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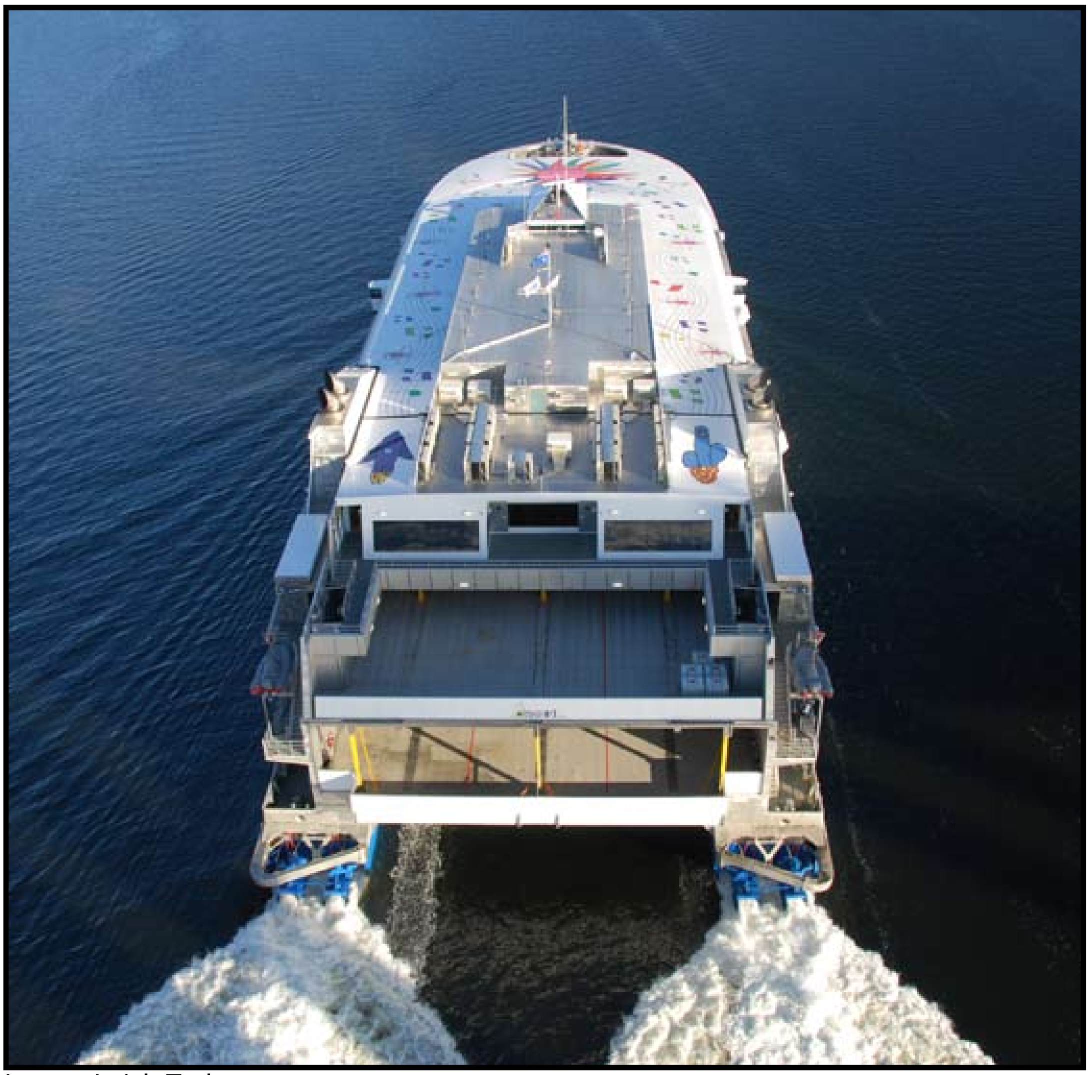

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HamiltonJet

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International Conference

WATERJET PROPULSION 5

11 - 12 DECEMBER 2008

RINA HQ, LONDON

This international conference continues the very successful series of RINA events looking at developments in waterjet propulsion.

