1. Introduction

In a previous project, the author developed new airfoils for a vertical axis wind turbine [1] using a CFD Solver called ADflow. It became clear that the performance of the airfoils in soiled conditions must be taken into account. The airfoils are highly sensitivity to surface contamination if neglected. To fix this, the author implemented a 'hacky' variant of the rough Spalart Allmaras (SA) turbulence model.

1.1 Goals

The goal of this project is to streamline and finalize this implementation. Namely the following sub-goals should be achieved:

- Modify the existing SA turbulence model for rough walls
- Test and verify the implementation.
- Use Algorithmic/Automatic Differentiation (AD) to differentiate the newly added code
- Test and verify the gradients for the rough variant

1.2 ADflow

The CFD Solver ADflow (AD stands for AD) is developed at the university of Michigan. It is based on a structured, multiblock solver called 'sumb'. It has been adapted for gradient based optimization by means of AD and the 'adjoint method'. Additionally it has some highly efficient and robust ANK and NK Solvers. Those are needed to achieve machine-precision convergence which is a requirement for efficient gradient basded optimization [3] [2] [4].

ADflow has a python interface which makes it fairly easy and straight forward to be used in optimizations scripts. But the heavy lifting is done in Fortran. This approach allows to combine highly effiecent and fast computations with the easy of a scripting language.

2. Theoretical Fundamentals

2.1 Boundary layer

2.1.1 Concept

2.1.2 Turbulent boundary layers

2.1.3 Turbulent boundary layer over rough walls

2.2 Turbulence Models

2.2.1 Spalart Allmaras (SA)

2.2.2 Modification of SA for rough walls

3. Methods

3.1 Implementation

3.1.1 General Ideas

3.1.2 Modifications to Wall distance computation

3.1.3 Modifications to SA source terms

3.2 Verification

3.2.1 SA rough

3.2.2 Gradients

4. Results

results

5. Conclusion

conclusion

Bibliography

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