ME46060 "Engineering Optimization – Concepts and Applications" Exercise 1

Subject: "Valve spring"

Objectives:
- Study of spring analysis model.
- Formulation of spring optimization model.

Introduction valve spring design problem

Figure 7-4 of reference [1] shows a typical design of a valve system of an internal combustion engine. The valve is opened by the camshaft, and closes by means of the valve spring. For proper operation and behavior of the valve system an adequate design of the valve spring is crucial. We consider this design problem in the following exercises.

To find the "best" design for the spring, we may formulate the design as an optimization problem, involving design variables, objective function(s) and constraint functions.
We assume that the valve system must fulfil the following (for this moment only qualitative) specifications:
- The stroke of the valve is given.
- In closed position the spring force may not be lower than a given value, in order to prevent gas leakage.
- If the valve is in opened position the spring force may not be lower than a given value, in order to prevent the rocker follower to come loose from the cam.

Above specifications mean that for now the spring design problem can be regarded as isolated from the cam and camshaft design. In fact this is the result of a decomposition procedure of the valve system, in which the spring is isolated from the other system components.

Exercise 1.1 Analysis model

Perform a rather quick scan (do not read everything in detail!) of references [1], [2] and [3]. The following list may assist you at this literature studie:

Relation(s) for:	Mott	Steinhilper	Roloff/M.
Axial spring stiffness		(7.66)	(10.48)
Shear stress	(7-4)(7-5)	(7.59)(7.60)(7.61)	(10.45a/b)
Linear spring deflection	(7-6)	(7.65)	(10.50)
Spring force	page 137		(10.49)
Mechanical work		(7.67) … (7.70)	(10.51)
First eigenfrequency			(10.52)
Spring buckling	p.144, fig.7-13	(7.79)	
Blocking length	page 139	(7.74) … (7.78)	(10.38) … (10.42)
Installation consideration	p.139, (7-3)		

Study the analysis model given in the MATLAB .m-file **springanalysis1.m:**
- Look at variable definitions and program comments.
- See which relations from literature have been implemented, and in what way.

Include a summary of your findings in the report.

Exercise 1.2 Optimization model

Formulate qualitatively the valve spring design problem as one or several optimization problems:
- Which design variables should be used? How can they be characterized (continuous or discrete, and deterministic or stochastic)?
- What objective function do you propose, and why? Can (may be conflicting) multiple objectives be identified?
- Which constraints should be imposed?

References
[1] Mott, Machine Elements in Mechanical Design, (bibl. KBB 85 MOT) pp. 132-149
[2] Steinhilper, Maschinen und Konstructions-Elemente, (bibl. KBB 94 STE) pp. 22-41
[3] Roloff/Matek, pp.272-278