OPTIMISING FLEET FUEL USAGE – HULL REVIEW

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INTRODUCTION

The initiative to Optimise Fleet Fuel Usage to Maximise Effectiveness (OFFU) was created in 2006, triggered by activity cuts. The need was strengthened in 2007 by the dramatic increase in the cost of fuel at the time. The programme addressed an array of fuel efficiency measures including operation & ship handling, training, machinery configuration, hull fouling, use of shore supply & changes to hull design (eg transom flaps). Progress on the hull fouling aspects has been previously published in the Review of Naval Engineering[1], however this article provides a review of the performance of all the hull aspects introduced and the associated increases in availability. Whilst the cost of fuel is fairly stable at the moment (Figure 1), it is likely to increase again as the global economy starts to expand once more, as it does the extant gains from OFFU will become more significant.

1. See *Optimising Fuel Usage By Reducing Hull Resistance* by Michael Walker (RNE, Summer 2008).

BACKGROUND

In 2007 the Fleet's activity was being cut, and prioritisations of activity over capability led to the approach of OFFU to buy back previously imposed "activity" cuts and further develop the existing culture among the operators to use fuel more efficiently. It was CinCFleet's intention to recover the loss of 20% of Fleet activity as far as possible and not reduce fuel allocations in order to sustain current reduced activity levels.

The success of this programme was dependent upon a wide range of naval organisations doing their bit to achieve the common goal, it also lead to a change in behaviours eg spending resource for no individual direct benefit. The edict "costs fall where they lie" was decreed and waterfront organisations now had to find budget to perform unscheduled hull cleans. As part of this initiative it was felt that the greatest savings could be gained from improving the efficiency of the hull and reducing the effects of fouling. Other areas would also contribute and every percentage would make a difference. The hydrodynamic aspects of the initiative were:

- Hull fouling & cleaning
- Anti-foul paints
- Propeller polishing
- Stern flaps
- Displacement and trim

At cruising speeds the majority of ship resistance is due to friction, it being mainly influenced by the area of wetted surface and its associated roughness. The influence of fouling increases the roughness, requiring more power which in turn increases fuel consumption.

ANTI-FOUL PAINTS AND HULL FOULING

In 2006 self-polishing anti-fouling paints on RN warships had an effective life of approximately three years. This did not tie in with the change in docking cycles from two and a half years to five or six years. As a result the paint wore out midway between dockings and the hull became fouled. It was evident this needing managing and the fouling trigger system was launched. This compared in-service resistance with clean hull values; immediately four ships reported high increases in resistance and thus fuel consumption. It was evident a change was needed when a Type 22 OPDEF'd a two knot

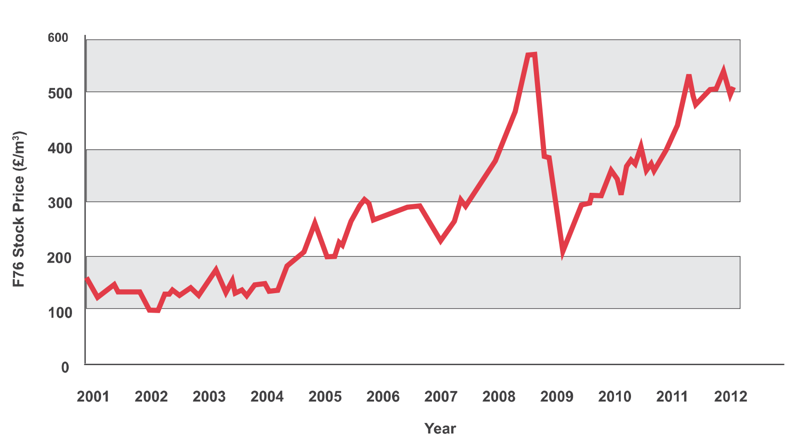


Figure 1: Marine Dieso (F76) Stock Price 2001 – 2012

Figure 2: HMS Campbeltown – top of sonar dome

Figure 3: HMS Daring – Foul Release coating after six years in service

reduction in top speed … the ship had a 70% increase in skin friction. The photograph from a Type 22 (Figure 2) is now a thing of the past. Monitoring shaft power once a month led to informed timing on cleaning decisions and a 20% increase in availability during the two and a half years prior to a docking period, without the need to uplift fuel allocations.

