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Optimus®

Application note

OPTIMIZATION OF REINFORCEMENT STRUCTURE OF A CRANE PEDESTAL

EXECUTIVE SUMMARY

A crane pedestal and its reinforcement structure are analyzed using finite element software as to predict and improve its structural behavior before a prototype is built. This application note shows how Optimus is used with MSC Patran, MSC Nastran and an in-house software to (a) identify the sensitivity of the static characteristic to the geometry and topology variation of the structure, (b) reduce maximum stresses.

1. SIMULATION FACTS

Simulation-based design process

Finite element software is used to simulate structural behavior based on input data provided by engineers. Unfortunately, this approach can only be used to validate designs. If the objective is to optimize structural behavior and to minimize stress peaks, Optimus is needed to explore the entire design space, to provide deeper engineering insights and to identify designs that meet or even exceed design specifications.

Software

- MSC Patran
- MSC Nastran
- In-house developed software

Models

The reinforcement part of the crane pedestal (Fig. 1) is meshed with MSC Patran and calculated with MSC Nastran. The results of the analysis, stress and stress distribution, are imported into an in-house developed software to predict the stress gradient.

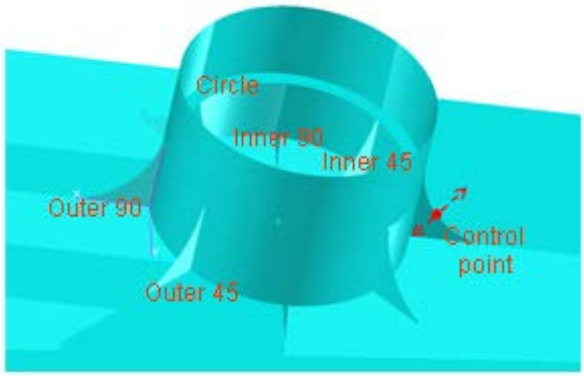

Fig. 1: Model of crane pedestal reinforcement structure

2. SOLUTION APPROACH

Simulation process automation

The simulation workflow is captured using the Optimus graphical user interface. This workflow includes the all software codes, as well as the related input and output files (Fig. 2). The engineer selects the input parameters and responses which are required for optimization, from the automatically generated parameter list. Optimus parameterizes the input file and parses the output file for the desired combination of output parameters, allowing for an automated execution of the simulation workflow.

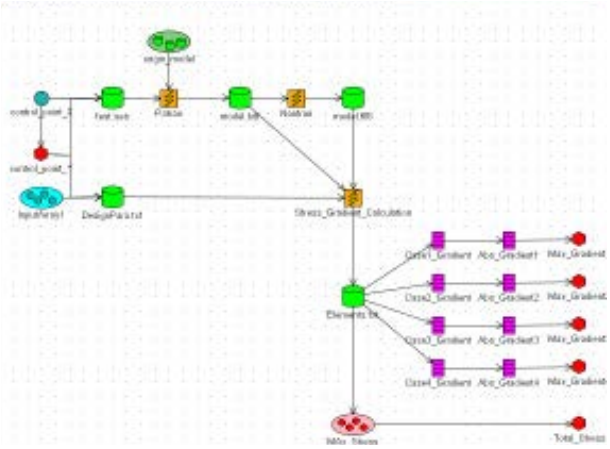

Fig. 2: Simulation workflow

Design parameter selection

7 design parameters are selected:

- 2 geometry parameters related to the control points on the reinforcement part.
- 5 parameters describing the topology of the reinforcement structure.

Design objective specification

The objective is to minimize the maximum stress of the reinforcement structure while keeping maximum stress gradient within limit.

Solution strategy

<u>Design Of Experiments & Surrogate Modeling (DOE/RSM)</u>

DOE techniques (a 4-level Full Factorial method on the 2 geometry parameters of the control points and a 2-level Full Factorial method on the 5 topology parameters of the reinforcement structure) generate sufficient data points to

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analyze the sensitivity of maximum stress and the maximum stress gradient with respect to input parameters variation (Fig. 3), and to fit a response surface model (RSM) or so-called surrogate model.

