Rain Flow Counting

Designation: E1049 − 85 (Reapproved 2017): Standard Practices for Cycle Counting in Fatigue Analysis

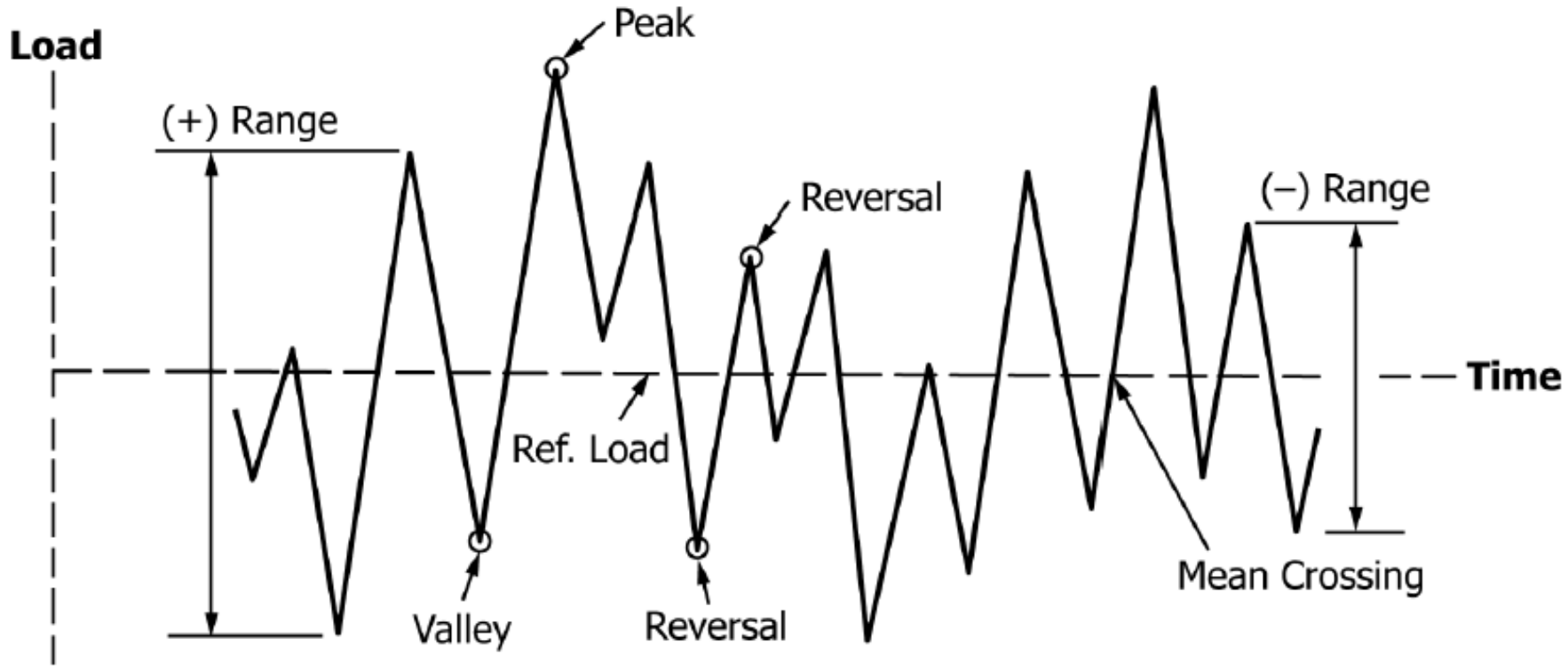
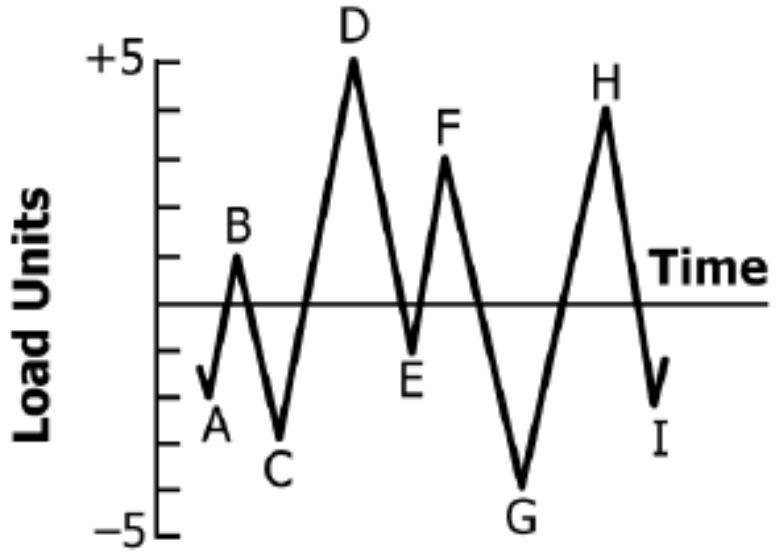


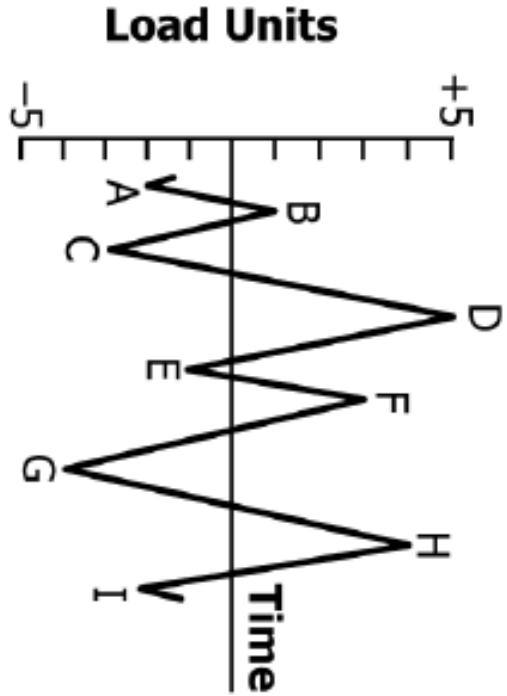
FIG. 1 Basic Fatigue Loading Parameters

Before applying rain flow counting, it is important to do the following:

1. Hysteresis gate (i.e., minimum stress change considered a fluctuating load)
2. Load reversals (successive points moving in the same direction are merged to count instances of load reversals)
3. Binning discretization (so that stress ranges of small differences are not counted as two different stress range)

- Rules for this method are as follows: let X denote the range under consideration; Y, the previous range adjacent to X; and S, the starting point in the history.
  1) Read the next peak or valley. If out of data, go to Step 6.
  2) If there are less than three points, go to Step 1. Form ranges X and Y using the three most recent peaks and valleys that have not been discarded.
  3) Compare the absolute values of ranges X and Y.
     a) If X < Y, go to Step 1.
     b) If X ≥ Y, go to Step 4.
  4) If range Y contains the starting point S, go to Step 5; otherwise, count range Y as one cycle; discard the peak and
  5) valley of Y; and go to Step 2.
  6) Count range Y as one-half cycle; discard the first point (peak or valley) in range Y; move the starting point to the second point in range Y; and go to Step 2.
  7) Count each range that has not been previously counted as one-half cycle.





