Fatigue Behavior and Monotonic Properties For AISI 4120 Mod Steel Four Point Bending Iteration 211

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Summary

The required strain-life fatigue data for AISI Iteration 211 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 Mod Steel specimens (Iteration 211). 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 sent to the AISI group for carburization. After being heat treated, the samples were slow cooled and reheated and quenched in oil. Then the samples were returned for fatigue testing. Before testing, the specimens had a final polish in the loading direction in the gauge sections using 600 emery paper. Metallurgy will be re-evaluated after specimens have been tested.

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 211.

After failure was indicated by the 50% load drop specified by ASTM, all specimens were fractured. No fisheye was observed on the fracture surfaces. 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 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 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 load and 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

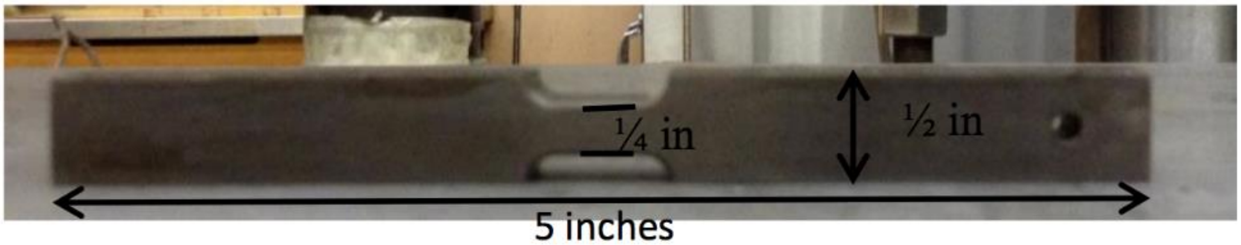

Figure 1: Bending specimen side view

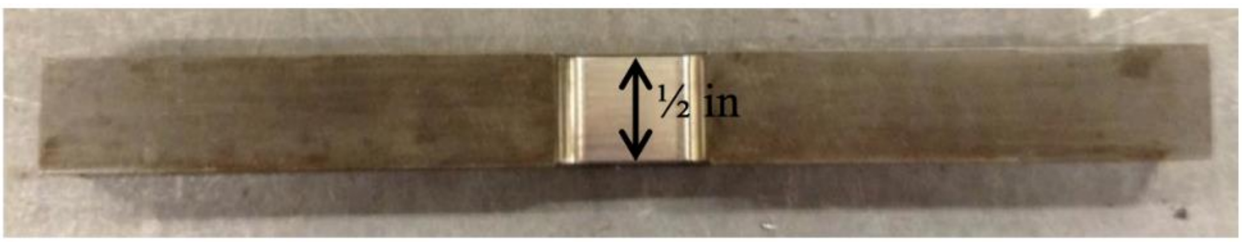

Figure 2: Bending specimen top view

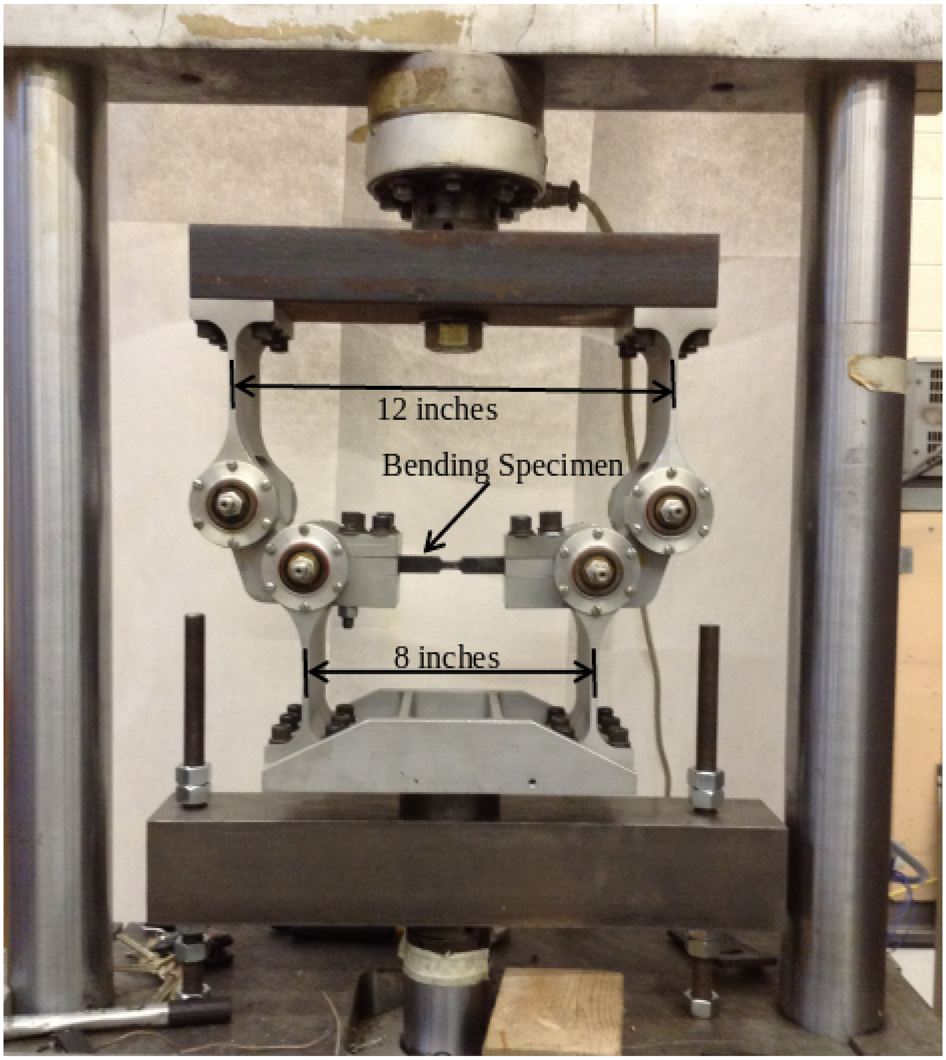

Figure 3: Bending Rig in the testing frame

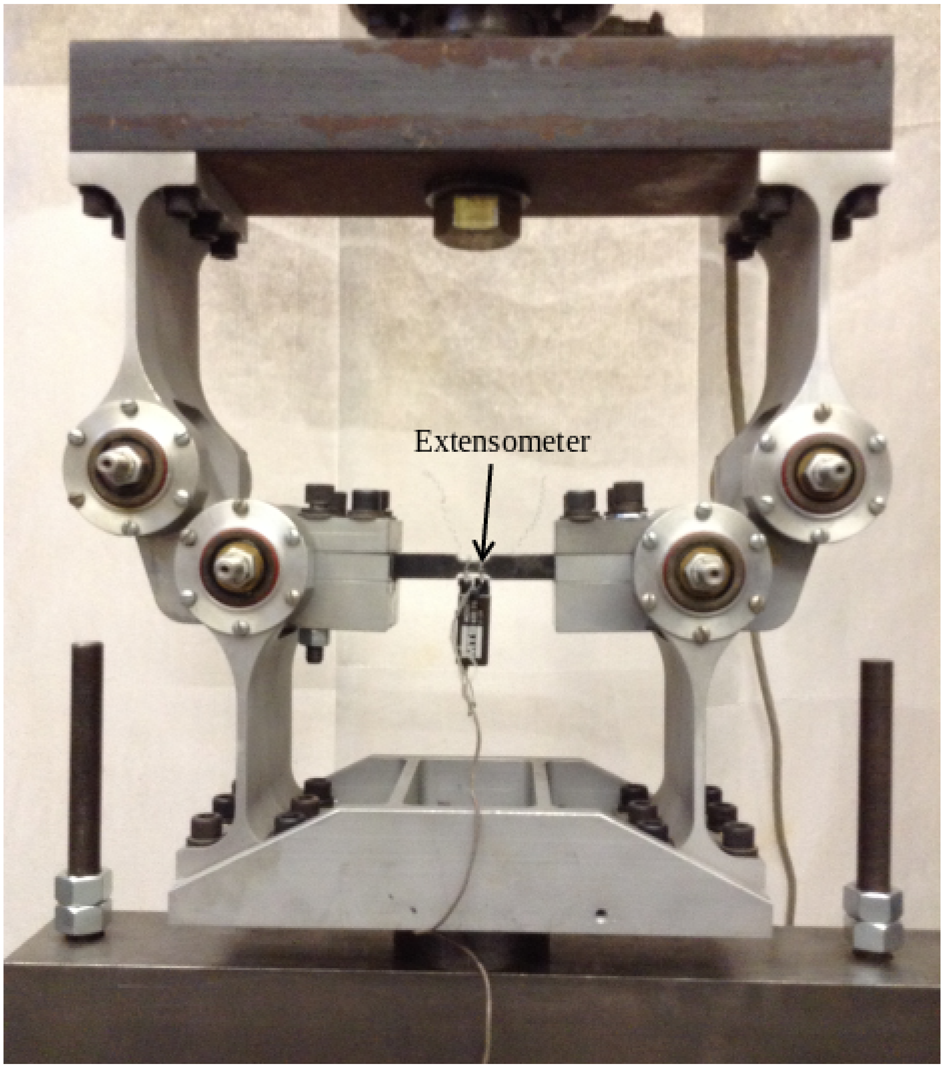

Figure 4: Extensometer installed on the bending specimen to measure the strain

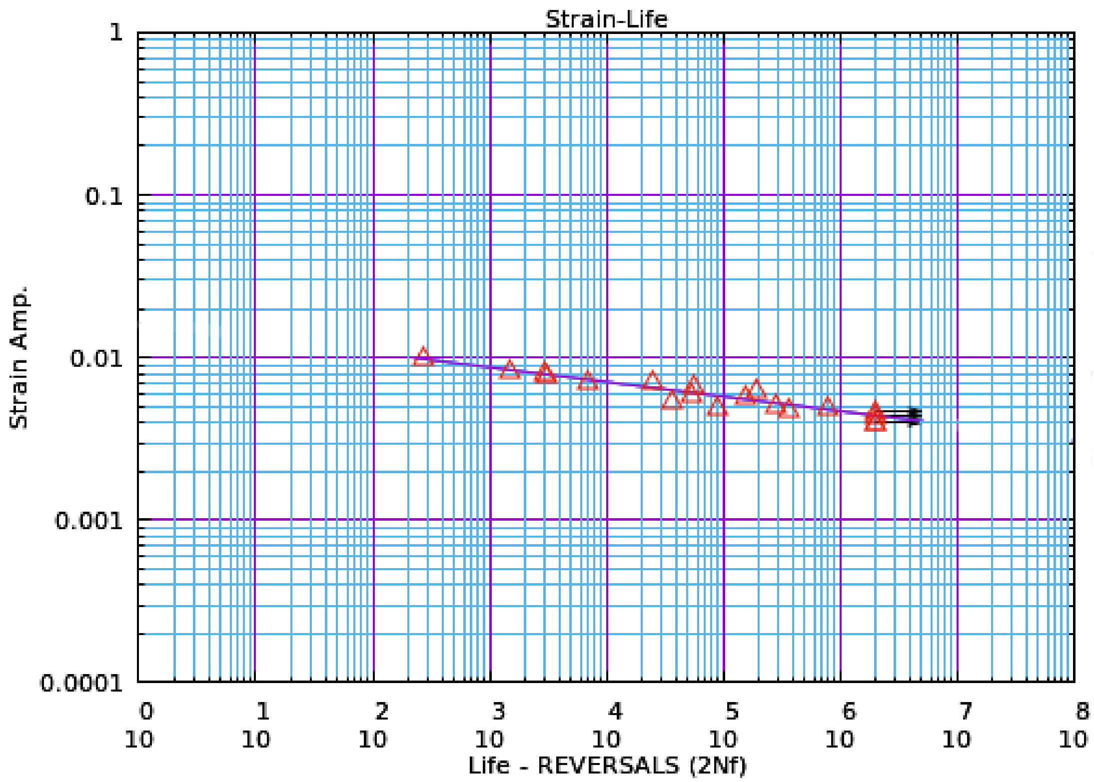

Figure 5: Strain-life fatigue curve for AISI 4120 Mod (IT 211)

Table 1: Chemical Analysis (Bar Average) for AISI 4120 Mod Steel (Iterations 211)

C	0.20
Mn	0.83
P	0.009
S	0.008
Si	0.31
Cr	0.85
Ni	0.15
Mo	0.20
Cu	0.20
Al	0.040
Ca	0.0006
Pb	0.0010

Table 2: Constant Strain Amplitude Data for AISI 4120 Mod Steel (IT211)

