OPTIMISATION of SPRING DESIGNS

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OPTIMISATION OF SPRING DESIGNS

SPRINGS

- End Users are responsible for spring designs – companies like Schneider Electric
- IST encourages spring manufacturers to validate the user’s designs and offer advice until…..
- The spring has been optimised
- Even then, continuous improvement is required
- The spring supply chain needs the best spring design software

OPTIMISATION OF SPRING DESIGNS

SPRINGS

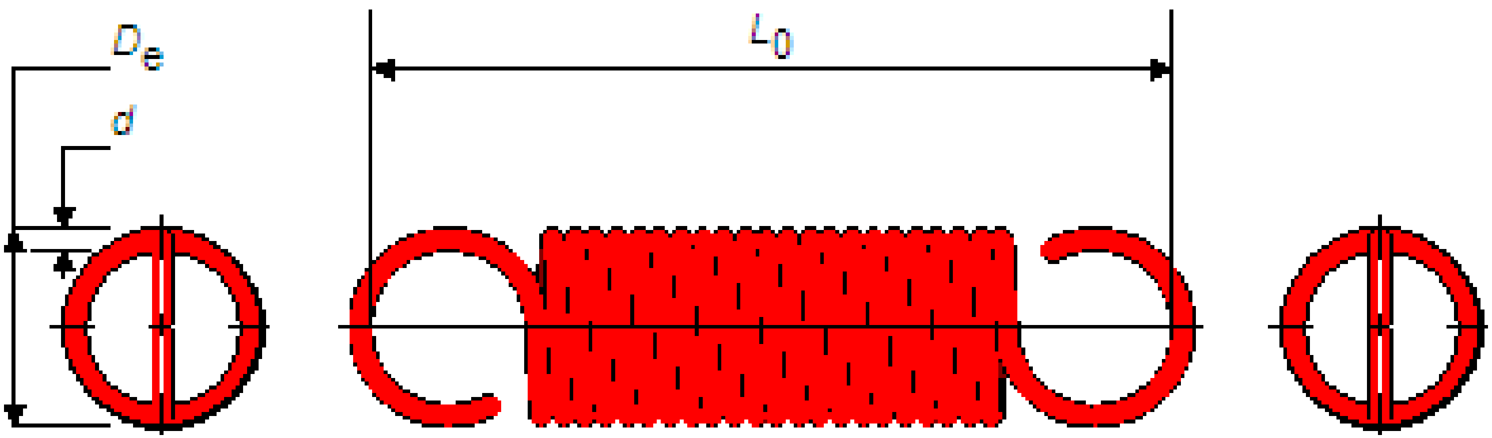
- IST, in collaboration with Schneider Electric, have developed spring optimisation modules
- The compression module was shown at the SNFR congress last year and at Interwire in May 2011
- The conical and torsion modules were demonstrated at the ESF Congress in Sept. 2011
- Today the extension spring module will be unveiled

OPTIMISATION OF SPRING DESIGNS

EXTENSION SPRINGS

This paper will explore the potential to design springs having certain characteristics, but less expensive, less heavy and/or less large

Let us take an ordinary extension spring like this:



