Nonlinear Reduced Order Modeling and Control for Transonic Flutter Limitation Cycle Oscillation

GuoWei Yang[1,†], Yan Tan[2], XueYuan Nie[3] GuanNan Zheng[4]

[1,†, 2, 3, 4]Key Laboratory for Mechanics in Fluid Solid Coupling Systems, Institute of Mechanics of CAS, China

[1,2,4]School of Engineering Science, University of Chinese Academy of Sciences, China

[1,†]gwyang@imech.ac.cn

[2]tanyan@imech.ac.cn

[3]niexueyuan@imech.ac.cn

[4]zhengguannan@imech.ac.cn

Abstract

The direct CFD/CSD coupling calculation can simulate linear and nonlinear flutter phenomenon, however, which is inefficiency and not conducive to mechanism analysis. Linear Reduced Order Modeling (ROM) can conveniently analyze flutter characteristics, but it is hard to analyze Limitation Cycle Oscillation (LCO). In this paper, a hybrid model is constructed by the combination of a linear model and a neural network nonlinear model, in which the linear model is firstly trained with the given train signal of small amplitude, and then the neural network model is only trained with the error between the nonlinear response calculated by CFD/CSD and the predicted value with the linear model for a given train signal with large amplitude. Taking a two-freedom transonic airfoil flutter as an example, it is indicated that the hybrid model can predicate the LCO. Lastly, the skin oscillation of airfoil surface is introduced to control LCO, it is indicated that the LCO can be suppressed effectively.

Keywords: Transonic flutter, CFD/CSD, Linear ROM, Nonlinear ROM, LCO.

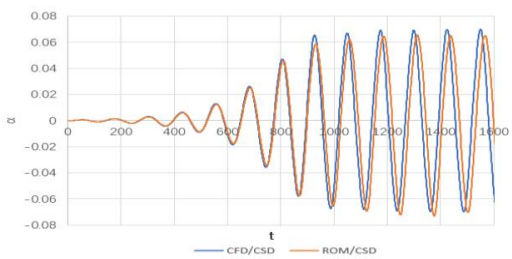

Fig. 1 LCO predicted by CFD/CSD and nonlinear ROM/CSD

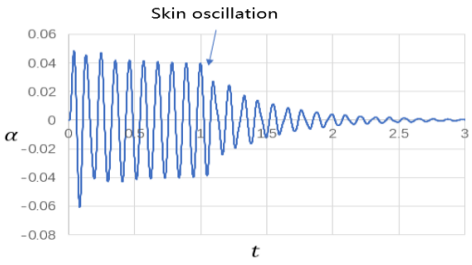

Fig. 2 Control effect of LCO with skin oscillation

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†Corresponding Author : Guowei Yang, Tel: +86-10-82544006, E-mail: gwyang@imech.ac.cn