GAD-CFD tool

Contents

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1. Introduction

As part of the Selkie Project's Work Package 6, Swansea University have developed a computationally efficient tool for simulating the performance and wake characteristics of horizontal axis tidal turbine (HATT) arrays.

The Generalized Actuator Disk – Computational Fluid Dynamics (GAD-CFD) tool is an open access, clearly documented tool for the marine renewable energy industry and the research community to facilitate their individual device design as well as array layout optimisation for energy output maximisation.

It is distributed through https://git.swansim.org/cee-turbine/GADRotorControl which contains the source code, installation instructions, and documentation, and it is updated regularly with the latest versions and new baseline cases.

2. Description

As a computational tool, GAD-CFD combines a standard finite volume solver of OpenFOAM with the GAD model for the rotor representation. It is designed to allows users to study site-specific HATT array cases with the ability to include the bathymetry of the site.

3. Software repository and versions

The repository webpage includes the release versions of the software together with several test case tutorials. Namely it includes:

- **GADSimpleFoam** (version 1): The initial version of GAD-CFD coupled with SimpleFoam library of OpenFOAM with no active control for the rotors.
- **GADRotorControl** (version 2): The latest version of GAD-CFD with pitch and stall active rotor control.

There is also a section for reporting issues found by the community, which is a particularly useful section for the development of the tool.

4. Structure of the Wiki page

The wiki page in the repository contains information related to the theoretical background of the tool, as well as an installation and user guide, and a series of tutorials. The layout is summarised in the following sections.

4.1. Theoretical background and fundamental of the model

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In the first sections of the wiki page (1 – 4) an overview of the model is presented including all the theoretical background, the fundamentals, and the mathematical formulation.

4.1.1. Model overview

Presents the general model overview regarding its scope and aims, with references that support this development.

4.1.2. The GAD-CFD model

A brief description of the foundation of the model and its mathematical formulation with schematics of all the theory and application for the model.

4.1.3. Aerofoil characteristics

The tool employs a detailed characterisation of the rotor blades by including distributions for chord, twist, and the foil distribution along the blade. Moreover, a variable Reynolds number is considered. In this section, all these aspects of the tool, and how are these interpreted computationally is described.

4.1.4. Rotor control

The latest version of the tool includes the implementation of active rotor control. This control allows the user to use power limiting for the rotor through two mechanisms, the stall and pitch. The implementation and computational treatment of these control options are described here.

4.2. Tool usage

The next sections of the repository wiki describe in detail how the new users will install and run their simulations using the tool.

4.2.1. Installation guide

This section describes in detail all the steps required for a standalone installation in Windows and Linux OS. A series of videos can also be found there with these steps for more interactive guidance.

4.2.2. User guide

In this section, the core of the tool is described. It includes all the commands the user has to execute in order to run the simulations. Moreover, it includes a detailed and structured description of all the variables included and how they are structured within the code.

4.3. Tutorial cases

In this section, several tutorial cases are included for a new user to get started with the tool, the results of these tutorials are also included so the user ensures the proper run of their simulations. These tutorial cases demonstrate a range of cases including

- A validated single rotor tank model[1]
- A CFD model of the FloWave tank at Edinburgh University. This case does not contain any rotors[2]
- The FloWave tank with one rotor implemented in the model[2]
- The FloWave tank with a three-rotor array[2]
- A three-rotor array in a cuboid domain. This is the benchmark case for the rotor control functionality

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5. Repository

The GAD-CFD repository can be accessed at the following link:

https://git.swansim.org/cee-turbine/GADRotorControl

[1] Edmunds, M., Williams, A. J., Masters, I., Banerjee, A., & VanZwieten, J. H. (2020). A spatially nonlinear generalised actuator disk model for the simulation of horizontal axis wind and tidal turbines. *Energy*, 194. https://doi.org/10.1016/j.energy.2019.116803

[2] Mycek, P., Gaurier, B., Germain, G., Pinon, G., & Rivoalen, E. (2014). Experimental study of the turbulence intensity effects on marine current turbines behaviour. Part I: One single turbine. *Renewable Energy*, 66:729–746. https://doi.org/10.1016/J.RENENE.2013.12.036