OPTIMISATION OF SPRING DESIGNS EXTENSION SPRINGS

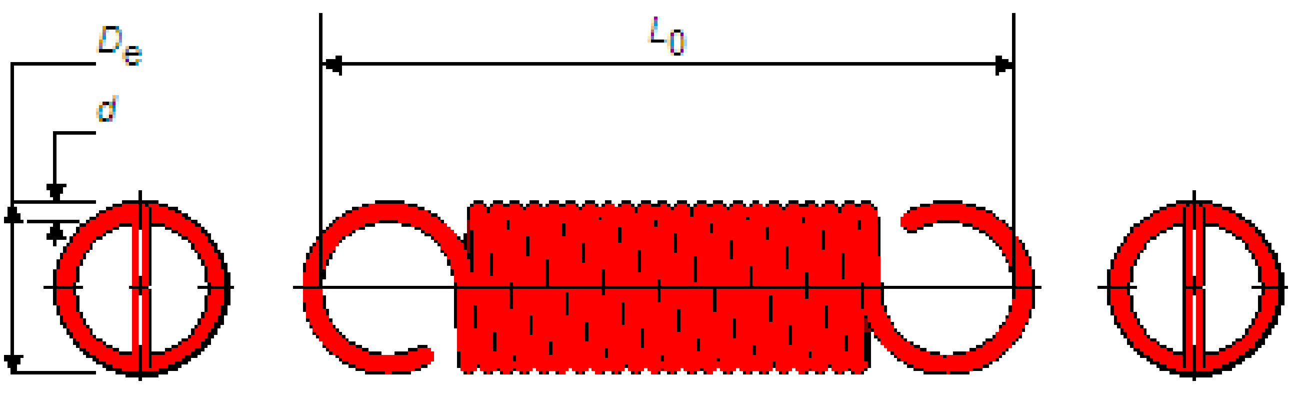
Material: Carbon steel to EN10270-1 DM

d = 1.6 mm, De = 14.8 mm, n_t = 22, Fo = 12N

Dynamic performance = 30,000 cycles required

Manufacturing processes: Coil, stress relief heat treat

Mass 15.4g per spring



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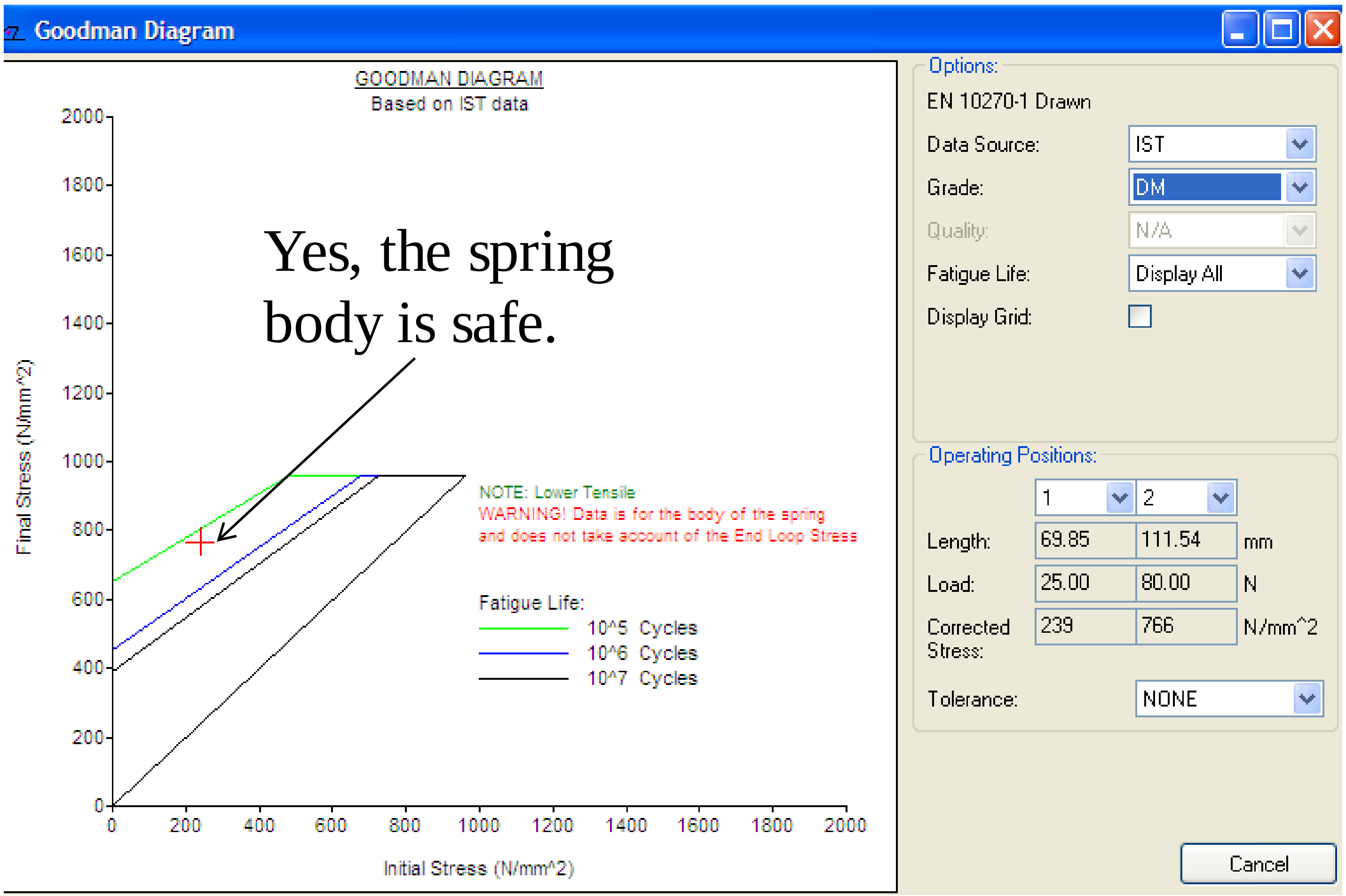
F1 is 25N and F2 is 80N

