Tech-Spring Report 8
TORSION SPRING FATIGUE PERFORMANCE

Introduction

Customers of the spring industry regularly ask what fatigue performance can be expected for torsion springs. The standard answer to this question is that each spring has to be treated separately because the frictional interaction with the supporting mandrel has a significant influence. This short programme of work is intended to provide data to confirm or deny this advice.

Springs

Torsion springs with a small gap between coils made from HD drawn carbon steel were supplied to the following design

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Details: 810

Spring Type Round / Rect Wire Torsion
Designed To: BS 1726-3 / BS8726-3
Tolerance Standard: BS 1726-3: 2002

Material
BS 5216 Patented Carbon

Youngs Mod (E):	206800	N/mm^2
Rigidity Mod (G):	79300	N/mm^2
Density:	.00000783	Kg/mm^3
Unprestress:	0-70	%
Prestress:	70-100	%

Wire Section:	Round Wire	
Leg Type:	Tangential Leg	
Length Leg 1:	19.00	mm
Length Leg 2:	16.00	mm

Design Parameters

Wire Diameter:	3.18	mm
Inside Diameter:	14.29	mm
Total Coils:	16.33	
Spring Rate:	19.96	Nmm/Deg (Calculated)

Calculated Data

Body Length:	55.11	mm
Body Length (Max):	55.63	mm
Partial Angle (Free):	118.80	Deg
Stress Factor:	1.16	
Spring Index:	5.49	
Mean Coil Dia.	17.47	mm
Outside Diameter:	20.65	mm
Wire Length:	932.75	mm
Weight / 100:	5.80	Kg
Natural Freq:	7815.5	RPM

Stress Data

	Lower Tensile	Operating Positions % Tensile 1	2
Grade 1	1220	12 U	108 O
Grade 2	1420	10 U	93 P
Grade 3	1620	9 U	81 P
Grade 4	1820	8 U	72 P
Grade 5 Specified	NO DATA		

Operating Data

	Operating Positions 1	2
Torque (Nmm)	399.11	3592.0
Spring Deflection (Deg)	20.00	180.00
System Angle (Deg)	265.68	427.20
Partial Angle (Deg)	138.80	298.80
Stress (N/mm^2)	146	1318
Inside Diameter (mm)	14.23	13.77
Body Length (Max) (mm)	58.60	60.10
Load Tol. Grade 1 (Nmm)	617.91	617.91

Fatigue testing

The springs were fatigue tested initially on a soft steel mandrel, and it was quickly observed that the spring wore a groove in the mandrel, which significantly affected the spring life. It was then decided to harden the mandrel, and this had the effect of causing wear of the spring such that the wire section reduced and the spring failed opposite this wear. Naturally it was then decided to match the hardness of the spring and the mandrel and the wear was then much less on both mandrel and spring and the fatigue life increased. All these tests were conducted with WD40 lubricant applied immediately after assembly of the spring.

Mandrel Hv	20 – 160°	20 – 180°
Soft	44,328	36,395
Hard	90,813 / 92,759	
Equal to spring	306,000	93,856

Shot peening the spring brought very little benefit as it failed when tested through 20 – 180° after 115,800 cycles.

Tests without the WD40 lubricant gave very scattered and inferior results

Tests in the unwind direction inevitably gave worse results, as follows

20 – 120°	32, 961
20 – 110°	90,039
20 – 100°	Unbroken at 343,000 cycles

Conclusion

Further testing of torsion springs would be beneficial in IST's opinon