Waterjets are now accepted as a proven technology, particularly for high speed craft and they are increasing their penetration into small craft, leisure, workboat, patrol and military markets. Today, waterjets are becoming the preferred propulsion choice where high efficiency, enhanced manoeuvrability, shallow draft capability and low maintenance are key requirements. Continuing developments now include very large units of 30MW capacity and the use of waterjets for high speed boost propulsion.

As the technology matures, designers need better tools to help predict the performance and efficiency of these systems across a wide range of operating conditions. Computational fluid dynamics is an increasingly powerful tool which has become almost universal, but traditional model testing and trials measurements are still required to confirm critical results.

Designers and manufacturers also continue to seek to reduce noise, wake and wash as well as optimise the strength and weight of the various mechanical components and to improve reliability, reduce installation time and maintenance.

day 1

09.30 – 10.00 **Coffee & Registration**

10.00 - 10.35 **Waterjet Applications in Vessels that Operate in Multiple Modes**
D Borrett & P Rae, Hamilton Jet, Australia

An offshore crew boat equipped with a dynamic positioning system is used to illustrate the requirements and capabilities of waterjets in “multi-mode” applications. Waterjets for this type of vessel must perform over the wide range of transit speeds resulting from variations in cargo loading, and deliver the high manoeuvrability needed for accurate station keeping. In addition to the waterjet propulsive efficiency at speed, key factors in achieving these goals are the steering efficiency, cavitation margins under high loading conditions, high available static thrust, and the speed and accuracy of thrust vectoring.

10.35 - 11.10 **Off-Design Behavior of Waterjets.**
N Bulten & R Verbeek, Wartsila Propulsion, Netherlands

Waterjets and waterjet inlets are usually designed for a limited number of operational conditions. During a turn and in manoeuvring conditions the flow in the inlet will deviate quite considerably from the flow in normal sailing conditions. This will affect the cavitation bucket of the inlet, performance of the pump and forces on relevant parts of the waterjet. Simulations of these effects in off-design conditions were made with aid of a CFD code. The paper gives an overview of the different phenomena occurring at these conditions and how this will affect overall performance.

11.10 - 11.40 **Coffee**

11.40 - 12.15 **Research of the optimum number of mixed flow waterjet pump blades based on CFD**
Yang Qiongfang, Naval University of Engineering, China

Effects of changing the number of pump blades of both rotor and stator on the characteristics of flow pattern and waterjet propulsion performances are principally investigated in this paper, which includes the changes of rotor blade numbers from 5 to 7 to the effect of Stodola slip factor, of stator blade numbers from 9 to 13 to the effect of commutating result acting on the outflow of impeller, and of both rotor and stator blade numbers simultaneously to the new pumps' performances. It shows that: given the condition of fixed pump revolution and vessel speed, the Stodola slip factor, the head, axial-thrust and power absorption are all incline as the number of rotor blades increase, but the efficiencies decline; the circumferential velocity of the nozzle outflow weakens with the increase of number of stator blades, but the improvement is approximately unchangeable when it comes to 11.

12.15 - 12.50 **A Multi-Objective Automatic Optomisation Stratergy for Design of Waterjet Pumps**
M Zangeneh, University College London, UK
B Da Costa & K.DaneshkhahAdvanced Design Technology

A pump designed for a waterjet application should be part of a robust and reliable propulsion unit that gives high propulsive efficiency. This should be accomplished with low weight, including entrained water, and small dimensions. The pump needs to cope with various inflow conditions without cavitation erosion problems or excessive noise. In order to meet these contrasting requirements, a design strategy is required that can consider a large part of the design space and provide information on trade-offs between contrasting design objectives. In this paper we present a design strategy based on coupling a 3D inverse design method, in which the 3D blade geometry is computed for specified distribution of blade loading, is coupled with a Multi-objective Genetic Algorithm.

12.50 - 13.50 **Lunch**

13.50 - 14.25 **Waterjet Pump Development for High Performance and Higher Power Density**
M Heder & R Aartojärvi, Rolls-Royce AB, Sweden

A pump designed for a waterjet application should be part of a robust and reliable propulsion unit providing a high propulsive efficiency. This can be accomplished by low weight and small dimensions. The new pump needs to cope with various inflow conditions without cavitation and structural problems. These and other requirements should all have an impact on the design. This paper presents the development of a new high performance mixed-flow waterjet pump with a higher power density than the previous design. The design objective has been to improve the cavitation performance of the pump in order enable a significant size reduction for a given ship speed and engine power. This will result in lower weight the pump unit as well as for the whole propulsion system. Size reduction has a positive effect also on the inflow to the pump and thereby the interaction between inlet duct and pump.

