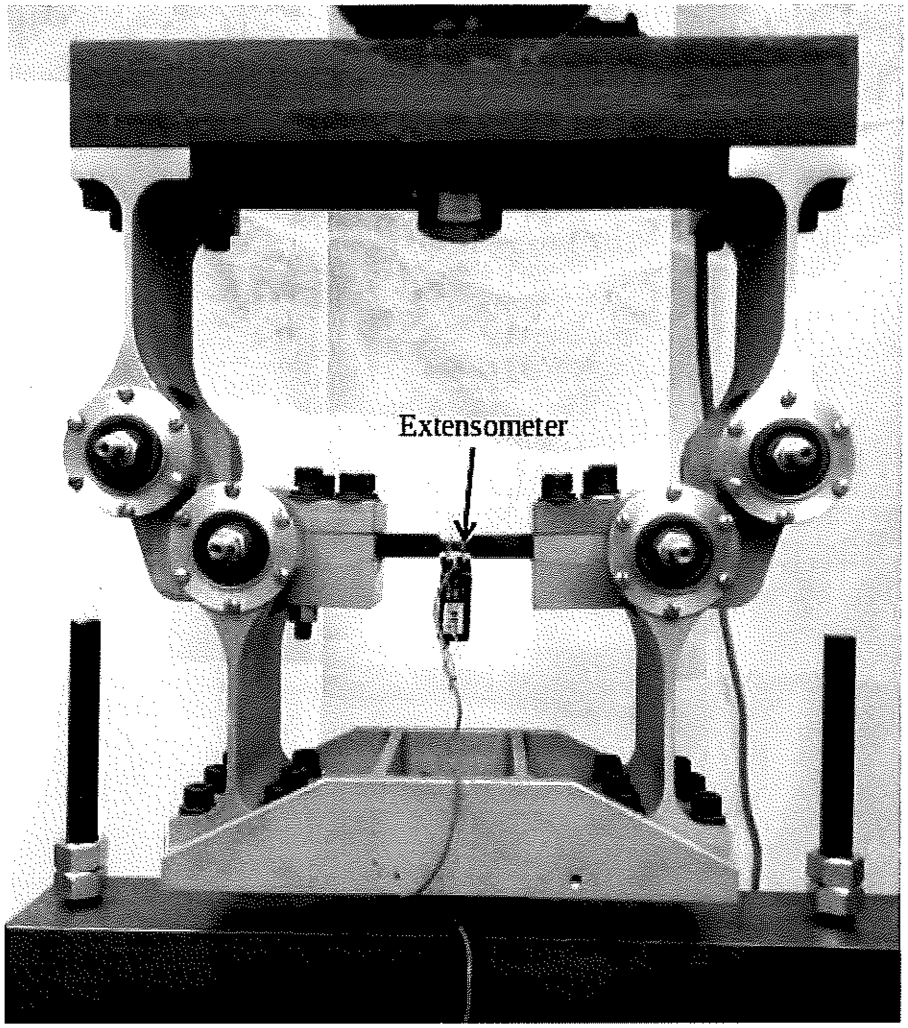

Figure 4: Extensometer installed on the bending specimen to measure the strain

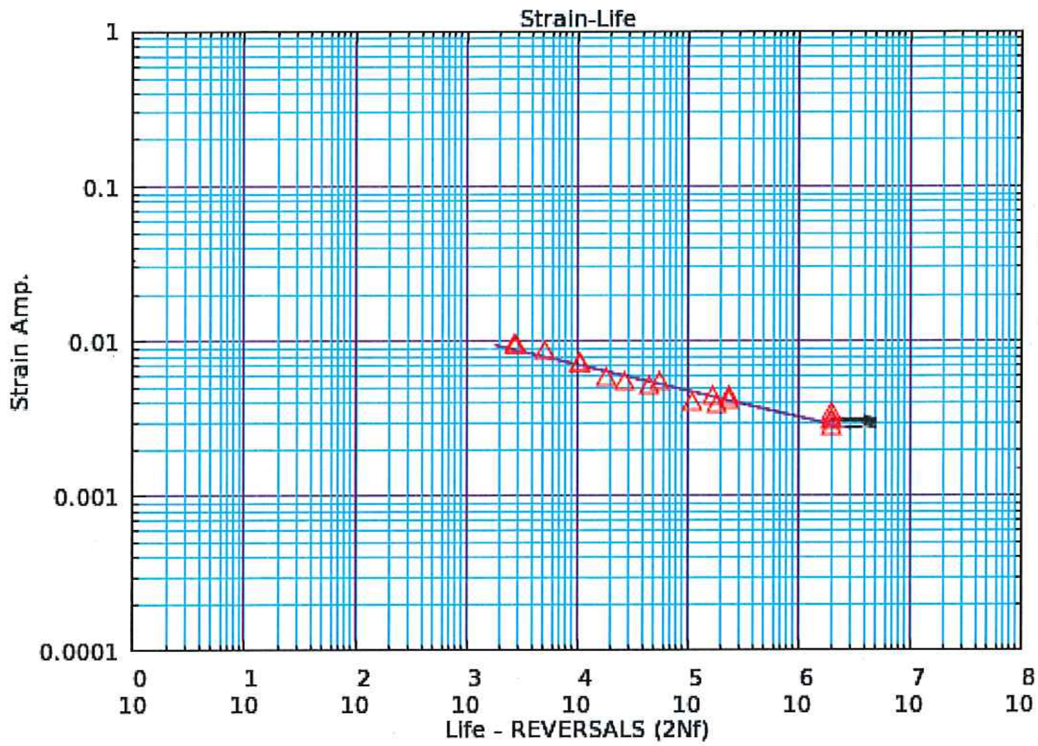

