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JetTorque

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

FROM THE BRIDGE

" **It is on the workboat front generally that the waterjet has progressed from being the exception to a commonly used alternative. Applications vary enormously from small fast rescue and pilot transfer boats to high payload catamaran ferries, ...** "

Quote from Marina Management International's Workboat Supplement June 1993.

Recognition of the waterjet as the preferred propulsion option is fueled by the every-day requirement for many work and patrol boats and fast ferries to operate at speeds well in excess of 30 knots, where the efficiency of this propulsion system out-strips that of conventional propulsors.

Not surprising then was the great amount of interest shown in the HamiltonJet display at recent International High Speed Surface Craft Conference and Exhibitions in Singapore and London. The model HM571 waterjet was reported to be one of the largest pieces of machinery on display and featured working hydraulic control systems for the steering and ahead/astern functions. Attendees of the exhibition were able to see firsthand how the separate steering and ahead/astern thrust vectoring functions of the HamiltonJet design could be used to achieve total vessel control throughout the entire design speed range, including zero-speed.

Many customers are realising the advantages of the Hamilton waterjet propulsion systems in larger applications with the HM Series

Recent installations include triple shipsets of model HM521 into two new crew boats servicing the oilfields of East Malaysia.

ONE OF THE NEW EAST MALAYSIA CREW BOATS WITH TRIPLE HM521 WATERJETS

Each of these 28.5 metre aluminium vessels are capable of ferrying 45 oil workers and equipment to the offshore oilrigs at speeds up to 25 knots. The triple waterjets, driven by MAN model D2848LE diesel engines producing 520kW, provide the vessels with shallow draught capability so they can transit the mouth of the river where they are based at all tides. Precise vessel control is achieved using a manual hydraulic helm with electric jog-stick backup for steering and HamiltonJet's electronic control system for ahead/astern thrust vectoring.

HAMILTON HM571 JET ON DISPLAY AT HIGH SPEED SURFACE CRAFT CONFERENCE

Quality Assured

To ensure that quality is an inherent component in every waterjet and not just the product of a series of mandatory inspection procedures, HamiltonJet's in-house quality programme, FOCUS, empowers employees with the responsibility of continuous improvement in their own areas of expertise.

Based on Total Quality Management (TQM) principles, the highest levels of quality are built into every aspect of the business as a result of the programme's continuous improvement procedures. All HamiltonJet personnel are highly skilled in their respective fields and FOCUS recognises them as being the most effective contributors to the quality goal in their own areas of expertise.

Teams involved in design, manufacture and marketing are empowered to focus on the many elements of each process and initiate procedural changes to ensure continuous improvement for the benefit of their customers.

One such team is that involved in producing stainless steel impellers, the heart of every Hamilton waterjet.

POURING STAINLESS STEEL IN HAMILTONJET'S IMPELLER FACILITY

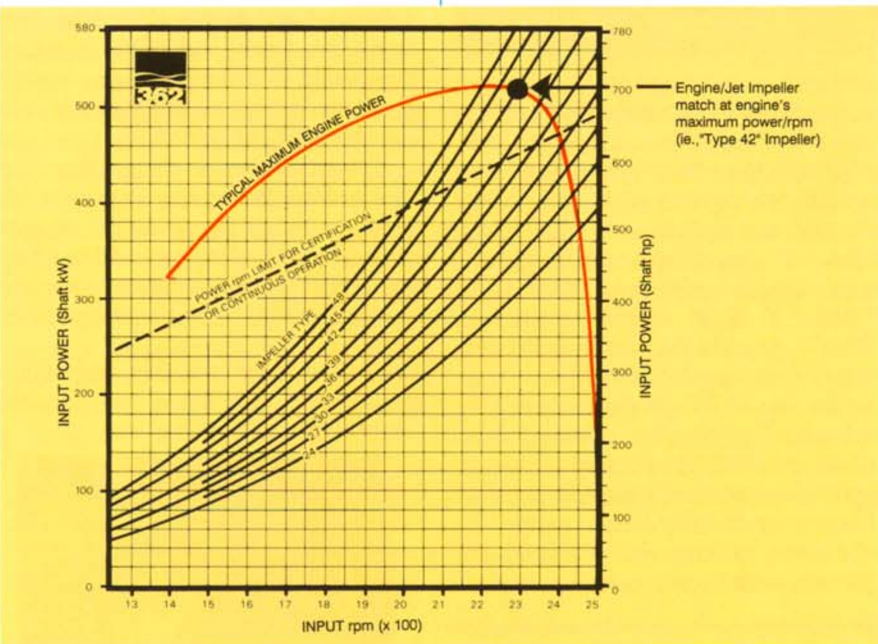
Operating from self-contained premises within the HamiltonJet plant with facilities for pattern making, stainless steel casting and precision machining, this team is responsible for the production of zero-defect stainless steel impellers, ready for passing to the next team involved in the production process.

