**Hydrodynamics of High-Performance Marine Vessels. Volumes 1 &2**

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**General**

This Magnus Opus runs to two volumes over a total of 836 pages, so it covers a huge area of research spanning from papers written in 1874, by Froude, to the date of publication of the book. This work is an essential guide to anyone new to the area of high-performance craft as well as died in the wool researchers. The list of references, chapter 19, contains 76 pages of papers! To be able to track these down for a new doctoral student would be difficult, but Professor Doctors have now achieved that. It is noted that the use of American spelling persists throughout, no doubt reflecting the award of an ONR grant, which supported the production of the work. It must be said that the quality of the pictures is outstanding and that applies to the figures, which are all produced in a uniform clear and precise manner. The attention to detail is first class; there are nearly 50 pages of contents, lists of symbols, tables, and graphical representations. Rather give a general overview of this large work I have summarised the each chapter.

**Volume 1**

*Chapter 1 Introduction*

This chapter of 12 pages introduces the concepts of high speed and the affects it has on the design of hulls that can achieve such speeds. The hulls can of course be monohulls, catamarans, or multi-hulls and then the air-supported vehicles are discussed in an overall manner, all of which are given separate chapters in the book. Finally as one might expect there is a dimensional analysis and Froude scaling definition.

*Chapter 2 Hydrodynamic theory*

This chapter of 25 pages explains the basic potential theory for water waves in deep and finite depth water. The concepts of phase velocity and group velocity are derived in a clear and consistent manner that mirrors that used in my own lecture course on fluid dynamics. What is illuminating is for practitioners to realise is the errors that can be inherent in the use of the deep-water conditions when in fact shallow water theory should be used. Therefore, subsection 2.4.2 is excellent.

*Chapter 3 Viscous resistance*

This chapter of 40 pages explains how the conventional methods of Naval Architecture are derived for analysing the effects of viscosity on the estimation of resistive forces to forward motion. What I found useful was to have a list of all the friction lines and their associated reference papers. So traditional Froude scaling is detailed together with methods more appropriate to multi-hulled vessels. Form factor estimation is introduced as in roughness of the wetted surface. In section 3.4, the current vogue of air lubrication is tackled showing that work has been ongoing for 50 years or more! Equally, riblets are explained, as are the injections of polymers to reduced overall drag of the hull. The final part of the chapter assess how air drag of the above water ship is estimated.

*Chapter 4 Transom sterns*

This chapter of 32 pages takes the reader through the some interesting ideas about why transom sterns have found favour in design. I did find the order of this chapter strange; I would have thought that it should have appeared after the final chapter on hull types. Again, the pictures in the book allow the whole aspect of transoms to be seen in the shipyard and underway. The author concludes that it allows the installation of a waterjet to be easily fitted to the boat. The theoretical reasons are then given their head: mainly fully ventilated flow, the conditions for ventilating are explored. The experimental validation using geosim series with a conclusion that the free surface behind a transom stern exhibits a high degree of unsteadiness in comparison to elsewhere in the flow. This of course is excellent news for researchers into this area! The aspects of measuring ventilation is explored, as is the determination of the critical transom-draught Froude number. The theory is presented using linearization with its inherent difficulties and then the theory moves to explore the non-linear inviscid flow models. Clearly, this is still a fruitful area for research.

*Chapter 5 Monohulls*

This chapter of 67 pages gives an insight into the whole aspect of the development of monohulls, which has dominated the high-speed marine sector. In this case, the theory of wave resistance, which by far is the major component of drag in the high-speed regime, using initially the point source travelling in deep water, the so-called thin ship theory. In particular, equation 5.52 is available for the intrepid designer to evaluate. This then is generalised with channels of finite depth and width. Experimental results of two geosim series are given for validation of numerical results. The numerical results at the depth Froude number of 1 are presented and compared to experimental results. After this mammoth set of work, the shallow-draught approximation is explored and comparison is given between numerical and experimental results for the Wigley hull. With high-speed monohulls, the trend has been for more slender forms with the inherent problem of lateral instability. This has then meant that foil-stabilisation has been rather than employing sidehulls, the subject of the next two chapters. The use of so-called T-foils is explored with its ability to control pitch and roll on many current catamarans. The conclusions indicate the use of stabilisers have a small drag penalty as well as indicating that the monohulls has an advantage over catamarans in reduced hydrodynamic resistance.

