Tech-Spring Report 14
Effect of non-axial forces, Grinding and Plating

A range of compression springs were supplied in order that the effect of non-axial forces could be evaluated. It is presumed that similar springs tested over a similar corrected stress range would give similar lives if made from the same wires and that the following parameters would have no influence:

a) Number of coils.
b) Spring index.
c) Spring end grinding.
d) Electroplating with Zn.

The purpose of this programme of work was to test these presumptions. One factor that could have a significant influence would be non-axial forces. A spring with high shear forces would be expected to have additional stresses when compared to a spring exhibiting low shear forces. the springs supplied are described in the following table, all being made from EN 10270-1 SH wire.

Identity	d/mm	D/d	πt	Lo/mm	Coiler	Unground Identity
ATVA	2.5	6	8	50	FUL31	U6
ATVB	2.5	8	8	65	FUL31	U3
ATVD	2.5	4	8	40	FUL31	U7
TECH1	2.5	10	8	85	FUL31	U5
ATVC	3.5	6.14	6.5	50	Bobbio	U1
ATVE	3.5	6.14	7.5	60	Bobbio	U3
TECHS	3.5	6.14	5.5	40	Bobbio	U2

A typical set of data produced on the non-axial force testing machine is as shown in graph 1 and table 2 below. This result is for the index 6 springs that had been plated. The bottom end if the spring was guided during the test by fitting it over a specially machined locating lug– mostly the tests were conducted with only one end located, but the test labelled “Both” had both ends guided. All springs were prestressed to block prior to this test.

Graph 1

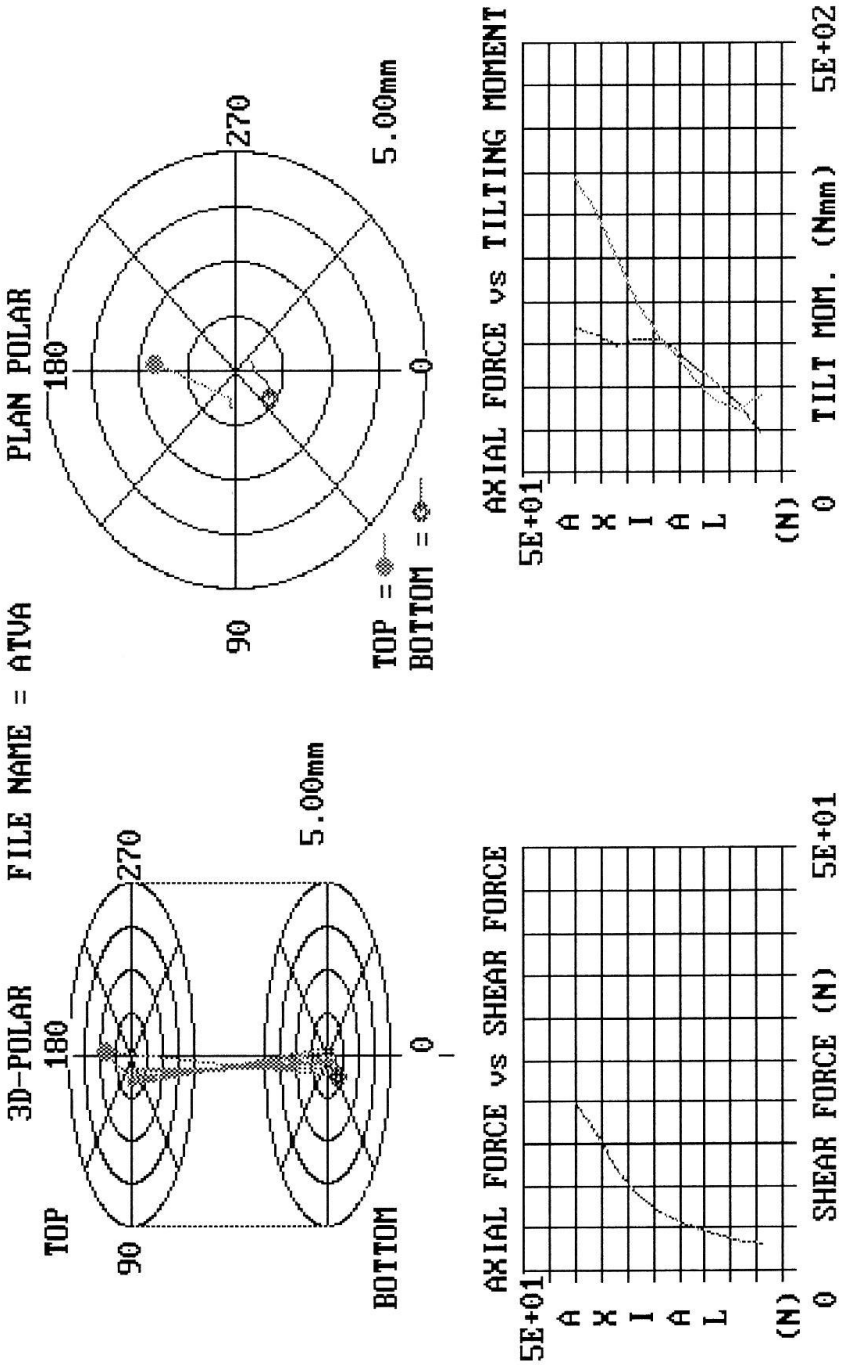
PLAN POLAR
FILE NAME = ATVA
180
270
0
90
5.00mm
TOP =
BOTTOM =
AXIAL FORCE vs TILTING MOMENT
5E+01
AXIAL FORCE (N)
0
TILT MOM. (Nmm)
5E+02
3D-POLAR
TOP
BOTTOM
AXIAL FORCE vs SHEAR FORCE
SHEAR FORCE (N)