➢ The load history of Fig. 4 is replotted as Fig. 6(a) and is used to illustrate the process. Details of the cycle counting are as follows:

(1) S = A; Y = |A-B |; X = |B-C|; X > Y. Y contains S, that is, point A. Count |A-B| as one-half cycle and discard point A; S = B. (See Fig. 6(b).)

(2) Y = |B-C|; X = |C-D|; X > Y. Y contains S, that is, point B. Count| B-C| as one-half cycle and discard point B; S = C. (See Fig. 6(c).)

(3) Y = |C-D|; X = |D-E|; X < Y.

(4) Y = |D-E|; X = |E-F|; X < Y.

(5) Y = |E-F|; X = |F-G|; X > Y. Count |E-F| as one cycle and discard points E and F. (See Fig. 6(d). Note that a cycle is formed by pairing range E-F and a portion of range F-G.)

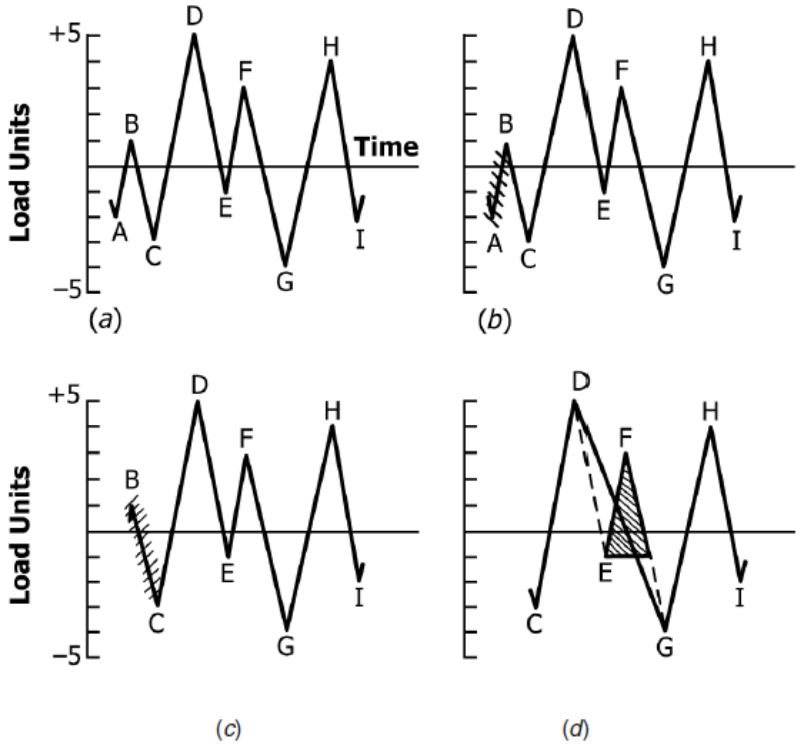
(6) Y = |C-D|; X = |D-G|; X > Y; Y contains S, that is, point C. Count |C-D| as one-half cycle and discard point C. S = D. (See Fig. 6(e).)

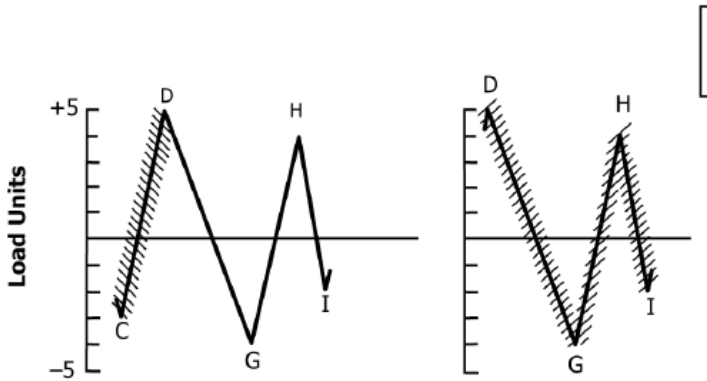
(7) Y = |D-G|; X = |G-H|; X < Y.

(8) Y = |G-H|; X = |H-I|; X < Y. End of data.

(9) Count |D-G| as one-half cycle, |G-H| as one-half cycle, and| H-I| as one-half cycle. (See Fig. 6(f).)

