Ship Scantling Optimization

LBR5 PRESENTATION – DCNS

Oct 2007 (PMA – DN&T-ULG)

PRINCIPIA

Ship Scantling Optimization

Introduction to LBR5 (Passenger vessels)

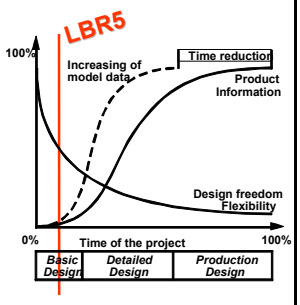
- **Framework**
  - LBR5 Software
    - LBR5 – Flowchart
    - LBR5 – Cost Model
    - LBR5 – Discrete Optimization
  - Application on a passenger midship section
  - Results and Conclusion
  - Overview of Multicriterion Optimization

Ship Scantling Optimization

Introduction

- Concurrent Engineering
- To make the best decision earlier
- **Multicriterion Scantling Optimization of the Midship Section in the early design stage**

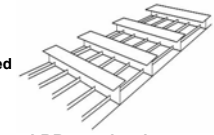
→ **Decrease global cost**
→ **Increase global performance**



Ship Scantling Optimization

LBR5 Software

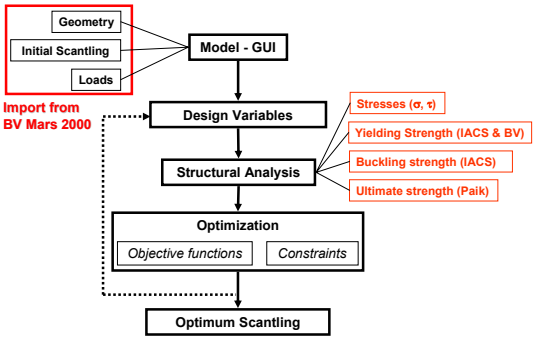
- **What is the LBR-5 tool ?**
  - **Scantling optimization tool for naval and hydraulics structures**
  - **Dedicated to early design stage**
  - **3D structural analysis based on a extruded 2D mesh**
  - **Scantling optimization of the structural elements**
    - 9 variables per strake
      - Spacing (frames & stiffeners)
      - Thicknesses & dimensions
  - **Different objectives are implemented**
    - *Minimize the manufacturing **cost***
    - *Minimize the structural steel **weight***
    - *Maximize the flexional **inertia***



LBR5 strake element

Ship Scantling Optimization

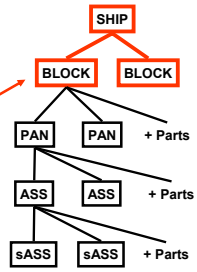
LBR5 - Flowchart



Ship Scantling Optimization

LBR5 - Cost Model

- **Cost Model**
  - **About 60 different fabrication operations have been selected**
  - **Takes into account about 30 types of welding and theirs unitary costs**
  - **Requires additional data about the structural model**



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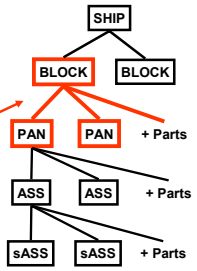

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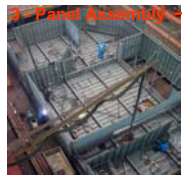

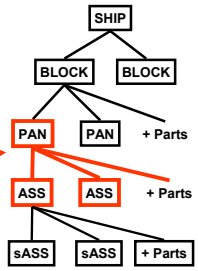

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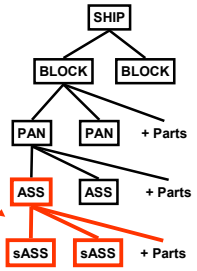

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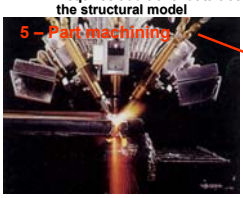
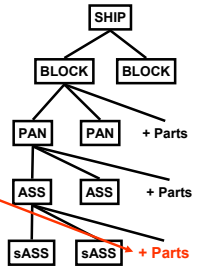




LBR5 Software - Application

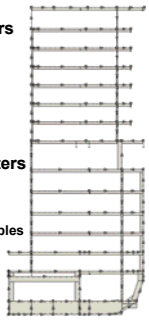
Passenger Vessel Model

Ship parameters

- LOA > 300 m
- Breadth ~ 40 m
- Height ~ 45 m
- 14 decks

Model parameters

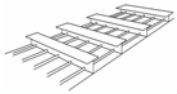
- 99 strake panels
- 19 pillars
- 383 design variables



Scantling design variables

For each stiffened plate element:

