RAindrops

Robert Allan Ltd. Information & News | Issue 7

The LNG Issue
Articles on the critical design aspects of LNG as a fuel in workboats

Predicting Power with ***RALCAD***
Powerful in-house resistance and propulsion software

Composite Shafting Systems in Workboats
Embracing innovative technologies

ROBERT ALLAN LTD.
NAVAL ARCHITECTS AND MARINE ENGINEERS

Perspective

Are LNG Tugs on Your Radar?

by Fuzz Alexander, P.Eng.
Senior Project Engineer

The use of natural gas as a propulsion engine fuel is certainly on many client's "interest" lists. Robert Allan Ltd. has done numerous studies and preliminary design work for gas fuelled tugs, pushboats, RoRo ferries, and research vessels. We have close liaisons with major Classification Societies for Rules and Guidelines that apply to safe and reliable operation of gas fuelled ships. We've participated in, and contributed to conferences, workshops and forums relating to both compressed gas storage (CNG) and liquefied gas storage (LNG) for marine vessels. Robert Allan Ltd. has close associations with major engine manufacturers and we are aware of gas fuelled engine developments and future availability for marine use.

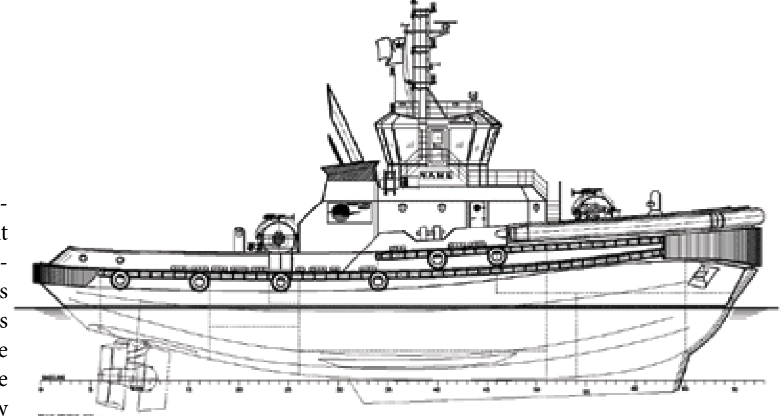
Well-proven and Class approved pure gas and dual-fuel engine technologies and LNG storage systems are available to implement into gas fuelled vessels. The primary challenge for tugboat applications is LNG storage capacity. Safe and practical location of cryogenic vacuum insulated LNG storage tank(s), and the associated regasification and pressure control equipment typically results in a significant reduction in vessel endurance on gas fuel. Alternatively a larger tug, or compromises to accommodation capacity or vessel configuration, may be needed to achieve a reasonable operating period between LNG refuelling. Robert Allan Ltd. has devised a number of LNG tank and tank hold configurations that can be considered without compromising the fundamental core performance characteristics of the basic tug.

Gas-fuelled tugs can be powered by gas-only engines, or by dual-fuel engines that can also operate on pure diesel fuel in the event that gas fuel is not available. Evaluation and selection of the most appropriate engine technology for a given application is important and Robert Allan Ltd. will evaluate several key factors including:

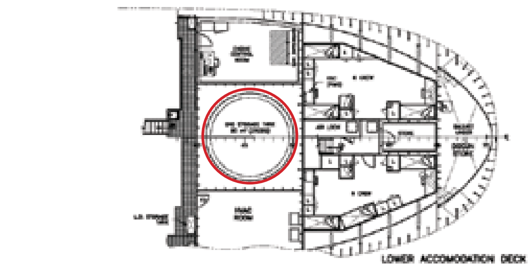
- LNG availability in the operating area and for delivery and dry-docking voyages, or redeployment of the vessel to an alternate operating area.

