Mathematical modelling for effects of fineness ratio, altitude and velocity on aerodynamic characteristics of an airship design using computational fluid dynamics

ABSTRACT

The external shape design change of an airship can be appropriately captured by design fineness ratio, which is defined as the ratio of airship's length to its maximum width. However, there is a lack of aerodynamic models that have been established for airship design purposes. In conjunction to this realization, the aim of this research work is to establish the effects of design fineness ratio of an airship towards its aerodynamic performance. The Atlant-100 airship is chosen as the reference design model for this study. In total, 36 simulation runs are executed with different combinations of values for the fineness ratio, altitude and velocity. The obtained CFD simulation results are then statistically analysed using Minitab software to evaluate the significance of the design fineness ratio effects. From the results, it has been found that smaller fineness ratio corresponds to higher aerodynamic lift and drag forces. As in the case simulated in this study, the smallest fineness ratio of 0.93 has been shown to correspond to the highest value of generated lift coefficient while having comparable value of generated drag coefficient with the other fineness ratios. This highlights that a smaller fineness ratio of the airship design is more suitable. The constructed mathematical models to capture these effects have also been validated with a few goodness-of-fit tests. For the regression model of fineness ratio impact on the lift coefficient, it has R 2 value of 0.941. When its predictive accuracy is tested with few simulated random cases, the maximum error obtained is only 6%. On the other hand, for the regression model of the fineness ratio impact on drag coefficient, the R2 value is 0.962 and maximum predictive error from the simulation random cases test is only 9%. Overall, it can be concluded that the constructed regression models have good predictive capability on the impact of design fineness ratio on the aerodynamic performance of the airship under this study**.**

Keyword: Fineness ratio; Airship design; Aerodynamic performance; Mathematical modeling