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Published in:
EWEC 2009 Marseille

Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

ID: 133
TRACK: TECHNICAL TOPIC: Aerodynamics and aeroacustics

COST REDUCTION OF LARGE EDDY SIMULATION OF AIRFOILS IN TURBULENT INFLOW

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This paper discusses simulations of airfoil flows by use of computational fluid dynamics. In recent work large eddy simulations (LES) of airfoil flows have proved superior to detached eddy simulations (DES); by resolving the inflow turbulence the agreement with experiments is improved. The scope of the present paper is to reduce the computational costs of LES by implying the inflow turbulence to the computational domain immediately upstream of the airfoil by an actuator disk. Thereby, only a small part of the domain in the close vicinity of the airfoil has to be resolved by a fine mesh.

Recent simulations of flows past a NACA 0015 airfoil at Reynolds number 1.6 million have shown that the flow is sensitive to the intensity of resolved turbulence. For angles of attack lower than stall the separation point moves upstream when the intensity of the resolved turbulence is increased. For angles of attack higher than stall the separation point moves downstream with increased turbulence intensity. Especially, close to stall the flow is very sensitive to the intensity of resolved turbulence. By including resolved inflow turbulence the agreement with wind tunnel measurements is improved.

This effect can only be investigated by large eddy simulations (LES) or direct numerical simulations (DNS). At Reynolds numbers in the order of a few millions the computational costs associated with LES are high, and DNS is many times more expensive. In detached eddy simulations (DES) only a small part of the domain near the airfoil is resolved into a fine mesh. Consequently, the inflow turbulence cannot be resolved in a DES.

The scope of the present paper is to reduce the computational costs of LES of airfoils in turbulent inflow. The effort is concentrated on reducing the required number of mesh points, by implying the inflow turbulence immediately upstream of the airfoil. In the previous simulations the inflow turbulence is imposed on the inflow boundary located several chords upstream of the airfoil. This approach requires that the entire upstream domain is resolved into a fine computational mesh to resolve the inflow turbulence as it is convected from the inflow boundary to the leading edge of the airfoil.

In this paper the inflow turbulence will be imposed on the upstream domain close to the leading edge of the airfoil. The turbulence is superposed to the mean flow by a volume source approach. The mean flow upstream of the actuator disk can be resolved by a coarse mesh, as it is a laminar, steady flow. This provides the ability to run LES of airfoils at the much lower cost of DES.

The method will be validated by its ability to recreate decaying homogenous turbulence in an empty tunnel flow. Further, the method will be applied to airfoil flows to show its accuracy and potential for saving mesh points in a practical flow case.