- Are the proposed engines and gas supply system configured for gas-safe engine room application? If not the vessel may require a design with special emergency shutdown features in event of a gas leak
- Is the load acceptance capability of gas fuelled engines suitable for the vessel's performance requirements
- Operating efficiency over the average load profile
- Capital and installed cost of gas fuelled engines and LNG storage and bunkering including regasification and pressure control systems
- Availability of suitable engine ratings for the application
- Alternate fuel sources whether by dual redundant gas fuel supply or by diesel fuel for dual-fuel engines
- Emissions compliance in normal (gas fuelled) mode and, for dual-fuel engines, when operating in diesel mode

Use of gas-fuelled propulsion engines will result in significant reduction in greenhouse gas emissions compared to current and future conventional diesel fuelled vessels. New marine emissions regulations will also result in reduced emissions from future diesel fuelled vessels, but this will require additional equipment and operating costs that may not be needed for a gas-fuelled vessel. Gas-fuelled ships can result in up to 20% net reduction in CO2 emissions compared to diesel. Gas fuelled engines also have NOx and particulate emissions at least as low as future diesels that will comply with the pending EPA Tier 4 and IMO Tier III emission standards that will become effective in 2014 through 2016.

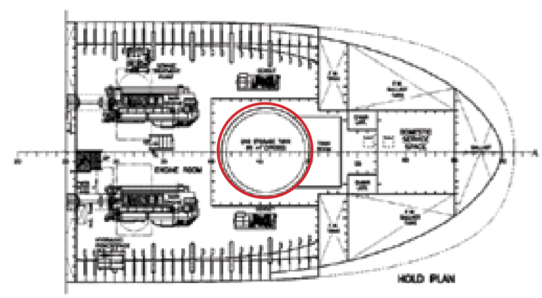

Typical 90t Nominal Gas-fuelled Ship Handling Tug

Current North American gas pricing (per energy unit) suggests that LNG fuel might be available at as much as 60% lower cost than conventional distillate diesel fuel. LNG prices in other regions are typically somewhat higher but generally offer fuel cost savings in the range of 25% to 40% of diesel. For applications with high operating load factors and high annual runtime the additional capital expense (CAPEX) of a gas fuelled tug or other vessel may be sufficiently offset by lowered operating expense (OPEX) to result in a net reduction in total life-cycle costs. In regions with carbon taxes or NOx taxes the reduced taxation levels would add to potential fuel cost savings. Robert Allan Ltd. invites clients to have us conduct feasibility studies and net present cost evaluations of conventional versus gas fuelled vessel applications.



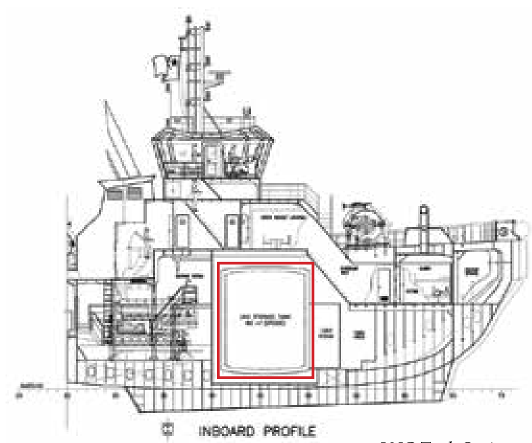
LNG tank hold location and storage capacity is challenging for small vessels: e.g. a 90t tug

Robert Allan Ltd. is well experienced and fully capable of conducting effective evaluations of gas fuelled vessel applications, and of carrying out complete gas fuelled vessel designs. If you are considering gas fuelled vessels please contact us. We'd welcome being your team partner in assessing the merits of an appropriate gas fuelled vessel design.



80 m^3 gross equals about 70 m^3 useable, about 35 hrs at full load and about 110 hrs at average loads

Fuzz Alexander has over 45 years of experience with electrical and mechanical engineering of diesel and gas turbine engine applications including a broad scope of marine propulsion, ship's service generation, and the associated electrical and mechanical aspects of machinery space systems. He also has past experience with pure gas and dual-fuel engine applications in land-based power generation and is enthused about the modern evolution of gas-fuelled engine applications to the marine marketplace.



