UNIVERSITI MALAYSIA SABAH

FINAL REPORT

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Autonomous Underwater Vehicle Manoeuvrability Studies

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SYNOPSIS

This research project is aimed to understanding the manoeuvrability of AUV and develop mathematical model to describe behaviour of vehicle interaction with the operating environment. A hovering type of AUV was defined base on the operation need of the AUV where it is likely to be applied in underwater research and exploring activities. Due to the increase demand of AUV, major efforts have been made in developing AUV in overcoming the challenging scientific and engineering problems caused by the unstructured ocean environment.

The theoretical modeling of the AUV had being developed via Newtonian mechanics approach and the 6-DOF dynamic equations of motion are derived throughout the process. The governing equations mainly constitute terms of rigid body inertia matrix, hydrodynamic damping matrix, restoring forces and moments, environmental and propulsion forces and moments. Subsequently, a feasible 3-D solid modeling of the AUV had been designed through iterative method with CAD and CAE verification. Fluid interactions and manoeuvrability design analysis was achieved through implementation of CFD tool, COSMOSFloWorks. The theoretical modeling developed had been simplified under several relevant assumptions and the second order non-linear differential equation solved using the programming software MATLAB to investigate the translational motion of the vehicle in the surging direction. The result from the model is the AUV motion relation, drag force and lift coefficient that could be utilized in the further AUV prototype development.

The solid 3D design of the AUV had been achieved through spiral design process of iterative method. The method involves design statement, preliminary design, conceptual design and detailed design. Fundamental hydrodynamic knowledge had been applied to facilitate the design of the AUV. The optimum thruster location had been identified and the optimum design achieved. The scope of physical solid modeling had been effectively implemented via CAD software. SolidWorks licence by Universiti Malaysia Sabah had been utilized as the CAD platform in developing the AUV 3D model.

Stalling phenomena had also been identified as 15° through simulation software, COSMOSFloWorks. The stall pitching angle defines where the unstable manoeuvring of the vehicle will occur. COSMOSFloWorks also had been utilized to examine the effect of current velocities towards the AUV lift and drag coefficients. The simulation was conducted at various Reynolds number and various pitching angles. The investigation has found that the lift coefficient and drag coefficient increases as the pitching angle increases, but the considered range of Reynolds number had no significant effect on these hydrodynamic coefficients. These results were important for the design of better guidance and control systems for the AUV to achieve effective manoeuvring in current flow environment.

SINOPSIS

Projek penyelidikan ini bertujuan untuk meneroka pemahaman untuk pengangkutan dasar laut automatic dari segi cara pergerakan and menemui model matematik untuk menerangkan kelakuan tersebut dengan keadaan sekeliling. Pengangkutan dasar laut automatic berlegar telah didefinasikan sebagai pilihan yang paling sesuai untuk aktiviti penerokaan dasar laut dan penyelidikan dasar laut. Disebabkan oleh peningkatan keperluan untuk pengangkutan jenis ini, banyak usaha telah dicurahi untuk mengatasi masalah-masalah saintifik dan kejuruteraan yang disebabkan oleh keadaan sekeliling dasar laut yang tidak berstruktur.

Penmodelan telah dikemukan melalui care Newtonian Mechanics Approach dan formula-formula dinamik bagi enam DOF untuk pergerakan. Persamaan-persamaan pengawalan kebanyakannya terdiri daripada matrik inertia badan keras, matrik redaman hydrodinamik, kekuatan and momen penmulihan, kekuatan and momen persekitaran dan pendorongan. Sehubungan dengan itu, satu model 3D telah direka dengan menggunakan bantuan perisian-perisian CAD dan CAE. Interaksi cecair dan analisis pergerakan telah dicapai melalui implimensi alat CFD and COSMOFloWorks. Pemodelan teori dikemukakan telah diringkaskan dengan beberapa anggapan and persaman tak selari peringkat kedua telah diselesaikan dengan bantuan perisian programming MATLAB untuk menkaji pergerakan pengangkutan tersebut dalam keadaan melonjak. Hasil-hasil daripada pemodelan adalah hubungan pergerakan pengangkutan dasar laut automatic, kekuatan mengheret dan pekali mengakat boleh digunakan dalan pembanguanan prototype pengangkutan dasar laut kelak.

Rekaan 3D penuh untuk pengangkutan dasar laut automatic ini telah dicapai melalui process rekaan lingkaran secara interaktif. Cara ini termasuk kenyataan rekaan, rekaan peringkat awal, rekaan konsep dan rekaan terperinci. Pengetahuan asas hydrodinamik telah diguna untuk melancarkan rekaan tersebut. Lokasi terbaik untuk penikam telah diketahui dan rekaan optimasi telah dimaterelasi secara virtual. Skop-skop bagi pemodelan bentuk fizikal telah diimplimentasi dengan perisian CAD. Lesen SolidWorks yang dimiliki oleh UMS telah diguna sebagai plakform CAD dalam pembentukan model 3D.

Fenomena tegun sebanyak 15 darjah telah diketahui melalui perisian simulasi COSMOFloWorks. Sudut tegun akan mengatakan di mana pergerakan tak seimbang akan berlaku. COSMOFloWorks juga digunakan untuk memeriksa kesan-kesan kelajuan air laut terhadap pekali mengheret dan mengangkut. Simulasi dijalankan dengan menggunakan nombor Reynolds and sudut tegun yang berlainan. Kajian menunjukkan pekali mengheret dan mengangkut meningkat apabila sudut tegun meningkat, tetapi perubahan nombor Reynolds tidak membawa perubahan terhadap pekali-pekali tersubut. Keputusan-keputusan ini adalah penting sebagai penanda-penanda untuk rekaan pengangkutan dasar laut automatic yang lebih unggul dari segi pergerakan dalam keadaan dasar laut yang sentiasa berubah.