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JetTorque

A Technical and Commercial View of the Waterjet Propulsion Market from HamiltonJet

FROM THE BRIDGE

"The continued rapid development of High Speed Marine Transport to meet commercial demands for larger and faster craft operating on more demanding routes has meant the need for propulsion systems with greater power and reliability".

Quote from Royal Institute of Naval Architects' - Notice of Waterjet Propulsion Seminar, Dec. 1994.

Waterjet propulsion is acknowledged in most quarters as the preffered choice for the majority of such craft. High speed vessels are growing in number, size and complexity, necessitating continual development work by waterjet manufacturers in the fields of product design and application engineering to ensure successful integration into all these vessels. To ensure designers, builders and operators have the best options available for these new generations of high speed craft, HamiltonJet has an extensive product development programme for the introduction of new models and features. Expansion of the product range to include models suitable for craft up to typically 60 metres long is paralleled by the packaging of components such as hydraulic and electronic control systems as an integral and complementary part of the propulsion system. Optimum propulsion options which integrate simply with other shipboard systems are the result.

MACHINING MODEL HM811 JET PARTS IN HAMILTONJETS' FACTORY

STOP PRESS

Largest Yet

A twin shipset of model HM811 jets, the largest in the current Hamiltonjet range, have been successfully sea-trialed in a 40 metre catamaran passenger ferry constructed in Canada. The 300 passenger vessel was commissioned by the owner of a chain of hotels spread along the St.Lawrence River and is being used to transfer guests between hotels and for whale watching excursions.

Post-launch sea trials proved the thrust generated by the jets exceeded that predicted for this vessel during the design process, providing speeds approaching 30 knots in a lightship state.

With a capability of accepting power inputs up to 3000kW per unit, the HM811 jet incorporates all the features found throughout the HamiltonJet range. Engineered into the total package are the cast intake and fabricated transition with standard intake protection screen and oil cooler for the hydraulic control systems. With all the individual propulsion functions such as steering, ahead/astern and manoeuvring optimised and assembled into a single package, Hamilton waterjets are constantly being selected where long term reliability and ease of operation are vital prerequisites for operators of craft such as fast ferries, oil-rig crew boats and pilot craft located in all corners of the world.

40 metre TWIN HM811 JET POWERED CATAMARAN FERRY RECENTLY COMMISSSIONED IN CANADA

New U.K. Base

As a commitment to providing total quality support for the HamiltonJet range in the U.K., the marine controls company of Wagner Engineering (U.K.) Ltd. has been aquired and renamed HamiltonJet (U.K.) Ltd.

As increasing numbers of the company's jets are being installed in technically sophisticated craft, close cooperation with designers and engineers on complex engineering issues is essential to ensure successful integration of the propulsion system. With over 20,000 jets installed worldwide, the HamiltonJet organisation has accumulated considerable practical information pertaining to the application of waterjets to most modern hull forms. The new company will have on-line access to this database to provide a comprehensive application engineering service together with spare parts sourcing and in-field logistic support. In addition to the HamiltonJet propulsion systems, the strong market base of hydraulic steering gear and engine controls from Wagner and Kobelt formerly handled by Wagner Engineering (U.K.) Ltd. will continue to be sold and serviced by the new company.

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MULTIPLE JETS - When More is Less

The operational advantages of waterjets are particularly apparent in commercial vessels and may be further enhanced by employing multiple propulsors in a single installation.

Waterjet size and configuration for a particular vessel will largely depend on the total jet nozzle area and power input required to achieve a given thrust, based on the vessels' bare hull resistance. However, the weight and capital cost of the propulsion equipment will place certain constraints on the options that are possible. The increased flexibility and redundancy of a multiple waterjet installation may serve to enhance the vessels' capabilities and in some cases, present a more viable and economical propulsion solution.

The relative ease with which multiple jets can be configured in most hull forms gives added flexibility in terms of machinery selection and arrangement.

TRIPLE HM521 JETS IN 20m PATROL CRAFT

Hull Forms

Ultimately, the particular vessel hull form/ geometry will determine whether multiple jets can be considered in the first instance - for example, a fast displacement catamaran with very slender hull may preclude a quadruple jet installation. Generally though, by employing a greater number of smaller propulsors with the engines staggered fore and aft in the hull, a compact and accessible machinery arrangement can result.