LNG Tank Options

R&D at Robert Allan Ltd.

by Vince den Hertog, P.Eng.
Vice President, Marine Engineering

In the past, technological advances proceeded at a fairly stately pace in the workboat industry, at least compared with say the aerospace or automotive industries. Today though, to stand still is to go backwards. The quest for better performance, lower emissions and better efficiencies are driving rapid improvements in engine technologies and a strong interest in hybrid propulsion systems and alternative fuels such as LNG. More stringent requirements for the safe handling of tankers and other shipping in harbours and at exposed terminal locations are pushing the demand for tug performance, manoeuvrability and reliability into new realms. Environmental impact and crew comfort aspect, such as on-board noise and motion, have also become higher priorities in the design of the modern tugboat than ever before. To stay at the forefront with our designs, a pro-active in-house research and development program is needed to make sure our clients benefit from the very best designs today and well into the future.

At any given time, R&D is progressing on several fronts here. Our CFD capability is pivotal in many cases. Besides resistance, escort force, and sea-keeping simulations, CFD is being applied to the hydrodynamics of azimuthing thrusters. Not only are we building a better understanding of how propellers interact with nozzles to generate thrust, braking, and steering forces, but also how the shape of the hull around the thrusters and the under keel clearance can influence actual performance. New, highly advanced CFD techniques developed through our R&D programs also let us look more closely than ever before at how water flows around individual propeller blades, whether cavitation will affect performance and, if blade shape can be optimized. All these efforts are geared toward better performance, higher efficiency and quieter running.

Innovative designs, from the ***BRAtt*** training tug to the ***RAstar*** hull design and the latest tandem Voith Schneider-propelled ***RAVE*** tug, are all children of R&D projects under-

“To stand still is to go backwards.”

taken independently at Robert Allan Ltd., or in collaboration with our clients. Development of ‘next generation’ designs continues, most recently on offshore service vessels with improved seakeeping characteristics, and advanced Articulated Tug Barge (ATB) systems where the tug bow/notch geometry has been optimized to reduce resistance and fuel consumption.

Of course, the success of our in-house R&D efforts depends on a number of computer-based design tools, some developed in-house, that let us explore and optimize new design ideas at an early stage in a timely and cost effective way. One such tool is our propulsion prediction software called ***RALCAD***. Built into ***RALCAD*** is an extensive database of hull resistance data collected from sea trial data, model test results and CFD data. This data is integrated with propeller performance prediction models and engine data, allowing us to make accurate bollard pull and speed performance predictions specifically for our vessels. The process is quicker and more precise than with third party ‘black box’ software which is not based on our high-performance designs.

As discussed separately in this issue, the low cost of natural gas compared with distillate fuels, and the new limits on NOx coming under IMO III for ECAs in January 2016, and under US EPA Tier 4, has made using LNG as fuel of great interest to our clients. Several of our current R&D projects are focussed on an upcoming generation of tugs that are designed around LNG as fuel.

However, LNG is not necessarily the panacea for the lowest environmental impact or best efficiency; Alternative propulsion systems based on hybrid technologies or pure battery electric systems for high efficiency operation and/or clean and quiet operation are making their way into the commercial workboat sector. Significant new developments with diesel-electric power system architectures as well as interest in the application of fuel cells are also behind some interesting ongoing projects at Robert Allan Ltd. Through our internally developed ***RAptures*** simulation software, we are supporting our clients to explore the possibilities through unbiased assessments of the fuel savings and emissions reductions potential of alternative systems. Not only does ***RAptures*** consider the specific characteristics of a vessel’s propulsion machinery and resistance characteristics, but also the actual operating profile, and how fuel consumption and emissions vary with it.

Some of our development work is focussed on individual systems. For terminal/escort tugs or offshore vessels at risk of exposure to toxic environments, we are working on practical designs to protect the interior of critical crew and machinery spaces in emergency situations, not only in design but also in testing of proof of concept prototypes, as described elsewhere in this issue.