Will this spring survive 30 thousand cycles?



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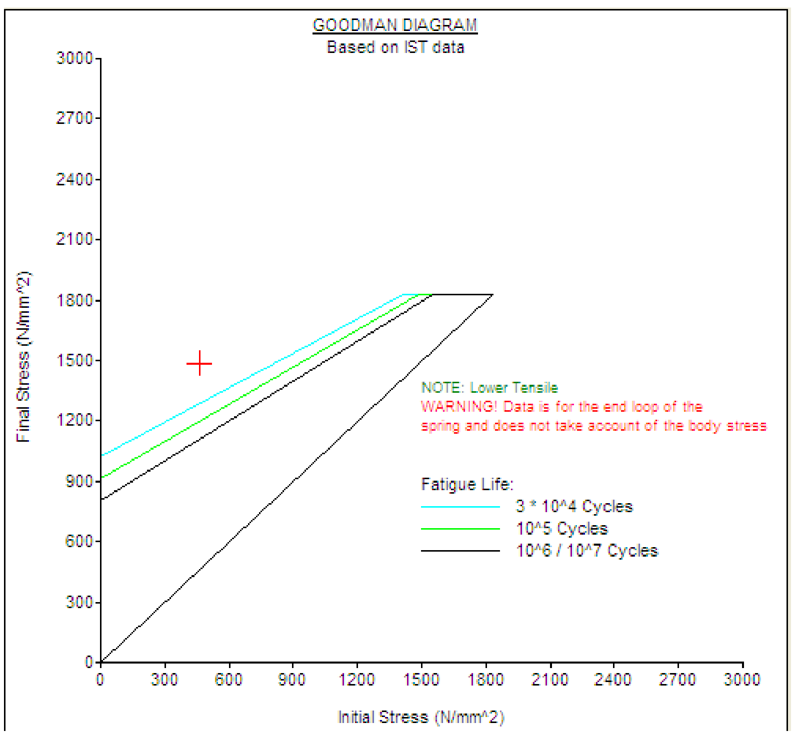
The spring body is near its limit for 30,000. Will the loops survive?

To find out, use “Spring Calculator Professional” and “Techspring” as the design authority



Sorry, NO

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The spring body is OK for 30,000, but the end loops may not survive.

For the first time, prediction of fatigue in end loops is available. How could the loops be improved?

