



Tech-Spring Report24A

The Effect of Stress Relief Temperature on Stainless Steel Spring Fatigue Tests

1. Introduction

Report number 21 detailed the results of studies into the effect of stress relief temperatures on Carbon Steel springs. It was concluded that a parallel study for the stress relief temperatures of Stainless steel springs should be done. Report 24 details the results of this work. This report details the further fatigue testing that was performed on a second batch of springs at IST, to re-confirm earlier results, which surprised the partners. The results of the residual stress analysis are to be added when they become available.

2. Spring Design

The spring design used for this study was as follows:-

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Date: 25/09/2009 09:04:39

Spring Type Round Wire Compression

Designed To: BS 1726-1: 1987
Tolerance Standard: BS 1726-1: 2002

Calculated Data

Solid Length:	22.00	mm
Solid Load:	1983.4	N
Solid Stress:	1747.3	N/mm ²
Stress Factor:	1.41	
Active Coils:	3.50	
Spring Index:	3.93	
Helix Angle:	8.40	Deg
Buckling Possible:	Not Applicable	
Buckling Definite:	Not Applicable	
Spring Pitch:	7.29	mm
Inside Diameter:	11.70	mm
Mean Coil Dia.:	15.70	mm
Wire Length:	273.47	mm
Weight / 100:	2.71	Kg
Natural Freq:	95169	RPM

Material

DIN 17224 Aust. Stainless
Youngs Mod (E): 195000 N/mm²
Rigidity Mod (G): 73000 N/mm²
Density: .00000790 Kg/mm³
Unprestress: 0-40 %
Prestress: 40-59 %

End Type: Closed and Ground
Dead Coils: 2.00
Tip Thickness: 50.00 %
End Fixation: Fixation not known

Design Parameters

Wire Diameter:	4.00	mm
Outside Diameter:	19.70	mm
Total Coils:	5.50	
Spring Rate:	172.47	N/mm (Calculated)
Free Length:	33.50	mm

Stress Data

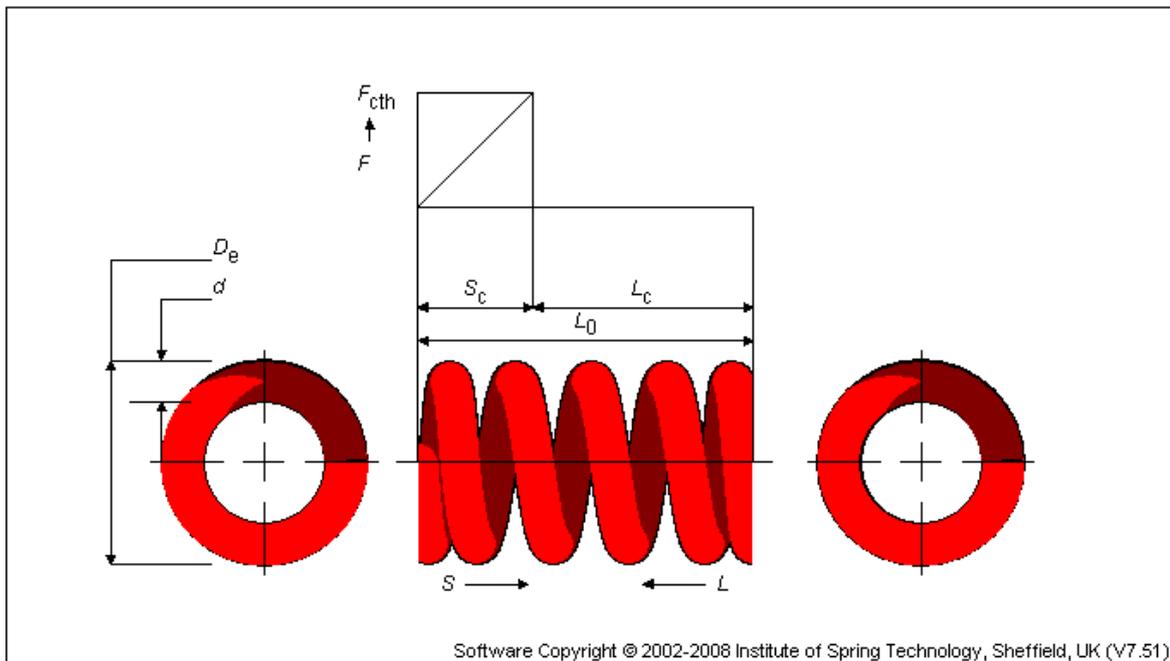
	Lower		% Tensile
	Tensile	Solid	
CrNi	1500	116 0	
Specified			

