WHITEPAPER

The ABB ETB (Electric Towboat)

The U.S. inland river market is ready for electric propulsion

Abstract

ABB's electric propulsion systems are available to help long-established towboat owners in the U.S. inland waterway market to solve some very modern challenges.

Electric propulsion has proven itself among owners of many different vessel types. Now ABB's electric propulsion systems are available to help long-established towboat owners in the U.S. inland waterway market to solve some very modern challenges. With regulators re-stricting emissions from ships to EPA Tier 4 standards, diesel electric propulsion offers owners a way to build compliant vessels operating on easier to meet Tier 3 main engines.

ABB has taken the time to understand the demands of this unique sector, creating solutions whose flexibility addresses new regulations, increasing CAPEX costs for new builds, the imperative for lower OPEX costs and demand for greater vessel reliability. The result is ABB's ETB (Electric Tow Boat), featuring an electric propulsion from ABB that can be delivered as customized towboat systems, including generators, propulsion motors, low volt-age switchboards and automation.

ABB's ETB solutions allow owners not only to enhance fleet management by standardizing engines across multiple horsepower needs, but tomake direct savings on operating costs and maintenance by improving handling responsiveness and enabling predictive maintenance.
In addition, due to the availability of multiple prime movers, the ETB is not exposed to single points of equipment failure.

Just as the diesel engine superseded steam, the combined benefits of the ETB represent the next generation of towboat for the US inland waterway network, from which there is no going back.

Authors: Edward Schwarz, Vice President, Sales, New Build Sales; Richard Rozok, Technical Manager, Sales, New Build Sales.

Edward Schwarz is responsible for business development and the development of new sales programs for ABB's marine and ports business unit in North America. With his long experience in the marine propulsion market, Ed brings new concepts to unique vessel applications.

Richard Rozok is responsible for developing new technical solutions for the North American new sales program. He brings proven technical expertise and the ability to find practical and creative solutions to solve vessel owner's problems.

ABB Electric Towboat

Inland operators should consider diesel electric propulsion, which is not only increasingly preferred by global shipping but which can meet Tier 4 standards

Introduction

At a time when speculation in shipbuilding and slow economic growth continue to haunt the maritime sector, owners find themselves under continuous pressure to minimize costs by maximizing operating efficiency.

Shipping has also come under increasing scrutiny from regulators and environmental bod-ies over its environmental and safety record, with emissions from ships the number one concern.

Recently introduced NOx emissions rules mean that conventional diesel mechanical ma-rine engines can only meet EPA Tier 4 performance requirements by adding bulky, complex and hard-to-maintain aftertreatment - either costly Exhaust Gas Recirculation, or Selective Catalyst Reduction using urea on board ship.

Alternatively, inland operators should consider diesel electric propulsion, which is not only increasingly preferred by global shipping but which can meet Tier 4 standards using Tier 3 main engines, without the need to devote space, engineering time or bunker calls to tech-nologies whose only function is compliance.

1. The pull of Electric Propulsion

1.1 Impact in shipping: It is a fact that electric propulsion has become part of everyday life - whether on board the trains we use in our commute, in the cars we drive and – increas-ingly - in ships and boats.

Owners of cruise ships, tankers, gas carriers, container ships, offshore vessels and tug boats, including some operating in the harshest conditions in the world, have chosen die-sel electric propulsion over its mechanical equivalent for its greater efficiency, flexibility and reliability. ABB, for example, has already supplied 1300 vessels featuring diesel electric propulsion.

Shipping analyst Clarksons Research recently reported diesel electric technology as deliv-ering advantages where maneuverability, variation in power demand and engine noise were important. Furthermore, Clarkson stated: “By optimizing the loading of the engines, diesel-electric systems can lower fuel consumption and emissions*.

1.2 US inland waterways in context: An estimated 4,000 towboats operate along the rivers of the United States, hauling 25,000 barges and carrying 630 million tons of cargo along 25,000 miles of waterway every year. Utility providers rely on rivers for 20% of their coal, while about 22% of domestic petroleum and over 60% of farm exports move on inland wa-terways.

Although a proudly independent sector, the US inland waterways industry comes under the same commercial and regulatory pressures as other parts of the shipping industry. The sector is newly subject to EPA Tier 4 requirements on NOx emissions, for example. One solution is to augment diesel mechanical engines with bulky, complex and hard to main-tain after treatment technology that requires the bunkering and storage of urea.

