Faculty Engineering Technology
Program Sustainable Energy Technology

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

W. de Vries

will give a presentation, entitled:

On the development of a two-way coupled fluid-structure interaction solver using a partitioned approach with application to helicopter blades

Date: **Friday December 11, 2015**

Time: **14:00**

Room: **Horst Building Room HT-700B**

Summary:
In order to investigate power harvesting from blade vibrations for the purpose of structural health monitoring, the development of an advanced numerical model incorporating both the structural and aerodynamic loads, is addressed in this present study. The fluid structure interaction problem of two rotating helicopter blades in a steady and inviscid flow is modeled using a partitioned approach. The main focus of this study is on the transfer of data between the fluid and structure domain.

The open source software suite *SU²*, developed at Stanford University, is employed as flow solver. The software suite contains a flow model of two rotating extrusions of a Naca 0012 airfoil, for which the Euler equations are solved on an unstructured grid in a rotating frame of reference. In order to determine the deflection of the blades two structure models are developed, one based on the Euler-Bernoulli beam theory and one based on the finite element method. For both structure models, modal analysis is employed to determine the deflection of the beam due the structural and aerodynamic loads. An interpolation scheme based on radial basis functions is used as coupling algorithm, to transfer the solution variables between the fluid and structure domains. In addition the scheme is employed to transfer the displacement to the volume mesh of the fluid domain.

The structure models and coupling algorithm are validated and successfully implemented in combination with the flow model. Results are obtained for a very stiff blade and very flexible blade geometry, allowing small and large displacements respectively. In addition, the influence of the rotational speed on the performance of the coupled fluid structure interaction solver is investigated. It is concluded that the results of both structure models are in good agreement, in terms of displacement, resulting lift and total work. The results for the stiff blade geometry show that small displacements lead to small variations in the aerodynamic load, whereas flexible blades lead to large deflections and strong variation in aerodynamic load. Consequently the solution for the stiff blades is converged after a few iterations whereas the solution obtained with the flexible blades converges after several iterations more. It is concluded that a higher rotational speed results in smaller deflections and a converged state is reached faster. At last it is concluded that the radial basis function based interpolation scheme gives good results for transferring data between non-matching grids and as mesh motion algorithm for unstructured grids.

For future studies it is suggested that the extension is made to unsteady flow conditions in order to verify the convergence behavior of the fluid-structure interaction solver. Furthermore, the effects of increased density may be investigated. Finally it is recommended that a more detailed structure model is adopted in order to simulate a more realistic test case.

Assessment committee:

Prof.dr.ir. C.H. Venner (chairman)
Prof.dr.ir. A. de Boer (external member)
Dr.ir. E.T.A. van der Weide (mentor)
Ir. J.P. Schilder (mentor)

Chairman,

d.d. _______________