UNIVERSITY COLLEGE LONDON

POST GRADUATE PROJECTS
2003

NAVAL ARCHITECTURE

Concept Design of different Marine Vehicles
A. AKINOLA Private Student Nigeria

One of the key issues that face ship designers is the choice of hullform that will effectively meet the requirements the design is target at in terms of vessel performance and cost.

This report gives comprehensive analysis of different concepts of marine vehicles. The concept design of these marine vehicles is properly examined. To produce a concept design, it is necessary to have a requirement. The requirements have been limited to payload (volume and weight) and speed at specified Sea State in this report.

The project thoroughly looked at ways of developing a design approach that will make use of stipulated requirements to obtain a ship concept with its form parameters if necessary that satisfy with minimum stability and seakeeping performance. The reason for developing such an alternative is to avoid wasting resources, money or time, on developing intermediate solutions which are leftover after final hullform that will successfully stand for the desired solution has been taken.

GZ curve of warships from Form Parameters
LIEUTENANT H. ALI PN

This report details the work done on the formulation of an empirical formula for the GZ curve for the warships based on the hullform parameters.

UCL undertakes short ship design courses, of one week duration. These courses mix lectures with a series of short design exercises. Given the short time available, it is necessary to provide simple computer tools to assist. Furthermore the learning curve for the tool must be short in order to ensure good educational benefit. There is a need for such a tool, which can calculate the GZ curve of a warship from its form parameters. Also during a ship design exercise, the need exists for a method of assessing the stability of warships at the initial stages of design, when only form parameters of the hullform are known, normally the transverse stability can be assessed in design development stage, and at this stage not much time is left to go back and start work from scratch.

The purpose of this dissertation project is to make a series of warship hull forms by making a systematic variation in hull form parameters. The SZ curves for these are to be used to produce a parametric method of estimating SZ/GZ curves for warship hulls.

At the start of this exercise, a very important issue was to select the hullform parameters, to be included in the empirical formula for the calculation of GZ curve. A number of parameters were considered and based on their effect on transverse stability only 4 parameters were considered. While selecting the parameters the limitations of software PARAMARINE for generating number of hullform quickly was also considered. A total of 98 hullforms were generated by systematic variation of block coefficient (Cb), Beam to Draught Ratio (B/T) and Flare Angle above water line (Kf) and for each hullform 2 different draught to depth ratio (T/D) was considered.

The cross curves obtained from these hullforms were used in regression analysis to get an empirical formula for the cross curves of stability of any ship, this can then be used for calculation of GZ for any value of KG.

The result obtained from regression analysis shows that the empirical formula obtained fits an approximate model to the GZ curve of warships: and it fits very accurately on the hullforms used for regression analysis (98 hullforms). This shows that although the regression model is very accurate, it has got some parameters missing in it which effect the stability and that is why it is an approximate fit to other hull forms and an accurate fit to hullforms used in regression.

The empirical formula can be used to get the approximate GZ curve or value of GM at initial stages of design, although it never represents the exact behavior. It also gives a good feel how different parameters, which are included in model, effect the stability of a ship. Therefore this can be used to get a guideline on selection of parameters at the initial stages of design.

Composite Structures – Design guidance for large vessels
LIEUTENANT P. BOXALL RN

The investigation of this thesis was into the feasibility of the production of basic guidelines for the use of composites within concept design for ships of approximately frigate/corvette size. Currently generic information, such as the tools for predicting the structural weight of a given ship size and approximate structural weight fractions, for use during early concept design and initial sizing of a vessel are only available for vessels constructed out of steel. However studies have indicated that there is currently insufficient experience and data, in particular for such large vessels in excess of 100m, which are yet to be constructed, to allow for the production of an empirical formula for structural weight. It was however possible to provide more specific guidelines available to assist with design, such as appropriate load factors for all failure modes, both local and global, along with additional considerations specific for the use of composites in design.