It is an exciting time for R&D. The unprecedented access to information over the internet, combined with highly powerful 3D design tools and analysis software such as CFD, FEA and naval architectural tools have quickened the pace of development possible, even within an office environment. Working with a staff that brings great new ideas, experience and enthusiasm to our development initiatives, it is certainly a pleasure to be involved with R&D at Robert Allan Ltd.

Practical Makes Perfect: Self-Contained Gas Protection Pressurization Systems

by Toshio Ouchi, EIT
Mechanical Engineer

The past decade has seen rapid growth in natural gas extraction and transportation of its liquefied form as LNG. Tugboat designs are continually evolving to ensure the safe and economical operation of the LNG tanker fleet at and around LNG terminals and ports. In places where there is some risk that gas may enter the atmosphere at an LNG terminal, there may be a requirement to not only equip the tug with a system to detect gas, but also the means to guarantee crew safety and allow the tug to continue a critical docking or escort operation until the danger passes. Similarly, tugs or offshore support vessels operating in areas where hydrogen sulphide could be released may require systems to detect gases and protect crew and critical areas from gas concentrations that could otherwise lead to explosion or asphyxiation.

Gas protection methods can be broadly divided into two general types: air filtration/scrubbing systems similar to those found in a Chemical, Biological, Radiological, Nuclear (CBRN) system, and pressurized fresh air systems similar to those found on some enclosed lifeboats (‘TEMPSC’ type) used on tankers and offshore rigs. On a tug or other vessel, the spaces protected by either system are collectively known as the “citadel”. CBRN systems typically found on navy ships are expensive and may be subject to military restrictions given the proprietary nature of the filters. Furthermore, filter-based CBRN systems are not typically effective at filtering hydrocarbons. In contrast, the approach with a fresh air-based pressurization system is to supply the citadel with clean, breathable air from on-board storage bottles so that enough positive pressure is maintained within the citadel that toxic gases are kept out. This latter type of system is generally preferable, although limited in the protection time available by the quantity of compressed air carried.

Gas protection pressurization systems need to take into account min/max citadel air pressures, action time, duration, air leakage, and ambient conditions. At the same time, any such system has to be reliable, practical, and cost-effective to install and maintain. With these aspects in mind, Robert Allan Ltd. established an internal R&D project to explore the effectiveness of one concept system and to validate semi-empirical calculations developed in-house to predict pressurization system performance. Working with our long-time associate Alan Reynolds of Offshore Research Ltd., we developed a simplified, practical test program to evaluate the design parameters, factors and verify equipment selection for a self-contained citadel air support system. The DNV Nuclear Biological and Chemical Protection rules were consulted as guidance for design parameters. To account for leakage rate factors from windows, doors and similar penetrations, typical residential house envelope test values were used as a starting point, since specific data for tugs or other marine vessels is hard to come by. From these inputs, a design of experiments (DOE) was developed to verify equipment selection methods, equipment performance and sensitivity, and to assess noise levels or freezing effects.

Cold surface temperatures due to gas expansion

Citadel test rig

To compare actual performance against predictions, a test rig was constructed to simulate the citadel protection in a gas leak scenario (shown left). The simulated citadel was a wood framed compartment lined with plastic sheathing, taped at the seams, and fitted with a typical residential door with weather stripping. An adjustable vent and over-pressure relief system were installed to allow variation in leakage rate simulation. It was estimated that the test cell was as air tight as a typical tugboat wheelhouse, perhaps more so. A scaled pressurization system consisted of a 60 minute - 4500 psi SCBA bottle, pressure regulator, valves and delivery piping. Test cases with varied flow rates were repeated to achieve a reasonable data sample size, or until repeatable values were obtained. Temperature effects on flow rate were observed down to -25°C. Overall, the tests gave us excellent qualitative and quantitative insight into the practical application, scope, and limitations of this type of gas protection pressurization systems.

Calculations, predictions, and analyses are important tools of design, but as any designer knows, empirical data is king. R&D projects like this one ensure that new designs are validated by real-world testing.