Figure 5: Strain-life fatigue curve for AISI 9310 (IT 177)

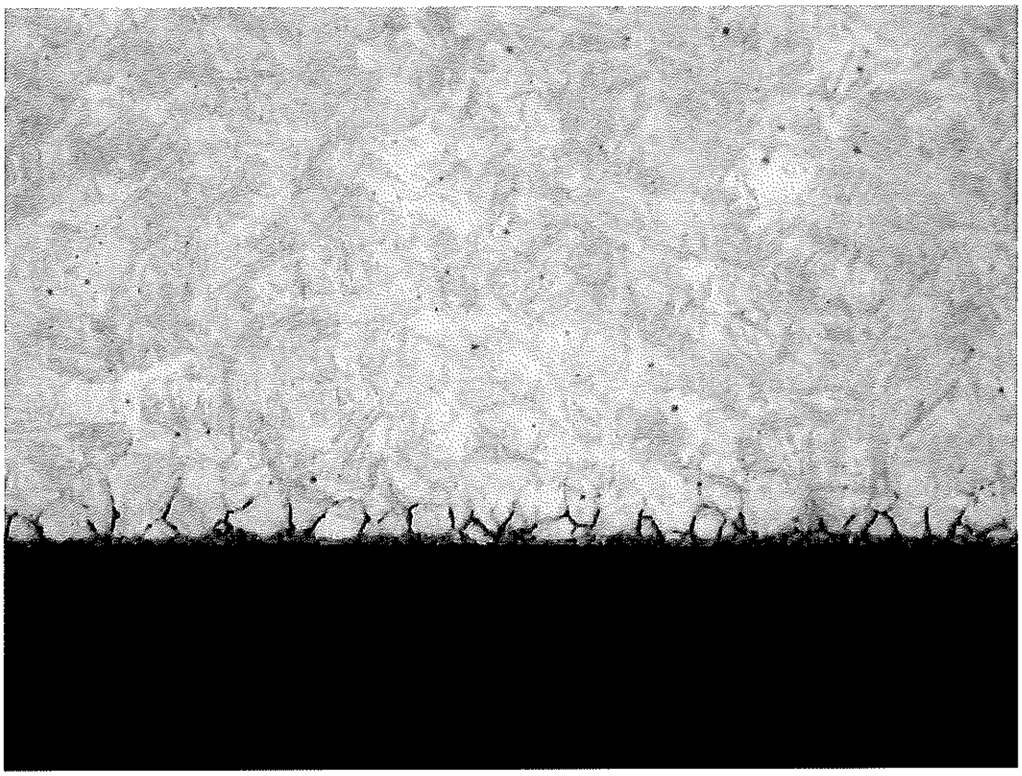

Figure 6: General microstructure at the surface of iteration 177 at 500X
(Micrographs provided by FCA)

