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Title
The impact of unsteady inflow conditions on the instability and transition of separated flows in low-pressure turbines

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Abstract
Low-pressure turbines (LPT) are subject to laminar flow separation when operating on a low-Reynolds regime [1]. These flow phenomena are ubiquitously found in other low-Reynolds devices such as micro aerial vehicles (MAV) and high-altitude unmanned air vehicles (UAV). The laminar separation will have a destructive impact on the aerodynamics and performance, hence, flow control strategies that may reduce or suppress flow separation are a forward direction towards more sustainable aerospace technologies. Flow separation is mainly associated with losses in flow momentum near the wall and the presence of adverse pressure gradient conditions. These phenomena characterize the size and dynamics of the separated flow, which in turn are dominated by the laminar-turbulent transition process [2]. In this contribution, we study the dynamics and instability properties of the separated shear layer in response to different inflow conditions, from laminar with harmonic forcing to freestream turbulence and explore flow actuation strategies.

A series of Direct Numerical Simulations and implicit Large Eddy Simulations are performed with a high-order DGSEM code [3] to simulate a wall-mounted bump-shaped geometry inside a channel. The bump geometry is designed to reproduce similar pressure gradients with those encountered on the suction side of an LPT blade. This geometry has been previously subjected to investigation, both experimentally and numerically [4,5]. Flow features are extracted by decomposing the flow into components that are respectively correlated and uncorrelated with the inflow conditions using a triple decomposition [6]. In laminar and uniform inflow conditions, Kelvin-Helmholtz (KH) instability develops upon the separated shear layer. This leads to the formation of spanwise vortices, and the subsequent nonlinear interactions between them trigger the transition to turbulence [7-9]. Under unsteady inflow conditions this transition process is altered by triggering early transition and even inflow disturbances that are moderate in amplitude are effective in reducing the length of the mean recirculation bubble. This can be exploited by means of controlled actuation via fluid injection at the wall. Our results suggest that actuation based on the excitation of the -local- KH instability can be less efficient in reducing the extent of the separated flow than alternative strategies addressing the global dynamics of the recirculation region.

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