→ 9 available design variables

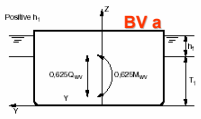


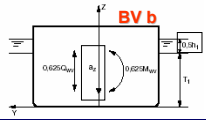
- *Plate thickness*
- *For longitudinal stiffeners (T)*
  - *Web height and thickness*
  - *Flange width*
  - *Spacing*
- *For transverse stiffeners (T)*
  - *Web height and thickness*
  - *Flange width*
  - *Spacing*

LBR5 Software - Application

- **Load Cases (Hogging & Sagging)**
  - "IACS" load cases (2)
    - Still Water and Wave (10^{-8}) hull girder loads
  - "BV a" load cases (4)
    - Still Water and Wave (10^{-5}) hull girder loads
    - Sea pressure ($T_{max,a1}$ & $T_{min,a2}$)
  - "BV b" load cases (4)
    - Still Water and Wave (10^{-5}) hull girder loads
    - Sea pressure ($T_{max,b1}$ & $T_{min,b2}$)
    - Inertial pressure

	HOG	SAG
Scantling draft	-	-
Ballast draft	-	-





LBR5 Software - Application

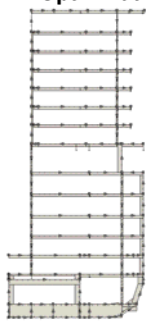
- **Structural Constraints ($\sigma \leq \sigma max$)**

Passenger Vessel Application	Load Case		
	IACS	BV a	BV b
Bending strength $\sigma \leq 175/k$ (IACS)	X		
Shear strength $\tau \leq 110/k$ (IACS)	X		
Compressive buckling of plates (IACS)	X		
Shear buckling of plates (IACS)	X		
Compressive buckling of stiffeners (IACS)	X		
Local stiffener bending strength (BV)		X	X

- **Equality constraints**
  - identical Δ_{stiff} between 2 elements vertically aligned (long. Stiff.)
- **Global constraints**
  - Minimum hull girder section modulus (IACS)
  - Minimum hull girder moment of inertia (IACS)
  - Maximum weight (stability)
  - Upper bound value of the gravity center location (stability)

LBR5 Software - Application

- **Optimization Problem Summary**



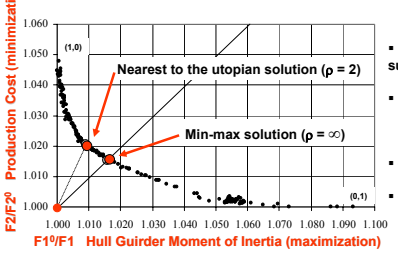
- **Ship parameters**
  - LOA > 300 m
  - Breadth ~ 40 m
  - Height ~ 45 m
  - 14 decks
  - 99 Stiffened panels
  - 19 Pillars
  - 10 Load cases
- **Optimization constraints**
  - 383 design variables
  - 1418 structural constraints
  - 56 equality constraints
  - 4 global constraint
- **Objective function**
  - Moment of inertia
  - Production cost
- **Design variables (5)**
  - Plate thickness (1)
  - Stiffener spacing (1)
  - Longitudinal stiffener scantling (3)

LBR5 Software - Application

- **Results**

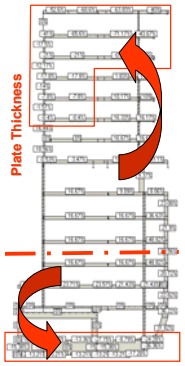
!!! Only 1 minute to calculate an optimum solution !!!

- *When the production cost is MIN → the Moment of Inertia is MIN (0,1)*
- *When the Moment of Inertia is MAX → the production cost is MAX (1,0)*

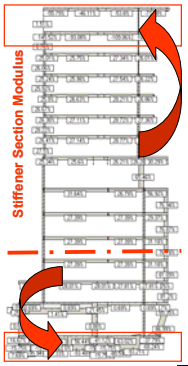


- Repeated weighted sum solution (ρ = 1)
- Random Weights
  - W_1 = random
  - W_2 = 1- W_1
- ~ 200 points
- ~ 100 minutes

Conclusions



- **Results**
- Nearest the utopian solution (ρ= 2)
- Section increase in the upper and the lower part of the midship section
- Discrete optimization
  - *Production cost*
    - *1.8%*
  - *Moment of inertia*
    - *15%*



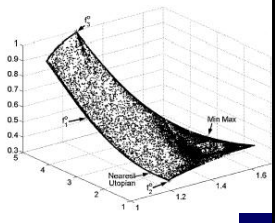
Overview of Multicriterion Optimization

- **Pareto Optimum Front**

A solution is Pareto optimal if it satisfies the constraints and is such that no criterion can be further improved without causing at least one of the other criteria to decline (Edgeworth – Pareto optimality)

→Pareto front is a set of optimal solutions

Mapping the entire Pareto front, by using, a.o. :



- **Repeated weighted**
  - **sum solutions**
  - **min-max solutions**

Conclusions

THANK YOU FOR YOUR ATTENTION