It was consequently decided that the focus of the thesis should be to provide a study to confirm whether with current composite technology a vessel of this size could be manufactured and if not, what advances in the material technology would have to be made to make it feasible. To facilitate this, the midship section of a current steel ship design (an early version of NFR 90) of 133m in length was redesigned with current composite technology to allow comparison between the two. This study indicated that the failure mechanism, which dominates the midship section design of an FRP ship, is overall buckling. In addition, with this particular design it was found that the ship would deflect 4 times more than that of steel ship, although the acceptability of this deflection will ultimately depend upon the function of the vessel. Finally it was concluded that structural weights of 60% of an equivalent steel ship would be a reasonable starting point during the initial sizing process. It is hoped that the thesis will help future students undertaking the ship design exercise with the latest guidance to the use of composites and other relevant references that will be of assistance.

An investigation into the effect of Side Hull Haunches on Trimaran Roll Damping
LIEUTENANT A. FOUAD PN

Haunches are usually incorporated in trimaran hull forms to ensure that the damage stability criteria are met. The effect of haunches on sea keeping performance, particularly on roll damping, requires model testing as the available seakeeping prediction software assume that the ship is wall sided above the water

line and hence cannot model the effect of haunches. This research work is an effort to establish the effect of haunch flare angle on roll damping.

A series of roll decay tests were conducted with wooden and foam haunches at zero speed on a small scale model. An energy method was initially used to predict roll damping coefficients assuming linear plus quadratic damping model. No significant change in damping was predicted over the range of haunch angles considered. It was felt that there was a need to improve the experimental set-up and the analysis procedure before making any conclusions. MATHISEN's perturbation expansion solution was consequently used as an alternative to energy method to see if it gives different or better results. The two methods are critically analysed and a comparison is presented in this report. The results of MATHISEN's method were found similar to those obtained using energy method. This led to error analysis and sensitivity study of roll damping prediction to different parameters and initial conditions. Noise was found a significant source of errors and hence the roll spectrum was analysed and noise filtration techniques were employed to improve the quality of the recorded signal. Curve fitting options, sensitivity of roll damping prediction to initial roll angle and the choice of the portion of decay selected for analysis were also briefly studied as these were found to affect roll damping prediction. Three new MATLAB codes are developed and one available MATLAB code was modified for the purpose of this research. Despite all the efforts to improve signal quality, experimental set-up and analysis procedure, the small scale of the model makes it very difficult to predict changes in damping coefficient with good reliability. It is found that current experimental set-up at UCL is not very well suited to recording small changes in damping coefficients.

A lot of problems were faced during this research. The research looks into the procedure adopted in the past for the analysis of roll data and provides some guidelines for further study. The author presents his analysis of the sources of problems and suggests improvements to the experimental set-up and the roll damping prediction technique. This may help early identification and removal of these problems in any further work.

Bring Computational Fluid Dynamics back into the Computer Aided Ship Design Process

A. LIVINGSTONE. Private Student

This creation of computer code to convert the * . STL file format output from Paramarine into the * . INP file format required by the UCL-created sea-keeping evaluation program 'uclskeep. Exe' is described. The inbuilt meshing of Paramarine is capitalized upon to try to enhance the link between Computational Fluid Dynamics (CFD) and Computer Aided Ship Design (CASD).