Operating Data

NO DATA

Spring Drawing

	Material:	Right hand helix	DIN 17224 Aust. Stainless
d	Wire Diameter:	4.00	mm
D_e	Outside Diameter:	19.70	mm
n_t	Total Coils:	5.50	
R_s	Spring Rate:	172.47	N/mm
L_0	Free Length:	33.50	mm
L_c	Solid Length:	22.00	mm
F_{cth}	Solid Load:	1983.4	N



3. Heat Treatment Program

The following heat treatment cycles were adopted:-

- a) 5 minutes @ 250°C after coiling.
- b) 15 minutes @ 250°C after coiling.
- c) 60 minutes @ 250°C after coiling.
- d) 5 minutes @ 350°C after coiling.
- e) 15 minutes @ 350°C after coiling.
- f) 60 minutes @ 350°C after coiling.
- g) 5 minutes @ 450°C after coiling.
- h) 15 minutes @ 450°C after coiling.
- i) 60 minutes @ 450°C after coiling.



4. Fatigue Testing Program

The heat treated springs were fatigue tested at 500 MPa and 600 MPa. The testing was performed at IST.

5. Fatigue Test Results Analysis by IST

The fatigue data for all heat treatment temperatures is presented below, and is grouped according to the treatment time.

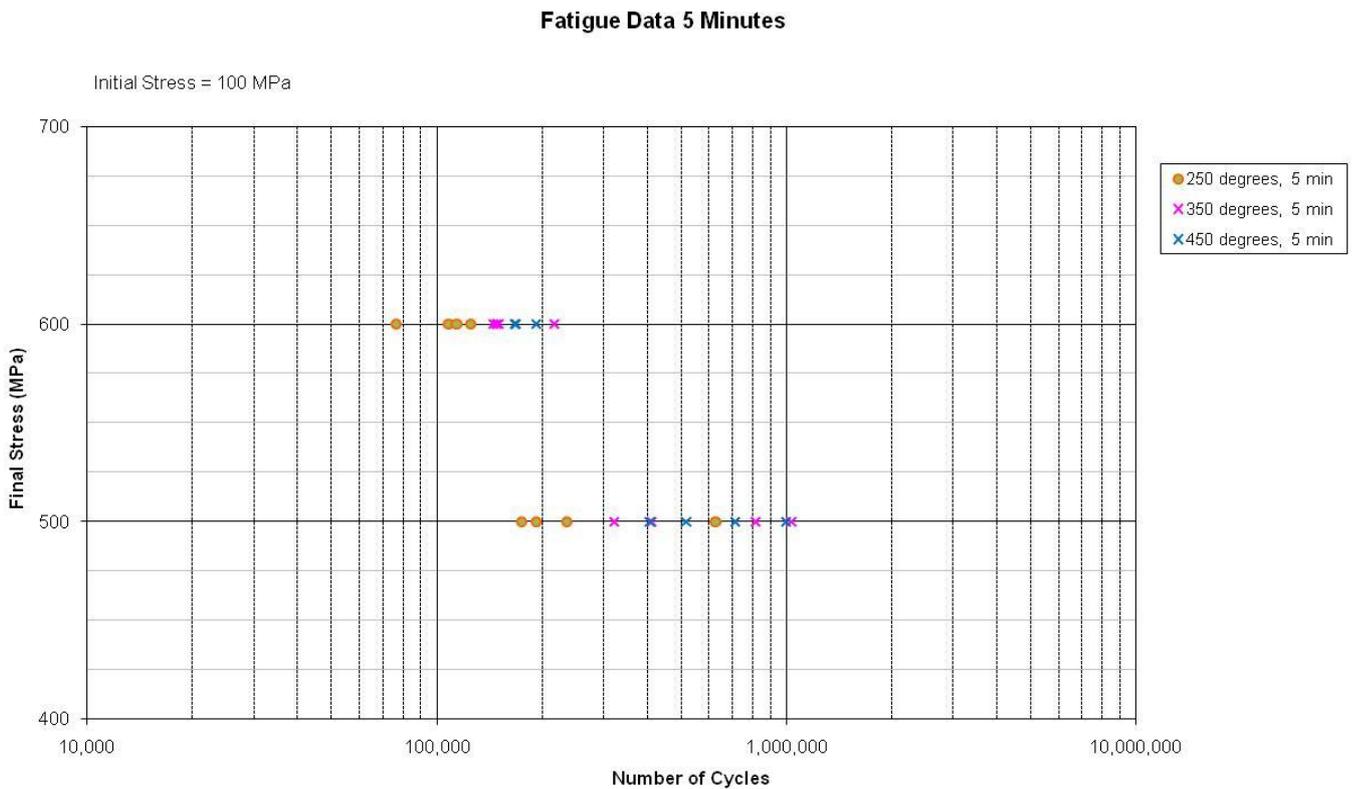


Figure 1. Fatigue data for all temperatures after 5 minutes heat treatment.



Fatigue Data 15 Minutes

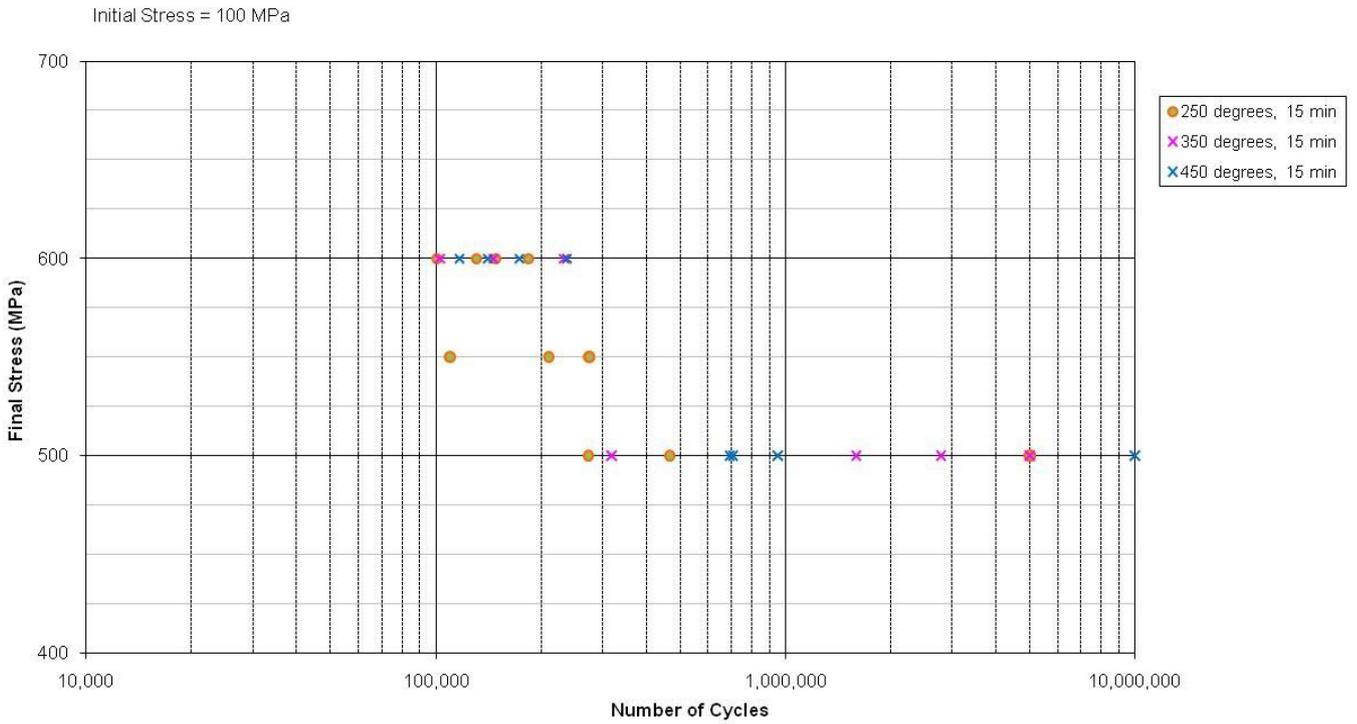


Figure 2. Fatigue data for all temperatures after 15 minutes heat treatment.