FROM THE ENGINE ROOM

ENGINE MATCH - Putting the Power In

Having determined, by tank test and/or calculation, the thrust and power required to meet the hull's operational parameters, an appropriate waterjet model can be selected considering factors such as optimum propulsive efficiency and optimum economic life.

Once the optimum size jet has been selected, it is then necessary to match this to a suitable engine to achieve the desired operational parameters.
For each HamiltonJet HJ Series model, a graph of Input Power vs. Input RPM is published to enable designers to superimpose similar engine data for the ideal direct drive match. Larger HM Series models invariably require a reduction gear drive.



TYPICAL JET POWER/RPM CURVES WITH ENGINE CURVE SUPERIMPOSED

No Overload

The power demand from a jet is proportional to RPM^3 and is virtually independent of the craft's hull speed so, with correct matching, engine overloading is eliminated.

The jet must be matched to the engine's **maximum power** output/RPM to ensure the design thrust requirement is generated - for each model within the HamiltonJet range, a number of impeller "rating" options are provided to facilitate this.

With the engine matched at it's full throttle power/RPM rating, at any other reduced throttle setting the power produced by the engine will be that which the jet absorbs and not the maximum the engine is capable of at that setting, ie., in the example below, power outputs of the engine at less than 2300rpm should be read from the "Type 42" impeller curve.

This feature is the opposite to that experienced with conventional propellers - propeller RPM is proportional to boat speed and therefore the engine load can be affected by changes in boat speed. As a propeller pitch is normally selected to give full engine RPM at a particular design displacement and speed, if the craft load is less than design, the propeller pitch will be too "fine" for the resultant higher boat speed and the engine will run "light" as it will be held back by the govenor.

Conversely, if the craft is laden above the design displacement, the selected propeller will be too "coarse" for the resultant lower hull speed, not allowing the engine to reach it's full RPM's and consequently overloading it.

Running an engine in an overloaded condition can produce higher than normal pressures and temperatures within the engine, shortening life.

Therefore the waterjet with it's non-engine overload characteristics is ideal for craft where the displacement is likely to vary, such as passenger ferries. By designing for the maximum laden condition, during times of lighter loading at the same throttle settings the hull will simply have a higher speed without affecting the engine. Alternatively, the throttle setting can be reduced to maintain the design speed, again without any affect on the engine.

Direct Drive or Gearbox

The number of impeller pitch options for a given size waterjet within the HamiltonJet HJ Series range enables multiples of jets to be directly driven from the engines for craft typically up to 60 tonnes displacement. Running at engine rpm's is made possible by the high resistance to cavitation inherent in the HamiltonJet design.

Advantages of directly driven jets are:

* **Simplicity**
* **Reliability**
* **Reduces vessel weight**
* **Lower installed cost**
* **No Power Losses**
* **No Loss of manoeuvrability (with HamiltonJet)**

However, as the jet unit diameter increases, the rotational speed must decrease and HamiltonJet's larger HM Series of units would normally require a reduction gearbox to effect engine matching and drive vessels up to around 250 tonnes displacement.