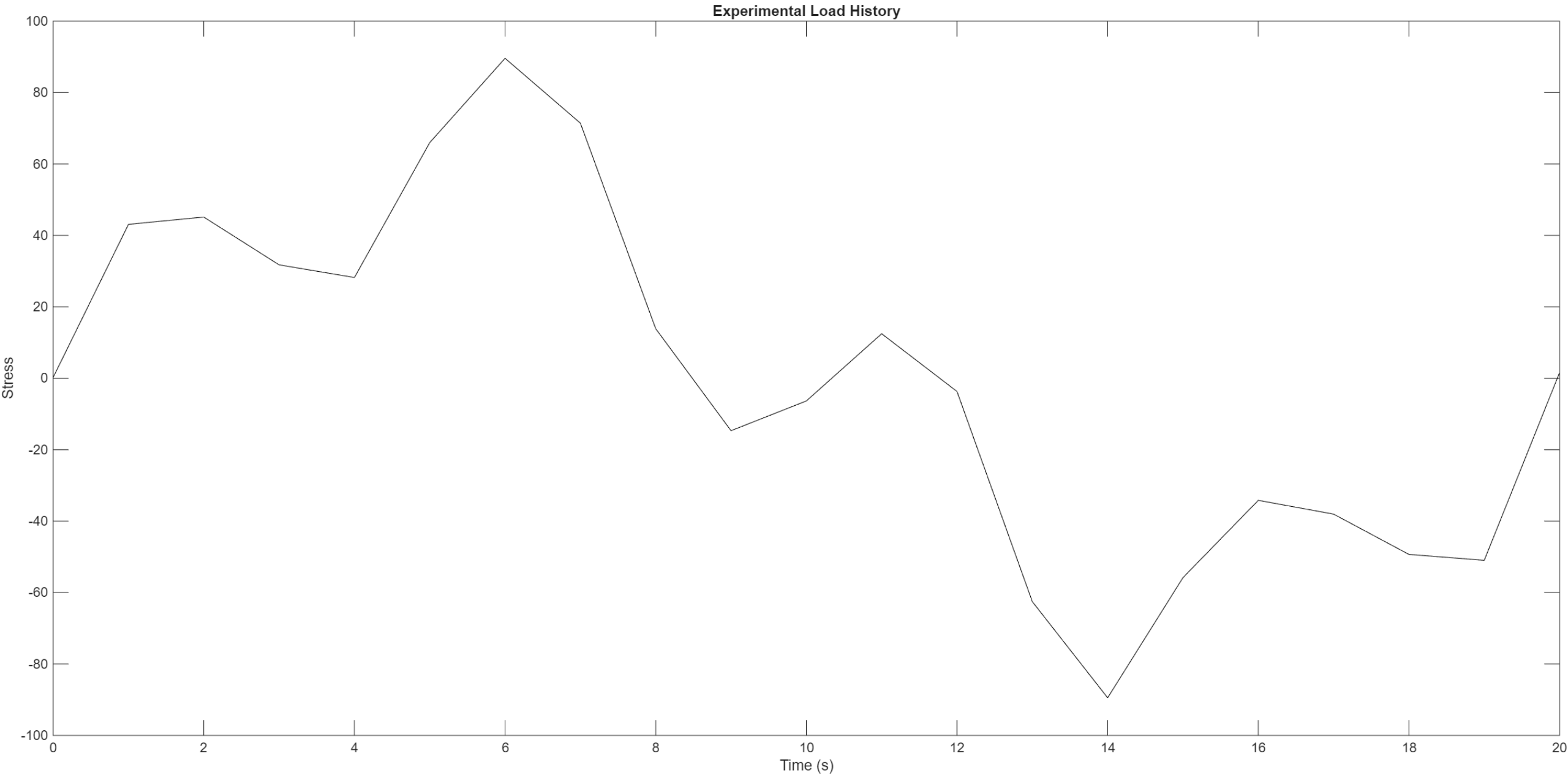
(10) End of counting. See the table in Fig. 6 for a summary of the cycles counted in this example