It's What We Do Best

by Robert G. Allan, P.Eng.
Executive Chairman of the Board

The delivery of the new ASD tug ***Macleod*** (shown below) highlights a lot of what is going on in the tug world today, and especially in the offices of Robert Allan Ltd., where our designs presently account for a large share of published tugboat new-buildings worldwide.

Although outwardly a relatively typical ASD ship-handling tug, the unique dual-draft capability of the ***Macleod*** was developed to address a very unique set of design constraints, predominantly a tug harbour with a draft limitation of just 4 metres. Constraints such as this are not that unusual, but 4 metres is certainly at the low end of operating drafts for modern ASD tugs, especially when the Bollard Pull required is 60 tonnes or more. If this tug were designed to operate continuously in the exposed outer waterways of Cape Cuvier, Australia at this low draft, it would have to be much broader and shallower than a typical harbour tug, and would consequently have a very high GM and associated very fast roll response accelerations, making work aboard very uncomfortable and potentially unsafe for the crew. The design solution proposed by Robert Allan Ltd. was to make this a "dual draft" tug, so that it could reduce draft to the lower limit for entry to / egress from the harbour, then by ballasting quickly work at a deeper and more practical draft for the ship-handling operations, with much more comfortable motions.

Whilst some might proclaim such a feature as "innovative", this is a relatively simple design concept developed and used by Robert Allan Ltd. on many designs dating back to at least 1970, particularly in projects for the Beaufort Sea and Mackenzie River in northern Canada, where a shallow river draft is unsuitable for the more exposed work offshore. Another "good old idea" made new in a different part of the world! The tug/mini-OSV Beaufort Sea Explorer (later Hudson Bay Explorer)was one example of exactly this sort of application, built in 1972 with a 4.5 ft river draft and an 8 ft. ocean draft. This ***DRAftmaster*** feature can be applied to almost any of our designs.

The tug business today is all about special applications, whether imposed by natural or man made limitations such as draft or canals or bridges, by regulatory limitations which force unnatural and frequently uneconomic or at best inefficient limits on vessel size or power, or by environmental cleanliness objectives. There are no "standard" solutions for these challenges, and each Owner has a different view of how they would like to approach such new designs. The same can be said for many other vessel types, perhaps even more so than for tugs, and we are also kept very busy developing major designs for research vessels, lifeboats, ferries, and icebreakers, each with their own individual sets of unique functional and operational requirements

Developing individual design solutions for our clients worldwide is our daily work as consulting naval architects. We have always prided ourselves on providing unique problem-solving ideas and design solutions for our Clients operational needs, rather than trying to force the adoption of standardized configurations. The demand for our services in this field is a testament to the need being fulfilled by Robert Allan Ltd. It is our duty to continue to think creatively… it is what we do best!!

RAmparts 3000** series tug **Macleod

Under Construction








On average, approximately one Robert Allan Ltd. designed tug is launched every week somewhere around the globe!

Type: ***RApport 2300***
Client: Brusco Tug & Barge
Shipyard: Diversifies Marine Inc., Portland, Oregon

Type: ***RAmparts 2800***
Number: 2
Client: Saudi Ports
Shipyard: Cheoy Lee Shipyards, Hong Kong

Name: ***RT Investigator***
Client: CSIRO, Australia
Shipyard: Sembawang Shipyard, Singapore
Info: http://csirofrvblog.com/

Type: ***RAmparts 2500***
Number: 6
Client: Smit Rebras
Shipyard: Keppel Singmarine, Brazil

Type: ***Z-Tech 2400***
Number: 2
Client: G& H Towing
Shipyard: Leevac Shipyards, Louisiana

Type: Shallow Draft, Double Hull, Oil Barge
Number: 2
Client: ITB Marine Group
Shipyard: Jiangsu Zhongzhou

Type: ***RApide 4500*** Shallow Draft Pushboat
Number: 8
Client: Hidrovias do Brasil
Shipyard: Uzmar Shipyards, Turkey