The US inland waterways sector is perceived as technically conservative, even though – historically - it pioneered the widespread adoption of steam boilers for propulsion, brought astonishing feats in lock system civil engineering and introduced 24/7 operations long before modern navigational aids. In fact, the US inland waterway sector can lay claim to having operated some of the first diesel electric vessels, back in 1930s.

The source of its reputation may therefore be hard-headed pragmatism: the US inland wa-terway industry tends to move decisively to new technology only when its adoption aligns with the business opportunities. The adoption of steam propulsion, for example, coincided with the open-ing of river traffic both up and downriver along US waterways, where dra-matically reduced tran-sit times helped to usher in the industrial revolu-tion.

1.3 Changing times It is fair to point out that leading players in the inland sector investi-gated diesel electric propulsion a decade ago but de-cided that the time was not ripe. In addition to changes to both the commercial and regulatory landscape, subsequent years have witnessed ac-ceptance of the 'electric' car - or at least hybrid vehicles which make greater use of electrical sys-tems.

While 'green' issues have played their part, elec-trical sys-tems are proving pivotal to the '4th In-dustrial Revolution', as one of three pillars: elec-trifica-tion, digitalization and connectivity.

- Electric systems are at the heart of this trans-formation because they enable the simple and efficient integration of power sources. Diesel electric systems use multiple generators to provide power for the propulsion plant via electric motors.

- In the wider maritime setting, electrical pro-pulsion systems have been selected by owners seeking fuel economy gains and greater sys-tem redundancy, especially in the passenger ferry and offshore supply vessel market

. 2. Vessel owner drivers for change – why now?

As noted, experience shows that US inland own-ers will commit to new technologies when it makes business sense. It is therefore fair to con-sider the factors suggesting that now is that mo-ment.

2.1 New Regulations: The new regulations cover-ing emissions from US inland vessels have major cost implications for owners looking to build new vessels, at a time when there is a significant re-quirement to replace an aging river fleet. The costs involved are significant enough to prompt considering the ROI of alternative technologies. The 'conventional' op-tion involves installing two large EPA Tier 4 main engines supplemented by an af-tertreatment system – either the costly EGR (Exhaust Gas Recirculation) option or SCR (Se-lec-tive Catalyst Reduction) that features additional piping, its own refill and urea storage tank and demand separate maintenance. There is no likeli-hood that investments in after treatment technol-ogy can be recovered from shipping contracts.

Where diesel electric propulsion is chosen, how-ever, EPA Tier 4 emissions requirements can be met using a solution that includes multiple EPA Tier 3 generator sets, with no prospect in sight of the need for costly upgrades.

2.2 Technical claims: The claim for the greater ef-ficiency of diesel electric propulsion tech-nology centers on the narrow range of operations at which mechanically-driven systems work most ef-ficiently – above 60% MCR. In fact, a diesel me-chanical system is typically optimized at a single point close to the 90% load.

In simple terms, diesel electric systems draw on variable frequency drives to deliver their efficiency across a broader operating profile, throughout the engine's total operational cycle.

This claim is as powerful today as it has always been, but the last decade has seen a substantial shift not only in the industry's commercial and regulatory drivers, but in public attitudes towards electric systems technology. In the case of automobiles, that attitude shift can be traced to the way initial skepticism was overcome by consistent positive experiences.

2.3 Fuel savings: The ability of electrical motors to generate full torque at zero speed makes power available immediately for increased operational safety, greater levels of safety and no requirement to over-torque, as is the case in the equivalent mechanical engine design. Greater responsiveness due to variable frequency operations enhances maneuverability and offers greater fuel efficiency overall. In cases where all engines are already running, and depending on engine loading characteristics, the ETB configuration can also switch from low load to full load more quickly, in a performance gain that will be discernable to the captain.

In the inland sector, it is often the contracted company paying for fuel. Therefore, at the more detailed level, the technical claim outlined above (2.1) takes advantage of variable frequency drives to optimize engine loads in a way that maximizes efficiency. By reducing the number of engines running to an optimal number, diesel electric propulsion reduces the number of engine hours spent operating at partial loads.

