Kletzin, Ulf, Weiss, Mathias :

State of the art methodologies for numerical spring design

Publikation entstand im Rahmen von:
Proceedings of Advanced Spring Technology - JSSE 60th Anniversary International Symposium, 2nd November 2007 at Fukiage Hall, Nagoya, Japan
S. 63-65

State of the Art Methodologies for Numerical Spring Design

Ulf KLETZIN , Mathias WEISS
Technical University Ilmenau, Faculty of Mechanical Engineering, Max-Planck-Ring 12, 98693 Ilmenau, Germany
TEL:+49-3677-69-2471 FAX:+49-3677-69-1251 e-mail: ulf.kletzin@tu-ilmenau.de
(Received 28, March 2007 Accepted 31, May 2007)

In order to achieve an economical product design process numerical simulation programs are used more and more often. These programs can only be used by specialy trained calculation engineers.
That's why two powerful object-oriented programs, the FEM-Springprocessor and the MBS-Springprocessor, were developed. The paper describes the programs and examples of use.

Keywords : Spring Design, Spring Analysis, Finite-Element-Method, Multi-Body Systems, Feature Concept, Object-Oriented, Ansys, Adams

1. INTRODUCTION

Springs have a complex geometry. In operation, large elastic deformations occur. Contacts within the spring, e.g. contact of coils and contact to bordering components are to consider. They all lead to great nonlinearities. Further difficulties are caused by spring natural oscillations in dynamic operations e.g. higher stress levels, frictions, noises as well as lateral movements. The experimental analysis of springs is time-consuming.

Therefore numerical simulation programs are used more and more often for an economical product design process. The above mentioned nonlinearities lead to very complex modelling. That's why these programs can only be used by calculation engineers, specially trained in the utilized numeric method and in spring technology. These engineers are hardly available in the small and medium sized spring manufacturer industry. That's why, the FEM-Springprocessor and the MBS-Springprocessor, two powerful object-oriented programs, were developed, both usable without special knowledge of the numeric methods (Finite-Element-Method, Multi-Body Systems) with an easy-to-use graphical user-interface.

2. FEM-SPRINGPROCESSOR

The Finite Element Method (FEM) is well suited for the calculation of stresses and for modal analyses.

The FEM-Springprocessor includes modules for typical springs, e.g. different helical springs, torsion springs, Belleville springs. Mentioned nonlinearities are considered, results are load curves, stresses and natural frequencies. The modelling of complicated springs, which do not refer to standards, is supported by geometry-oriented modules (called features).

The example spring according to fig. 1a is used in a horizontal adjustment of a car seat. The geometrical shape of the example spring is described by one straight and 6 curved strip sections (geometry-oriented features), from which the system after scaling and position determination by user inputs automatically generates a shell model of the spring. The required coupling conditions result automatically from placing the feature in the construction context.

Furthermore the function of the spring is described by non-geometrical characteristics which have to be specified, like the used material, the contact elements between the legs 1 and 7, the boundary and load conditions and the type of analysis as function oriented characteristics.

The user is supported by input masks which can be

filled out easily.

Fig. 1f shows the characteristic curve of the spring with a section of almost constant spring force, which results from the support of the legs 1 and 7 together, computed by means of a nonlinear structural analysis.