14.25 - 15.00 **Research on Hydraulic Performance of Hybrid Propulsion System**
Cun-lou Sun, Navy University of Engineering, China

Hybrid propulsion systems of waterjet(s) and propeller(s) have many advantages. In this paper, hybrid propulsion system of a waterjet and two propellers is researched particularly. When doing that, pure waterjet and open-water propeller performances are researched and results are verified by experimental data. Flow region of the hybrid propulsion system is simulated by solving RANS equations and interaction of the two propulsors are analyzed. Different rotating direction of the propellers will affect the velocity distribution at inlet ducting and thus the performance of waterjet.

15.00 - 15.35 **Testing Air-Augmented Waterjet Propulsion**
A Gany, A Shemer, A Gofer and D Harlev, Israel Institute of Technology, Israel

A novel design of an air-augmented waterjet propulsion system has been successfully tested, resulting in a remarkable increase in the system’s thrust. This research may present a conceptual revolution for increasing boost capability and maximum attainable speed from a given waterjet system, similarly to the role played by an after-burner in a jet engine. A number of test series have been conducted using a full scale waterjet complex of a Yamaha jet ski. The data obtained from the original motor operation with no air injection served as a baseline. To study air injection effect each test series included thrust measurements at different motor rpm’s with a controlled injection of airflow.

15.35 - 16.05 **Coffee**

16.05 - 16.40 **Simulation of Dynamic Characteristics of Waterjet Propulsion Plant and Its Application on Troubleshooting**
Yongsheng Wang & Ding Jiangming, Navy University of Engineering, China.

A mathematical model describing the dynamic characteristics of a marine waterjet propulsion plant was built up. The rotating-speed vs. power curves of the diesel engine from a test-bed and the speed vs. thrust curves of waterjet were modelled by means of the neural networks. Other components of the waterjet propulsion plant, such as reduction gearbox, were also modelled by manufacture's data. These main components models were integrated into the whole waterjet propulsion system in a simulation program for dynamic characteristic analyses on MATLAB platform. In a case that searching the reason of a friction clutch failure in the reduction gearbox during manoeuvring operation of a waterjet-propelled fast boat, the applications of dynamic characteristic simulation in troubleshooting of waterjet propulsion system was played a very useful role in analysis of main cause for the failure.

16.40 - 17.15 **Numerical Simulation and Analysis of Cavitation Performance of a Waterjet**
Chengjiang Liu & Yongsheng Wang, Navy University of Engineering, China.

With SST turbulent model, hydrodynamic performance of a waterjet at non-cavitation conditions is obtained by calculating RANS equations with computational fluid dynamic (CFD) method firstly. The comparison between calculation results and data from manufacturer shows that the numerical model and method is creditable. Then, cavitation performance of the waterjet is calculated and analyzed with mixture homogeneous cavitation model based on Rayleigh-Plesset equations. Numerical results, such as power and thrust, agree well with manufacture data. The critical inlet velocity ratio (IVR), when cavitation occurs, is obtained. The calculation results show that mass flow rate and total head of the waterjet pump are reduced when cavitation occurs on rotor blades, and thrust declines. The cavitation on rotor blades gets stronger as IVR falls at constant power condition. Inlet duct cavitation lags behind the rotor cavitation, and nozzle cavitation in form of spatial cavitation occurs ahead of the rotor cavitation, but there is no cavitation on nozzle wall.