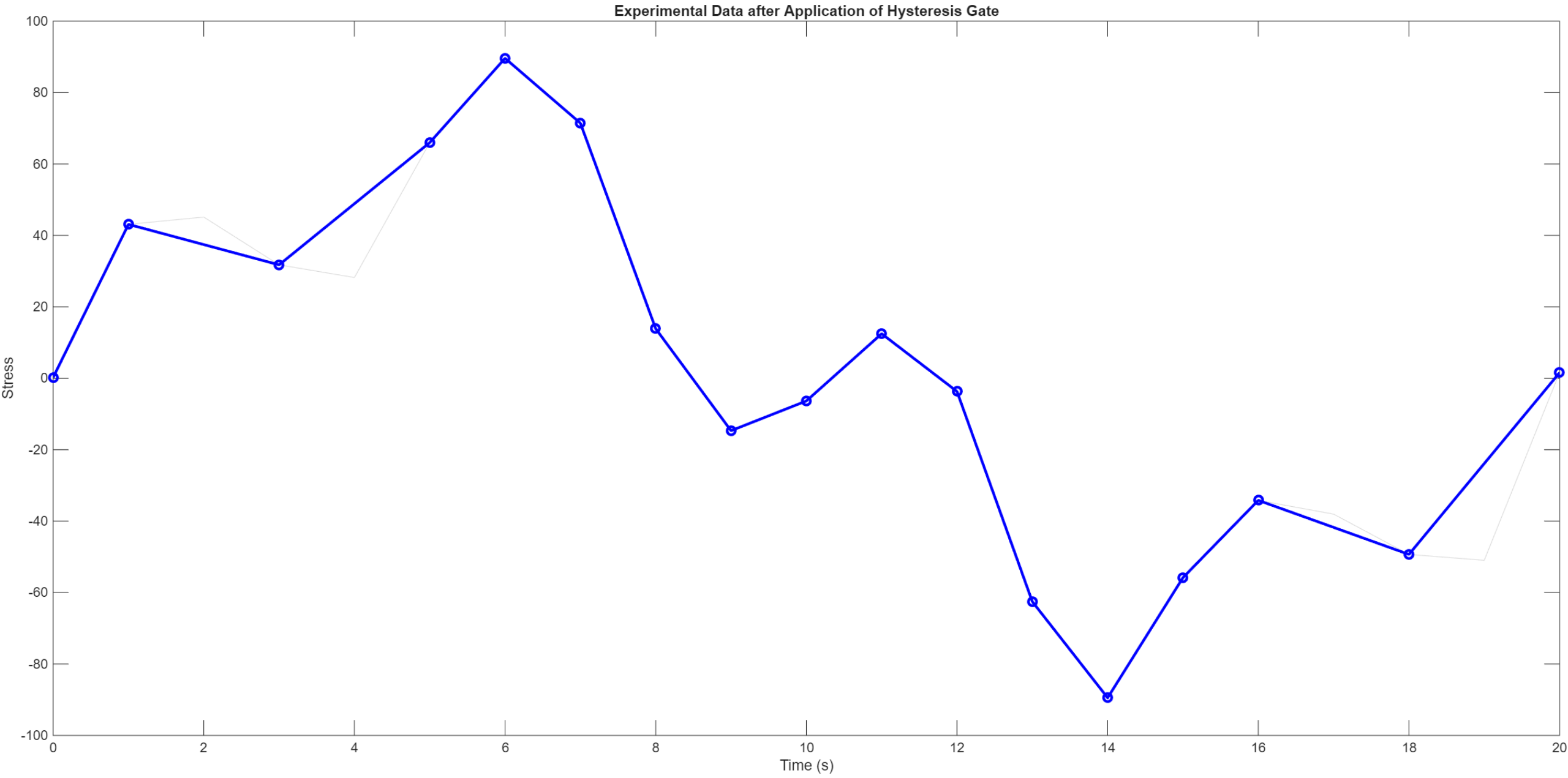


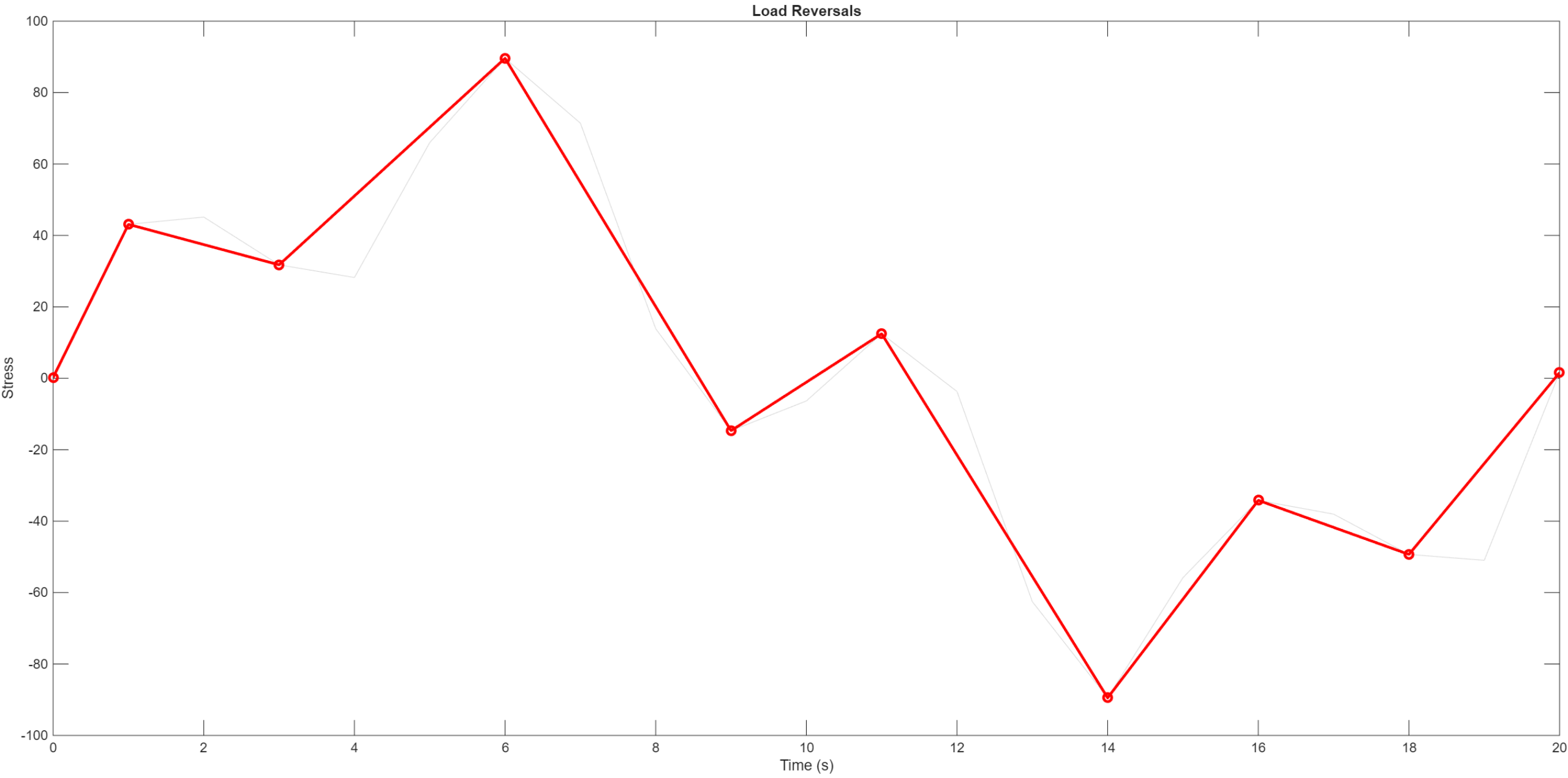


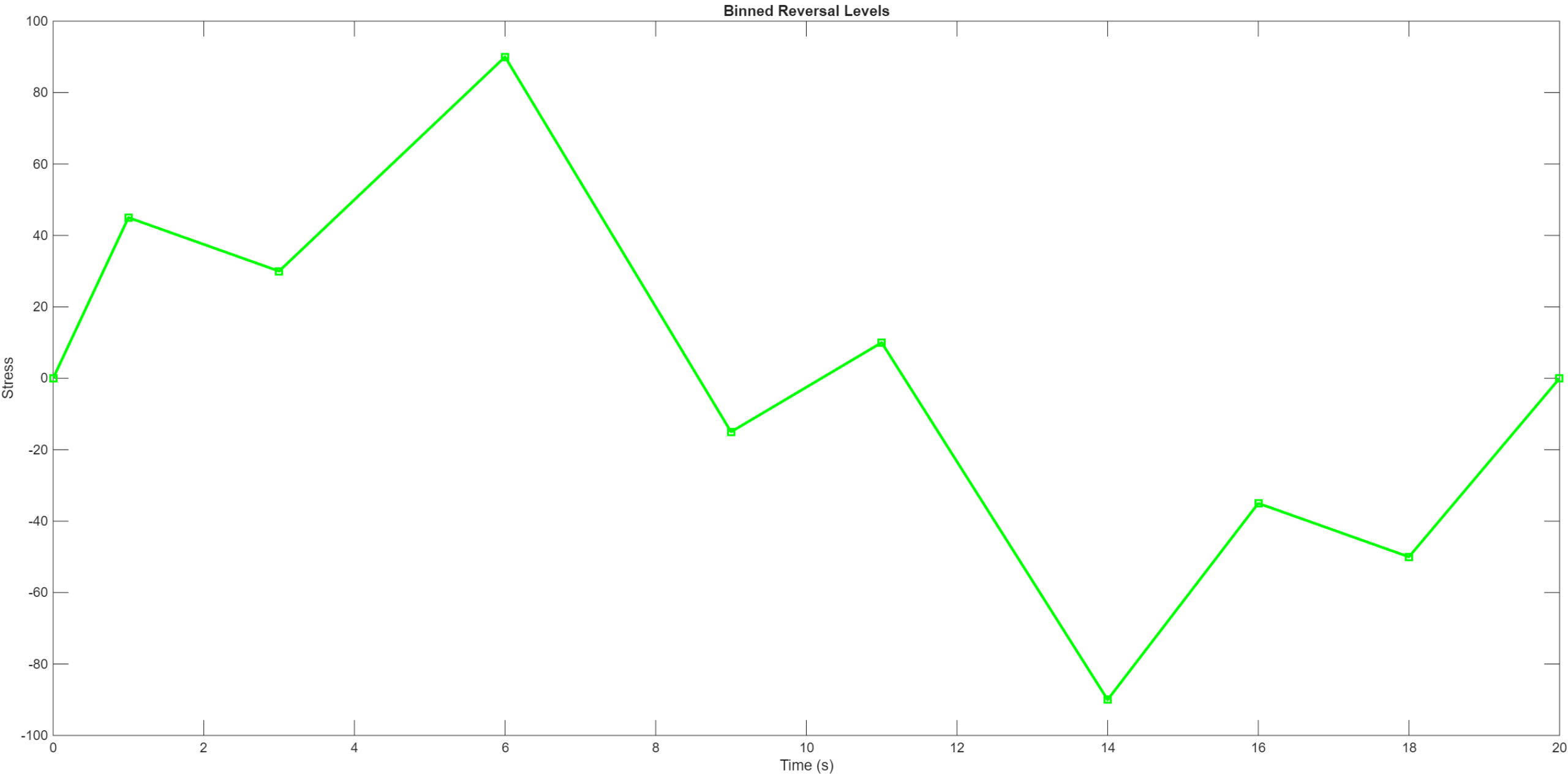
Range (units)	Cycle Counts	Events
10	0	
9	0.5	D-G
8	1.0	C-D , G-H
7	0	
6	0.5	H-I
5	0	
4	1.5	B-C , E-F
3	0.5	A-B
2	0	
1	0	