Table 2

DATA FILE NAME = ATVA

TOP OF SPRING				
LENGTH (mm)	X CO-ORD (mm)	Y CO-ORD (mm)	RADIUS (mm)	THETA (Degrees)
44.00	0.14	2.15	2.15	183.66
41.78	-0.36	0.81	0.89	156.24
39.56	-0.52	0.45	0.68	130.91
37.33	-0.59	0.29	0.66	115.80
35.11	-0.65	0.17	0.67	104.52
32.89	-0.66	0.13	0.67	101.11
30.67	-0.71	0.12	0.72	99.99
28.44	-0.78	0.12	0.79	98.43
26.22	-0.85	0.10	0.86	96.74
24.00	-0.85	0.12	0.86	97.81

BOTTOM OF SPRING				
LENGTH (mm)	X CO-ORD (mm)	Y CO-ORD (mm)	RADIUS (mm)	THETA (Degrees)
44.00	-0.65	-0.90	1.11	35.69
41.78	-0.37	-0.89	0.97	22.41
39.56	-0.25	-0.80	0.84	16.96
37.33	-0.18	-0.73	0.75	13.96
35.11	-0.15	-0.69	0.71	12.40
32.89	-0.10	-0.64	0.65	9.11
30.67	-0.02	-0.56	0.56	2.38
28.44	0.13	-0.45	0.47	343.52
26.22	0.25	-0.38	0.45	326.83
24.00	0.27	-0.33	0.43	321.31

SUMMARY OF AXIAL AND NON-AXIAL FORCES					
LENGTH (mm)	AXIAL FORCE (N)	SHEAR FORCE (N)	TILTING MOMENTS TOP (Nmm)	BOT.	END COIL TORQUE (Nmm)
44.00	40.97	2.95	88.29	45.60	-9.45
41.78	80.80	3.31	71.93	78.15	-23.17
39.56	120.53	3.91	82.46	101.34	-41.63
37.33	159.90	4.69	105.54	119.58	-59.06
35.11	199.13	5.65	133.93	141.36	-79.20
32.89	237.98	6.90	160.54	154.49	-102.26
30.67	277.08	8.77	198.75	156.42	-124.88
28.44	316.75	12.02	251.25	148.97	-147.82
26.22	356.75	16.25	305.17	159.94	-175.73
24.00	397.73	20.01	343.00	169.17	-202.84

The important results are maximum shear force (as a proportion of the axial load), maximum tilting moment, and maximum end coil torque.

	Shear / Axial Load / N	Tilting Moment / Nm	Torque / Nm
ATVA	20 / 398	343	202
ATVA plated	24 / 396	533	153
ATVB	19 / 228	655	223
ATVB plated	19 / 230	852	83
ATVDP Both	10 / 433	207	147
ATVDP one	8 / 432	221	146
ATVD	9 / 430	268	141
U7	14 / 410	350	81
TECH1	15 / 210	323	260
ATVC	70 / 659	1917	410 bent
ATVC plated	40 / 422	716	296 straight
ATVE	42 / 624	1524	444
ATVE plated	48 / 617	875	333
TECHS	73 / 620	1410	332
TECHS plated	50 / 540	710	278

None of these springs has particularly high non-axial forces apart from the TECHS batch, and even this batch had lower values when plated – the above results are usually an average of two. It is IST's contention that the non-axial forces are not high enough in any of these batches such that their influence on fatigue life would be detectable. However, there are some lessons that can be learnt about non-axial forces from these results, namely:

a) Small index springs give low non-axial forces
b) Springs with x+1/2 coils give higher shear forces than those with a complete number of coils
c) If non-axial forces are to be studied further in TECH-SPRING, springs with few coils, a relatively large spring index and +0, +1/4, +1/2 and +3/4 coils would be required

Batches ATD with and without plating and batch U7, a very similar design, have been prestressed to 32mm and then fatigue tested with the following results.

Batch	Test Lengths		Approx Corrected Stress Range	Life	
ATVD	38	33	188-882	312, 450	10^7
ATVD plated	38	33	188-882	968, 760	10^7
U7	38	33	188-882	253, 350	10^7
U7 plated	38	33	188-882	8,034, 520	10^7
ATVD	38	32.5	188-951	285, 570	285,570
ATVD plated	38	32.5	188-951	660, 650	6,024,160
U7	38	32.5	188-951	10^7	10^7
U7 plated	38	32.5	188-951	1,314,130	1,411,850

The scatter in this data is large, and as a result it is difficult to drawn conclusions, but it does not appear that the plating has had an adverse effect, and the unground springs, U7 have performed as well as their ground counterparts.

Similar testing could be undertaken on any of the batches described in this report if partners are of the opinion that such testing would yield useful results. There are about 60 springs in each batch, so these springs should be looked upon as a valuable asset for TECH-SPRING that could be used or tested as partners decide.

Conclusion

1. Non-axial forces, when low, have no effect upon spring fatigue performance.
2. End grinding has no effect upon fatigue performance providing that the spring is located on an appropriate spigot.
3. Plating had no effect upon the fatigue performance of these springs. Other IST tests have shown a very small adverse effect.

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