Minimum Drag

Conventional propeller installations are disadvantaged by the effects of appendage drag. *Waterjets, with their flush inlets, offer no appendage drag penalty, even as the numbers are increased.*

Flexibility

Vessels are often required to have a dual speed capability such as for low speed loitering or high speed boost applications. With a relatively low powered jet installed between the main jet drives, or other forms of propulsors, low speed loitering can be carried out effectively with the main engines shut down. At higher speeds, this system can be employed in a boost function and since a waterjets' power absorption is independent of boat speed, there is no risk of overloading the engine during the transition from low to high speed. In some cases, the jet booster unloads the propellers so that they operate more efficiently than they otherwise would.

In an all jet installation, in the event of one or more jets being shut down, there is no possibility of engine overloading at the reduced speed and also no "dragging" appendage to contend with, as would be the case with a propeller. The cavitation performance of the waterjets will determine the operational limits with the remaining jets running - full power may be maintained to each propulsor if the boat speed is above the minimum (cavitation limit) for the jets.

Controllability

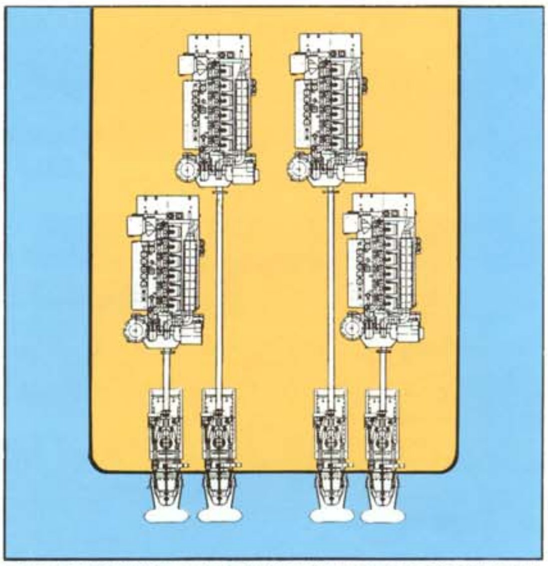
While even a single jet with it's independent steering and ahead/astern deflectors can provide 360° manoeuvring capability, multiple jets offer additional combinations of translational and rotational movements such as moving sideways as well as the added redundancy.

Quadruple jets in catamaran or monohulls are typically configured in a similar fashion to a twin arrangement, with each pair of jets installed in tandem. One of each pair could be installed as a boost jet with steering only capability, although the preference is that controls remain on all jets.

A monohull with triple steerable and reversible jets allows simple and effective sideways manoeuvres together with the ability to loiter on the centre jet only. HamiltonJet provide control systems where the steering is synchronised on all jets, eliminating the complexity of differential steering and greatly simplifying the control system.The necessary redundancy in a jet control system (eg., back-up control, multiple power supply etc.) is complemented by the redundancy offered with the multiple jet configurations so the temporary loss of one part of the system would not compromise the operational capabilities of the vessel. In fact, many experienced operators specify multiple jet installations for the express purpose of maintaining normal operations, even with one propulsion system out of commission.

Optimising Multiple Jet Configurations

The most important factor affecting waterjet selection is the jet nozzle size or area. For multiple propulsors it is the combined nozzle area of all the jets employed that is important. The nozzle size and the efficiencies of the pump and intake of the waterjet, together with wake factor and thrust deduction, will determine the overall efficiency (or P.C.) that is obtainable. Within certain limits, the larger the nozzle size the higher the P.C. and consequently thrust, at a given boat speed and power input.



TYPICAL MULTIPLE JET INSTALLATION SHOWING 'STAGGERED' MACHINERY CONFIGURATION

The 'optimum' nozzle size is that which results in the minimum power input to reach the desired vessel speed.

However, although P.C. improves with increased jet size, in practice other factors such as waterjet weight and capital cost will significantly limit the extent that this can be applied.

As jet nozzle size increases, the power required to reach a given boat speed decreases since the efficiency, and hence thrust gain, is greater than the increase in hull resistance due to the added weight of the jet. However, beyond the optimum nozzle/jet size, the increased weight of the jet increases resistance to a point where P.C. actually decreases as more power is required to push the heavier jet.