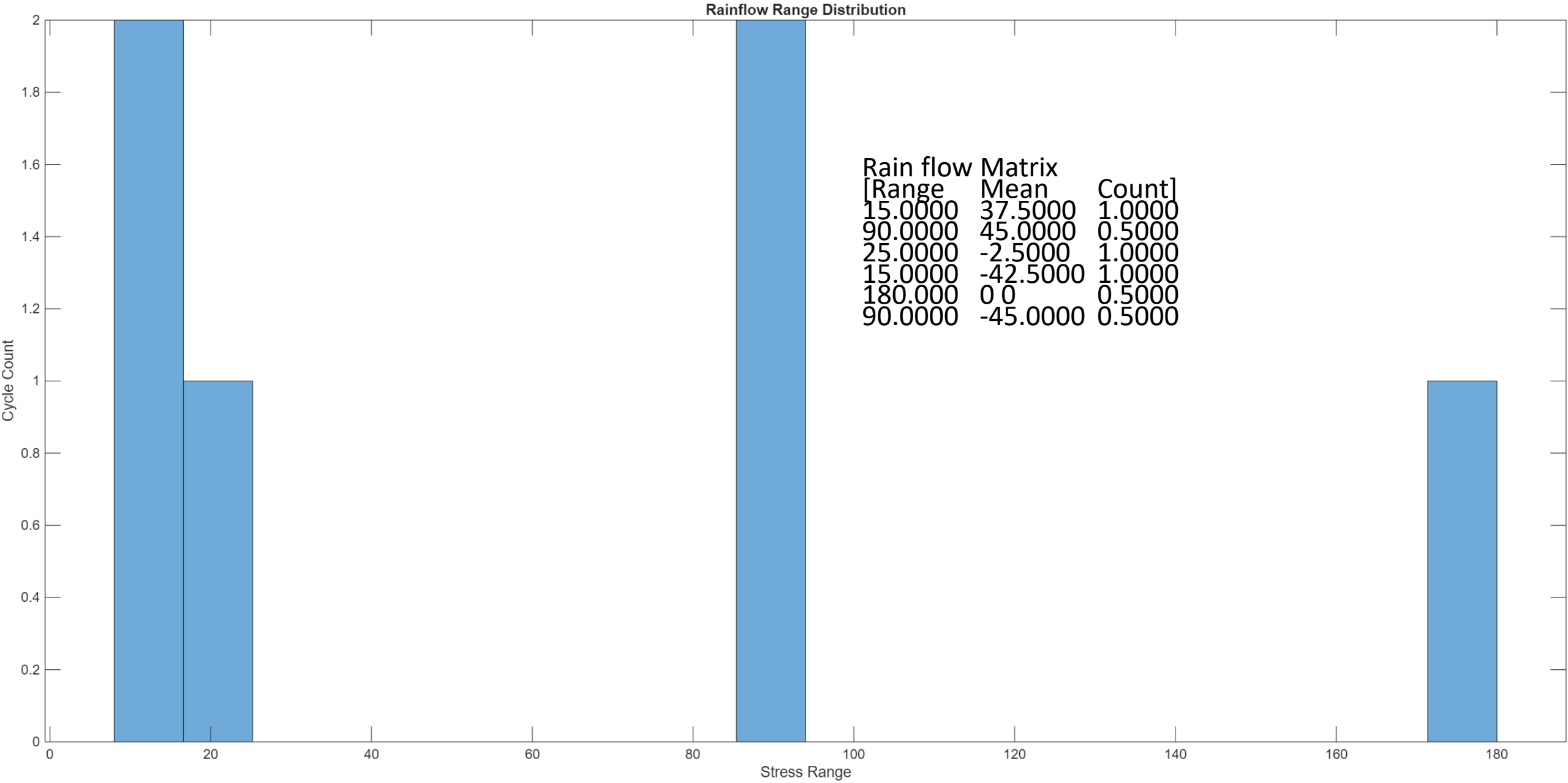
FIG. 6 Rainflow Counting Example

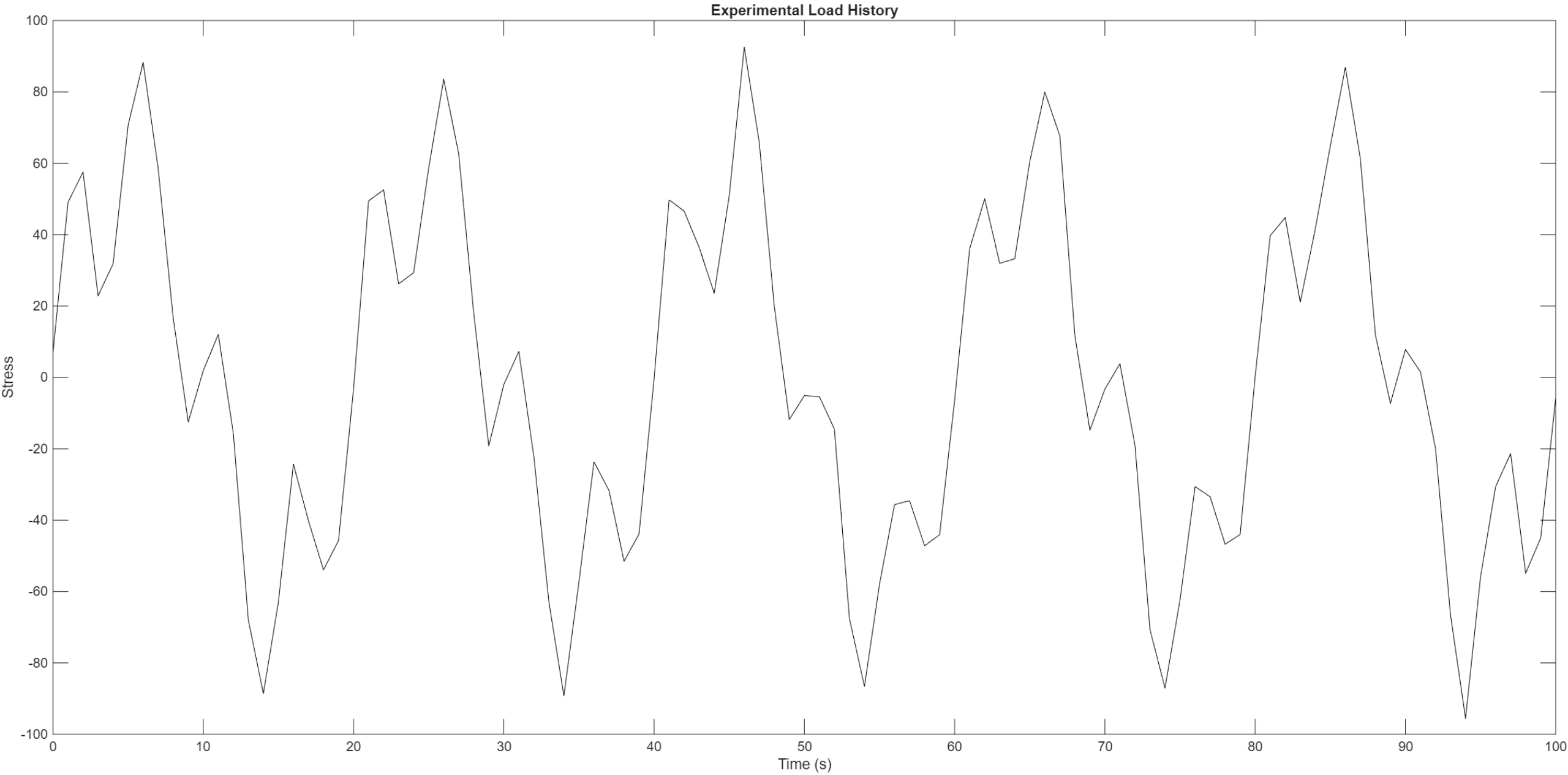

Experimental Load History
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
2
4
6
8
10
12
14
16
18
20

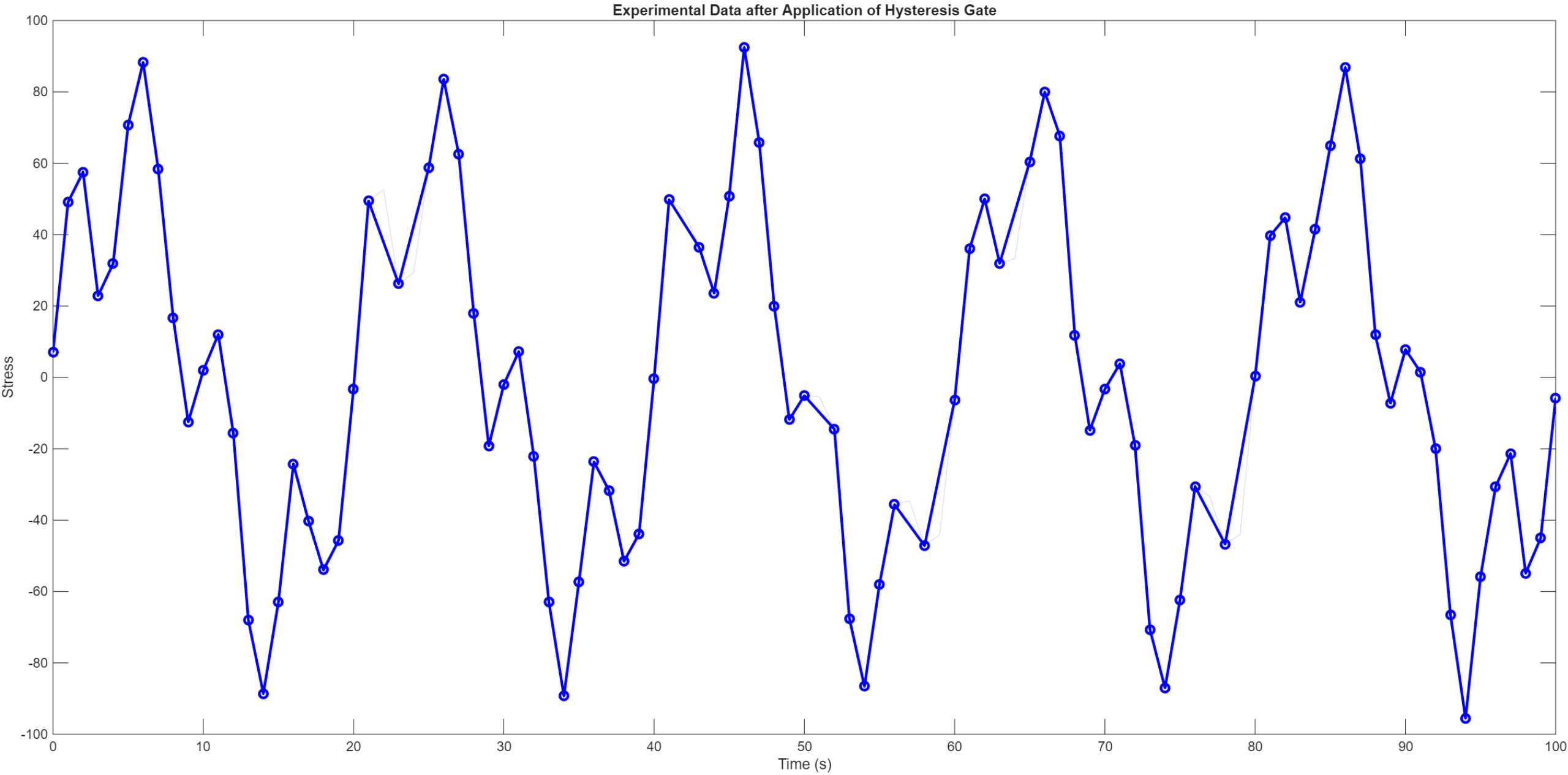

Experimental Data after Application of Hysteresis Gate
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
2
4
6
8
10
12
14
16
18
20