1. Use DH wire
2. Shot peen end loops
3. Reduce loop diameter

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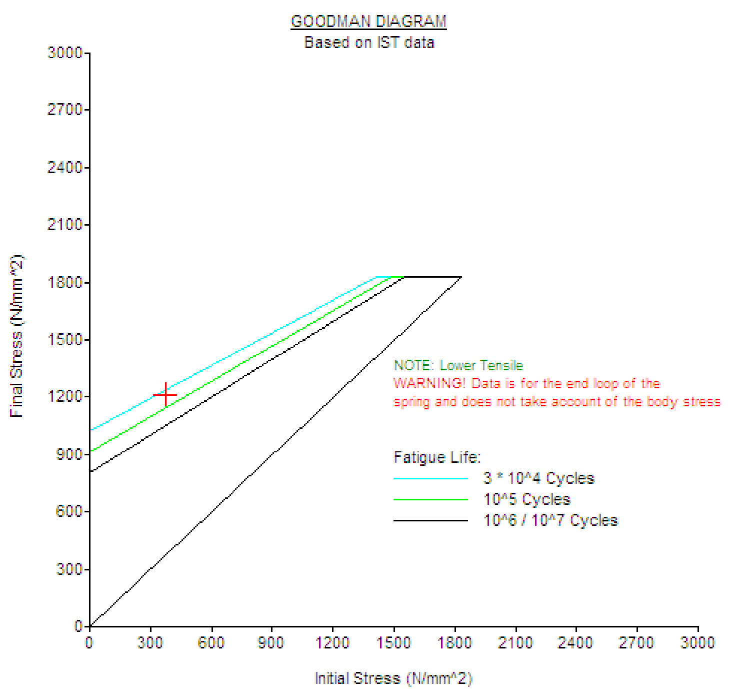
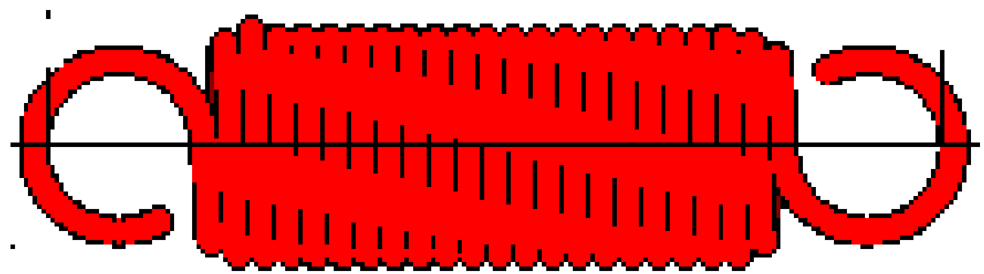
OPTIMISATION OF SPRING DESIGNS

The spring body is near its limit for 30,000. Will the loops survive? NO

1. Reduce loop diameter. Using DM wire, reduce loop from 14.8 to 12.0 mm





OPTIMISATION OF SPRING DESIGNS

This spring design has been made safe, but can it be optimised? It is working near its limit. How can its mass be reduced?

Use software developed by the team of IST, Sheffield & Schneider Electric, Grenoble and Lab. Génie de Méchanique de Toulouse.

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Schneider Electric

Developed with LGMT

It is a program for extension spring validation with a module for optimisation.

OPTIMISATION

The spring is near its limit for 30 thousand.

Cannot change F1, F2

The space envelope available is De = 16 mm max. L1, L2 need to be as short as possible, but R must be between 1.35 and 2.7 N/mm

Perhaps d, nt or De can be reduced.