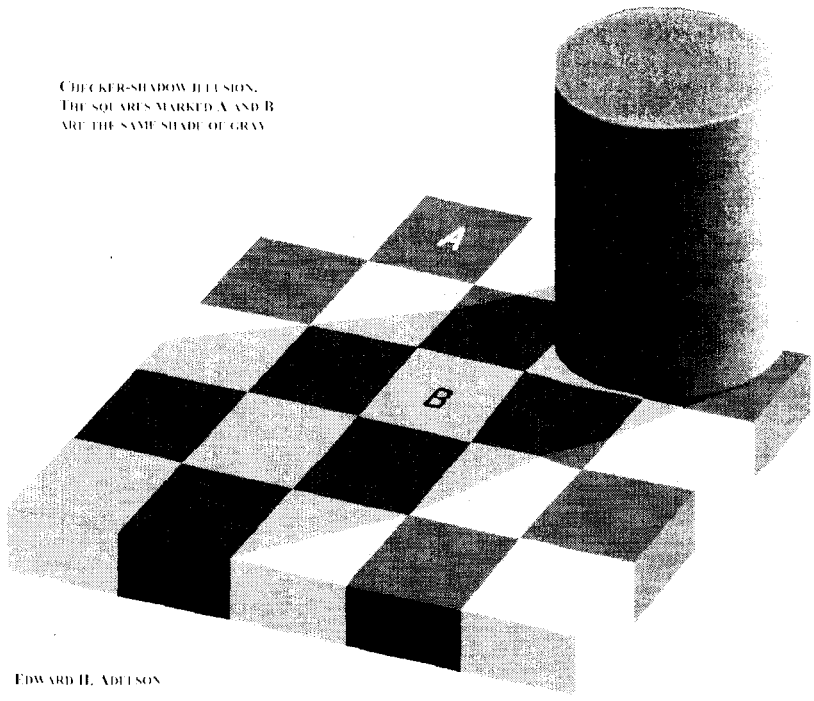


FIG. 1 THIS OPTICAL ILLUSION GIVES AN INKLING OF JUST HOW FRUSTRATING PROGRAMMING IS, IN A WORLD OF CONFLICTING SYNTAX.

Exploration of Passenger Ship Layout against Fire Effects
M.SUJITH SAM. Private Student India

The design of cruise ships are influenced by a numbers of factors which range from:

- Their role and operational capability in a competitive commercial market.
- Through life costs.
- A whole load of technical requirements such as addressing the various safety issues, providing high levels of comfort and at the same time operating as environmentally friendly as possible.

One of the major tasks involved in the design of a cruise ship is to research and assess the various safety issues which needs to go into the design and this can become a major factor when the layout is being altered using the conceptual design tool SURFCON©. The factor, which affected the alterations on all the designs, had to do with the passenger evacuation and the formation of congestion points at various points along the length of the ship.

The dissertation discusses the use of the Building Block Design Methodology, the conceptual design tool SURFCON©, and cruise ship design in general. Several discussion points on various areas of design are illustrated as well; these include the powering aspect of design, the stability implications and overall design limitations based on dimensions.

From the resultant balanced ships, each of which were laid not so that the congestion problem would be avoided, it can be seen that a simple (like the one

used in this thesis or even something more complex) passenger evacuation program can be tied up with SURFCON© at the early stages of the design work so that the naval architect can make sensible decisions about the vessel layout with the safety aspect in mind early on the design process.

The bulk of the work and time that went into this thesis was spent getting used to the PARAMARINE© and SURFCON© software packages after having no prior knowledge of either of the two packages. However, with time the tool was found to be more flexible and at a later stage when a few variants were modeled using SURFCON©, it was realized that it has potential for being a highly useful concept design tool.

Comparative Studies for High Speed Applications Monohull vs Catamaran vs Trimaran
LIEUTENANT G. UNNIKRISHNAN IN

Selection of a hull form that is the most appropriate for a specific set of customer requirements in the concept design phase would involve conducting the actual design process including the use of a sizing spreadsheet. Consequently, with the existing ship design procedure, every time a staff requirement is given, the designer has to go through the basic initial design sizing process. It is quite tedious and may not actually predict the correct hull form that is best suited to meet the customer's operational requirement unless the same process is repeated for different hull forms and a detailed performance analysis undertaken.

This thesis undertakes a comparative design study of three different hull form types for high-speed applications. Before the actual formulation of the new method, a thorough study of the different comparison studies conducted the world over was undertaken. This was to give an insight into the methodology adopted and the areas to be focussed on in these studies. It was concluded that such a design study to produce some general guidelines to design the hull form based on the initial input has never been done before. Hence the aim of the thesis was to eventually establish a logical approach to hull form selection without the requirement of going through the concept design stage initial spreadsheet sizing and the iterations involved. This would result in the prediction of the right hull form that would be the most efficient given a customer's operating requirements.

