Fit for purpose

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From June 6 – 10, ABB Turbocharging joined global leaders and influencers of the internal combustion engine industry at the 28th CIMAC World Congress in Helsinki, Finland, in our long-running role as a major sponsor and exhibitor. And once more, it was our pleasure to host a traditional ABB Evening. Our company’s active participation in the Congress included a number of technical papers in which we presented our ideas for turbocharging solutions. I would like to thank all of our customers and business partners for the many fruitful technical and business discussions that took place in the course of the Congress.

Following hot on the heels of the CIMAC Congress is, of course, SMM 2016 – the leading international maritime trade fair in Hamburg.

We will be present at SMM 2016 from 6 – 9 September. You can find us at Stand 202 in Hall A3, and we are already looking forward to meeting you there. Among the latest products we will be showcasing are the A160-L, a noise reduction package and the A100-M axial. Those of you who missed the opportunity at CIMAC to learn about our completely new MXP® turbocharger, designed specifically for marine auxiliary engines, will be pleased to know that it will also be one of our highlights at the SMM. And in one-on-one conversations we will discover together the service solution that best meets your unique requirements, enabling reliable and cost-effective operations that improve overall productivity and profitability.

I hope you enjoy reading this issue of charge!, in which you will find several references to the SMM host city of Hamburg. I and my colleagues look forward to meeting you there.
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MXP® – a turbocharger designed and optimized for marine auxiliary engines
The MXP is the first dedicated turbocharger from ABB Turbocharging to be designed in a development cooperation with IHI Corporation. Specifically for small bore medium-speed marine auxiliary diesel engine platforms with up to 2 MW power output, its simple and robust design makes life easier for engine builders and operators alike.

**Marine vessels such as bulk carriers, oil tankers or container ships generally cover their onboard electrical power needs with generators powered by marine auxiliary diesel engines. These engines operate with heavy fuel oil (HFO) in combination with HFO-capable turbochargers. Most marine vessels are equipped with two to four such auxiliary diesel engines, usually positioned side by side. The engines run at a fairly constant part load most of the time – not their most efficient operation regime.

HFO is used extensively in marine auxiliary diesel engines and has the advantage of being cheap. However, HFO has a high level of contamination that causes fouling, heavy wear and corrosion – all of which lead to a deterioration in turbocharger efficiency and an increase in fuel consumption. Periodic maintenance, cleaning and replacement of worn parts can mitigate these deleterious effects.

Clearly, there is a need for a turbocharger that is specifically designed and optimized for marine auxiliary engines so that the challenges of part load, emissions, HFO quality, fuel economy and service can be satisfactorily addressed. With all these factors in mind, and with extensive input from customers as to what their specific requirements are, ABB Turbocharging and IHI (ABB Turbocharging’s licensee and also joint venture partner for its sales and service organization in Japan) embarked on a product development cooperation to produce a brand-new turbocharger for marine auxiliary diesel engines up to 2 MW. The result is the MXP turbocharger.

The MXP was launched during the CIMAC congress in June 2016 and has the following features:
- Designed for ease of use and service.
- Designed for optimal part-load operation.
- A simplified and robust construction enables trouble-free use with HFO and pulse operation.
- Customer-friendly and easy condition-based maintenance by, for example, a crew supported by a self-service app.
- Lower total cost of ownership.

**Turbocharger design**

To make operation and service – ideally, by members of the ship’s crew – easy, the MXP design has the minimum number of parts and assembly steps. To ensure complete user-friendliness, the specific requirements of engine builders and end users were collected, analyzed and fed into the design process.

The MXP turbocharger design consists of an HFO- and pulse-capable radial-type turbine wheel, a radial high- and medium-pressure compressor stage, optimized plain bearing systems and bearing casing, a lightweight air filter silencer and the required gas and air ducting.