A vessel that spends 40% of its operation time at less than 50% propulsion load can be worked using two engines instead of three when compared to a mechanical driven system. This capability results in fuel economies when engines are under part load.

2.4 Redundancy: The diesel electric solution allows power to be distributed to either propulsion motor, meaning that the impact of a prime mover failure is minimized. The vessel can be designed as both a Z-Drive and conventional propeller vessel and has multiple prime movers which means if an engine fails the vessel can remain in service at a reduced capacity.

Redundancies also eliminate single point failure removing a vessel from service, said ABB. In the equivalent mechanical system, the loss of a prime mover leads to the loss of 50% of the propulsion and an entire shaft. On the diesel electric towboat, the loss of a generator set only results in the loss of 25% of the maximum available power while still delivering power to both shafts. The diesel electric system also facilitates multiple back-ups for electrical generation.

2.5 Safety: This means that, in one very important respect, the ABB ETB system is undoubtedly safer than its rival diesel mechanical systems: if one engine fails in a twin-engine diesel mechanical set-up, the vessel loses 50% of its installed power and, even worse, loses its ability to steer.

In the ABB ETB design, the system can be configured so that the same single engine failure can lead to only a 25% reduction in available power, with this loss having no effect on steering. In addition, ETB system redundancies are built-in to critical components, so that a single point of failure will not cause a total loss of propulsion.

Those working the boat also benefit from increased comfort due to lower noise levels and vibrations.

3. Operational considerations

3.1 Operating profiles: The ABB ETB towboat has an ABB electric propulsion system that includes generators, propulsion motors, low voltage switchboards and automation and can be optimized when in standby mode, moving empty or full barge loads and when travelling up river, down river and in high water. The system exploits variable frequency drives to optimize power use over a wide span of operations: when in standby or moving empty barges, for example. In addition, ABB's responsive Direct Torque Control for propulsion thruster applications is claimed to be the most accurate and smooth speed and torque control in the industry.

ABB has been fine tuning its diesel electric technology for application to a towboat design, basing its work on a study of real river operations undertaken over a 365-day period covering 500 push boat vessels. The study concluded that the true nature of push boat operation is not 100% continuous duty or anything close to it. The market does require equipment that perform day-in day-out in harsh environments, but operating profiles vary greatly depending on boat type, contract, time of year and rivers traveled.

In summary, the number of vessels operating at over 80% loads for most of the time was much lower than expected, while many operators spent most of their time operating at below 50% power, with 80% loads only required in short peak periods. These findings invite consideration of the benefits to costs conferred by diesel electric propulsion's ability to run the optimized number of engines: from idle to about 25 percent load, only one engine is required.

3.2 Maintenance gains/vessel availability: ABB understands the importance of asset avail-ability and works every day to design aftermarket services ensuring the highest standards to keep vessels running. Its understanding has been sharpened by serving markets where day rates are extremely high and sensitive, such as the oil & gas industry.
If the vessel only has one type of engine on board, the number of spare parts for both the vessel and shore side support can be reduced. Further maintenance advantages for diesel electric propulsion include:

a. Owners can standardize engines through multiple horsepower vessels, with the impact felt on the bottom line due to streamlined maintenance/ minimized spare parts hold-ings

b. Greater levels of system redundancy, eliminating single point failures and leading to increased vessel reliability

c. The use of standardized and proven products supported by local ABB US service team located in Houston, backed by comprehensive familiarization and training programs from ABB to ensure that those on board adapt seamlessly to diesel electric operations.

3.3 Diesel electric technology onboard: One objection that has sometimes been raised when greater use of electrical systems onboard vessels has been raised is the lack of rele-vant knowledge and experience among marine engineers brought up on mechanical solutions. What does a mechanic know about a diesel electric vessel?

Electric Propulsion is simply the concept of using an electrical power plant consisting of multiple generators driven by diesel engines to produce electricity that is, in turn, used to power electric propulsion motors. Even so, ABB's Marine Academy trains operators to become more proactive in operating and maintaining equipment to maximize availability minimize less downtime. Course participants can visit ABB factories or workshops and obtain answers from the engineers who designed the equipment and systems themselves.

However, ABB understands and is addressing a changing aspect to vessel management: the modern towboat does not operate with an electrician onboard, so our equipment must be robust enough to operate with very little onboard interaction.