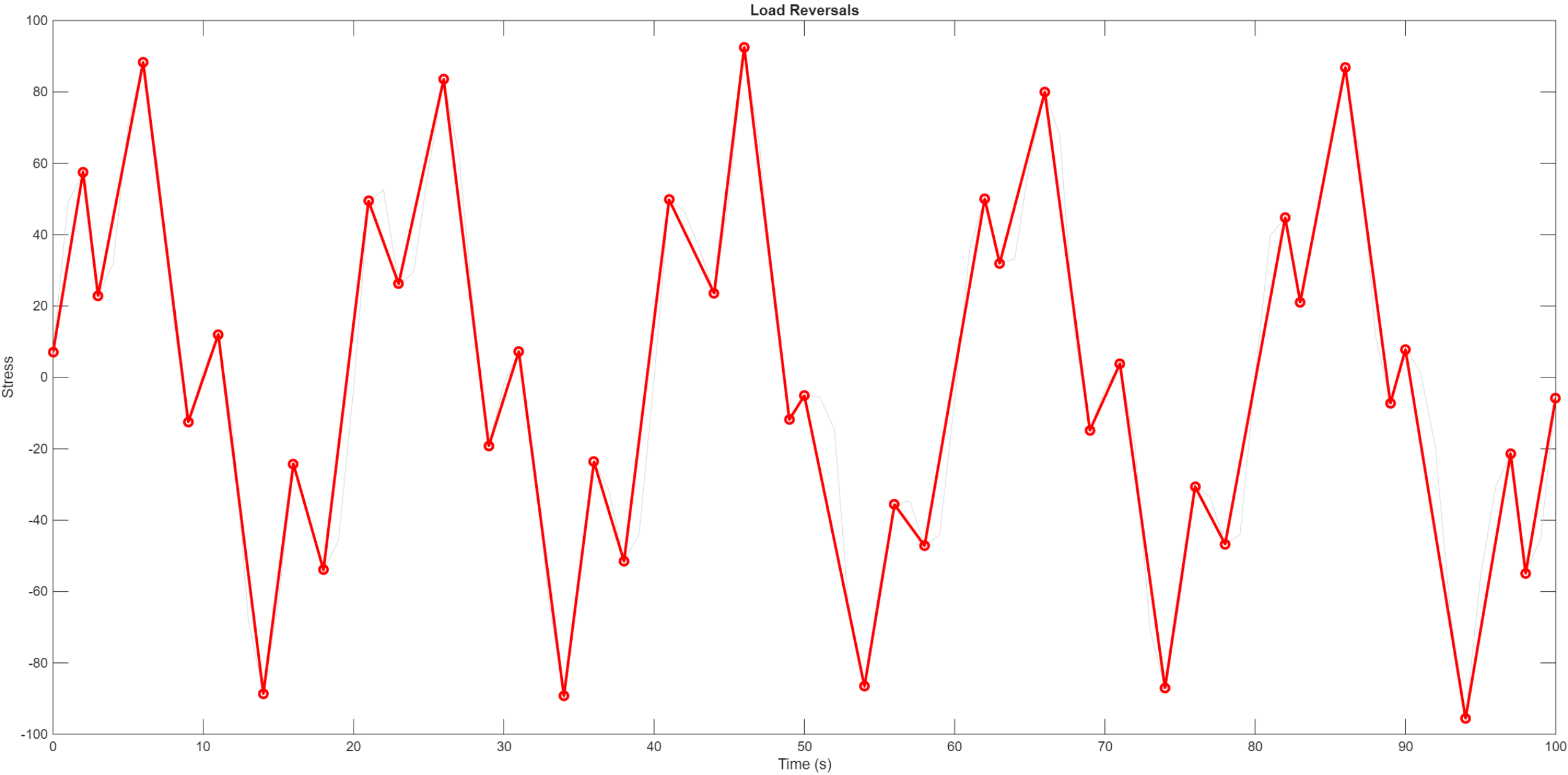

Load Reversals
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
2
4
6
8
10
12
14
16
18
20