The product series consists of three frame sizes covering an air flow range of 0.6 m³/s up to roughly 3.5 m³/s (Fig. 1). The pressure ratio ranges from 3.5 to 5.2 for the smallest design and up to 5.4 for the largest frame size. The frame size and specifications for the compressor and turbine stages can be chosen to cover all engine operating points within the flow rate and pressure ratio range stipulated.

**Fig. 1: Frame size coverage map.**
The MXP turbocharger design, including the gas path through the ducts, is shown on page 4. It features a new casing concept with integrated shroud contour geometry into the volute on both the compressor and turbine stage. The nozzle ring is semi-open and easy to clean or replace. It is made from a tough material to protect against wear erosion and thermal fatigue.

An innovative design makes the bearing overhaul service-friendly (Fig. 2). This design features a so-called bearing unit that includes the radial and axial bearing parts, the thrust ring and the compressor-side shaft sealing arrangement. The bearing unit can be pre-assembled and stored as a spare part. It is fixed by six screws within the bearing casing; the circumferential positioning of the screws ensures poka-yoke (mistake-proof) assembly. The casing is designed for easy access and all fasteners for one turbocharger frame size basically feature the same thread dimension, strength class (8.8) and tightening torque.

**Performance**

A sample compressor map with a low-solidity diffusor at a moderate pressure ratio for the MXP product series (smallest frame size) is shown in Fig. 3. The operation line of a sample marine auxiliary engine is shown, together with expected operation points at 25 to 110 percent engine load. Depending on the engine setup and layout, the characteristics of the compressor map can be adjusted by using a different type of diffusor area specification. To extend the map width at higher pressure ratios, an inducer casing bleed system (stabilizer) is used for the impeller.

Depending on the engine setup and layout, the characteristics of the compressor map can be adjusted by using a different type of diffusor area specification.
Joël Schlienger, who joined ABB Turbo Systems in 2004, is head of Product Technology in the Marine Auxiliary Product Group. His experience includes the first generation Power2 charging system and he is currently leading the joint development with IHI Corporation of the new marine auxiliary turbocharger MXP. Joël received a Mechanical Engineering degree from the Swiss Federal Institute of Technology (ETH) in Zurich and completed his PhD in 2003.

MXP turbocharger series:

- TCO reduction potential due to simplified turbocharger design.
- Pulse-charged capable turbine with multi-gas inlets for marine auxiliary diesel engines running with HFO fuel.
- Turbocharger service can be done by crew using standard tools.
- Condition based maintenance (CBM) supported by digital app technology.
- Additional benefits in part-load efficiency and load response.

With regard to fuel efficiency, the MXP is optimized for part-load operation – and potentially full-load operation – by increasing the turbine/compressor wheel diameter ratio. This optimization shifts the efficiency peak to part load and improves the performance and fuel consumption within the expected marine auxiliary engine load range, as illustrated in Fig. 4.

Maintenance

A particular feature of the MXP turbocharger is the ease with which the end user can perform maintenance himself – and with tools that are found in any toolbox. Even the bearing cartridge and the compressor wheel can be removed and replaced using standard tools.

Field experience with existing products shows that the turbocharger condition (in particular wear and fouling) very much depends on the marine auxiliary engine type and operating point as well as the quality of the HFO fuel. These factors result in service or repair intervals that vary from engine to engine. For this reason, MXP adopts a condition-based maintenance (CBM) instead of schedule-based approach, so that unnecessary servicing and component exchange – and associated costs – are avoided. An app-based interactive self-service support guide for CBM with issue resolution is available for the MXP.

The low maintenance effort required for the MXP and its optimized design ensures that users of marine auxiliary diesel engines up to 2 MW now have a turbocharger product that is not only robust, efficient and easy to operate at partial or full load but also offers a very competitive total cost of ownership.

With regard to fuel efficiency, the MXP is optimized for part-load operation – and potentially full-load operation – by increasing the turbine/compressor wheel diameter ratio.

