AUTOMATED OPTIMIZATION WITH THE OPX INTERFACE USING THE EXAMPLE OF VEHICLE STABILIZERS

Sergej Schneider, Mubea Fahrwerksfedern GmbH

Weimar, 2nd of June 2017
1. THE COMPANY “MUBEA”
2. CHASSIS PART STABILIZER BAR
3. (OPTIMIZATION) WORKFLOW
4. XML-BASED INTERFACES IN OPTISLANG
THE COMPANY „MUBEA“
THE COMPANY „MUBEA“

Facts

- Global market leader in development and manufacture of automobile products
- Owner-operated family company since 1916
- Lightweight component design specialist
- Vertical integration from raw material to finished product
- Internal development of products and production processes
THE COMPANY „MUBEA“

Represented worldwide

North and South America:
- 5 locations
- 2,400 employees

Europe:
- 22 locations
- 8,800 employees

Asia:
- 9 locations
- 1,800 employees

© Muhr und Bender KG - Confidential
May 29, 2017
THE COMPANY „MUBEA“

Product portfolio

Chassis

Body

Powertrain

Industry
THE COMPANY „MUBEA“

Products

Coil Springs

Stabilizer Bars

Stabilizer Bar add-on parts

GFRP Leaf Springs

Chassis

Wheels
CHASSIS PART STABILIZER BAR
Characteristics of stabilizer bar
- Links right and left suspension
- Compensates / decreases roll angle during turning manoeuvres wrt. local body frame
- Loaded under torsion (and bending)

Increasing spring rate results in higher compensation of roll moment

Profile designs
- Solid
- Tubular
- Hammered
- Multiple wall thicknesses at const. outer diameter (MTT)
Stabilizer design

- Fixed routing due to limited design space
- Mechanical properties (spring rate) may only be adjusted through stabilizer bar profile
- Profile design is restricted by production-wise feasibility
  - Maximum wall thickness $t$
  - Minimum / maximum wall thickness ratio $D_{out}/t$
  - Form of crossing depending on raw material
    - Tailor Drawn Tube
    - Tailor Rolled Tube

[Source: Daimler AG]
- Stabilizer is described via a polyline with circular cross sections
- Stabilizer profile may be separate input detached from routing
- Geometry and boundary conditions are parametrized in APDL
  - Neglecting paddle geometry
  - Using own meshing algorithm
- Static mechanical analysis using implicit solver in ANSYS
- Using quadratic elements
- Design objective is spring rate with minimum stabilizer mass below limit fatigue life
Example of mass minimization for a stabilizer bar with multiple wall thicknesses

- Displayed stabilizer bars are equal in spring rate (i.e. same function)
- Utilizing the stress limits (von Mises) mass could be reduced by ca. 400 g to ca. 2.400 g

Mass reduction by 400 g to 2.400 g
(OPTIMIZATION) WORKFLOW
Motivation

- The design process is iterative, where
  - the stabilizer profile is adjusted
  - the FEA is performed
  - the results are compared with target values
- The design process takes a lot of time and experience
- An automatization of this process would relieve the project engineer of this time consuming task and allow him/her to invest his/her time otherwise
- It is expected to find better designs using optimization algorithms
Optimization tasks using PDM

- Optimization order is created in a PDM system
  - A reference design has to be attached
  - Geometric and FEA restrictions have to be provided with their respective tolerances
  - Input parameters may also be set as constant

Snippet from the optimization order interface
A service running on the calculation server checks regularly, if not-processed optimization orders are queued.

The optimization workflow is:

- Order is loaded and the order's status is updated in the database
- Calculation is performed based on the reference design in ANSYS
- Input and output is text-based with a variable number of parameters and (geometric) restrictions
- XML interface files are created for optiSLang and the optimization is performed
- Best design is loaded and saved to the database
- The order's status is updated in the database and the orderer is informed via email
XML-BASED INTERFACES IN OPTISLANG
The optimization process in optiSLang may be controlled via batch and an XML-file.

The XML-based interface in optiSLang 6.x.x is called OPX.

The XML file for problem description has to be recreated specifically for each project due to variable number of parameters.

- A DTD (Document Type Definition) file may be used to describe the XML file's structure.
- DTD files are also used to check XML/HTML files for structural integrity.
- Many computer languages support XML databinding to extract and create object from those DTD files.
  - The XML object will contain all elements with their attributes defined in the DTD file.
  - Using an XML object elements may be added and edited at run-time as often as needed before the XML (OPX) export is performed.
A DTD file consists of a root element:
- (Sub)elements and attributes are defined top-down
- Element and attribute names have to be unique
- Frequency indicators may be used to enforce that certain elements are used (multiple times) or restrict an element to a single occurrence
- Attributes may be either arbitrary strings or enumerations

For older optiSLang versions 3.2.x DTD files are located in the installation directory

For the OPX interface a DTD file may be create manually based on the interface description
The OPX file consists of the following elements:

- **NODES** (input/output files, solver etc.)
- **EDGES** (connections between NODES)
- **NODE_ATTRIBUTES** (detailed information for all prior defined NODES)

Example:

- The element EDGES contains a set of the subelement EDGE
- The element EDGE has to appear at least once (frequency indicator +)
Conclusion

- Optimization algorithms are powerful tools in the design process with regards to lightweight products.

- Given a parametrized structural element a generally valid optimization workflow can be defined.

- Data bases may be used to administrate optimization tasks and results.

- Project specific OPX files may be created automatically and optiSLang may be controlled via batch und OPX files.

- Automated processes are more performant and less sensitive to errors than manual processing of optimization tasks.

- Automated processes may free bound resources and allow focusing on other tasks.
Thank you very much for your attention!