Gearboxes are often installed on smaller size units but this is generally to use the reversing function to be able to backflush the waterjet when operating in weedy or polluted waterways.

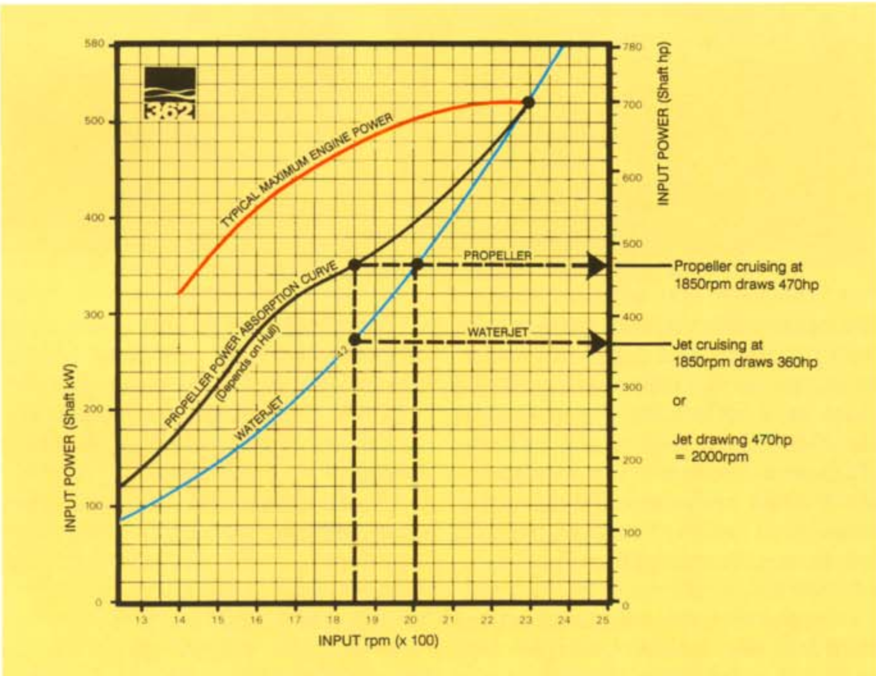
Designing for Cruising

If a typical propeller power/RPM input curve is compared with that of a waterjet for the same craft parameters, it is noted that whilst the maximum points are the same, differences occur at mid-range power inputs. This is an area that a vast majority of craft would normally operate as whilst they are designed for a certain maximum speed/load, they would often run at less than this maximum to cope with sea conditions etc.

From the graph below, it can be seen that for a particular cruise power (eg. 470hp), the waterjet will run at a higher rpm than the propeller.

Because of this higher RPM, an operator familiar with propellers might gain the impression that the engine is being worked harder in the cruise range and so the propulsion system is less efficient.

It is important for the designer and operator to realise that with a jet the engine will run faster at cruise compared to a propeller, but that the power absorption, and thus fuel consumption, will be similar.



TYPICAL JET POWER/RPM CURVES WITH PROPELLOR CURVE SUPERIMPOSED

18.5 METRE PILOT BOAT 'VOYAGER' FOR THE DUTCH PILOTAGE SERVICE TWIN HAMILTONJET MODEL HM571 WATERJETS - SPEED 31 KNOTS

EFFICIENCY - How Is It Best Measured?

It is usual to include efficiency factors into the jet/engine selection procedure so the craft will provide the operator with the best transport efficiency figures when in actual operation. Propulsive Efficiency (PC) is a commonly used factor for calculating efficiency and comparing propulsion options.

This can be defined as follows:

$$PC = \frac{\text{Effective Horsepower (ehp)}}{\text{Shaft Horsepower (shp)}}$$

where -

shp = shaft horsepower at the engine flywheel.

$$ehp = \frac{R \times V}{325.9 \text{ (constant)}}$$

R = hull resistance (lbs)

V = vessel speed (knots)

This is a measure of the efficiency of the conversion of shaft power to thrust required to push the naked hull.