At the same time as the hull fouling management system was being introduced, two ships were trialled with the new foul release silicone-based anti-foul paint being used by the Merchant Navy. This works by providing an ultra-smooth surface which prevents fouling from adhering strongly to the hull. If ships are alongside for an extended period fouling will attach itself, however once the ships exceed a threshold speed, typically 10–15kts (depending on coating specification), the fouling will wash off. This foul release coating does not damage the environment (unlike conventional anti-fouling paints which kill fouling life with toxins) and is easier to maintain as well as lasting for the period between docking. Some confidence in this paint system had been gained from the operation of the trimaran demonstrator RV Triton. During a docking (now with a commercial owner) the hull was inspected and “one was able to move the barnacles around with your hand”. The coating was seven years old. However there were risks for RN ships, which regularly experience extended periods alongside, unlike their merchant counterparts, that foul release may not be as effective. The completion of the first coating trials around 2008 on HMS Northumberland and HMS Montrose were, however, a success and the decision made to adopt foul release across the fleet. An example of its effectiveness is illustrated in Figure 3, which shows HMS Daring after six years in the water without any cleans.

Nearly all RN ships are now coated with foul release coatings with projected benefits in the order of £600k to £1m of fuel over ten years of operation for each destroyer or frigate. This does not include any allowance for manufacturers’ stated claims that the lower skin friction of the coating can reduce the frictional resistance by up to four percent. In general the move to the new coatings has been an overriding success; there of course have been the odd occurrences of application issues and on one occasion an MCMV with one engine down was unable to steam above the paint threshold speed thus entering an ever worsening spiral of fouling. These issues are rare however, and are compensated by the overall cost savings achieved through application of the new coatings.

The regime of detecting fouling and managing hull cleaning needed to adapt with the implementation of foul release, the key concern being the extended period of inactivity. Another navy had trialled this coating and found it to be ineffective, but the ship on which the trial was conducted had spent nine months inactive in a tropical climate and the calcareous growth had taken a stronghold going through the coating and would not wash off. The Standard Manoeuvre and RN operational doctrine in high risk fouling areas is adequate to avoid the imposition of any new condition monitoring processes such as a routine “full ahead”.

The monthly shaft power “trigger” returns used to inform the hull fouling management system (identifying ships with 18% increase in resistance) will continue in order to detect any coating damage or fouling accumulation, and where fouling is suspected the ship is advised to steam at full power for an hour to remove the growth. The E-Flubcon system has simplified the return system for these trigger results, however the number and quality of returns made is below par and the practice not yet completely embedded. Figure 4 overleaf contains actual data showing how the monitoring is used to inform decision making for each individual ship.

PROPELLER FOULING

Polishing propellers annually is routine, noting that during a year a fouled propeller can add up to 4% to fuel consumption. There has always been nervousness about following the merchant marine

