VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

ALGORITHMIC MODIFICATIONS TO A MULTIDISCIPLINARY DESIGN OPTIMIZATION MODEL OF CONTAINERSHIPS

By

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Abstract

When designing a ship, a designer often begins with “an idea” of what the ship might look like and what specifications the ship should meet. The multidisciplinary design optimization model is a tool that combines an analysis and an optimization process and uses a measure of merit to obtain what it infers to be the best design. All that the designer has to know is the range of values of certain design variables that confine the design within a lower and an upper bound. The designer then feeds the MDO model with any arbitrary design within the bounds and the model searches for the best design that minimizes or maximizes a measure of merit and also meets a set of structural and stability requirements.

The model is multidisciplinary because the analysis process, which calculates the measure of merit and other performance parameters, can be a combination of sub-processes used in various fields of engineering. The optimization process can also be a variety of mathematical programming techniques depending on the type of the design problem. The container ship design problem is a combination of discreet and continuous sub-problems. But to avail the advantages of gradient-based optimization algorithms, the design problem is molded into a fully continuous problem.

The efficiency and effectiveness with which an optimization process achieves the best design depends on how well the design problem is posed for the optimizer and how well that particular optimization algorithm tackles the type of design problems posed before it. This led the author to investigate the details of the analysis and the optimization process within the MDO model and make modifications to each of the processes, so that the two become more compatible towards achieving a better final design. Modifications made within the optimization algorithm were then used to develop a generalized modification method that can be used to improve any gradient-based optimization algorithm.

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Symbols and Abbreviations	Description	Units
α	Variable for 1-D Minimization	
B/D	Beam/Depth	
C1	Blending Coefficient	
CG	Height of the center of gravity from keel	Meters
COM	Component Object Model	
CT	Maximum constraint value for being active	
CTMIN	Maximum constraint value for being violated	
DOT	Design Optimization Tools	
$F(\mathbf{X})$	Objective Function	$/ton/k-mile
FB	Freeboard	Meters
FB_{min}	Minimum Freeboard	Meters
$g(\mathbf{X})$	Inequality Constraint	
GM	Metacentric height	Meters
GM_{min}	Minimum metacentric height	Meters
∇F	Gradient of Objective Function	
∇g	Gradient of inequality constraint	
∇h	Gradient of equality constraint	
$h(\mathbf{X})$	Equality constraint	
IBar	Interface Bar	
IFoo	Interface Foo	
L/D	Length/Depth	
L/D_{max}	Maximum length/depth	
λ	Weight parameter	
MDO	Multidisciplinary Design Optimization	
MMFD	Modified Method of Feasible Directions	
N	Net Point	
NT_d	Number of tiers on deck	
ϕ	Positive Integer	
RFR	Required Freight Rate	$/ton/k-mile
RFR_i	Initial required freight rate	$/ton/k-mile
RMS	Root Mean Square	
S^q	Search Vector in the q^{th} iteration	
SLP	Sequential Linear Programming	
TEU	Twenty-foot Equivalent Unit	
θ	Push-off factor	
W	Artificial Variable	
X^q	Vector of design variables in the q^{th} iteration	