Fatigue Data 60 Minutes

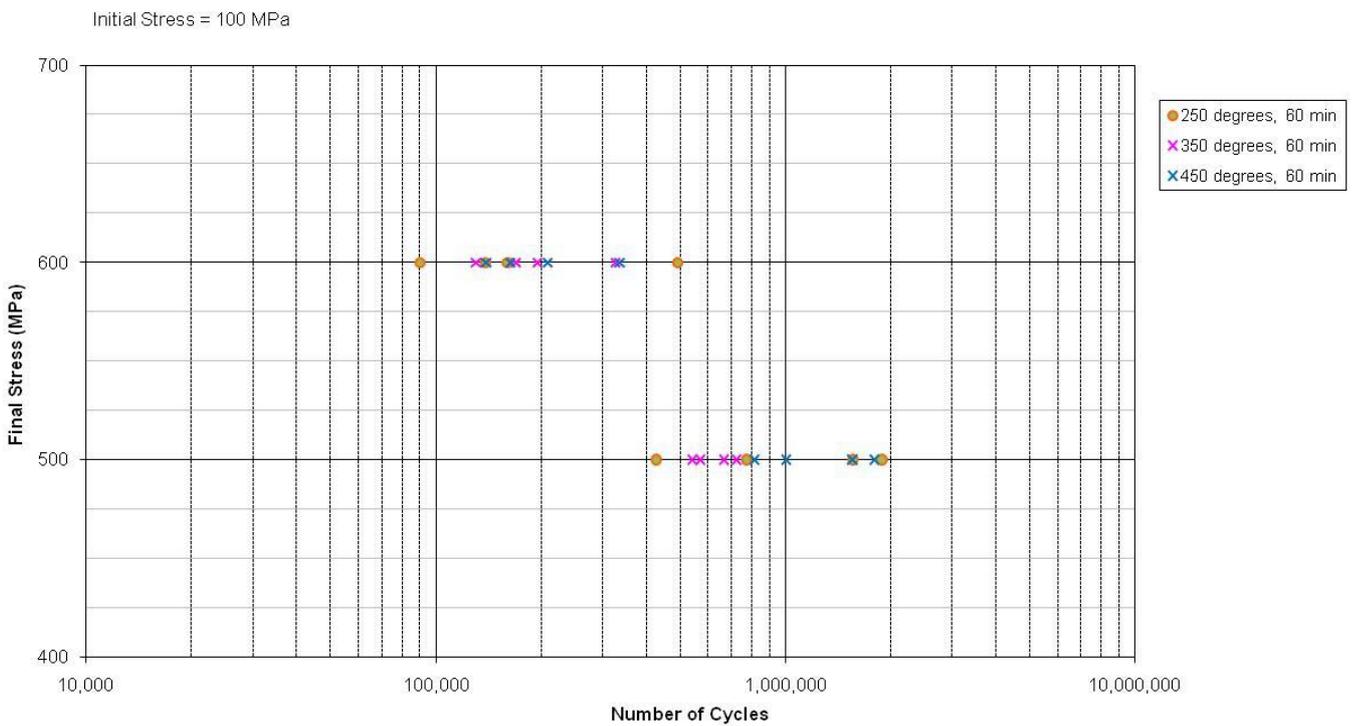


Figure 3. Fatigue data for all temperatures after 60 minutes heat treatment.

6. Discussion

Plotting the fatigue life based on the first spring failure at 500 MPa for each temperature reveals that the 450°C heat treatment gives the best improvement. It is also clear that a 5 minute treatment time is not optimum.

The 600 MPa fatigue tests did not provide statistically useful data for this type of analysis.