A set of plots one each for the warship and the fast ferry were generated with the help of a number of balanced designs/empirical expressions from data obtained from existing ships. For a warship a monohull/trimaran hull form has been used. Certain plots do differ between the hull forms but the overall sequential design methodology is the same. In order to create a catamaran hull design flow chart an effort was made using the SES design concept without the lift fans coupled with certain inputs from the fast ferry design. For the fast ferry design only the monohull/catamaran hull forms have been used. The design methodology used in the UCL trimaran fast ferry design was based on the trimaran warship concept but incorporating the merchant ship weight groups. This trimaran ferry design did not seem to fit into the concept of the existing fast ferry design, so the design of a fast trimaran fast ferry was not undertaken. For performance evaluation, monohulls of different displacements were generated using software PARAMARINE Ver 3.1.1 and these were the exported into PC GODDESS Ver 3.0 to undertake the sea keeping analysis. Slamming frequency, MSI and Vertical accelerations were analysed for different speeds, varying displacement and plots were developed using standard criteria to evaluate the speed reductions caused due to the set criteria. The same plots could be used for a trimaran with certain modifications but no analysis was done for a catamaran as the catamaran hull form could not be modelled in this version of PCG.

The new design methodology had to be verified to check the effectiveness in the actual designs. For this a number of UCL warship designs both monohull/trimaran including that of the LCS and existing fast ferries were used to validate the design plots and guidelines. All the designs obtained were with ± 20% of the actual balanced ship designs obtained using spreadsheets calculations. All the design analysis had to be undertaken using the range of assumptions proposed.

MARINE ENGINEERING

Fatigue Crack Shape Control by Stitch Cold Rolling
LIEUTENANT J. BOYLE RN

Fatigue crack initiation and evolution have been the focus of research for well over a century, with numerous investigations into crack prevention and means of prolonging fatigue life. To support this, a number of surface treatments have been developed, including cold rolling, which introduces beneficial compressive residual stresses into the surface of the material. The existence of these residual stresses is known to prolong the fatigue life of components.

In recent years an increasing acceptance that cracks will occur has led to a greater focus on early identification and control of their development. One such area is the concept of stitch cold rolling. Developed by the NDE Centre at UCL, stitch rolling consists of cold rolling in which a targeted area of a specimen is left un-rolled. This has been demonstrated to force crack initiation in the un-rolled region and to directly affect crack shape evolution. This offers benefits in many applications, from dramatically reducing the areas of a component requiring monitoring for crack initiation, through to the potential for 'designer' cracks that are forced to grow through a component, causing leak before break as opposed to catastrophic failure.

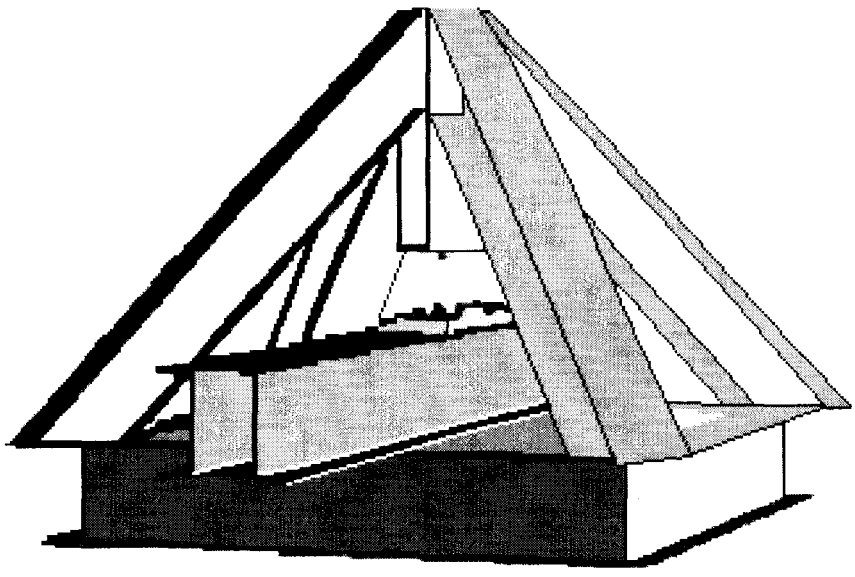


ILLUSTRATION OF A COLD ROLLING RIG

The aim of this project was to design and build an experimental rig to carry out cold rolling in a controlled manner. A number of test specimens were produced in a variety of stitch rolling configurations to verify and demonstrate the effectiveness of the apparatus. Specimens were subjected to fatigue testing to investigate the effect of the stitch rolling process on crack shape evolution. A MATLAB program was also developed to investigate theoretical prediction of crack shape evolution for direct comparison with the experimental results and to predict the effect of different crack aspect ratios on crack growth in support of future stitch rolling research.