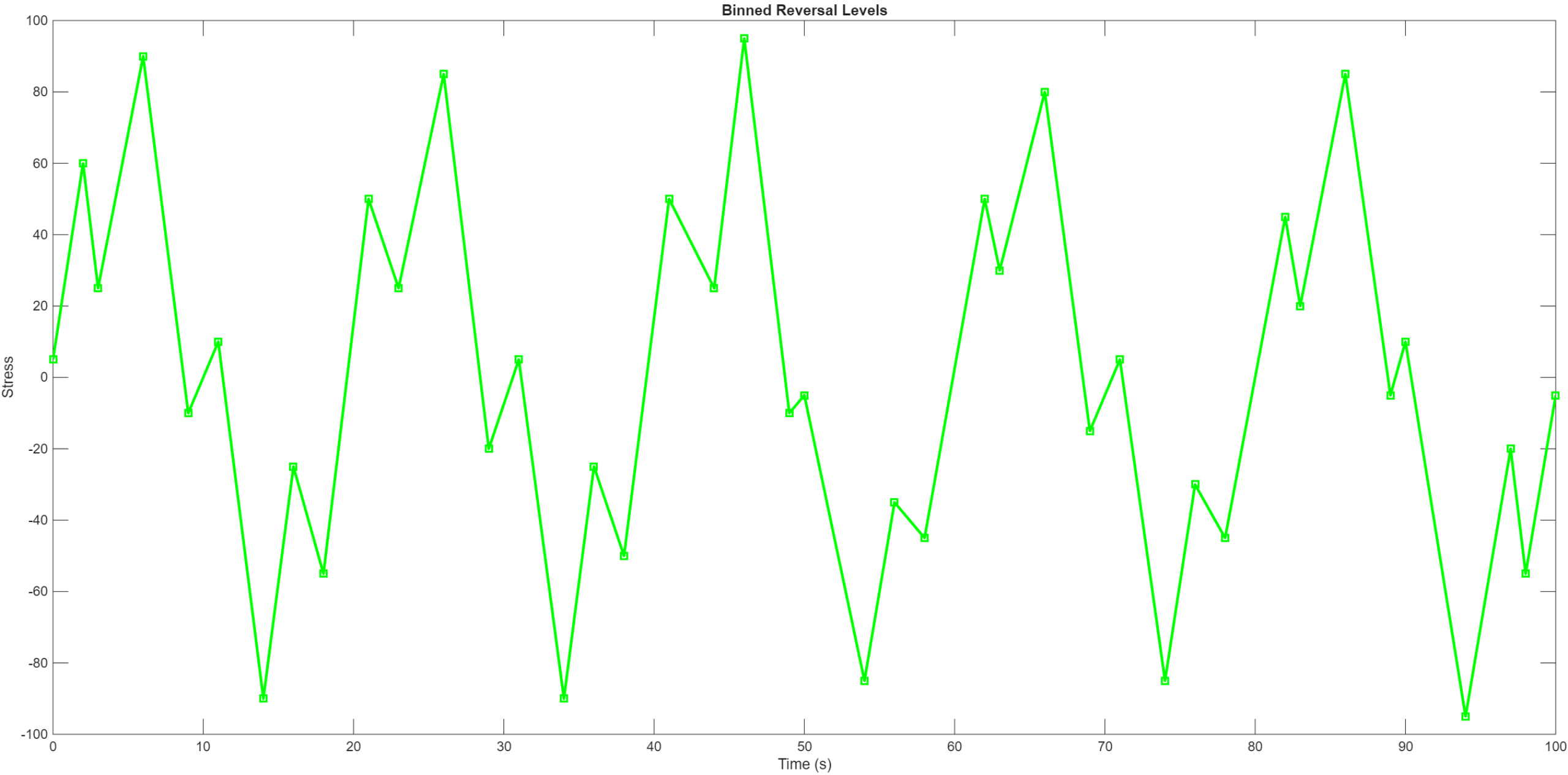

Binned Reversal Levels
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
2
4
6
8
10
12
14
16
18
20

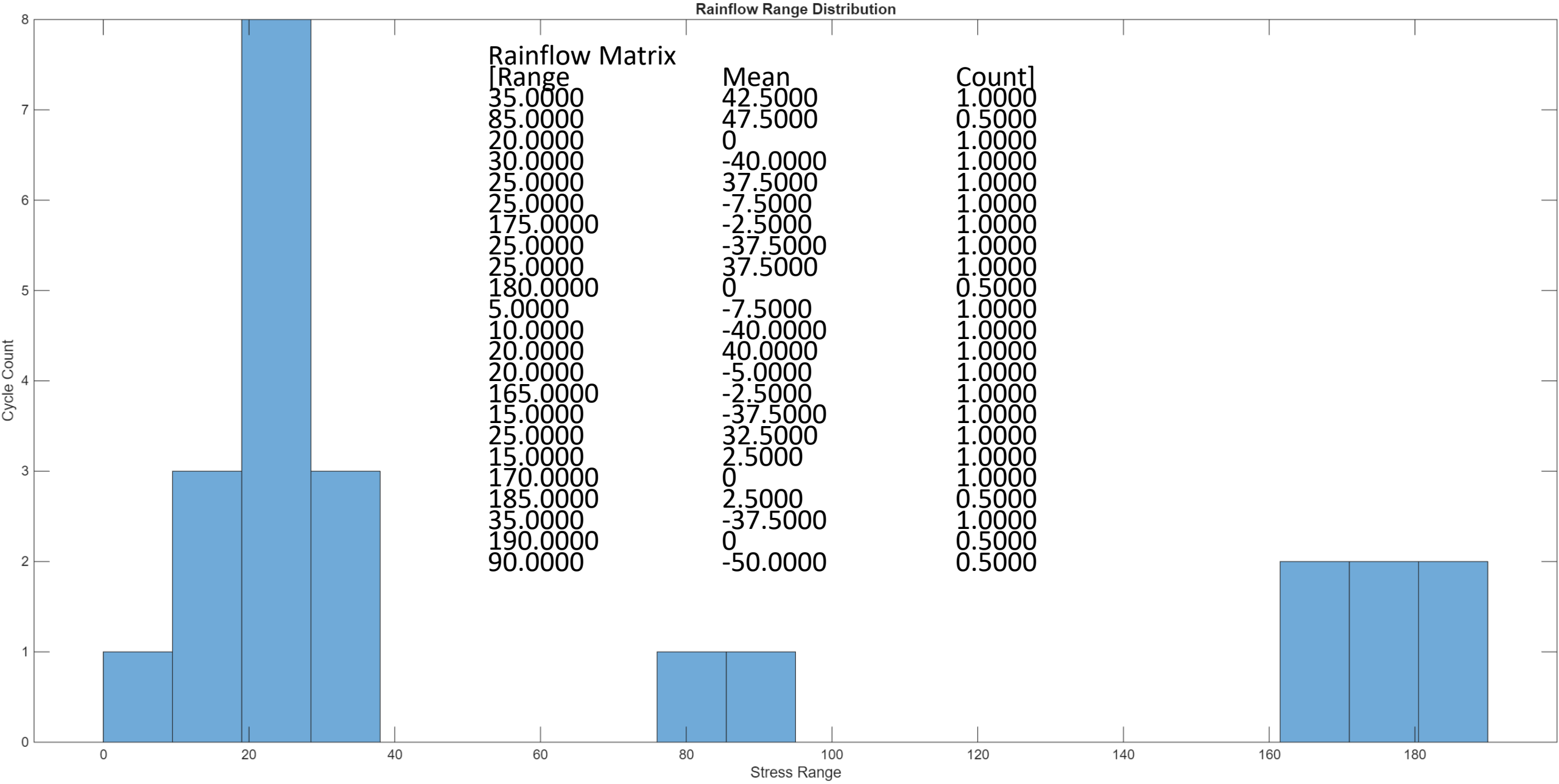

Rainflow Range Distribution
Cycle Count
Stress Range
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
20
40
60
80
100
120
140
160
180
Rain flow Matrix
[Range Mean Count]
15.0000 37.5000 1.0000
90.0000 45.0000 0.5000
25.0000 -2.5000 1.0000
15.0000 -42.5000 1.0000
180.000 0 0 0.5000
90.0000 -45.0000 0.5000


Experimental Load History
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
10
20
30
40
50
60
70
80
90
100


Experimental Data after Application of Hysteresis Gate
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
10
20
30
40
50
60
70
80
90
100


Load Reversals
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
10
20
30
40
50
60
70
80
90
100


Binned Reversal Levels
Stress
Time (s)
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
10
20
30
40
50
60
70
80
90
100



Rainflow Matrix

[Range	Mean	Count]
35.0000	42.5000	1.0000
85.0000	47.5000	0.5000
20.0000	0	1.0000
30.0000	-40.0000	1.0000
25.0000	37.5000	1.0000
25.0000	-7.5000	1.0000
175.0000	-2.5000	1.0000
25.0000	-37.5000	1.0000
25.0000	37.5000	1.0000
180.0000	0	0.5000
5.0000	-7.5000	1.0000
10.0000	-40.0000	1.0000
20.0000	40.0000	1.0000
20.0000	-5.0000	1.0000
165.0000	-2.5000	1.0000
15.0000	-37.5000	1.0000
25.0000	32.5000	1.0000
15.0000	2.5000	1.0000
170.0000	0	1.0000
185.0000	2.5000	0.5000
35.0000	-37.5000	1.0000
190.0000	0	0.5000
90.0000	-50.0000	0.5000