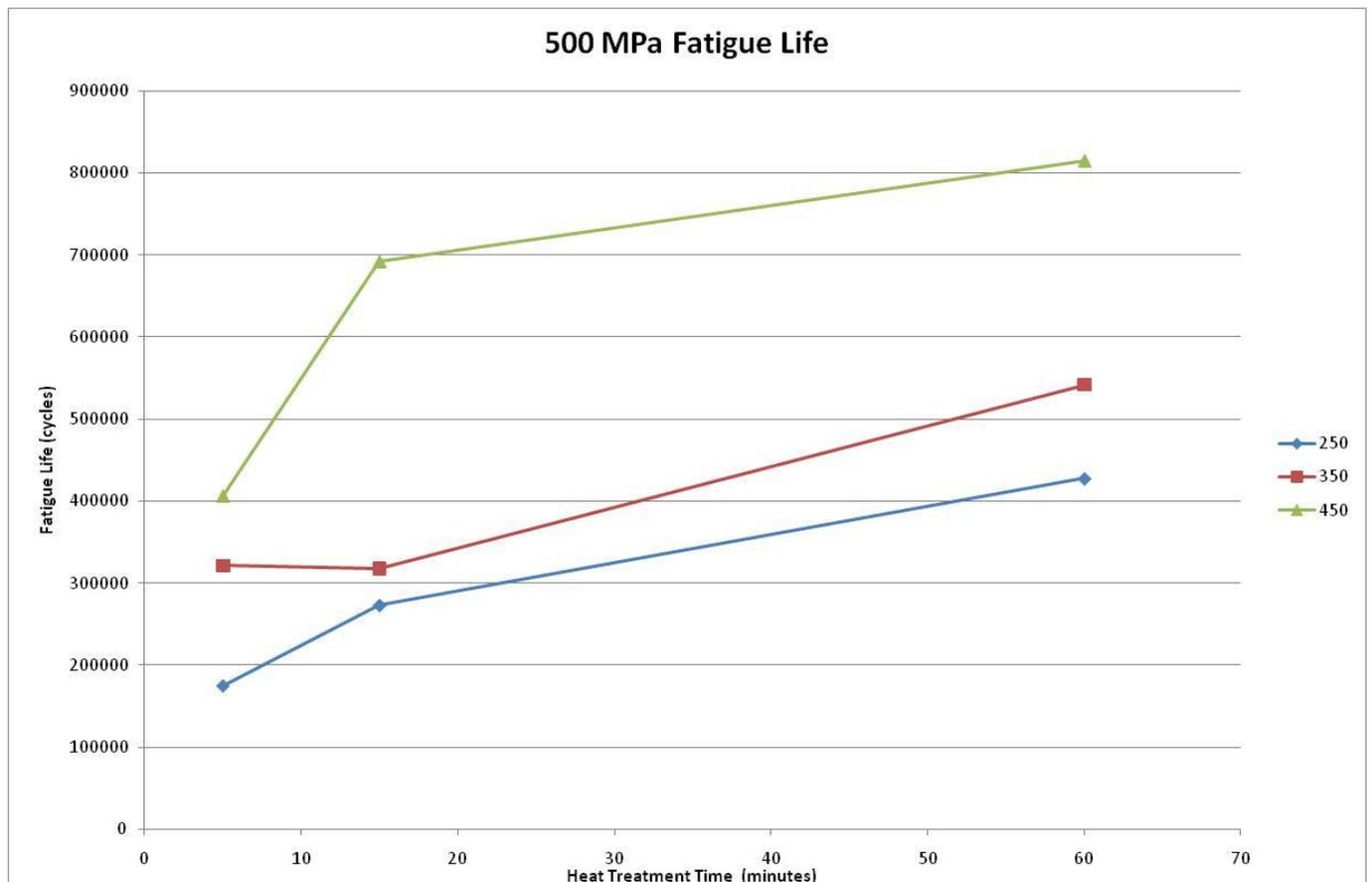


Figure 4. First failure fatigue life vs. heat treatment time at 500 MPa.

7. Conclusions

A stress relieving heat treatment of 450°C for at least 15 minutes should be applied to stainless steel springs in order to reliably improve the fatigue performance.

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