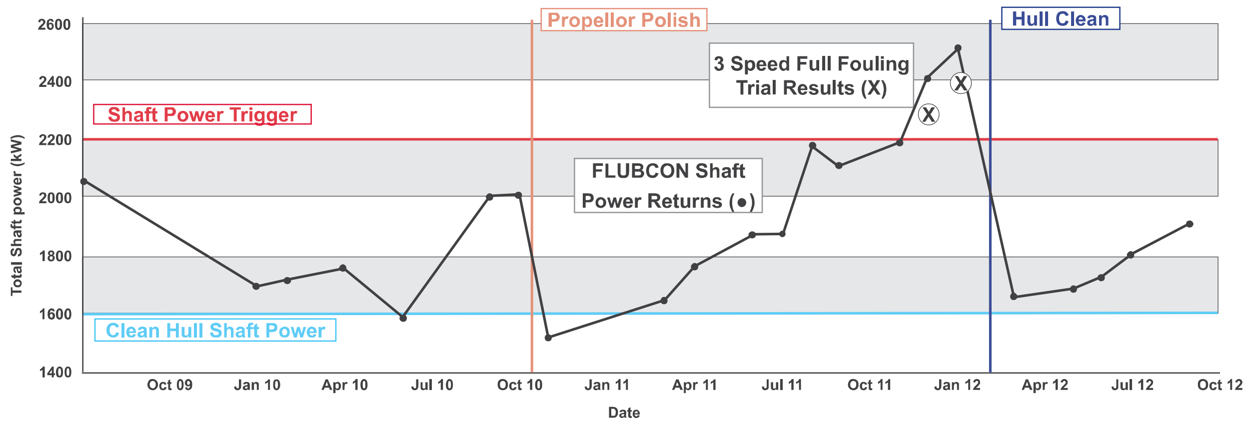


Figure 4: Example of ship shaft power returns

with anti-fouling propellers and the impact it may have on naval capabilities. To assess the issues of adherence, performance and signature, HMS Chatham had one of her propellers coated with foul release as part of a minor trial (Figure 5). Unfortunately the ship was decommissioned whilst only 18 months into the trial. Another trial on a Type 23 is nearly a year old and she has had the first diver survey; in general the adherence is good, as expected there has been some loss of coating at the propeller tips, but not enough to cause concern, and no significant growth was seen in the exposed areas, most probably as it will have been washed off by the same mechanism that removed the coating. The diver's video showed that the build-up of slime from recent inactivity was washed off easily by the diver's hand. The ship has been noise ranged and the results show no differences from before.

TRANSOM FLAPS

Transom flaps create a vertical lift force at the transom, and modify the pressure distribution on the after portion of the hull. These flow field changes cause a reduction in drag on the ship's afterbody, and modify the wave resistance of the ship. This relatively inexpensive change to the ship can significantly reduce fuel consumption. The transom flap fitted to the Type 23 (Figure 6) provides, on average, a reduction of 6% in resistance in the speed range of 7–13 knots and 13% at speeds above 13 knots. On the basis of the success of the Type 23 trial, transom flaps were also fitted on Type 42 and CVS.

The reductions in resistance are worth in the order of £60m over 10 years for the fleet at £500/m^3 fuel costs, this represents a good return for £100k fitting costs per ship.

DISPLACEMENT AND TRIM

The payload in proportion to the Basic Ship is small in warships, as most operate at relatively constant displacement, however reducing unnecessary payload will deliver savings in a similar manner to a car. The ability to capitalise on these savings is more limited for RN ships as they carry fuel and munitions necessary to expedite immediate tasking. The percentage reductions can be scaled linearly up to a 10% reduction in displacement (eg if a 1% reduction in displacement reduces shaft power by 1%, then a 10% reduction in displacement reduces shaft power by 10%).

Most ships of the Fleet are considerably heavier than designed, due to capability insertion through life, as was the case for the Type 22s. This meant they sit deeper in the water, with transom stern immersions much greater

Figure 5: HMS Chatham propeller foul release coating

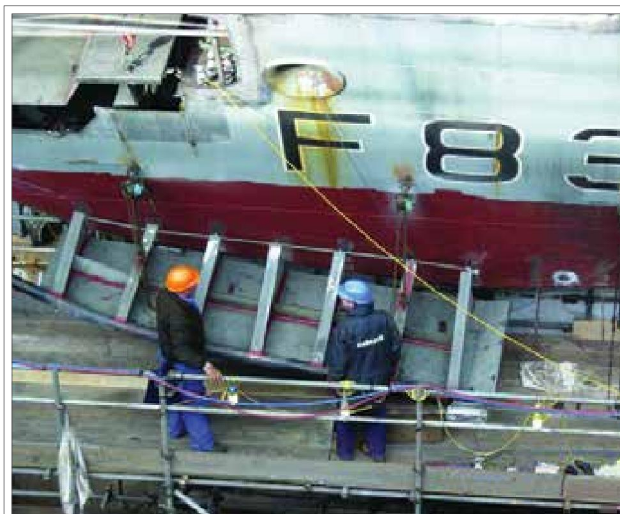


Figure 6: Transom Flap being fitted to a Type 23 frigate

than desired. At speeds below approximately 20 knots the flow of water off the bottom edge of the transom does not break away cleanly to leave a "dry" transom, but becomes entrained and is dragged along by the ship. This results in significant parasitic drag. Conversely, at speeds above 20 knots the flow breaks away cleanly, leaving a void behind the ship. This gives the ship a virtual increase in effective length which reduces resistance.

