World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:11, No:10, 2017

Structural Design Optimization of Reinforced Thin-Walled Vessels under External Pressure Using Simulation and Machine Learning Classification Algorithm

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Abstract : An optimization problem for reinforced thin-walled vessels under uniform external pressure is considered. The conventional approaches to optimization generally start with pre-defined geometric parameters of the vessels, and then employ analytic or numeric calculations and/or experimental testing to verify functionality, such as stability under the projected conditions. The proposed approach consists of two steps. First, the feasibility domain will be identified in the multidimensional parameter space. Every point in the feasibility domain defines a design satisfying both geometric and functional constraints. Second, an objective function defined in this domain is formulated and optimized. The broader applicability of the suggested methodology is maximized by implementing the Support Vector Machines (SVM) classification algorithm of machine learning for identification of the feasible design region. Training data for SVM classifier is obtained using the Simulation package of SOLIDWORKS®. Based on the data, the SVM algorithm produces a curvilinear boundary separating admissible and not admissible sets of design parameters with maximal margins. Then optimization of the vessel parameters in the feasibility domain is performed using the standard algorithms for the constrained optimization. As an example, optimization of a ring-stiffened closed cylindrical thin-walled vessel with semi-spherical caps under high external pressure is implemented. As a functional constraint, von Mises stress criterion is used but any other stability constraint admitting mathematical formulation can be incorporated into the proposed approach. Suggested methodology has a good potential for reducing design time for finding optimal parameters of thin-walled vessels under uniform external pressure.

Keywords : design parameters, feasibility domain, von Mises stress criterion, Support Vector Machine (SVM) classifier
Conference Title : ICMMAC 2017 : International Conference on Mathematical Modeling, Analysis and Computation
Conference Location : Barcelona, Spain
Conference Dates : October 30-31, 2017