Session:

Detached Eddy Simulation of an SD7003 Airfoil

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Introduction

The process of laminar separation with following turbulent re-attaching is a major challenge for computational fluid dynamics. Typical RANS models cannot reproduce it correctlywithout additional model adaptation. LES and DNS have become affordable only for quasi two-dimensional configurations at moderate Reynolds numbers [1-3].

For the investigation of fully three-dimensional cases like wing configurations or large scale turbulentstructures interacting with the separation process hybrid methods are an interesting tool. They are capable of reproducing the separation process as shown in previous work by the authors [4]. The presentstudy compares the results of a Large Eddy Simulation featuring the WALE turbulence model with thosefrom a hybrid simulation using a DDES approach. With both models simulations of the laminar separationon a SD7003 airfoil have been performed at different angles of attack and for different extensions in spanwise direction.

Numerical setup

Both LES and DDES have been performed using the OpenFOAM® flow solver.In the LES the domain extends one tenth of the chord length in spanwise direction with periodicboundaries. The mesh has a size of 19.7×10^6 cells. For the DDES computations with the same domain size as well as with a largerone have been performed. With the same spanwidth the mesh features only 3.8×10^6 cells, while for a span of half the chord length in increases to 8.6×10^6 cells.

Results and discussion

The two methods show a very similar behaviour with slightdifferences in the streamwise locations of separation and reattachment.When comparing the turbulent velocity fluctuations in the region of transition the magnitudeof both the mean turbulent kinetic energy k as well as of the cross correlation $\langle u'v' \rangle$ is higher in theDDES results. The location of the fluctuation maxima in relation to the separation region are very similarin both cases. The separation itself differs slightly, thus the absolute location also is produced differentlybetween the two approaches.

Besides the magnitude of the fluctuations also their frequency spectra areof interest for the solution. In the separation region the shear layer vortex shedding frequency dominates, while further downstream the fluctuations produce rather evenly distributed noise. Figure 1 shows spectrafor three points located in the turbulent boundary layer of the airfoil upper side at *x/c=0.29*, *0.73* and *1*.In the first point the vortexshedding frequency dominates. The DDES shows it higher and clearer than theLES. This indicates, that in the LES the vortices are immediately starting to break into smaller structures,while the DES preserves them more distinct and delays their three-dimensional breakup.In the second and third point the peaks are spreading over a wider range. The fluctuation intensity produced by DDES is higher than by LES. One cause might be, that the soonerbreakup in LES allows more energy to be dissipated.

Beside the results from different angles of attack the final paper also will feature the influence of spanwisedomain extension for DDES. The comparison between DDES and LES will be presented for $\alpha=4°$ and *6°*.With DDES also a case at high angle of attack will be included.

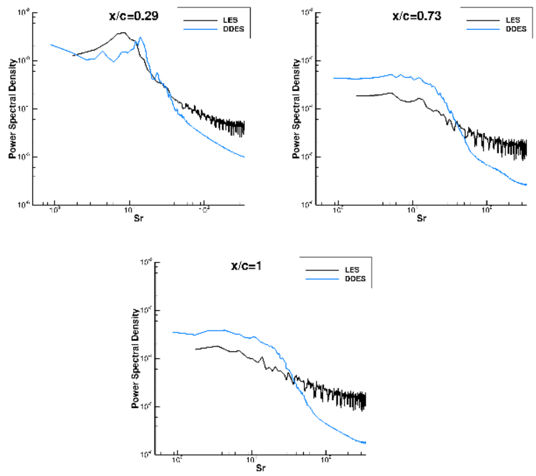

Fig. 1 Spectra of pressure fluctuations in points along the upper side of theairfoil.

References

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