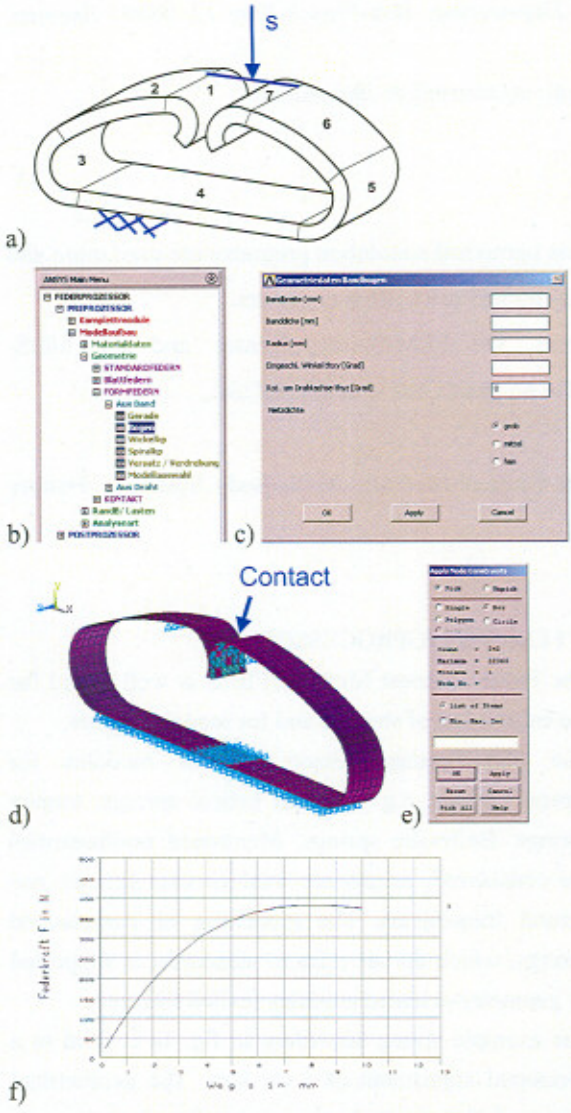

Fig.1. Calculation of the characteristic curve of an equal force spring. a) Disassembling of the spring geometry in geometry-oriented features, b) Menu selection, c) Input mask "bended band strip" d) shell model with boundary conditions and loads, e) Pick- and control-boxes for contact definition, f) characteristic curve

The FEM Springprocessor is developed inside the all purpose Finite-Element Software ANSYS using the ANSYS Parametric Design Language (APDL) and the User Interface Design Language (UIDL) [1]. Because of its modular structure it is easy upgradable with additional spring types, features or types of analysis.

3. MBS- SPRINGPROCESSOR

For the analysis of highly dynamic applications, the additional use of Multi-Body Systems (MBS) is advised. The MBS-Springprocessor includes models for helical compression springs.

As one example of use its application for the dynamic analysis of a valve spring of a combustion engine according to fig. 2 is described.

Special problems like dynamic force increasing, coil striking and lateral spring movements are considered.

The presented MBS model is characterised in particular by the accurate reproduction of spring geometry and by the detailed modelling of the end and turn over coils as well as their force fitted coupling to the spring retainer.

Every coil of the spring is separated in rigid parts (rigid bodies) wich are flexible coupled in three dimensions (fig. 2a, fig. 2b). Between the coils contact elements are used which make it possible to investigate coil striking. The coupling to the spring retainer is realized with contact features including friction attributes.

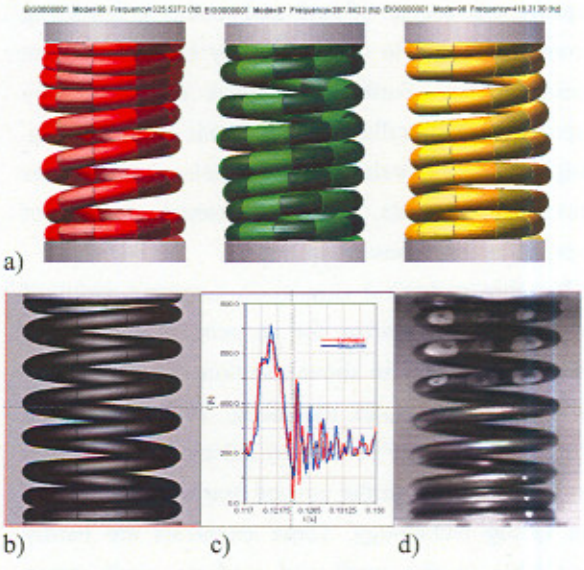

Fig.2. Dynamic investigations at a valve spring. a) Animation of the natural frequencies, b) cam driven animation with MBS-Model c) comparison of the results of dynamic spring action simulation and measurement, d) to b synchronous video of a high speed camera

The user is supported by an easy-to-use input mask for specification of the required parameters. It contains data wich are known to the designer. The import of measuring data from a special image processing measuring device is also available.

The verification of the computation results over measurements of a cam shaft test stand resulted in an outstanding agreement (fig. 2c).

The MBS - Springprocessor is developed inside the Multi-Body System Software ADAMS [2].

4. CONCLUSION

In order to solve the in article 1 mentioned problems in spring design both programs were developed at Ilmenau Technical University and are already available. Methods and actions of their usage were demonstrated with examples [3]. One future work will be the upgrading for fatigue calculations of helical springs.

REFERENCES

1) U. Kletzin, *Finite Elmente basiertes Entwurfssystem für Federn und Federanordnungen*, Dissertation TU Ilmenau, Verlag ISLE 2000.
2) T. Wittkopp, *Mehrkörpersimulation von Schraubendruckfedern,* Dissertation TU Ilmenau, Verlag ISLE 2005.
3) U. Kletzin, D. Micke, *Entwurfssystem für Federungen: Gesamtkonzept und FEM-FEDERPROZESSOR,* VDI Tagung Federn - unverzichtbare Bauteile der Technik, VDI-Berichte 1972, Fulda 2007.

Presented at JSSE 60th Anniversary International Symposium on Spring Technologies (November 2nd, 2007)