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| 14 March 2017 | |
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| Steve Marshall |
| DES NAG SHIPSTAB |
| Naval Authority Group  Larch 3a  MoD Abbey Wood #2315  BRISTOL  BS34 8JH |

Dear Steve,

**EngD Four Year Sponsorship - 17 - TEST/001/HYDRO/PROP/CCF/9006/37768**

1. **Introduction**

Over the first year the aim of Nicholas McCaw’s EngD is to develop his skill set, by undertaking six taught modules in computation modelling and undertake small research activities. During this year individual research elements have been performed in order to develop knowledge on propeller hydrodynamic and structural performance.

1. **Achievements last 6 months**

Semester 1: Taught Modules

The three completed courses, taken in the first semester, were:

* Advanced Computational Methods 1
* Simulation and Modelling
* Numerical Methods

All these courses have been completed with a mark of over 75 %.

Further to the taught modules additional workshops have been completed. These include: Presenting your research, Research Methodology for Scientist and Engineers, Technical Writing Skills and Introduction to Teaching Skills.

Semester 1: Individual research

Firstly a literature review has been undertaken. This involved reading through the proceedings of the International Towing Tank Conference (ITTC) to find the state of the art technology in the marine sector. The main area of concern was the propulsion committee. The conference notes discussed new types of propellers such as contra-rotating propellers, hybrid propulsion and azimuthing thrusters. Another emerging technology in marine propulsion is flexible blade propellers where composite materials are used in marine structures. This was of particular interest to me with Dr. J Youngs 2010 paper on hydroelastic scaling. There was also a section detailing to the need for research and development. These areas where discussed with Professor Turnock with the idea of potential summer projects in mind. It was decided that the scope of the research and development needs where excessive for a summer project.

Furthermore the SMP conference proceedings where reviewed. The main objective of the review was ,again, to obtain a general picture of the state of the art. However papers of interest where read in more detail such as: ‘Propeller optimization using an unsteady Boundary-Element Method’ by Evert-Jan Foeth and ‘Effects of Turbulence models on RANSE predictions of transient flow over blade sections‘ by Luca Bonfiglio.

The chapter titled 'Numerical Methods for Propeller Analysis' from the book 'Ship Resistance and Propulsion' by Professor Turnock was also read through. This chapter described Blade Element Momentum Theory (BEMT) as well as the numerical procedure to solve for the thrust and torque coefficients.

The BEMT was then implemented into Python with initial results varied against FORTRAN code. The code has been further improved with the addition of integrating XFoil into the code to improve accuracy of the lift and drag coefficients. More improvements are planned as described in the future work section. Finally OpenFOAM tutorials have been undertaken.

1. **Significant issues in last 6 months**
2. **Plan for next 6 months**

Semester 2: Taught Modules

The three courses to be completed this semester are:

* Advanced Computational Methods 2
* Applied Statistical Modelling
* Professional Research skills

Semester 2: Individual research

As a propeller blade experiences a load the blade will deform due to the load. The BEMT code will be further improved by implementing Timoshenko beam theory through finite element analysis. The objective is to obtain an approximation to the deformation through Timoshenko beam theory. Furthermore the code will be improved by the addition of time steps and ,if time permits, an unsteady flow input.

Further to this an investigation will be made into open source structural codes to couple with the OpenFOAM CFD output. It has been found that OpenFOAM has some structural modelling as part of its simulation software. However additional software will be researched to find the most suitable.

Finally a report will be written summerizing my research and marked by Prof. Stephen Turnock.

Summer Project

There is still a limited understanding of how structural vibration of a marine propeller affects the loading and noise levels of marine propellers. Such calculations require significant computational resource and effective methods of coupling the structural response to the loading is still an open question. The aim of this project is to explore possible routes for coupling an opensource CFD package OpenFOAM to available structural solvers. As a first step the problem will be focused on a conventional low aspect ratio control surface for which QinetiQ has access to high quality experimental data for validation purposes.

1. **Risks/dependencies over the next 6 months**

Risks over the next 6 months are: failing all modules (unlikely), I am inexperienced in commercial dealings therefore there is always a risk I may use software under an academic licence which may be an issue for QinetiQ to use. I am also dependent on my references completing security clearance forms.