17.15 - **General Discussion & Evening Drinks Reception**

day 2

09.30 - 10.00 **Coffee**

10.00 - 10.35 **Overview of Recent Developments in Testing of Waterjets at NSWCCD**
Martin J. Donnelly, Naval Surface Warfare Centre, US

In the past decade the U.S. Navy has gained much experience with waterjet-propelled ships. Existing propeller test facilities have been modified to accommodate waterjet tests. NSWCCD has also undertaken numerous tow tank self-propulsion tests of both high speed catamarans and large waterjet-propelled monohulls designed for sealift operations. These tests use extensive LDV measurements of inflow boundary layers, pump internal flows and nozzle discharge flows to determine flowrates and quantify non-uniformity factors in accordance with ITTC recommendations for powering predictions. The ITTC approach is augmented with an inlet wake scaling procedure developed by NSWCCD to make full-scale predictions from tow-tank self-propulsion tests. This modified procedure is compared to a waterjet vendor's approach and full-scale trials measurements. The vendor approach prescribes the input power levels and determines the vessel performance from pump curves and input coefficients for wake fraction, inlet loss coefficient, and thrust deduction.

10.35 - 11.10 **An experience of improving propulsion performance of a patrol vessel**
N Morén, Marine Jet Power AB, Sweden

In the period until 2006, a series of 65-metre patrol vessels with the classic round-bilge hull shape were built at Jong Shyn Shipbuilding Co. in Kaohsiung, Taiwan. Based on the first operational results of these vessels, it was decided by the customer that the vessels performance needs comprehensive improvement. The target was to ensure that the vessel would be able to operate at intermediate speeds on any number and with any combination of engines running without restriction of their rating, to provide a balanced using-up of engines lifetime. Such target made it necessary to use waterjets with a very low speed of cavitation inception (so-called cavitation limit).Within the framework of modernization program, a new vessel (FC62 Project) was designed that differed from the 'prototype' in that it had different principal dimensions and displacement in conjunction with hard-chine hull shape with reasonable bottom deadrise. A significant innovation was the use of two auxiliary rudders of comparatively small area intended to control the vessel's heading after reaching a certain speed. This permitted to completely renounce using the waterjet steering nozzles as a means of heading control in this operating mode, which substantially increased operating efficiency of the waterjet units.

11.10 - 11.40 **Coffee**

11.40 - 12.15 **Scaling of Waterjet Propulsor Inlet Wakes**
Michael B. Wilson, Naval Surface Warfare Centre, US

Because of the lower Reynolds number of a manageable-sized scale model of a waterjet-propelled ship, there are notable scale effect problems involved with self-propelled model testing. Model hull boundary layers are relatively thicker than those at full-scale, and model frictional drag is relatively larger. Model scale velocity distributions are not as full as the corresponding high Reynolds number flows on the ship. The influences of the large volume of ingested propulsion flow on the net frictional drag and local hull pressure distributions are significant and complex. Since an objective of model scale testing is the prediction of full scale delivered power, flow rate, and head rise there is continuing interest in approaches to overcoming some of the scale effect difficulties. This paper presents a procedure for attacking a part of the scaling issue by the adjustment of the model scale flow rate so that the full scale values may be estimated while maintaining the same thrust loading developed by the waterjet. Results from a specific example of a waterjet self-propulsion test are presented along with a comparison with a simpler wake-scaling approach.

12.15 - 12.50 **Numerical Simulation of Vortex Shedding for Flow around Intake Grid in Waterjet Propulsion**
Chang Shuping, Wang Yongsheng, Ding Jiangming, Naval University of Engineering, China

the waterjet has been widely applied in modern ships. In the water area where the sailing condition is bad, intake grid need to be installed at the inlet of a duct in order to prevent the wastes entering into the duct and damaging the impeller of waterjet when the ship is sailing at high speed. There are some instances now where the damaged grid parts were sucked into the high-speed waterjets, which damages the impeller, in end makes the ship unable to function and cause a huge economic loss. The article employs the methods of theory analysis and numerical research for answer the question whether vortex-induced resonance is one most important reason why the grid was broken. A intake grid installed at real ship model is formulated and meshed by domain decomposition structured grids. Computational fluid dynamics method is applied to simulate the flow around grids for getting vortex shedding period or pulsating force frequency. At the same time, it uses the finite element method to calculate the vibration modal of intake grid. After comparing vortex shedding frequency with natural frequency, it makes the suggestions as to how to avoid intake grid resonance and how to design, install intake grid properly.

12.50 - **General Discussion**

International Conference

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