It is therefore necessary to consider other relevant parameters that will affect the determination of the optimum jet size, in particular -

- **Maximum Transport Efficiency Factor** (T.E.)
- **Maximum Overall Propulsive Efficiency** (P.C.)
- **Minimum Lifetime Propulsion Cost** (L.P.C.)

Whereas the 'optimum' jet may return solely the highest P.C., when operational criteria such as fuel cost and consumption, operating hours, payloads, vessel economic life and discount factor etc. are considered, the resulting jet selection is usually a compromise of a less than optimum jet but one which achieves the above factors, **over the economic life of the vessel.** HamiltonJet have developed a software package to select the optimum nozzle size on this basis.

Multiple Jet Costs

Generally, cost savings can be achieved by the installation of a triple or quadruple installation of relatively small jets compared with a twin installation of larger units. This is largely due to the fact that, in many cases, smaller engine "series", where the cost/kW is typically much lower, can be used. Additionally, multi-jets greatly increase the scope for engine selection as there are many more options in the lower power ranges. From an operating cost viewpoint, savings in downtime due to the inherent redundancy of a multiple installation may be significant, especially on a commercial vessel and as spare parts costs tend to be proportional to capital costs, maintaining the additional equipment should not necessarily be a disadvantage.

A Case Study ......

As an approximate quantitative comparison, the chart below compares a twin and quadruple jet installation in a hypothetical passenger ferry of the following specifications -

Length: 28.0 metres (LOA)
Displacement: 70 tonnes (laden)
Nominal Payload: 14 tonnes (160pax)
Design Speed: 35 knots (laden)
Hull Resistance: 80kN @ 35 knots (laden)
Trip Distance: 20 NM
Fuel Load: Equivalent 3 hours running

	Jet 'A'	Jet 'B'
Installation	**Twin**	**Quad**
Nozzle size	0.320m	0.230m
Total Nozzle Area	$0.161m^2$	$0.166m^2$
Power Input/Jet	1200skW	600skW
Minimum Speed (1)	22 knots	16 knots
Weight Jets	1.09	1.0
Weight Engines	1.08	1.0
Total Weight	**1.08**	**1.0**
Cost Jets	1.0	1.18
Cost Engines	1.5	1.0
Total Cost	**1.23**	**1.0**

(1) Minimum speed for continuous full power operation (cavitation limit)

For this simplified comparison, the weights and costs of the waterjets and engines have been 'non-dimensionalised', with the least costly and lightest options being given a value of 1. Interesting points to note for this hypothetical vessel are the quadruple jet option offers savings in both capital costs and weight. Weight savings would translate to increased payload capacity after fuel load requirements are satisfied. The P.C. for each configuration is similar so the total power input to achieve 35 knots is the same and whilst the smaller jets in the quad installation have lower component efficiencies, the total nozzle area is slightly greater. The quadruple arrangement also has a greater cavitation margin with the added advantage of being able to operate safely on 3, or even 2 jets at full power. The data used to prepare this study is based on realistic parameters gained from similar craft presently in service.

...... and in Practice

"Alaska Dream" is a catamaran ferry licensed to carry up to 150 passengers from Junneau in Alaska to an island mine 15nm offshore. The 30.5 metre long vessel, with a laden weight of 72 tonnes, is powered by quadruple HamiltonJet model HM422 jets direct driven via clutches by Caterpillar 3412 diesel engines, each producing 560kW at 2100rpm. Two propulsion sets are fitted in each hull and maximum speed at laden weight is 28 knots.

The vessels' charter calls for it to operate every day of the year and some relevant operational statistics (as at October 1994) are -

- Commenced operations July 5, 1988.
- 1,751 days continuous service.
- 8,588 total hours underway
- 193,440 nautical miles travelled
- 12,077 one-way trips

The vessel has never missed a trip for mechanical reasons. The vessel has been operated on odd occasions on three jets only due to minor mechanical problems of one sort or another and it is the inherent redundancy in the quad jet configuration that allows this. On three jets, a top speed of 22.5 knots in laden condition is achieved and this is above the cavitation limit for the installed jets. Jet maintenance has been limited to annual replacement of zinc anodes and after 8000 hours operation, the waterseals were replaced and the impellers reconditioned.