Type: ***RAmparts 3500***
Number: 2
Client: Tianjin Port
Shipyard: Sanlin Shipyard, Shanghai

Type: ***RApport 2400***
Client: Signet Maritime Corporation
Shipyard: Owner's Shipyard, Mississippi

Type: ***RAmparts 3200***
Number: 2
Client: Signet Maritime Corporation
Shipyard: Patti Shipyard, Pensacola, Florida

Type: ***RAstar 3200***
Client: SMIT Lamnalco
Shipyard: Cheoy Lee Shipyards, Hong Kong

Type: ***TRAder 2000***
Number: 2
Shipyard: Besiktas Shipyard, Turkey

Type: ***TundRA 3400***
Client: Groupe Ocean
Shipyard: Owner's shipyard, Quebec

Type: ***RAmparts 3200***
Client: PSA Singapore
Shipyard: Yuexin, China

Type: ***RAmparts 3200***
Client: Yuexin, China
Shipyard: Yuexin Shipyard





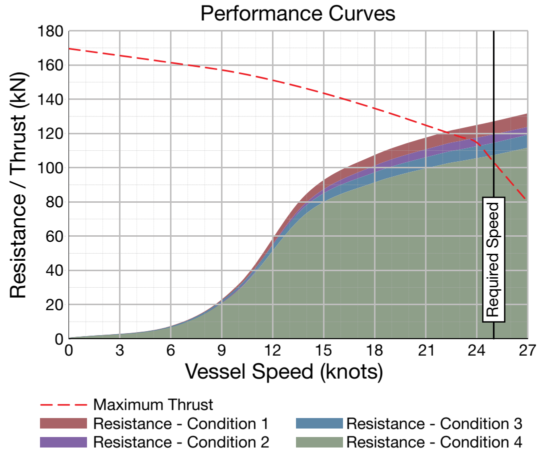

Predicting Power with *RALCAD*

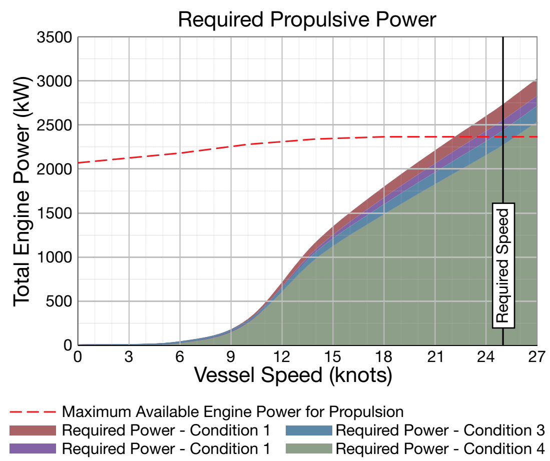
by Mike Phillips, P.Eng.
Naval Architect

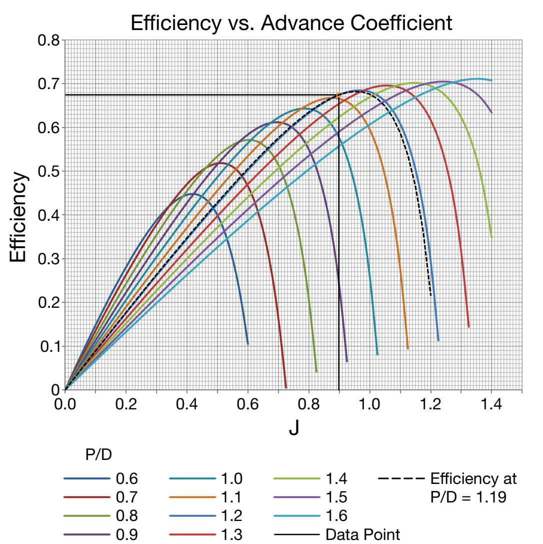
Vessel powering predictions are not for the faint of heart. Relatively precise predictions of required propulsion power are typically required at an early stage in design, often before anything more than a first draft of a new vessel's arrangement is available. But accurate estimates are needed since a significant change in power later usually has undesirable consequences. So how can a designer reliably predict the powering requirements with so little information? Model tests or CFD are the most tempting answers, however there are almost always time and cost constraints which make it challenging to use these methods for early stage design. There are also many regression models available in both the public domain and in commercial software, but all are hampered by the fact that it is difficult to ascertain if they give a reliable prediction for what is quite often a significantly different hull form. The problem is especially acute for tugs and other workboats for which Robert Allan Ltd.'s experience has shown that the generic regression models are simply not sufficiently accurate.