Merchant Ship Damage Control
LIEUTENANT COMMANDER D. BRIDEAUX CN

The objective of shipboard Damage Control (DC) is to prevent damage from occurring and to reduce the impact of damage that does occur. If damage control is successful then the likelihood of a ship not having an incident and completing its mission, or at least surviving an incident and returning to port, is improved.

Merchant ship DC philosophy is to make the ship inherently safe and focuses mainly on actions taken in advance of an incident, with the majority of these actions affecting the design or construction of the ship. The requirements of a merchant ship design are regulated by a series of International conventions and Flag State regulations. These international conventions, the most important being the Safety Of Life At Sea (SOLAS) convention, have developed over time based largely on technology changes and lessons learned from maritime disasters. In order to stay current, the SOLAS convention has been amended, recently every 6 to 12 months, with many of these amendments being retroactively applied to ships already in service. The goal of this convention is to ensure that ships have sufficient inherent safety and flexibility to preserve the safety of life at sea.

Naval ship DC philosophy assumes that the ship will be exposed to greater threats and that damage is likely. The goal of warship damage control is to make the ship less vulnerable to the threat, less susceptible to damage, more able to recover and ultimately to ensure that the weapons system is able to remain in theatre and continue fighting. A warship must also be inherently safe and must have an enhanced flexibility to respond to any damage control problem. This flexibility is achieved through a greater level of system control and redundancy, and a high level of equipment and manpower available for damage control.

This paper reviews the philosophy that has developed through the merchant ship regulations for Safety of Life at Sea and looks at the impact that the amendments to those regulations are having on the existing merchant fleet. The merchant ship DC philosophy is compared to the warship philosophy of float, move, fight to identify areas where the application of warship philosophies could enhance future merchant ship rule development in view of the increasing threat.

Modelling and Real-Time Simulation of an Integrated Full Electric Propulsion Warship
LIEUTENANT C. FERREIRA BN

The aim of the project is to develop system models based on the proposed Type 45 destroyer propulsion system using appropriate computer modelling packages such as MATLAB/SIMULINK Power Systems Block Set and High Level Languages. Some sub-system models are already in existence, such as the WR21 ICR gas turbine and propeller, from earlier studies, so it will be possible to focus on the modelling of the electric components, which are the main and novel part of the system.

Once a system model has been developed, studies will be undertaken for a number of scenarios such as:

- Transient analysis such as crash stop.
- Faulted electrical systems.
- Operation of small diesel engines when paralleled with large gas turbines.

The following tasks will be carried out:

1. Establishing the key governing equations for propulsion design.
2. Establishing equations for the various equipment within the propulsion system.
3. Modelling the propulsion system using computer based tools.
4. Undertaken performance analysis in steady state.
5. Comparing performance with declared results in the literature.

Special consideration will be taken during the modelling of the Advanced Induction Motor regarding the reference frame to be adopted. The usual 'qd' reference frame simplifies the simulation, but leads to imprecise evaluation of phase currents in the case of unbalanced voltage supply. Alternative methods of modelling without the use of reference transformation will be assessed, and the results analysed.

Finally the requirements for real-time simulation will be determined. Computational modelling and simulation of engineering systems are very usual ways of de-risking new projects, and generally requires a large amount of successive 'runnings' of computer models, in order to adjust and test parameters, and to generate the maximum amount of output data for further analyses by specialist teams. In addition control algorithms are being currently designed incorporating computational models, which generates data in order to calculate the 'error flag' and define the control action. For these reasons the real-time simulation is an important issue, and ways of reducing the simulation time through software or hardware upgrades will be assessed.

An investigation into the use of Polymer Based Materials in Power Transmission Gearing

LIEUTENANT, M. GOODALL RN

Today, polymer gears are selected over steel in certain applications offering advantages such as:

- Silent operations.
- Minimal cost.
- Low weight.
- Ease of manufacture.