*Chapter 6 Catamarans*

This chapter of 22 pages explores the recent development of powered catamarans, which have developed in the past few decades. As in the previous chapters, many really excellent pictures of catamarans of various design houses. These show the development of the designs from relatively small displacement up to the modern very large wave piercing designs. Again, the reader is treated to the determination of wave resistance using slender body theory and in particular, the effects of testing in towing tanks because of wall interference. Experimental validation of the theory is given from two sources, namely AMC and University of Southampton. The clear conclusion is that linear theory gives reasonable correlation between the experiments and theory. The interference caused by the demi-hulls is explored in terms of parallel and staggering the configuration. It seems that a good prediction can be made from linear theory for the total resistance. The staggered hulls superior performance is also validated.

*Chapter 7 Trimarans and other multi-hulls*

This chapter of 38 pages continues from the previous discourse on multi-hulls and the bigger trimarans are exemplified with MV *Triton* and USS *Independence.* The theories presented in the previous chapter is again used to estimate wave resistance and total resistance values. Whilst there is a great deal of interest in this style of design, there is a paucity of experimental data in comparison to that of catamarans. Interestingly, there are figures presented using CFD software to illustrate the bow wave profile and is associated free surface. This is an area of research that is taking advantage of recent changes to CFD software. The number of side hulls is investigated and Figure 7.14(a) is indicating that mono-hulls have the best characteristics in that it possesses the lowest total resistance. The SWATH hull concept is then viewed and the reader is directed to section 7.6 for some interesting conclusions. An interesting comparison of monohulls, trimaran, and sesquimaran is given.

*Chapter 8 Air-cushioned vehicles*

This chapter of 83 pages explores the air-cushioned design. There are some pictures of the earliest ACVs manufactured. The early development of Hovercraft in the UK is explained and the development of skirts and their material properties. The change from SRN1 to the propeller driven SRN2 onwards is clear to see. The cutaway diagrams for the whole series of SRN is extremely instructive. The other companies who went onto develop hovercraft are shown with interesting pictures of the water jet and air propulsion VT series which were large craft. Parallel development took place with smaller handy sized hovercraft such as the HD series. The chapter then shows the development of Hovercraft in a whole series of countries throughout the world. In fact, this is probably the most encyclopaedic set of data for ACVs that I have ever seen and is to be commended to those readers new to the craft. After 40 pages of detailed information of worldwide designs, the design of lift systems is explored in theory and of course, the plenum chamber and annular jet flow that was favoured by many designers. The theory of a travelling pressure platform is given for the estimation of wave resistance. The familiar resistance curve with humps and hollows that give rise to the cobblestone effect are produced. Experiments were conducted by NPL and this is a good source and review of their findings. The question of optimisation is addressed but there are no experimental data available to validate the findings.

*Chapter 9 Skirts and seals*

This chapter of 56 pages explores the remaining element not dealt with in the previous chapter, i.e. that of skirts and seals. The early designs of ACVs hade daylight under the hull, this of course necessitated the installation of a huge power to lift the craft and maintain this equilibrium. The use of a skirt or seal to contain the air cushion was a major development. Therefore, the material and design of multi-sectioned plenum chambers has led to many varied designs. All those are explored within this chapter and as far as I can see, there is as complete a discourse that can be found of this subject. The aspects of the research reported in this chapter includes the use of techniques to measure the waves within the internal chambers. The remaining problem is the wear of the skirts and seals and data is given on this problem in figure 9.14. The theory used allows for linearization’s of pressure segments to be explored and then to derive overall estimates of wave resistance.

*Chapter 10 Surface-effect ships*

This chapter of 44 pages allows the reader to understand the development of what are often called side walled hovercraft. The various incarnations of this design are given in detail within the pictures and backed up by sufficient theory to allow those interested in this are to be able to produce design estimates for powering. The major problem is still with the flexible seals at the bow and stern and how to produce a resilient enough material to allow for daily usage.

**Volume 2**

*Chapter 11 Planing Craft*

This chapter of 60 pages takes the reader through the definitions of planning followed by a history of the development of such craft and notes that Froude’s experiments in 11875 deduced a deadrise angle of 3.3 degrees is very similar to current craft values. The pictures in figure 11.2 allow the reader to experience the power of such craft. The type of hullforms used for planning craft are discussed in detail and the advantages of round bilged and hard-chine forms in particular. The chapter takes the reader through the whole of current theories starting with semi-empirical methods for flat plates using much of the work of Savitsky for validation. The next topic is that of prismatic surfaces and hence onto equilibrium conditions and usefully for engineer and research student alike some sample calculations are presented.