Fig. 4: Performance benefits for part-load optimized turbocharger.
Power boost for Senegal

Turbocharger upgrades on Wärtsilä 46 engines for Senelec’s Kahone II plant significantly reduce fuel consumption and exhaust temperatures.

Text Thorsten Bosse, Omar Kindo, Photography Senelec, ABB Turbo Systems Ltd

Located, as it is, less than 1,500 km from the equator and sitting at the edge of the Sahara Desert, the extreme ambient conditions encountered in Senegal pose particular challenges for power generation equipment. Senelec, the Senegalese national electricity company, recently contracted Wärtsilä and ABB Turbocharging to carry out a series of turbocharger upgrades on some of the diesel generators that are so critical to the nation’s power supply. Exhaust temperature was a main focal point of the exercise as the extreme ambient heat encountered at these latitudes means that the engines often have to be run in a derated mode – a loss of potential power generating capacity that is significant for a country which needs every Watt of power that can be produced. charge! magazine spoke to some of the people involved to find out more about the project.

Gensets powered by Wärtsilä 18V46 engines

Senelec’s Kahone II base load power plant, located some 300 km from Dakar, the capital, employs a group of diesel generators to provide base load power to the national grid. Like many other utilities, Senelec depends heavily on the high reliability and performance of its Wärtsilä 18V46 engines fitted with ABB TPL 77 turbochargers.

Wärtsilä is a global leader (the company has operations in over 200 locations in more than 70 countries) in advanced technologies and complete lifecycle solutions for the marine and energy markets, making it an excellent partner for ABB Turbocharging in diesel power generation projects around the world. Wärtsilä emphasizes sustainable innovation and total efficiency in its products and thus maximize the environmental and economic performance of its power plants. This fits in very well with the requirements of the Kahone II installation.

Like many other utilities, Senelec depends heavily on the high reliability and performance of its Wärtsilä 18V46 engines fitted with ABB TPL 77 turbochargers.
Diesel generators are critical to Senegal’s power supply.
Senelec’s Kahone II power station generates a total of 104 MW using three different diesel engine/turbocharger configurations: four Wärtsilä 18V46C2 diesel engines with eight ABB TPL 77-A30 turbochargers (60 MW); two Wärtsilä 18V46C4 with four ABB TPL 76-C33 (30 MW); and four Pielstick 8PC2-5L with four ABB VTR 401-2 (14 MW). Wärtsilä West Africa has a shared operations and maintenance contract with Senelec, and currently they run the six Wärtsilä engines that provide 90 MW of the total plant output.

**Turbocharger upgrade**

Because of the extreme heat, the engines are often derated, that is, operated at less than their full capacity. Such a situation may be improved by a turbocharger upgrade. By replacing the existing compressor stage of the turbocharger with an improved version with increased speed margin, derating is no longer necessary. Not only that, but fuel consumption and exhaust gas temperatures can also be reduced significantly.

Senelec had been engaged in a process of improving the quality of its services – all in line with its mission to ensure energy availability at any time and at an affordable price. However, Mr. Thierno Oumar Kane, Production Director at Senelec was initially unsure about the benefits of a turbocharger upgrade: “I was dubious at the beginning about the real gains a turbocharger upgrade could bring to our engines. My colleagues at Senelec, as well as myself, showed some hesitation and asked ABB and Wärtsilä to give some performance guarantees.”

When Wärtsilä OEM equipment is involved, ABB always engages in a collaborative approach to the project. The project delivery is then, effectively, carried out by one team, reducing complexity and making things simple for the customer by presenting a single face and providing an overall package price for parts, upgrade, testing, emissions measurement and technical documentation. Accordingly, the Wärtsilä and ABB team delivered the required performance guarantees to Senelec, and a project to carry out an upgrade of the TPL 77-A30 turbochargers to TPL 77-A32 on the Kahone II Wärtsilä W18V46C2 diesel engines (four engines and eight turbochargers) was given the green light. The upgrade work was carried out along with major engine maintenance by ABB and Wärtsilä personnel and was performed without major interruption to the power-generating duties of the plant. The project was a landmark as it represents the first upgrade from TPL 77-A30 to TPL 77-A32 in Africa.