Unfortunately their use is limited to positional and low power transmission systems. The aim of this study was to quantify current polymer gearing performance, and investigate possible methods of improving their capability relative to steel gearing. This entailed the creation of a number of analytical and finite element models to compare the performance of both steel and polymer gears. The results illustrated failure modes of bending and contact in polymer and steel gears respectively. This lead to the designing of a composite gear concept, formed from a number of punched steel plates, separated by steel spacers and encapsulated in a polymer. After further investigations concerning material selection and composite structure behaviour, it was proved that Phenolic, a thermosetting polymer, would be ideally suited to the gear tooth loading characteristics. Further

theoretical analysis of the proposed composite gear concept illustrated a potential load carrying capability greater than a dimensionally identical pure steel gear, combined with associated reductions in weight and cost.

Unmanned Ships

G. GRONTIS, Private Student Greece

In the early 1960's, in order to compete with the cost effective operated fleets of flags of convenience and the heavily subsidised Eastern block countries, shipping companies in Europe and Japan started to implement shipboard automation to reduce their operating costs.

Since 1970's automation has been continuously introduced on board ships and consequently fewer people are employed in a typical merchant ship than was the case prior to the middle of the twentieth century. The drive towards smaller crews is not a new phenomenon, however. In the latter half of the nineteenth century many sailing vessels were rigged, or re-rigged, because such arrangements required fewer men than the full-rigged ships that could no longer compete with the increasingly economical steamers then entering service.

Nowadays the automation process has reached a peak with the introduction of 'periodically unattended machinery spaces' and 'integrated bridge control systems', which have enable 'one man watch' operations to be quite possible.

The project aims to investigate, from technical and economic viewpoints, the feasibility of a totally automated, unmanned merchant ship as an option to solve economic and manpower difficulties at sea.

Application of AIP Technologies and Zebra Batteries for VICTORIA class submarines

LIEUTENANT COMMANDER R. GULATI CN

The Canadian coastline is bordered on three sides by three different oceans. These include the Atlantic and Pacific on the East and West Coast. In the north lies the inhospitable and frozen Arctic Ocean, which ship and diesel submarine vessel traffic is unable to transit for the majority of the year. For this reason, Canada has been unable to assert her sovereignty over this part of her domain since confederation.

Canada does not possess any nuclear powered ships or submarines. Her navy uses only traditional technologies such as air breathing gas turbines and diesels engines. In the late 1980s there was great hope and the nation was close to acquiring a fleet nuclear propelled submarines. The choice had been narrowed to the RN TRAFALGAR Class and the French RUBY class. However, this acquisition was cancelled in 1988 due to fears from the general Canadian population who did not wish to see Canada go 'nuclear'. Since that time, the Canadian navy has been exploring non nuclear alternative submarine propulsion technology which would allow limited patrols Canada's third ocean in the north.

There are non air-breathing alternatives to the nuclear option. These are as follows:

- SSn which uses a small reactor to conduct low speed operations and trickle charge the batteries.
- Fuel cell technology is past the stage where it is an intellectual or research curiosity. The application of this technology to the marine industry and more specifically to VICTORIA Class submarines will be investigated and assessed in this paper.

- Stirling Cycle - This report will investigate the applicability of the Stirling cycle engine to the VICTORIA class submarine.
- Closed Cycle Diesel technology which uses a traditional diesel engine and carries its own oxygen in tanks.
- Traditional Diesel Engine and Improved Zebra Batteries. Recently, Rolls-Royce PLC (UK) has developed a high density long lasting battery known as the Zebra Battery which offers over four times the energy density of traditional lead acid batteries

This report will survey the current state of the art with regard to AIP systems and batteries. This will be done via literature survey and interviews. Interviews will be conducted with submarine officers and factory representatives. The results will be presented and compared with regard to size, cost, operational benefits and RAM. In the end, a recommendation will be made to see what is the best option for a successful Engineering Change for the Canadian Forces VICTORIA class submarines.