OPTIMISATION

Input values + DM wire

Design Requirements

Objective: Minimum | Spring Weight

Reset

	Minimum	Maximum	
Wire Diameter:			mm
Outside Diameter:		16.00	mm
Inside Diameter:			mm
Mean Coil Diameter:			mm
Spring Rate:	1.35	2.70	N/mm
Free Length:			mm
Body Length:			mm
Added Length:			mm
Ratio L1 / L0:			
Initial Tension:			N
Operating Length L1:			mm
Operating Load P1:	25.00	25.00	N
Operating Length L2:			mm
Operating Load P2:	80.00	80.00	N
Spring Travel (L1-L2):			mm
Energy (L1-L2):			N.mm
Spring Weight:			Kg
Natural Frequency:			RPM

Output values

Calculated Data

Objective:	Spring Weight:	0.0115	Kg
Wire Diameter:		1.74	mm
Outside Diameter:		16.00	mm
Total Coils:		12.25	
Spring Rate:		2.63	N/mm
Initial Tension:		6.04	N
Free Length:		48.10	mm

Operating:	L1	55.31	mm	P1	25.00	N
	L2	76.24	mm	P2	80.00	N

Result – d 1.74 mm, nt 12.25 and De 16 mm

Mass reduced from15.4 g to 11.5 g

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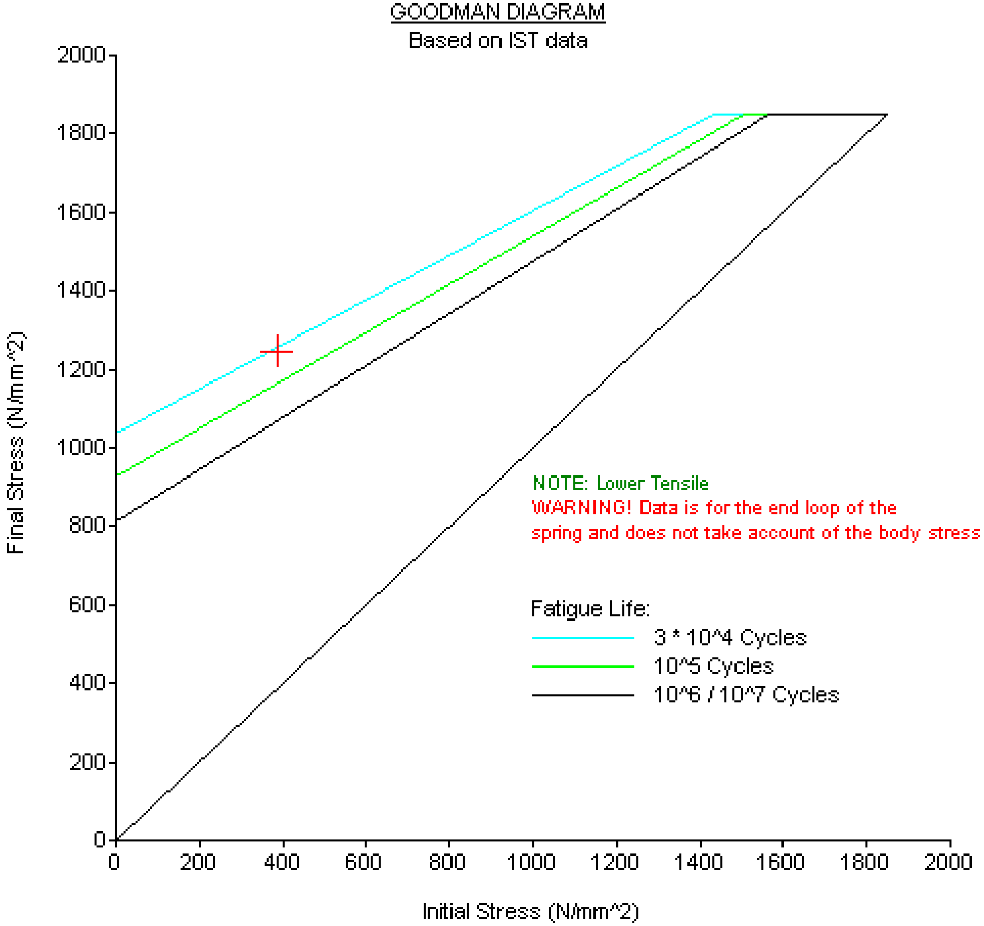
New design has fewer coils, but will the loops be OK for 30,000 cycles? Yes, but with no safety margin.