4. Technology for tomorrow

4.1 Connectivity: Power distribution based on diesel electric technology can exploit new sources of energy (e.g. batteries) which can be introduced to optimize efficiency (for example, through peak shaving). In fact, drawing on its ABB pioneering role in electrification products, robotics and motion, industrial automation and power grids, ABB is writing the future of industrial digitalization by: bringing electricity from any power plant to any plug; and automating industries from natural resources to finished products.

Today, ABB has approaching 1,000 vessels whose onboard equipment is connected by sat-ellite link to ABB Ability™ Collaborative Operations Centers, monitoring 24/7 from three main centers located in Singapore, Norway, and USA. Exemplary indicators include the monitoring of motor winding temperatures, the water pressure of the cooling system of propulsion drives, critical alarms, actual values like RPM, power, torque, and events such as unbalances, the status of the satellite link, and the status of RDS system on board.

4.2 Predictive maintenance: By having this critical equipment and operational information available, all ABB power and control systems support Remote Diagnostic System and Condition-based Monitoring, making it easier for inland waterway operators to comply with Sub Chapter M and reduce engine maintenance requirements/costs. The enablement of predictive engine maintenance also allows major maintenance periods to be scheduled at owners' convenience. With shift in technology we see a greater ability to support vessels remotely thus decreasing the need for technical expertise on the vessel.

ABB can alert its customers of the risk that a drive is going to fail, or that a bearing needs lubricating/servicing. Today, an engineer on board a ship can grant remote access to a technical expert sitting onshore, to get a system up and running again. The data can also be interpreted to infer that the average speed of the vessel would benefit by being reduced, saving fuel. Again, predictive analysis can show that certain operations are leading to unnecessary wear and tear, and that adjustments could lead to less downtime, reduced use of on-call service engineers, increased operational performance and lower dry-docking cost.

5. Partner benefits of diesel electric propulsion

There are many benefits for naval architects and shipyards available from diesel electric towboats that cannot be claimed for their conventional diesel mechanical counterparts.

5.1 Naval Architects: The number one advantage for vessel designers is that diesel electric systems bring flexibility. Diesel mechanical systems are fixed by shaft-lines and require most of the vessel's weight (engines and gearbox, propeller or thrusters) to be consolidated aft. This requires offsetting through additional ballast.

ABB electric propulsion system allows for the even distribution of heavy equipment throughout the vessel, liberating design ideas so that they can be developed to better serve the ship's operating duties. The ETB solution from ABB is also delivered in a compact, reliable and more cost-competitive solution than ever before.

When selecting the design and equipment for a vessel type, special consideration is given to how and where the vessel will operate. ABB uses only proven technology that it is confi-dent will withstand the rigors of inland river operation.

5.2 Shipyards: ABB's standard scope of supply includes all the power generating systems (generators), power distribution, automation control and electrical power consumers (propulsion motors). This means that shipyards and owners have only one company to work with on the main electrical systems. ABB also offers some of the most extensive and inclusive standard warranties in the marine industry.

Most issues occur in the installation process. Oversights here can lead to issues that plague a vessel for its entire life. With a large team of ABB project managers, service engineers and electrical engineers available as support, shipyards receive complete ABB system solutions developed for easy integration into the vessel. ABB takes a very active role in supporting the installation of its systems during the construction period, working closely with the shipyard to ensure proper installation, set-up and commissioning of our system.

5.3 Supply-side economics
A full list of benefits available to those involved in delivering diesel electric propulsion also include:

a. Day 1 material availability for the main components dimensions

b. Flexible design allows for more efficient vessel designs - less need for wasted ballast

c. Less vibration and no shaft lines to align - no gearboxes needed

d. On site and remote support from the system designers

e. Simple Installation - almost turnkey complete electrical system from one supplier

f. Hull design does not need to follow the propulsion engine and shafting

g. Lower slow speed noise targets can be achieved easier with small engines

h. Can be used for both thruster (L-drives) and conventional designed vessels

6. Conclusion

ABB is a world leader in power, automation and control systems across a range of sectors and has been delivering electric propulsion systems for use on board vessels for more than 70 years. Over that time, it has been evolving less expensive, more compact and more ro-bust systems shipboard electrical systems.

