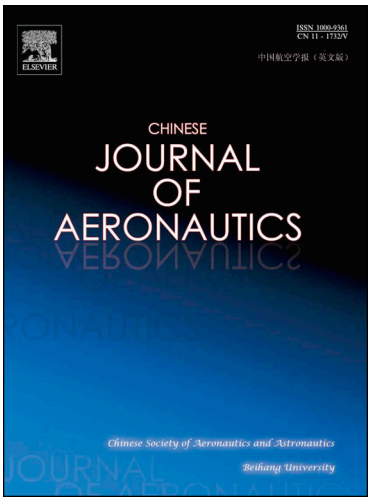

Full Length Article

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PII: S1000-9361(17)30195-4
DOI: http://dx.doi.org/10.1016/j.cja.2017.08.011
Reference: CJA 904

To appear in: *Chinese Journal of Aeronautics*

Received Date: 30 November 2016
Revised Date: 13 January 2017
Accepted Date: 20 March 2017

Please cite this article as: Q. Zhao, Y. Ma, G. Zhao, Parametric analyses on dynamic stall control of rotor airfoil via synthetic jet, *Chinese Journal of Aeronautics* (2017), doi: http://dx.doi.org/10.1016/j.cja.2017.08.011

Chinese Journal of Aeronautics 28 (2015) xx-xx

Contents lists available at ScienceDirect

Chinese Journal of Aeronautics

journal homepage: www.elsevier.com/locate/cja

Parametric analyses on dynamic stall control of rotor airfoil via synthetic jet

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Received 30 November 2016; revised 13 January 2017; accepted 20 March 2017

Abstract

The effects of synthetic jet control on unsteady dynamic stall over rotor airfoil are investigated numerically. A moving-embedded grid method and an Unsteady Reynolds Averaged Navier-Stokes (URANS) solver coupled with *k-ω* Shear Stress Transport (SST) turbulence model are established for predicting the complex flowfields of oscillatory airfoil under jet control. Additionally, a velocity boundary condition modeled by sinusoidal function has been developed to fulfill the perturbation effect of periodic jet. The validity of present CFD method is evaluated by comparisons of the calculated results of baseline dynamic stall case for rotor airfoil and jet control case for VR-7B airfoil with experimental data. Then, parametric analyses are conducted emphatically for an OA212 rotor airfoil to investigate the effects of jet control parameters (jet location, dimensionless frequency, momentum coefficient, jet angle, jet type and dual-jet) on dynamic stall characteristics of rotor airfoil. It is demonstrated by the calculated results that efficiency of jet control could be improved with specific momentum coefficient and jet angle when the jet is located near separation point of rotor airfoil. Furthermore, the dual-jet could improve control efficiency more obviously on dynamic stall of rotor airfoil with respect to the unique jet, and the influence laws of dual-jet's angles and momentum coefficients on control effects are similar to those of the unique jet. Finally, unsteady aerodynamic characteristics of rotor via synthetic jet which is located on the upper surface of rotor blade in forward flight are calculated, and as a result, the aerodynamic characteristics of rotor are improved compared with the baseline. The results indicate that synthetic jet has the capability in improving aerodynamic characteristics of rotor.

Keywords: Airfoil; Rotor; Dynamic stall characteristics; Synthetic jet; Flow control; Navier-Stokes equations; Parametric analyses; Moving-embedded grid methodology

1. Introduction

Due to combination of freestream velocity and rotation velocity of rotor in forward flight, helicopter rotor encounters different flow conditions. The periodic variations of Angle of Attack (AoA) make rotor undergo unsteady dynamic stall on retreating blade, and it induces the loss of lift, and increase of drag and pitching moment of rotor, which significantly impact the stability of rotor and aerodynamic performance of helicopter, resulting in restriction of the speed envelope of helicopter. [1, 2]

In recent years, the rotor technology has tended toward methods of enhancing aerodynamic performance over a wide range of operating conditions. Passive designs involving blade geometry are limited by the conflicting requirements created by advancing blade compressibility and retreating blade stall; hence

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