Tug and Barge Coupling Systems
LIEUTENANT A. MURCHIE RN

Tugs and barges have operated for hundreds of years and in America alone tugboats, towboats and barges move more than 800 million tonnes of cargo every year. Within this field, the last 40 years have seen more and more owners and operators turn away from hawsers and heavy towing gear and move towards pushing barges at sea. The benefits of pushing barges are numerous but essentially it improves safety, reduces capital and operating costs and allows design and configuration flexibility. To this extent, 'pusher' tug barge units are not only replacing towed barges but also encroaching on the conventional shipping market.

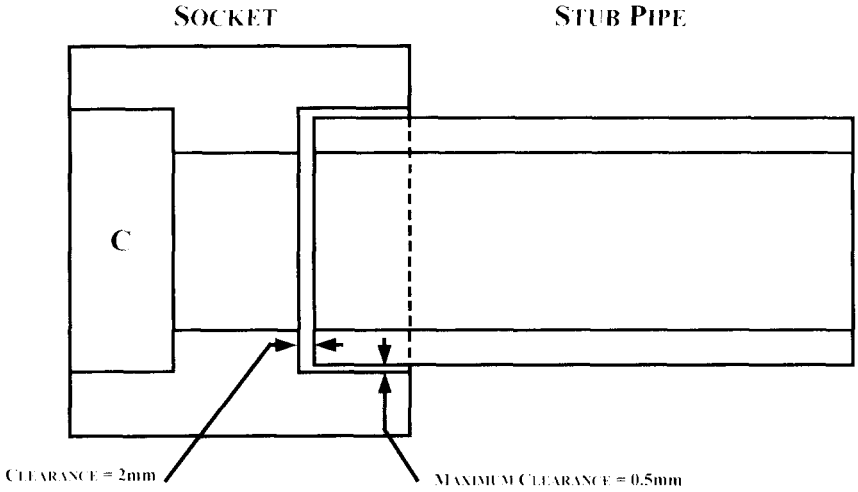
As the benefits of pushing have been realised, various methods of connecting the tug to the barge have been developed, most notably in the US coastal trades to Japan. These systems range from variations of simple rope lashings to complex mechanical linkages designed to either rigidly connect the units or allow them freedom in one or more planes/axes. Most modern systems utilize a specially shaped notch at the barge's stern which mates with the tug's bow. An articulated linkage then connects the two vessels, permitting them to pitch independently of each other whilst maintaining a positive connection.

This report details the development of pushed barges, their current uses and discusses their general and economic advantages over pulled barges and conventional ships. The basic linkage types are explained and descriptions given of the major connector systems currently in service. The requirements of a new connector system are then defined, concepts proposed and details of the final design solution provided.

Investigation into the failure of Socket Welded Joints in Hydraulic Systems employing Finite Element and Failure Analysis Techniques
LIEUTENANT P. NIMMONS RN

Welded 'sockets' are a commonly employed fabrication technique for the assembly of 'all welded' high pressure systems. The use of 'Cupro-Nickel' sockets and pipe work in the construction of hydraulic systems is commonplace, with a socket or sleeve connection being used to join prefabricated sections in situ. Failure of the closure welds in these assemblies is both costly and difficult to repair, leading to an extended period of system down time. One such socket weld failure was used as the basis for the project.

The subject weld had failed with a through thickness defect leading to a hydraulic leak. The weld was repaired, however, subsequent non destructive examination revealed a second defect on the other closure weld. The assembly was removed and the geometry of the weld profile revealed by sectioning.



SOCKET ASSEMBLY

The removed assembly was used in conjunction with the weld specification to construct a finite element model. The model was then manipulated to establish the stresses around the circumference of the suspect weld. The results from the finite element analysis were then employed within a fracture mechanics failure analysis following the guidance prescribed by the British Standard (BS7910).

The procedure was encompassed into an Excel spreadsheet constructed to predict the life of such a weld, and suggest a suitable inspection interval based upon geometric deviation from the specified pipe/socket clearance.

Heat Management in Electrically Propelled Warships
LIEUTENANT S.RAWSON RN

The heat loads within a warship are a consequence of operation and will depend upon machinery load, ambient conditions and location. Managing heat impacts upon areas that are crucial to sustaining worldwide operations such as habitability, weapon and propulsion systems performance.

