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Optimal conceptual design using NSGA-II algorithm for Galápagos interisland service small craft including flaps

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In early 2020, sea trials carried out in some interisland high-speed boats in Galapagos confirmed the need to improve the comfort of the passengers during those trips. Results from those tests showed very high levels of vertical acceleration which, according to ISO 2631 standard, provoke high negative effects on the passengers, as was directly observed. This project aims to design at conceptual level a fiberglass reinforced plastic high-speed boat including flaps, with minimum vertical acceleration while also considering the boat resistance. The design variables considered were length, beam, longitudinal position of the center of gravity, hull deadrise angle, flap deflection angle and its chord. In addition, the constraints considered were dynamic trim angle for porpoising, length-beam ratio, metacentric height, freeboard, and required area for passengers. A multi-objective optimization method available in OpenPlaning, an open-source Python-based framework, was employed. The resistance was evaluated with a combination of semiempirical formulations with a prismatic hull assumption that included the effect of waves, whisker spray and flaps; while the vertical acceleration was estimated with formulations from lab tests based on significant wave height. To estimate the Pareto front, the NSGA-II (Non-Dominated Sorting Genetic Algorithm) optimization algorithm is chosen considering the complex relations and number of design variables. First, the benefits of including flaps to reduce the boat planing angle, and as result a reduction in the motion acceleration were confirmed. Also, results show that sea performance of the boat is highly affected by LCG position, deadrise angle and angle of flap. The combination of these parameters that helps to reduce the objective functions are identified. Finally, the estimated Pareto front identifies a set of solutions, which shows that the acceleration could be reduced by up to 19% and the resistance to advance of the boat by 5% with the increase of some design variables.

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