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AEROELASTIC CONTROL OF COMPRESSOR BLADES IN TRANSONIC FLOW USING PLASMA ACTUATORS

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ABSTRACT

The purpose of the present work is to assess numerically the effectiveness of plasma actuators for controlling the aeroelastic response of a compressor cascade in transonic flow conditions. The potential suitability of such actuation for subsonic flows has been proved by the authors in previous works. Consistently with the approach employed for subsonic flows, pairs of actuators are located on the trailing edge of the blades, on the pressure side (PS) and on the suction side (SS). Actuators are operated to generate an induced flow either in the direction or against the freestream – setups referred to as downstream and upstream actuation, respectively. Computations at constant angle of attack with either PS or SS actuation are carried out first, to investigate the effects of plasma on the mean behavior of the flow and of the airoads. Subsequently, traveling wave pitch mode simulations for the clean and actuated cascade are performed. It is shown that properly triggered alternate PS/SS actuation – and adequate body force – can effectively reduce vibratory loads and enhance the aeroelastic stability of the cascade.

INTRODUCTION

The demand for lighter and more efficient aero engines has significantly grown during the last few years. To achieve this goal, modern compressors have been conceived with increasingly larger pressure ratio per stage. Natural consequences of these solutions are an aggressive blade loading and high flutter sensitivity, especially for long and slim blades. Blade design approaches aiming specifically at improving the aerostructural stability have been proposed [1, 2]. Also the aerodynamic performance is significantly affected on such highly loaded blades. Indeed, larger pressure gradients over the blade suction surface may anticipate the stall onset, therefore degrading the overall compressor performance. Diverse active flow control techniques have been proposed to optimize the aerodynamic performance of heavily loaded blades. Solutions like flow blowing, blades with adjustable angle of attack, movable leading edge, Gurney flaps, and adaptive camber – usually driven by piezo-actuators or shape memory alloys – have been proved to have a significant effect on the developed airloads [3–8].

Large interest has been lately addressed towards plasma