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**What we’ve achieved with this upgrade:**

- Fuel savings of 2 percent (500,000 Euro annually).
- Power output increase of 2 MW (330,000 Euro annually).
- 40 to 45 K reduction in exhaust gas temperatures resulting in higher reliability.
- Strengthened cooperation with the engine OEM Wärtsilä.
- First upgrade performed in Africa.
- A happy customer, ready to do the next upgrade of this kind.
Customer satisfaction

Mr. Kane was very pleased with the outcome: “After the upgrade, the exhaust temperature was down by 40 to 45 K and we had a reduction of the specific fuel oil consumption of about two percent. We were very satisfied.” Mr. Kane continued, “not only did we get the temperature and fuel reduction but it now seems we can also get an extra 500 kW from each of our Wärtsilä 18V46 engines.” Previously, Senelec had had to derate the engine for about six hours during the day when it was very hot (temperatures can reach 40°C). After the upgrade, the engine can run all day long, all year at a constant, high setting with no issues. The ability to get an extra 500 kW out of each engine for six hours a day for six months of the year brings about revenues of roughly 340,000 Euro for additionally sold power (assuming an energy sales price of 0.18 Euro/kWh). Reduced fuel consumption contributes almost another 500,000 Euro of savings per year (at a fuel price of 300 Euro/t), so that the upgrade investment pays back in less than a year for Senelec.

Mr. Ousseyyou Ndiaye is Wärtsilä West Africa’s General Manager, Sales and Marketing: “We at Wärtsilä are very pleased with this turbocharger upgrade project. We delivered significant improvements in operating temperatures in the challenging environment in Kahone. The customer also has expressed satisfaction with the saving it allowed in engine specific fuel oil consumption. This was another excellent collaboration between ourselves and ABB.”

“Kahone is a great example of performance improvement,” commented Mr. Abdousalam Ndir, Wärtsilä West Africa’s Power Plant Manager at Kahone II. “Since the turbocharger upgrade we have noticed a real improvement in typical engine running parameters: charge air pressure and average exhaust gas temperature after the cylinders, and exhaust gas temperatures before and after the turbochargers have decreased. Now we are able to operate the engines at full load without any alarms related to high deviation of these parameters.”

Wärtsilä West Africa’s Senelec O&M Contract Manager, Mr. Raghupathi Tendolkar, adds, “In the early discussions we did not really see the added value and the end user asked us for some performance guarantees we were not sure we could achieve. After all, it was the first time in Africa that ABB TPL 77-A30 turbochargers were upgraded to the TPL 77-A32 type – and the ambient conditions were pretty extreme too, so it took us a lot of time and energy to get a final agreement. However, the result exceeded our expectations. With this upgrade, Wärtsilä and ABB have once again provided an innovative solution that reduces power production costs, with a quick return on investment.”

Service stations

To minimize downtime on any future service and maintenance work on the new turbochargers in Senegal, advantage can be taken of ABB’s global service presence: ABB operates a wholly owned network of more than 100 Service Stations in over 50 countries, covering all the major geographic areas of demand for turbocharger service. Each site has specially trained engineers and is equipped to service the full range of ABB turbochargers – so help is always at hand.

The positive results of the upgrade hold promise for future, similar upgrades. The last word is left to Mr. Kane, “after these results, we are determined to repeat the experience for our engines at the Cap Des Biches site – this time without asking for guarantees of the benefits”.

Information on upgrades on engines in other applications, such as marine and rail, as well as their benefits, can be found in charge! 2|2014 and charge! 2|2015, respectively.