This is followed by modifications to planing hull theory and the effects of different elements of the geometry of the vessels. The detail is immense, precise, and definitely useful to practitioners of design and the research student. I found the order of this chapter a little strange in that theories were talked about at the start and then the theory is given in detail from page 434 onwards, but at this stage, it is focussing on three-dimensional methods. The use of CFD methods is then given full rein showing how theory and experiments are converging. Optimisation is then ad dressed and the final section gives details of the hyper-planing vessels such as Spirit of Australia

*Chapter 12 Wave Generation*

This chapter of 50 pages allows the reader to understand the wave generation characteristics in deep, shallow and width constricted situations. All of these parameters affect the height of the generated waves and in turn reflect the amount of power that a ship has to put into the water to operate at different speeds in widely varying operational conditions. The theory elaborates the velocity potential methods for defining the wave height and the wave pattern in different conditions. The effects of multi-hulls is shown to be predicted well as is also shown in Molland *et al* (2004) who were aiming at optimising a catamaran form operating on the River Thames. It is good to have the effects of viscosity, surface tension, and surface elasticity explored in some detail. The contour plots of wave terms are well presented in figure 12.8. The work on air-cushioned vehicles is too brief and misses the work of PACSCAT e.g., Molland *et al* (2005) which contains contour plots of the wave system inside and outside the pressure field. The work of SES ships brings together nicely all the known work on wave pattern measurements and as the author states, it is pleasing to note the good correlation between theory and experiment. As in Chapter 11, the characteristics of ship waves appears a long way into the text. I think this should have been much earlier in the chapter, since many researchers start from here. The text reinforces the theory of Laitone and Stoker and the fact that the transverse and divergent waves meet on the kelvin line, but with a phase difference of 90 degrees. The importance of this chapter is in re-enforcing the decay rate of the wave system in both deep and shallow water. Non-linear effects are addressed for reduced depth situations and show the wall effect on wave height generation. Overall, the chapter is an excellent point for new research student to start from existing methods and experiments.

*Chapter 13 Sinkage and Trim*

This chapter of 32 pages deals with the prediction and experimental measurements of Sinkage and trim of vessels in confined waterways. The work focuses on the regression work of Barrass and also that of Fergusson for relatively straightforward cases, but the chapter then goes on and develops the forces but without the explicit details. The theories are velocity potential methods which use work generate din the previous chapters of this book. The results of the experiments conducted on the catamaran series of Southampton are used as trial horse and concludes that the comparison could be good or indifferent depending upon the reference point used for origin of the co-ordinate system. The effect of the Froude number is clear to see in both experiments and theory and trends are identical. The chapter then explains how air cushioned vehicles (ACV) have a theory that allows again give approximately similar values. For surface effect ships, the paucity of wave elevation data within the chamber does not allow comparisons with theory. The chapter finishes off with data generated for a Wigley Hull in shallow water and shows a clear agreement with theory. Perhaps the work of Squires (1992) and the allied work of Wu and Eatock-Taylor could help with validation.

*Chapter 14 Unsteady effects on resistance and wave generation*

This chapter of 38 pages covers a topic that is often neglected, that of unsteady effects on ship resistance and wave generation. The author sets up the problem as a second order differential equation for all the problems that have been elucidated before, this ship theory, pressure fields and SES craft. The solutions are presented for example equation 14.15 on page 551. The problem then is the interpretation of the last two terms and how accurate can these be evaluated numerically. As far as I can tell, the methods are complete, as I would expect and sufficient information is given for example using the steady state limits to gain confidence in the answers. The main problem is the lack of reported experimental data, but where it does exist; the trends are good and in some cases very close indeed to the numerics. The aspects of this chapter that are rarely reported are those associated with manoeuvring in such cases. The equations 14.62 and 14.63 will go a long way to help designers and researchers in this area.

*Chapter 15 Motions of displacement vessels in waves*

This chapter of 44 pages and allows the reader to understand the current level of knowledge in this area of research of displacement vessels in a seaway. The results from theory and experiments in general have good agreement for heave and pitch and for the later plane motions; the answers are tolerable if a reasonable estimate of roll damping can be made. There is a much longer text available in Lloyd, *Ship response in a seaway.* The biggest experimental challenge will be with ships and ship models that have stabilisation using T-foils or some akin to this stabiliser. The biggest differences seem to be with measurement of wave height, see figure 14.22 (c).

*Chapter 16 Motions of nondisplacement vessels in waves*

This chapter of 42 pages is a continuation of the previous chapter but for ACVs, SES and planing craft. Good source of data for verification of numerical methods.

*Chapter 17 Afterword*

This final chapter of 17 pages contains extra experimental resistance data that applies to various studies within the other chapters. The author also discusses an alternative measure of the resistance of a vessel in terms of the transport factor.

Chapter 18 Appendix

This contains a dictionary of ship terms and usefully for many a reminder of many mathematical relationships, from Pythagoras’ Theorem, cosine, and sine integral Wehausen wave functions.

Thus to summarise an excellent book in two volumes that will be a source for a wide variety of engineers new or old to designing high-performance marine vessels as well as doctoral research students and many current researchers in this active field of study.

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