The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Transition of separated flow over a bump under unsteady inflow conditions

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Key Words: *Separated flow, laminar-turbulent transition, hydrodynamic instability, direct numerical simulation, low-pressure turbines*

Laminar flow separation is a ubiquitous phenomenon present in several aeronautical applications, such as low-pressure turbines (LPT) and Micro Aerial Vehicle wings. Flow separation is associated with detrimental effects on aerodynamics and performance. These effects are related to the size and dynamics of the separated flow, which in turn are dominated by the laminar-turbulent transition process. While transition in separated flows and the underlying hydrodynamic instabilities are relatively well known for steady flow conditions [1,2,3], the impact of temporal variations on the incoming flow has received less attention [4]. In this work, we study the qualitative and quantitative changes on the separated flow dynamics on account of unsteady changes in the inflow conditions.

Direct numerical simulations of a channel flow with a bump will be performed using a discontinuous Galerkin spectral element code [5]. Under steady inflow conditions, laminar separation occurs past the bump peak; a self-excited formation of spanwise-dominant vortices in the separated shear layer is followed by an abrupt transition to turbulence [6]. The time dependence will be imposed by means of a temporal variation of the inflow conditions, mimicking the passage of the upstream blade's wake in an LPT. The unsteady inflow induces transient dynamics on the separated flow, potentially changing the transition scenario, and its impact on the aerodynamic forces. The resulting instability and transition process will be studied using the DNS data and analyses based on modal and nonmodal linear stability theory.

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