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Reduced Order Modeling For Plasma Aeroelastic Control of Airfoils in Cascade: Dynamic Mode Decomposition

P. Neumann[1], V. Motta[1], L. Malzacher[1],
T. D. Phan[2], R. Liebich[2], D. Peitsch[1],G. Quaranta[3]

[1] *Technische Universität Berlin, Str. des 17. Juni 135, 10623 Berlin, Germany*
[2] *Technische Universität Berlin, Marchstr. 12-14, 10587 Berlin, Germany*
[3] *Politecnico di Milano, via La Masa 34, Milano MI 20156, Italy*

Abstract.

A dynamic mode decomposition is carried out for the flow field of a compressor cascade with plasma actuators employed for aeroelastic control. Numerical assessments carried out in previous works have shown that alternate triggering of pressure side/suction side actuators installed at the trailing edge of the blades can effectively reduce vibratory loads and enlarge the flutter boundaries of a linear compressor cascade. With the twofold aim of having an in depth understanding of the flow physics associated to plasma actuation and of developing an optimized control law for the actuators, the dominant structures of the pressure field are extracted via a dynamic mode decomposition. The decomposition is conducted on the actuated and non actuated pressure fields at several inter blade phase angles. The fundamental effects of plasma actuations on the flow field, and in turn on the blade loading, are identified and discussed. The procedure allows to get an useful picture of the main fluid mechanic phenomena associated to plasma aeroelastic control on turbomachinery bladings.

Key words: Reduced Order Modeling, Dynamic Mode Decomposition, Plasma Actuation, Aeroelastic Control.

1 Introduction

The demand for lighter and more efficient aero engines is continuously growing. To face these challenges, compressors with increasingly larger pressure ratio per stage have been designed. Natural consequences of these solutions are increasing risks of fatigue and flutter phenomena on compressor blades. Degradations in aerodynamic and aerostructural response are also encountered on pulsed detonation engines, currently under study within the Collaborative Recearch Center 1029 of Technische Universität Berlin[1]. Several solutions have been proposed to control flow separation and minimize pressure losses arising on these novel configurations [1–6]. Among the conceived approaches, plasma actuators seem to be very promising, thanks to their lightness and to their almost negligible intrusiveness in the

[1]Substantial efficiency increase in gas turbines through direct use of coupled unsteady combustion and flow dynamics, https://www.sfb1029.tu-berlin.de/menue/sfb_1029/parameter/en/.