DTU Wind Energy
Department of Wind Energy

Sizing optimization of jacket structures under time-dependent stress constraints

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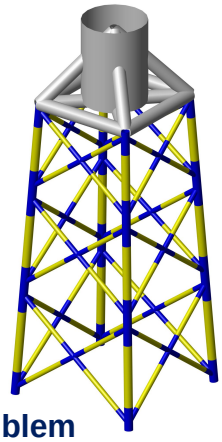


Introduction

Design optimization of offshore jackets is a challenge due to several reasons:

- **Prohibitive number of dynamic constraints on structural criteria such as stress, displacement and fatigue.**
- **Calculating the design sensitivities of these constraints is computationally very expensive.**
- **The required memory storage is very large.**

Aim

The aim of our research is to develop special purpose numerical optimization techniques that can effectively handle the vast number of dynamic constraints.

Model

- **Timoshenko beam elements**
- **Axial stresses: $\sigma(\mathbf{u}(\mathbf{t}))$, obtained after solving:**

$$\mathbf{M}\mathbf{a}(\mathrm{t}) + \mathbf{C}\mathbf{v}(\mathrm{t}) + \mathbf{K}\mathbf{u}(t) = \boldsymbol{f}(t).$$

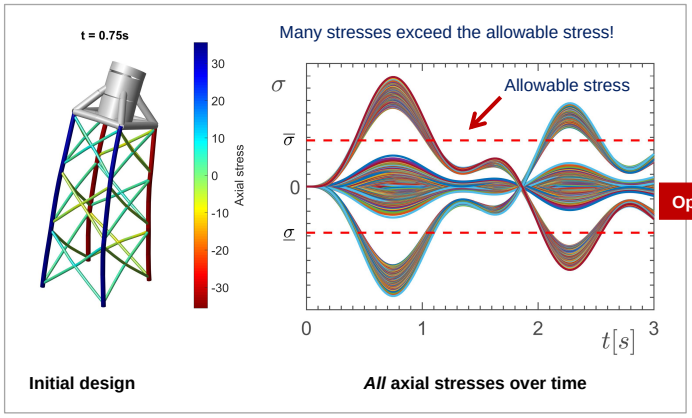
- **Newmark-β**

Preliminary optimization problem

- **Minimize mass subjected to axial stress constraints that should be satisfied at all point at all times.**
- **Design variables: diameters and thicknesses of the members. After variable linking 18 independent variables.**

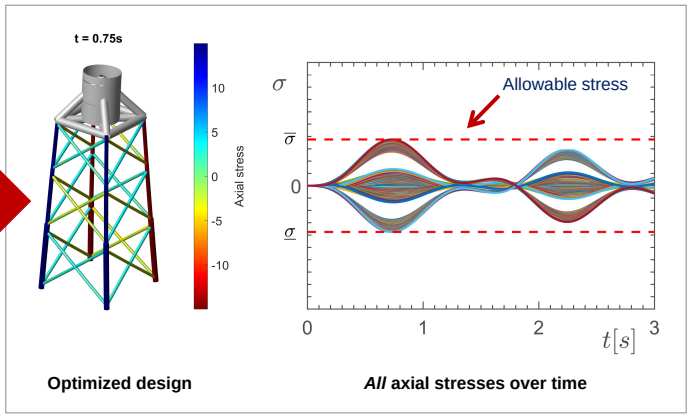
Result

Preliminary result of optimizing a jacket under time-dependent axial stress constraints.



Initial design **_All_ axial stresses over time**

Optimized



Optimized design **_All_ axial stresses over time**

- **3136 stress responses considered over 151 time steps; i.e. ~1 million constraints vs. 18 design variables.**
- **Interior-point solver Ipopt [2] found an optimized jacket design after 100 iterations.**
- **Axial stresses of the optimized design satisfy the allowable stress at *all points* in the structure at *all times*.**
- **Current capabilities limited by computationally expensive design sensitivities and corresponding memory storage.**

Conclusions

Preliminary results indicate that we can successfully obtain optimized designs which satisfy dynamic stress constraints. However, the large number of constraints makes calculating design sensitivities computationally expensive and requires large memory storage.

Future work focusses on reduction techniques of both optimization problem and analysis.

References

[1] M. Muskulus and S. Schafhirt, Design Optimization of Wind Turbine Support Structures – A Review, Journal of Ocean and Wind Energy, 2014.
[2] A. Wächter and L. T. Biegler, On the Implementation of a Primal-Dual Interior Point Filter Line Search Algorithm for Large-Scale Nonlinear Programming, Mathematical Programming, 2006.

This work is part of ABYSS: 2014-2017