StrAmpl	2Nf	StressAmpl* ksi	Mean Stress* ksi	PlsStrAmp	Modulus** ksi	Comments	Spec ID
0.00996	266	310	0	0	31148		9
0.00825	1518	251	0	0	30429		10
0.00818	3002	243	0	0	29769		Calib 2
0.00787	3030	215	0	0	27355		15
0.00719	25030	190	0	0	26403		18
0.00714	7026	225	0	0	31462		11
0.00684	56260	184	0	0	26947		13
0.00637	190626	178	0	0	27918		20
0.00600	52820	195	0	0	32520		23
0.00575	153988	178	0	0	30956		14
0.00538	36632	191	0	0	35587		1
0.00516	278540	161	0	0	31240		16
0.00495	90160	150	0	0	30334		17
0.00492	798418	155	0	0	31447		22
0.00480	365418	165	0	0	34386		21
0.00469	2000000	142	0	0	30224	#runout	19
0.00438	2000000	142	0	0	32438	#runout	12
0.00402	2000000	123	0	0	30507	#runout	7
0.00401	2000000	133	0	0	33217	#runout	8

* "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 3: Rockwell C Hardness Test Data for AISI 4120 Mod Steel

Specimen ID	Test 1	Test 2	Test 3	Average
17	58	58	58	58.00
14	57	58	58	57.67
20	58	59	54	57.00
Overall				57.56