Fortunately, Robert Allan Ltd.'s extensive experience in the design of these types of vessels gives the company a unique advantage in this field. By combining our wealth of archived trials results, and combining them with new information sets generated by CFD, we have successfully created our own prediction models for our most popular hull forms and assembled them into a powerful and proprietary new software package named ***RALCAD***.

RALCAD goes beyond simple resistance predictions though. It has a full suite of capabilities including resistance, propulsion, engine power availability checking, range and endurance, as well as a standard report generating module. In addition to providing a much higher quality of hydrodynamic predictions throughout all stages of the design, the program reduces the amount of time associated with these calculations to a fraction of what was previously required. The only thing missing is the level of difficulty that used to exist.







Composite Shafting Systems in Workboats

by Erik Johnston, P. Eng.
Project Engineer

The concept of using composites in shafting systems for the marine industry is not new. Although composite shafting has been available for more than 15 years now, adoption of this lightweight material instead of solid steel shafting is not yet widespread in workboats, despite the potential for considerable benefits to the vessel owner. Robert Allan Ltd. first used this system more than 12 years ago in the ***RAmparts 2500*** class tug ***Tim Quigg***, and have done so in many applications since.

Composites for drive shafts generally use two types of fibres: glass fibres or carbon fibres. Carbon fibre-based composites have gained popularity over glass fibres in recent years, due to higher strength properties and decreased cost.

Composite shafts offer easier installation and maintenance, reduced weight, and the potential for reduced capital and operational costs, depending on the application. These benefits stem mainly from the elimination of pedestal bearings and their associated foundations: Bearing foundations take time for shipyards to build and install, occupy valuable space, and complicate pipe routes. Not only are the bearings themselves costly, but they also require careful alignment during installation and maintenance over the life of the vessel. By eliminating bearings, composite shafts can often become cost competitive with traditional solid steel shafts when the total length of shaft exceeds 3-4 metres or so. Although hollow steel shafts are also an option, the low weight and high stiffness and strength of composite shafting typically make it the better choice overall.

On a visit to a local shipyard that had just installed their first composite shaft in a tug, a yard representative told me how surprisingly easy it was to install the shaft. He said it was amazing to see just two guys carrying a 15 foot (4.6m) length of shaft from the stores, and lower it into the vessel. A solid steel shaft would have required a lot more effort!

Composite shaft systems are particularly suitable for where the engine and driven equipment (Z-drive or VSP) are set up in a straight-line arrangement. This way, almost all the bearings can be eliminated. In contrast, when a 'straight shot' is not possible – typically because of space or geometric constraints on the installation of the engines with respect to the azimuthing drives - then Cardan shafts (double universal joint shafts) are unavoidable. These in turn require bearings to absorb radial forces that universal joints inherently generate as they rotate. Consequently, composite shaft solutions tend to be most favourably applied to larger tugs and other workboats where longer shaft lines allow for a straight-line installation.

Experience with many successful installations in our vessels over years of operation has shown that with composite shafts the owner stands to gain the benefits of a robust propulsion system, often with fewer components, and lower operational costs in the long run. The application of composite shafts is one example of how Robert Allan Ltd. embraces innovative technologies where they are proven reliable, and will give our clients the very best workboat solution for their specific operations.

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RAindrops

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On the cover: ***RAmparts 3200*** ASD tugboat ***BB Coaster*** in the rough North Sea off the west coast of Zealand, Denmark. Photo courtesy of Buksér og Berging.