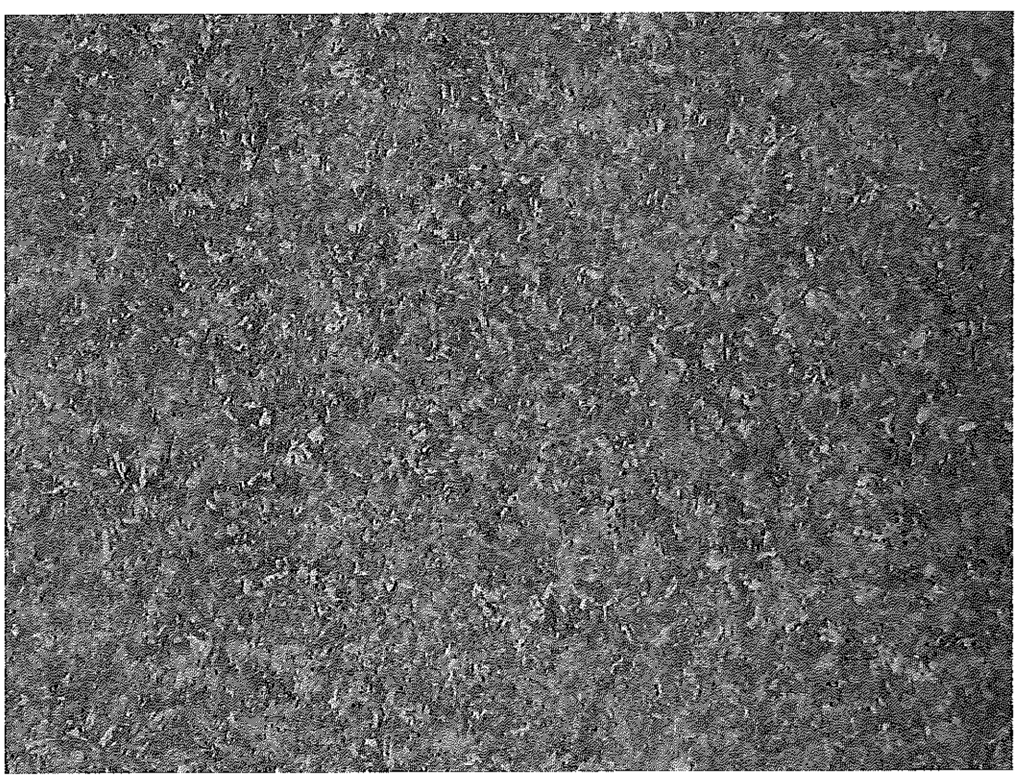

Figure 7: General microstructure in the core of iteration177 at 100X
(Micrographs provided by FCA)

Table 1: Chemical Analysis (Bar Average) for AISI 9310 Steel (Iterations 177)

C	0.12
Mn	0.62
P	0.007
S	0.014
Si	0.19
Ni	3.12
Cr	1.11
Mo	0.09
Cu	0.16
Sn	0.008
Al	0.022
V	0.003
B	0.0002
Ca	0.0012
N	0.0066
As	0.004

Table 2: Constant Strain Amplitude Data for AISI 9310 Steel (IT177)

StrAmpl	2Nf	StressAmpl* ksi	Mean Stress* ksi	PlsStrAmp	Modulus** ksi	Comments	Spec ID***
0.00952	2694	194	0	0	30782		5
0.00951	2780	199	0	0	31807		calib 1
0.00857	5114	187	0	0	27916		1
0.00719	10852	171	0	0	28803		6
0.00711	10418	176	0	0	32662		7
0.00575	18186	166	0	0	30402		13b
0.00541	27570	158	0	0	29720		12b
0.00539	55440	142	0	0	25869		2
0.00517	44356	142	0	0	30008		3
0.00440	240612	114	0	0	24292		10
0.00436	167148	117	0	0	29592		4
0.00416	241886	118	0	0	28525		14
0.00396	111714	128	0	0	31683		16b
0.00394	184420	125	0	0	26382		9
0.00347	2000000	110	0	0	31683	# runout	16
0.00312	2000000	102	0	0	27076	# runout	15
0.00300	2000000	100	0	0	30402	# runout	13
0.00280	2000000	90	0	0	29720	# runout	12

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

** Modulus = (Initial StressAmpl. / Initial StrainAmpl.)

*** Some specimen IDs, have a digital number with a letter B, such as 9B, it means that specimen no.9 was tested at a low strain amplitude without failure, and then tested again at a higher strain amplitude and given the label "9B"

Table 3: Rockwell C Hardness Test Data for AISI 9310 Steel

Specimen ID	Test 1	Test 2	Test 3	Average
9	36	39	39	38.00
10	36	39	37	37.33
16	33	40	38	37.00
Overall				37.44