The aim of this thesis was to undertake a whole ship assessment of heat management in electrically propelled warships. To identify where heat loads occur, determine where losses can be reduced or recovered and investigate energy efficiency techniques.

Every user of energy will have an impact upon heat and thus whole ship management encompasses a great many disparate areas. Yet heat within a ship is currently viewed as an issue simply to be mitigated. Failure to address heat management at the early design stage fails to optimize the platform, reduce energy consumption and ultimately drive down costs. Heat will be of greater significance to warship that employ integrated electrical propulsion and development of a thermal model would benefit future ship designs.

A thermal model of ship has been developed using software that simulates the thermal performance of buildings. The main applications of the program are in assessment of:

- Environmental performance.
- Ventilation analysis.
- Prediction of energy consumption.
- Plant sizing.
- Analysis of energy conservation options.
- Energy targeting.

The programme uses dynamic simulation to model the thermal response of a structure over a set period. Heat loads were based upon the weapon and propulsion systems of the Royal Navy's Type 45 destroyer operating at full load in the Persian Gulf. This provided an assessment of the ship's performance under specified conditions and enables the impact of the thermal processes within a ship to be calculated. The benefits and limitations of using building performance software as the basis of a ship thermal model is discussed.

To thesis has also explored the potential of energy efficiency options including:

- Waste heat recovery.
- Alternatives to refrigerated heat sinks.
- Variable speed drives.
- Solar shields
- The use of efficient electric motors within ships.

Control of High Speed Littoral Ships
C.TSIREBOLOS. Private Student Greece

Recent experience has, in a dramatic way demonstrated that there is a need to improve the hydrodynamic design, construction and operation of HSC (High Speed Craft) with regard to safety. The safe operation of high speed craft in congested waters and harbour areas requires improvements in onboard management, manoeuvring and handling control, navigation and basic knowledge of craft performance characteristics.

Due to its very nature, high speed navigation sets demanding requirements for the crew. Fast ferries often operate in areas of high traffic density and in restricted waters, factors that make the stress on navigators high. Knowing the limitations of the man-machine system and knowing the effects of human and technical failure is absolutely vital in order to ensure safe system handling and operation. A highly automated working process, which can be found on modern high speed craft, is marked by an especially high demand of human information processing and ability of decision-making.

This project attempts to identify the options for reducing risk within a littoral environment and how technologies are being exploited to assist in the safe operation of the vessel. Emphasis is given in the use of navigational decision aids such as Automatic Identification Systems and novel vessel control methods.

Particular studies are focused on the integration of navigational aids and the human-machine interface when operating at high speeds and how different control surfaces may be used to carry out the control function.

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Permanent Magnet Machines for the Royal Navy

LIEUTENANT K. WATKINS RN

With the recent developments in power electronic converters such as the PWM and improvements in rare earth magnetic material properties the PM Synchronous Motor has undergone a revival with major manufacturers investing in the technology. This has been evident in the development of the Siemens Permasyn and the ABB Podded Motor drive. However, these motors are 'one-offs' designed for a specific application where space and weight are more important than the cost of the motor itself. This study concentrates on small to medium size motors and studies the feasibility of replacing the traditional asynchronous motor with a PM synchronous one.

This report logically flows through the development of PM materials, concentrating on NeFeB and SmCo using respective demagnetisation curves to discusses the advantages and disadvantages of each. Radial and Axial Flux machines are then investigated with the emphasis on the role their possible use onboard. The report also utilizes optimization methods to discuss optimal motor size when considering cost versus material of PM versus copper windings on the rotor. The study then focuses on the direct comparison between torque, power and size considerations of the asynchronous and PM synchronous machine.

To complete the study a Simulink model is developed of a PM Synchronous motor using field oriented control. The models outputs are then compared against the results of an asynchronous motor to validate assumptions on performance. A sizing tool using Excel has also been developed and has also been validated using the Simulink model.

Finally, the results of the study are drawn together to establish the relevance of PM motors in onboard applications.

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The full reports are held at the University and further information may be obtained from:

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