Success Story
COMET

Advanced Engineering Design Automation

AEDA - Advanced Engineering Design Automation
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K-Projects
COMET subproject, duration and type of project:
MFP5 - Automated Development and Optimisation of Modular Products, 05/2015 - 10/2016, multi-firm

Automated Optimisation of Box-Type Booms of Ship Cranes

In order to live up to challenging customer requirements, Liebherr-Werk Nenzing GmbH (LWN) offers multiple variants of cranes. For each application scenario, these cranes are tailored to the customer's specifications, i.e. load cases, environmental and boundary conditions as well as regulations and standards. The focus of the here conveyed project was mass and cost-oriented optimization of the dimensioning parameters of the middle section of a box-type boom crane. An optimisation algorithm and a software prototype were developed, implemented and tested. Several reference test cases were provided by LWN to assess the prototypes performance and a reduction between 5 to 10 % of the mass and cost was achieved.

Goal, Challenges, and Results

The goal of this project was to demonstrate the feasibility and the potential of optimisation methods and tools for the development of customer-specific cranes at LWN. The focus was on optimisation of the dimensioning parameters of the middle section of a box-type boom crane.

The middle section of the boom is divided into segments, each of which lies between two bulkheads or a bulkhead and the pivot- and end-section, respectively (see Figure 1 below).

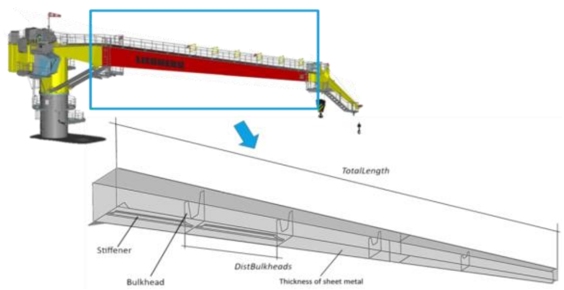

Fig. 1: CAD-model of box-type boom crane and sketch of the middle section

In order to design a functioning boom, within each segment static proof for sheet metals as to stress, fatigue and buckling has to be performed. After collection of geometric and physical characteristics as well as business requirements, the optimization problem was formally defined (objective functions, variants, costs, materials, etc.). Further, test scenarios as well as reference data was collected. Based thereon, an optimization algorithm and corresponding software prototype was developed, implemented and tested. Figure 2 shows the information of the developed prototype: an initial configuration and customer specific load case scenarios (Safe Working Load, min/max radius, mission profiles, etc) are used as input. The user-interface enables the designer to select the stop conditions as well as objective functions of the algorithm. Beginning with the first iteration loop, the optimizer iteratively adjusts the design and runs FE analysis until stop criteria are satisfied. Finally the corresponding documentation is generated automatically. Regarding the provided reference cases, reduction of costs and mass of 5 to 10 % were yielded.

Federal Ministry of Science, Research and Economy
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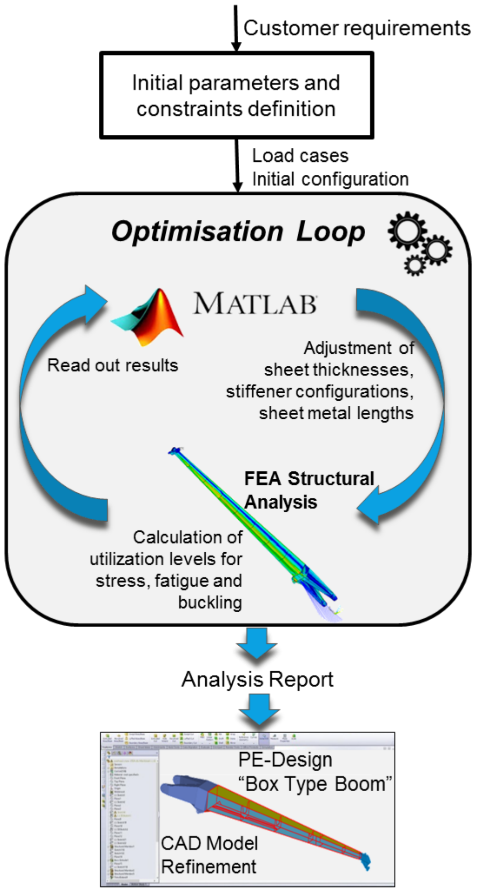

Fig. 2: Optimisation workflow

Optimiser prototype development

Due to problem characteristics and constraints, the implementation of a heuristic based optimization was pursued. In this respect, a three step procedure, as illustrated in Figure 3, was developed. The optimisation starts with the lightest configuration possible as a starting point, i.e. no stiffeners and minimum plate thicknesses. In the first step, thicknesses of sheet metals are successively increased so that constraints with regards to stress and fatigue are satisfied.

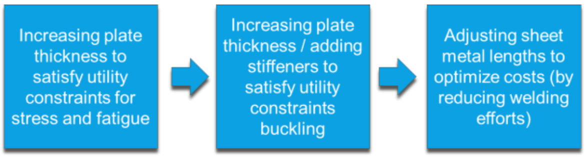

Fig. 3: 3-step procedure characterizing the heuristic for box-type boom optimisation

Secondly, plate thickness is further increased so that buckling constraints are satisfied for each segment. This is compared to the results yielded when stiffeners are added for satisfaction of buckling constraints. The lighter / cheaper version, depending on the objective function, is selected and used for further calculations. The buckling problem can be considered separately, since the addition of stiffeners has marginal impact on the proof with regards to stress and fatigue. In the third step, thicknesses and lengths of sheet metals are modified in order to minimize costs with regards to welding between sheet metals. The algorithm has been implemented in MATLAB® R2015a and interfaces with existing software tools from LWN are implemented prototypically.

Impact and Effects

Within this project, the optimisation of a box-type boom with respect to multiple objective functions was successfully performed. The developed prototype demonstrates the feasibility of heuristic-based optimisation including automated structural analysis. Thus, refinement of designs and investigation of variants is enabled within few hours. Consequently, the industrial partner will profit sustainably from development of the optimization prototype with respect to:

- Increased productivity and reduced lead time for dimensioning box-type booms;
- box-type boom weight reduction;
- Reduction of production costs.

Contact and information

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