Optimising trim has a relatively small effect; a level to slight stern trim is best, but managing trim is difficult for warships as most are not designed with extensive ballasting capacity.

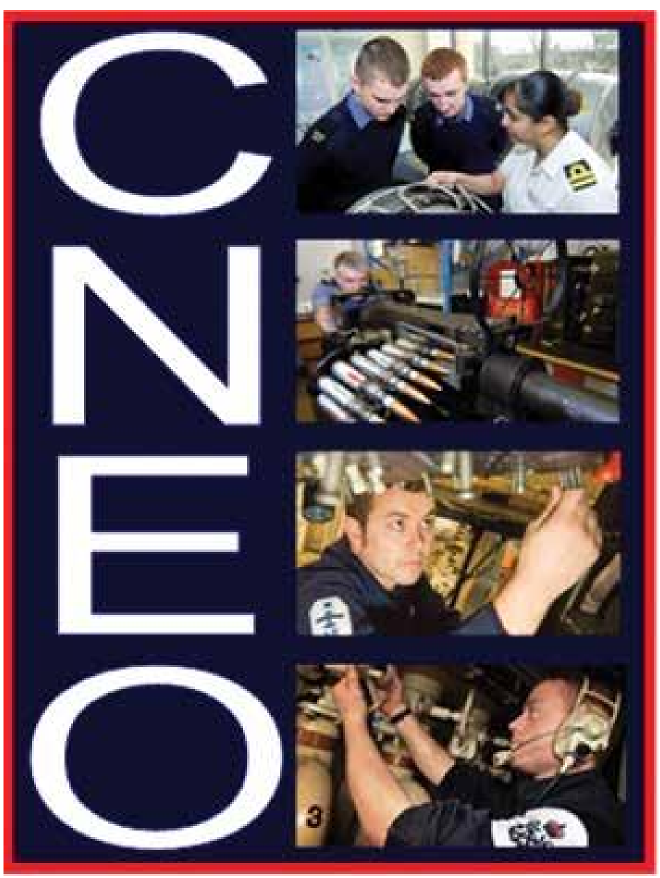
THE FUTURE

The majority of solutions offering major hydrodynamic savings have been explored and implemented, and it is likely that future developments in this area will be limited only to small percentages. These will be worth pursuing where through life cost/benefit demands, potential examples being new propulsion devices and onboard condition monitoring of fouling.
The RN will continue to follow, and most likely adopt, new mercantile anti-foul coatings as they arise, with developments driven by profitability due to the rising cost of fuel. Future sustainability targets are pending with a government-wide operational fossil fuel consumption reduction of 18% by 2020 and 20% by 2030. Unfortunately the baseline date for these targets already includes the implemented savings outlined in this article and with bigger ships replacing the existing RN fleet, fuel consumption savings on current allocations will be a real challenge.

SUMMARY

When the Hull Fouling Management Programme was instigated in 2007, four heavily fouled ships were immediately identified. Over the following two years cleaning hulls became routine, but since 2009, as awareness about managing the issue grew and furthermore as a result of the implementation of new anti-foul technology, cleans have reduced dramatically. Now, with the majority of hulls having the silicone-based foul release (where the fouling has difficulty attaching and washes off at cruising speeds), no demands for hull cleans have been received in the past two years. The programme commenced following demands for increasing activity by 20% with no uplift in fuel allowance. By combining the hydrodynamic initiatives of hull fouling monitoring, new anti-foul coating, transom flaps, reducing displacement, optimising trim and ensuring propellers are polished, this target has been met.

WANT TO KNOW MORE?
The Hull Fouling Management Programme is run by Steve Marshall, Ship Hydrodynamics, Naval Authority Group. For further information regarding the Programme please contact desnag-shipstab@mod.uk



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