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Aerodynamic Load Assessment of a Model-Scale Helicopter in Shipboard Operation

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1 Introduction

Rotorcraft shipboard operations are often characterized by an increased workload for the pilots due to the aerodynamic interaction of the helicopter wake with the flow perturbations caused by the superstructures of the ship. This in turn may increase the risk associated with those operations. To enhance the safety of such demanding tasks, a series of flight tests are performed to identify the Ship Helicopter Operational Limitation (SHOL) which defines the boundaries of safe operation for a particular ship-helicopter combination in terms of maximum allowable wind speed and direction relative to the ship [1]. Development of SHOLs requires the necessity to perform numerous at-sea trials that are extremely expensive, time-consuming and inherently associated with high risk. To reduce the number of tests and also to improve the pilot training, development of Dynamic Interface Simulation (DIS) is a promising solution which could be further used to expand the SHOL envelopes and improve the design of future platforms [2,3]. However, to increase the fidelity of the simulation, it is necessary to have reliable data on the aircraft behavior. For this reason, a series of test campaigns are being performed at large Wind Tunnel of Politecnico di Milano (GVPM) to better characterize the interacting aerodynamic environment of a helicopter operating in close proximity to a vessel resulting in a fully-coupled dynamic interface [4, 5].

2 Content of the proposed paper

This paper presents an experimental framework to identify the ship-airwake disturbances applied on the rotor during the shipboard operations. To this aim, two main steps are proposed: identification of the dynamic inflow model of the helicopter without ship-airwake, followed by ship airwake identification while helicopter is approaching the flight deck. Here, the experimental setup is introduced briefly and then main objectives of the experiment will be discussed.

2.1 Experimental Setup

The experimental setup, which has already been exploited in previous experiments [5], consists of a 4-bladed helicopter model and a simplified ship geometry (SFS1). The ship model is a 1:12.5 scaled-model of SFS1 which is a highly simplified but representative ship geometry. The helicopter model consists of a fuselage and a rotor which has four untwisted and untapered rectangular blades, with NACA23012 airfoil. The previous helicopter model has been redesigned to add the swashplate mechanism so that collective and cyclic commands can be applied in order to excite the loads for the purpose of identification and for trimming the rotor while approaching the flight deck. The rotor rotational speed can be set by means of a brushless, low-voltage, electrical motor with an electric controller. The loads acting on the rotor are measured using a six-components strain gauge balance nested inside the fuselage with the sampling frequency of 100 Hz. Parameters of the model compared with Bo105 are summarized in Table 1.

Table 1: Parameters of Wind Tunnel model and full scale Bo-105.

Characteristic	WT model	Bo-105
Number of Blades	4	4
Rotor Radius(m)	0.485	4.9
Angular Velocity(rad/s)	212.6	44.4
Blade Chord(m)	0.042	0.27
Tip Reynolds Number	$2.95e5$	$3.9e6$

2.2 Planned Experiments and Expected Results

A series of wind tunnel tests has been planned to be performed in large test chamber of the large Wind Tunnel of Politecnico di Milano (GVPM). First part of this campaign is focused on identification of dynamic inflow model in different environmental conditions. In the second part, a landing trajectory will be simulated by placing the rotor in a series of points. Rotor loads will be measured at each point with sufficient sampling frequency to capture the unsteady loads which are expected to be concentrated in the range of 0.2-2 hz in full scale. Across this bandwidth, the magnitude of the spectrum is representative of pilot workload in response to the airwake turbulence. Mapping the spectrum in full scale will enable to design gust filters to reproduce same unsteady loads for the full scale model. This step is expected to improve the fidelity of the full scale Dynamic Interface Simulation environment in terms of pilot workload.

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