Faculty Engineering Technology
Program Mechanical Engineering

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

Marc Broersma

will give a presentation, entitled:

On the development of a high order accurate, steady, pseudo-compressible solver

Date: **Friday August 28, 2015**

Time: **09:30**

Room: **Horst Building Room N.109**

Summary:

Solving the compressible Navier-Stokes equations near the incompressible limit may cause the numerical scheme to become ill-conditioned. To overcome this problem, the incompressible Navier-Stokes equations can be solved. However, due to the lack of a time dependent term in the continuity equation, the mathematical character differs from the compressible Navier-Stokes equations. A solution to this is to complement the continuity equation by a derivative of pressure with respect to pseudo time which allows the equations to be solved using a 'compressible flow' type solver. When the solution converges, the added derivative becomes zero and the formed solution is the solution to the incompressible Navier-Stokes equations. This method is known as the artificial compressibility method and these equations are solved using high order finite difference schemes in the departments' compressible flow solver package *MooseFlow*.

Higher order approximations can be advantageous for efficiency. However, due to their wider stencil, a stable boundary discretization is not straightforward. To be able to proof stability of the scheme theoretically, summation-by-parts (SBP) difference operators are used which are constructed such that energy estimates of the discretized equations can be obtained. When a decreasing energy norm can be shown, the numerical scheme is theoretically proven stable. Along with the SBP operators, a specific implementation of the boundary conditions is necessary to obtain an energy estimate. This boundary treatment is known as the 'simultaneous approximation term' (SAT) and applies the boundary conditions in a penalty type manner. In order for the numerical scheme to be stable, the strength with which the boundary conditions can be enforced must be analysed. These stability conditions are derived for both the inviscid and viscous part of the pseudo-compressible equations.

The inviscid part of the equations is implemented and the numerical calculations show stability and convergence as expected. Various test cases have been considered, including flow past a circle cylinder and a wing. Also, the theoretical obtained stability coefficients are validated and discussed.

Assessment committee:

Prof.dr.ir. C.H. Venner (chairman)
Dr.ir. E.T.A. van der Weide (mentor)
Dr.ir. R.G.K.M. Aarts (external member)
G. Giangaspero, M.Sc.

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d.d. 27 juli 2015