ABSTRACT

The operation of helicopters at ships on-board has always been a very complex task owing to the presence of ship air wakes, high velocity gradients, widely varying turbulence length scales as well as the bluff shape ship superstructures. Further, this complexity increases with the addition of helicopter downwash during landing/take off. In addition, these difficulties are more critical for small category frigate class ships. This is mainly due to (i) compactness in shape and size along with fixed design considerations, (ii) the sea-keeping motions encountered in high seas provide a non-stationary oscillating platform, and (iii) the visual cues reduce drastically due to sea spray. Further, the onboard landing deck area is limited (typically twenty percent the entire ship top deck area) due to the vessel stability constraint. In essence, the above-mentioned constraints lead to shipborne helicopter operation being one of the most challenging and difficult tasks in every naval organisation. Hence, an early assessment of the resultant flow environment over the ship helodeck for at early design stage is very crucial to minimise the risk associated with the shipborne helicopter operation.

The study is thus aimed to seek a suitable cost-effective early stage preliminary design tool to evaluate the essential flow features of coupled ship-helo airwake and overcome the complexities associated with shipborne helicopter operations. The study utilises the available experimental and numerical resources to understand the combined ship-helo airwakes characteristics on helodeck contributing to influence the helicopter aerodynamics, and explore solutions for economical early stage approach in order to improve the safe ship-helo operations margin. The ship airwakes and their effect over the flow characteristics of the flight deck region has been analyzed experimentally and computationally. An outstanding problem is to operate a helicopter in the regions of coherent, high-amplitude/less-frequency turbulence flow, which develop from the sharp edges and additional bluff bodies on the ship superstructure. Therefore, in order to gain insight into the ship airwake characteristics, the experiments have been undertaken on internationally accepted Simplified Frigate Ship (SFS2) along with the helicopter fuselage (ROBIN) at initial stage of investigations. The experimental investigations have been undertaken into two stages. In the first stage, the isolated ship airwake case have been studied experimentally. The combined ship-helo configurations have been extensively investigated with respect to the flight approach path followed on onboard helicopter operations over the helodeck in the second stage of experimental study. Subsequently, the steady flow investigations have been undertaken in order to establish a suitable numerical methodology to reasonably capture the flow characteristics of the experimental studies in the third stage of study.

Subsequently, the fourth stage of study presents a conceptual method to gain insight into the combined ship-helo flow phenomena over a helodeck. One of the prime objectives of this study is to develop an economical design tool employing both experimental as well as computational techniques to simulate the ship-helicopter coupled environment regime at early design stages reasonably well, so as to ease the burden of expensive and risky sea trials. For this purpose, a simplified dynamic interface (SDI) model is proposed to investigate the coupled effects of ship airwake and helicopter downwash. The study reports a parametric analysis to investigate the coupled ship-helo airwake behaviour and its impact on helicopter fuselage over the ship helodeck for different ship speed regimes by the proposed SDI model. The study also reports the influence of 'In Ground Effect' over the helodeck under different downwash conditions.

Further, an attempt has been made to setup preliminary single statistical value-based design criteria to grade the ship-helicopter interface for ensuring minimum standards of safe helo-operations. The proposed approach is limited to the identification of some dominant resultant coupled ship-helo airwake flow features which influence the helicopter aerodynamics. Results discuss the efficacy of the present approach by highlighting the impact of the coupled flow dynamics in terms of induced fuselage drag, cross-flow characteristics, rotor plane wake and velocity gradients that exist over the helodeck region.'

In the last stage of study, an unsteady flow analysis has been undertaken on isolated ship (SFS2) to established a suitable unsteady approach for the ship airwake investigations. The overarching aim of this study was to reasonably capture the dominated energy frequency range which affect the onboard helicopter operations. This study provides some insights into the unsteady ship airwake characteristics. Results obtained using three modelling approaches for unsteady ship airwake characteristics namely, Unsteady Reynolds Averaged Navier Stokes (URANS) simulation, Scale Adaptive Simulation (SAS) and Detached Eddy Simulation (DES) discuss the effectiveness of the approaches. The study also attempts to compare mean flow quantities between the unsteady flow approach and steady flow approach

Finally, the proposals for further research have been laid out which are expected to aid in the endeavour towards a complete numerical assessment of the ship-helo interaction problem in future and creation of ship helo operating envelopes (presently created through rigorous First-Of-Class Flying Trials: FOCFT) within the realms of a laboratory.

Keywords: Ship-Helicopter Airwake, Simplified Dynamic Interface (SDI), Helicopter Downwash, Turbulent Flow.