Due to the increased demand for electrical systems in all aspects of our lives, ABB can ex-ploit economies of scale to create and adapt technological breakthroughs for the maritime industry. Towboat owners and operators facing new regulatory, commercial and societal pressures can be assured that diesel electric propulsion is a mature and proven technology refined over decades for ease of installation, space-saving and efficiency, whose perfor-mance claims are documented.

* Clarkson Research: Setting A Course Towards A Cleaner Future March 31, 2017.

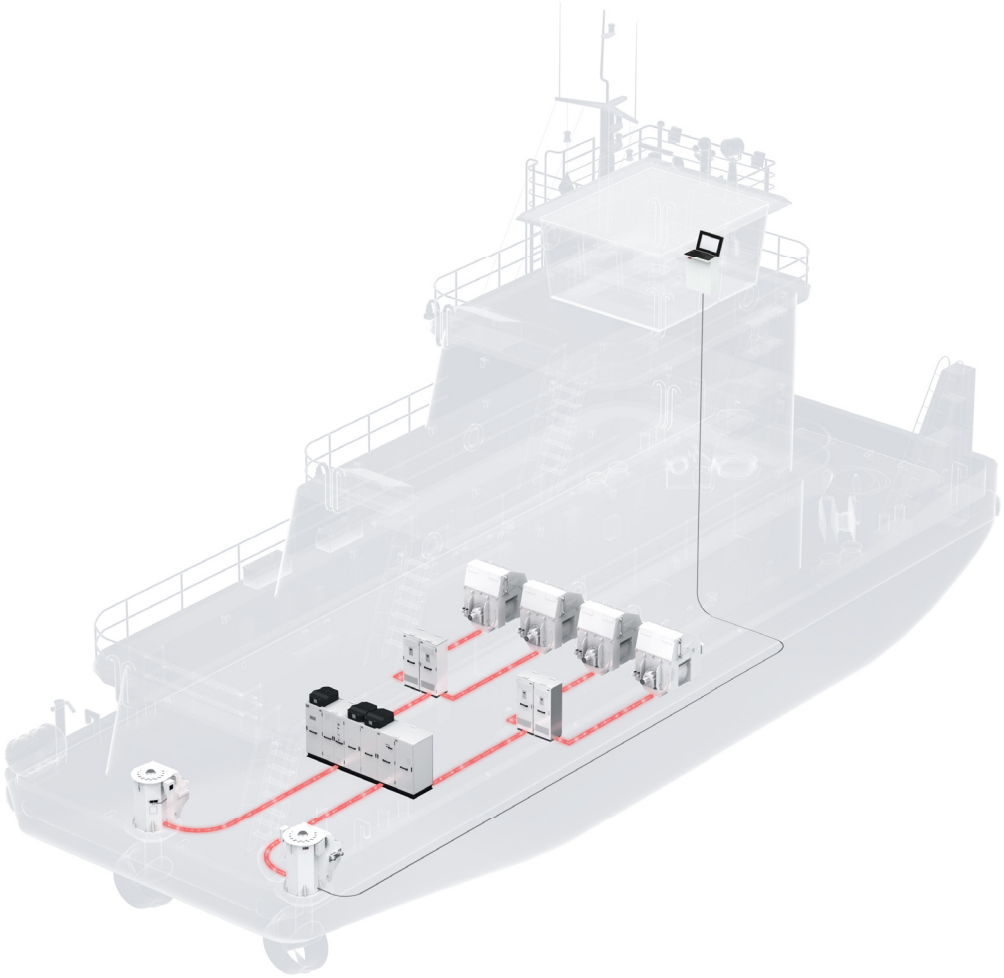

ABB Inc. Marine & Ports
MIRAMAR, FLORIDA:
11600 Miramar Parkway, Suite 100
Miramar, 33025, Florida, USA

HOUSTON, TEXAS
3700 W Sam Houston Pkwy S,
Houston, 77042, Texas, USA

Authors
Ed Schwarz
Phone: +1 954 224 8680
Email: edward.schwarz@us.abb.com

Richard Rozok
Phone: +47 930 71 954
Email: richard.rozok@no.abb.com

abb.com/marine

3AUA0000080942 REV A 18.5.2010 #14995