Correlation of Full-Scale Isolated Proprotor Performance and Loads

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Introduction

A full-scale isolated proprotor test is currently being conducted in the USAF National Full-Scale Aerodynamics Complex (NFAC) 40- by 80-Foot Wind Tunnel at NASA Ames. The test article is a 3-bladed research rotor derived from the right-hand rotor of the AW609. This rotor was manufactured by Bell Helicopter under contract to NASA. In this paper, this research rotor is referred to as "699". The test, nearly completed, is an integral part of the initial checkout test of the newly developed Tiltrotor Test Rig (TTR), whose purpose is to test advanced, full-scale proprotors in the NFAC. Figure 1 shows the TTR/699 installed in the 40- by 80-Foot test section. The TTR rotor axis is horizontal and the rig rotates in yaw on the wind tunnel turntable for conversion (transition) and helicopter mode testing.

Figure 1. TTR/699 installed in the USAF NFAC 40 by 80-Foot Wind Tunnel.

To date, a substantial amount of wind tunnel test data has already been acquired. The completed operational conditions include hover, airplane mode (cruise, wind tunnel airspeed V = 61 to 267 knots), and the helicopter and conversion conditions (with a comprehensive sweep of the TTR yaw angle ranging, to date, from 90-deg yaw helicopter mode to 30-deg yaw conversion mode at varying airspeeds). This 699 proprotor performance and loads correlation study uses these newly acquired wind tunnel test data.

This paper represents the third analytical study, coming after two earlier analytical studies on the TTR/699, that is, a 2018 paper on pre-test predictions of 699 performance and loads (Ref. 1), and an upcoming January 2019 paper on aeroelastic stability analysis of the TTR/699 installed in the 40- by 80-Foot Wind Tunnel (Ref. 2). Reference 8 will present an overview of the entire TTR/699 test program. For completeness, Ref. 3 addresses the development and initial testing of the TTR. Background information on the TTR effort at NASA Ames can be found at the Aeromechanics website: https://rotorcraft.arc.nasa.gov/Research/Facilities/ttr.html.

To the authors' knowledge, the full-scale results presented in this paper are the first of their kind. A literature survey brought up several existing correlation studies, but these were either based on small-scale test data (for example, the studies performed by the University of Maryland) or full-scale aircraft flight test data (for example, flight tests conducted by Bell Helicopter). Separately, the 2009 NASA study involving the JVX rotor is relevant (see Ref. 4). The JVX is closely similar to the 699 in size and aerodynamics, and is accordingly a good reference for performance

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