Often, generalised statements of this or that propulsor having a PC of X% are made, however, the issue of PC is very complex and in fact may not be a good method of comparison. As can be seen from the above formula, PC includes factors of hull resistance and power input, therefore it is specific to individual applications.

The only true basis of comparison of waterjets and propellers must be against naked hull resistance - this then says jet thrust compares with nett propellor thrust (gross propeller thrust **less** appendage drag). It is common with propellers for the appendage drag to be included with the naked hull resistance, in which case the efficiency calculated is **propeller** efficiency, **not propulsive** efficiency as defined above. This propeller efficiency will be higher than the true propulsive efficiency and cannot be directly compared with the propulsive efficiency calculated for the waterjet.

Perhaps however, a more practical approach is to look at the actual power requirement to push the vessel to a specific speed and the resultant fuel consumption. This of course is also dependent entirely on the hull resistance and, as it takes additional horsepower and consequently fuel to overcome the appendage drag, these factors must be included in this method for a more realistic comparison.

Setting Standards

Rescue organisations around the world have very definite views on what is the best hull design, propulsion system etc. and the answers usually lie in what is best for the local conditions encountered by these various organisations.

It seems unlikely then, given the wide variety of conditions encountered around the globe, that one design could become accepted as a standard and adopted by other organisations. However, a lengthy development project by the Dutch Lifeboat Institution (KNRM) has seen their 'Valentijn' class small fast being accepted as suitable for the needs of the Italian Coastguard (Corpo delle Capitanerie di Porto).

The KNRM has long been at the forefront of the move towards faster lifeboats and saw the rigid inflatable (RIB) concept with waterjet propulsion as suiting their conditions of steep seas and sandy beaches. In 1984 they began the development of the 15 metre 'Johannes Frederik' class. Prototypes were built to evaluate various ideas and propulsion systems - a number of makes of waterjets were tested with twin HamiltonJet model 362 jets proving to be the preferred option for these craft. Several of these craft are now stationed at ports around the Dutch coastline.

At the same time, the KNRM were also working on a design for a smaller craft that could be beach launched and retrieved to cover the areas where mooring facilities were not available and so 'Project Valentijn' was born.

'Valentijn' is 10.6 metres overall and can be launched and retrieved using a special hydraulically powered integrated tractor and cradle.

Powered by twin HamiltonJet model 291 waterjets driven by Volvo TAMD 71B diesel engines, these self-righting craft have a top speed of 33 knots. Despite operating most of the time in sandy water, the KNRM advise the waterjets have given good service with the absence of dangerous underwater rotating components making them ideal for retrieving people from the water. From 1984 to mid 1992, the 'Johannes Frederik' and 'Valentijn' class crafts undertook 345 lifesaving actions, of which 106 took place in winds over Beaufort Force 7.

It was this successful track record that lead the Italian Coastguard to seriously consider the 'Valentijn' for their own coastal rescue services and the first six such craft were recently delivered to their stations around the Italian coast.

The half open wheelhouse of these craft afford the crew members unrestricted movement but with protection from the elements which are likely to be encountered on a rescue mission. All rescue equipment is stored onboard in four waterproof lockers and radar, radio, electronic and engine displays can be viewed throught waterproof covers.

ONE OF THE SIX NEW ITALIAN COASTGUARD RESCUE CRAFT

The hull design and outstanding manoeuvrability provided by the Hamilton waterjet propulsion systems enables close contact with disabled craft without risk of damage to craft or people.

These craft are the culmination of a long evaluation process to determine a standard that will take these organisations through to the 21st century with a design that is ideal and proven for it's intended role. These craft are another example of the proven suitability and acceptance of the HamiltonJet propulsion system for applications where effectiveness and reliability are paramount.

DUTCH LIFEBOAT INSTITUTION RESCUE CRAFT, 'VALENTIJN'

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