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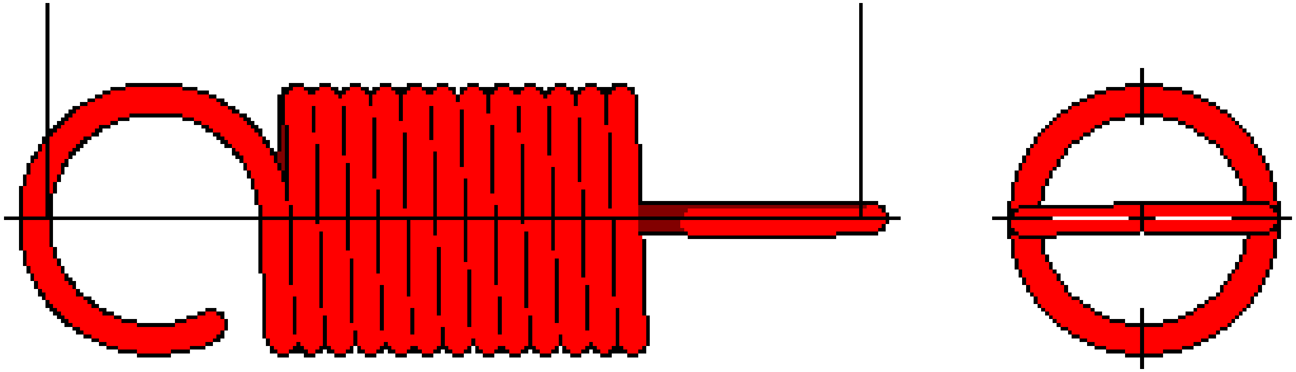
New lighter spring has loops same diameter as body so will be cheaper and easier to manufacture



OPTIMISATION

What advantage will use of DH wire accrue?

Grade: DH

d becomes 1.50 mm

De becomes 12.03 mm

nt becomes 16.36 mm

The result: Mass = 8.21g

Calculated Data

Objective:			Spring Weight:	0.00821	Kg
Wire Diameter:				1.50	mm
Outside Diameter:				12.03	mm
Total Coils:				16.36	
Spring Rate:				2.70	N/mm
Initial Tension:				6.37	N
Free Length:				44.10	mm
Operating:	L1	51.00	mm P1	25.00	N
	L2	71.37	mm P2	80.00	N

Does a 28% saving justify use of DH?

OPTIMISATION

There are many possibilities with this new optimisation software.

Many “what if” questions can be posed and almost immediate answers are provided.

For instance, this exercise could be repeated with stainless steel wire.

Optimisation for other parameters is possible

OPTIMISATION

Program constraints and options

Minimum
Maximum

Default Limits

	Minimum	Maximum	
Spring Index:	4.00	20.00	
Total Coils:	3.00		
Mean Coil Diameter:		160.00	mm
Max. Operating Length:		3000.0	mm
Ratio L1 / L0:	1.15		

NOTE: Maximum coil diameter and maximum operating length may be overwritten by the specified design requirements

Reset | Apply | Cancel

- Wire Diameter
- Outside Diameter
- Inside Diameter
- Mean Coil Diameter
- Spring Rate
- Free Length
- Body Length
- Added Length

- Spring Rate
- Free Length
- Body Length
- Added Length
- Ratio L1 / L0
- Initial Tension
- Operating Length L1
- Operating Load P1
- Operating Length L2
- Operating Load P2
- Spring Travel (L1-L2)
- Energy (L1-L2)
- Spring Weight
- Natural Frequency
- Fatigue Life Factor

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OPTIMISATION

Conclusion

1. A reduction of mass from15.4g to 8.21g has been achieved with an improvement of fatigue risk in the loops.

2. Springmaker's customer's designs could be optimised (max or min) for:

   Rate, F2, Natural Frequency, Mass, Internal or External Diameter

3, Optimisation modules for compression torsion and conicals are available

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