The quad jet configuration has played a major role in the vessels' provision of a continuous uninterupted service in a remote location.

QUADRUPLE JET PASSENGER FERRY "ALASKA DREAM"

Reference:
Phillip A. Rae - Operational Experience with Multiple Waterjet Installations - 11th Fast Ferry International Conference, Hong Kong Feb. 1995

FROM THE LOG BOOK

Everything Under Control on DEC'S

Parallelling the jet development programme at HamiltonJet has been the implementation of sophisticated complementary control systems.

Recent installations of the new HamiltonJet Digital Electronic Control System (*DECS*) have shown it to significantly enhance the vessel's operational capabilities. The system has been extensively tested in the field in craft including:

- the 32 metre catamaran charter dive vessel "Palau Aggressor II" built by Nichols Bros. of the U.S.A. This vessel is powered by twin HM571 jets.

and

- "Mr.Mel", a 43.2 metre Crew Boat powered by quadruple model HM571 jets. This vessel was built at the U.S. yard of Swiftships Inc. and will be used for servicing oil rigs in the Gulf of Mexico.

DECS has been designed to be an integral part of the HamiltonJet propulsion system in craft typically from 30 to 60 metres long. Configured from a sophisticated range of custom designed modules having extensive input/output capabilities, the system affects control of steering and astern deflectors on each jet using conventional operator inputs. Extensive use of electronics provides a flexibility which enables *DECS* to be interfaced with other onboard systems such as an autopilot and electronic engine controls. Simple low maintenance actuating mechanisms are used to ensure continuous trouble-free service.

Modular System

The heart of each *DEC* System is a microprocessor based Command and Monitoring Unit (*CMU*). One *CMU* is provided for each jet to affect independent primary control functions.

Key components of the *DEC* System include -

MAIN HELM STATION on the CREW BOAT "MR.MEL" SHOWING ELECTRIC WHEEL HELM, SINGLE LEVER THROTTLE/ ASTERN CONTROLLERS and the 'DECS' PANELS FOR MASTER WATERJET, TRANSFER and GEARBOX CONTROL

Main Helm Station, which can comprise either electric wheel helm or joy stick steering with single lever throttle/astern levers for primary vessel control.

Master Control Panel, incorporates all switches, indicators and alarms relating to primary vessel control as well as facility for emergency backup control.

Master Transfer Panel, transfers control from the main station to a remote location elsewhere in the vessel.

Gearbox Panel, to engage 'drive', 'neutral' or 'backflush' gearbox functions. Since primary vessel control is normally maintained simply by vectoring the jetstream with the appropriate jet deflector, this facility is usually reserved for 'backflushing' the jets to clear debris blockages.

Remote Control Station, where the Master and Transfer Panels are repeated for command of the vessel away from the main station.

Proportional Control

DECS provides fully proportional control of both steering and ahead/astern functions, with movement of the appropriate jet deflector following that of the respective commands from the helm.

Synchronised Steering

In multi-jet installations, *DECS* allows the steering deflectors to be driven in synchronism, eliminating the need for mechanical links between the jets. All manoeuvres, including sideways movement, can be performed without the requirement of differential steering, enhancing reliability.

Integrated Package

To ensure a synergistic interface between all components, Hamilton waterjets and their control systems are an integrated package, designed and built in-house by Hamiltons' engineers. In addition to the Company's policy of supplying components such as intakes and transition ducts as standard parts of each jet, a hydraulic pump (*JHPU*) is engineered into the jet as an integral component. Under control of the *CMU*, proportional valves in the *JHPU* meter hydraulic flow to the actuating cylinders of the steering and astern deflectors.

Capability to pre-program the control system, along with pre-plumbing and testing of the hydraulic circuits prior to despatch from the Hamiltonjet factory ensures minimal installation and commissioning requirements.

REMOTE AFT WATERJET CONTROL STATION on the CHARTER DIVE BOAT

The Digital Electronic Control System is one of a number of options available from HamiltonJet. Other systems are available for less complex or special applications such as loiter jets and HamiltonJet can make recommendations on receipt of craft details.

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