Single Objective Optimization

OPTIMUS performs a Self-Adaptive Evolution (SAE) on the surrogate model, which yields a good starting point for optimization run directly on the analysis sequence.

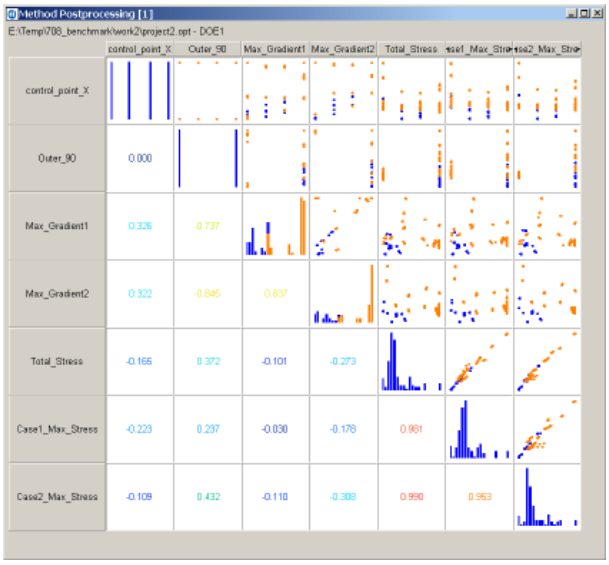

Fig. 3: Correlation diagram showing sensitivity of maximum stress and maximum stress gradient to input parameter variation

3. Results

Design Of Experiments & Surrogate Modeling (DOE/RSM)

Fig. 4 shows 3D plots of the response surface model (RSM) for the maximum stress as a function of the selected design parameters. This surrogate model is used to avoid expensive computations during the optimization process, while guaranteeing the required accuracy.

Single Objective Optimization

Optimus identifies an optimal combination of design parameters, resulting in a 12.7% decrease of maximum stress in the crane pedestal reinforcement structure. All maximum stress gradients satisfy the imposed constraints (Fig. 5).

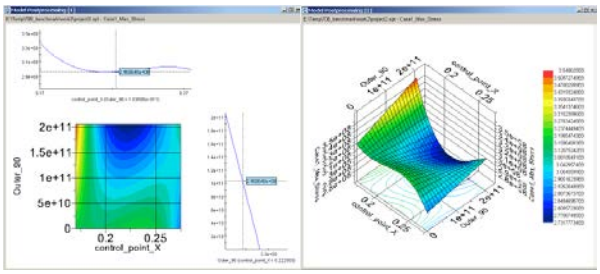

Fig. 4: The surrogate model generated by Optimus shows maximum stress as a function of the selected design parameters

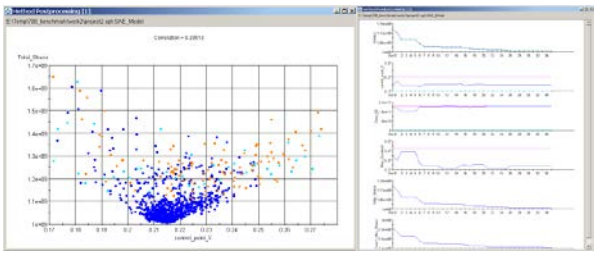

Fig. 5: Optimization convergence of objective function: minimizing maximum stress while keeping maximum stress gradient within limit

4. Benefits

- Optimus easily captures and successfully automates simulations involving MSC Patran, MSC Nastran and an in-house developed code, delivering a repeatable simulation process.
- Optimus frees the engineer from repetitive administration tasks, and delivers the information that is needed to gain deeper engineering insights.
- Optimus quickly identifies the sensitivity of structural properties related to a variation of the design parameters, at a limited computational effort.
- Using a selection of DOE and numerical optimization techniques, Optimus is able to identify design parameter values that reduce maximum stress by 12.7% - all of this in a fraction of the time required with conventional solution approaches.

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