“After the upgrade, the exhaust temperature was down by 40 to 45 K and we had a reduction of the specific fuel oil consumption of about two percent. We were very satisfied.”
How will the Internet of Things shape the future of turbocharging technology?

Much is being said about the opportunities presented by connecting sensors on devices to the internet, enabling accessibility to vast quantities of data. For industrial organizations it seems the opportunity exists, but for turbochargers just what is that opportunity? How will it shape or be shaped by current and emerging industry dynamics?

Text Alexandra Christie, Photography Morten Rakke
As highlighted by the editor of Marine Propulsion magazine earlier this year, this is a “paradigm shift in marine operation”.

**Changing market dynamics**

It’s clear why the noise around this is growing, and it is precisely at a time when in the shipping industry the sustained low price of fuel, slowdown of global growth, and limited investment are bringing challenges. Other power industry sectors face similar difficulties. Therefore, the possibility of finding a way forward via new, sustainable revenue streams becomes more interesting.

Amidst the global economic downturn of 2009, a Bloomberg News article stated: “the creative thinking that’s needed to weather the storm of an economic downturn can lead to new markets and revenue streams”. If this is true of all industries, we now have a real rationale for engine builders, operators and their suppliers to explore potential solutions. At ABB Turbocharging, we now seek to answer a new set of questions: Can diesel and gas engines, and turbocharging become a “digital industry”? To make this happen, how will engine industry stakeholders work together? Where is the real value for customers?

**Potential for turbocharging**

The most obvious potential is around service and maintenance of turbochargers. Earlier this year ABB Turbocharging launched MXP, a completely new turbocharger dedicated for marine auxiliary engines. Designed to enable a condition-based maintenance concept, the operator independently determines maintenance scheduling which can be done by the ship’s crew. This new approach, is just one example of our segment-specific approach to product and service solutions that we anticipate will lead our transition from preventive to predictive maintenance, enhanced by the benefits that engine data can bring to turbocharging.

Further promising service initiatives are in progress with expectations of launching the first solutions in the near future.

In addition, there are also implications for improved product design and application engineering. The availability of insights from actual engine operation will enable engine builders and suppliers to develop and design products far more closely matched to customer applications. For turbochargers, this will lead to more precisely calculated air delivery characteristics, greater flexibility in product design and ability to adapt to as many of the engine’s potential operating circumstances as possible for optimal operation.

To make this happen, our industry’s biggest challenge is defining how turbochargers can fully be a part of this digital transformation. It will rely on the close interaction and interdependence of firstly engine builders who have access to data, secondly component suppliers with specific expertise, and thirdly advisory system suppliers able to integrate this information into existing and new customer systems. If this can be realized, we see potential for turbocharging offerings around safety, reliability, efficiency of operation and maintenance, uptime and increased power output, asset performance and fuel savings. This has always been our business focus, but further development with key industry alliances is what we predict will better support our customers in achieving competitive advantage.
Is two-stage turbocharging on low-speed, two-stroke engines feasible?

The market that could benefit from this type of turbocharging is large. Simulations support a movable sleeve technique as one possible approach.
In recent years, two-stage turbocharging on four-stroke diesel engines has had great success in applications such as automotive, marine and power generation. The combination of high overall compression ratios and high turbocharging efficiency from intercooling allows engines to be constructed that have both high power density and remarkable fuel efficiency. By using Miller intake valve timing, these engines can also keep NOx emissions to a minimum.

Two-stage turbocharging on low-speed, two-stroke engines is a different matter. Some research progress was made in the aftermath of the 1970s oil shocks, but interest in the topic waned when the world became used to the new regime of high and erratic oil prices. Also, other factors – such as the success of single-stage turbocharging – further reduced the motivation for more development. Consequently, there are currently no two-stage turbochargers on low-speed, two-stroke engines.

**Turbocharging of low-speed marine two-stroke engines**

The absence of two-stage turbochargers for low-speed, two-stroke engines is not due to a lack of a market for them – two-stroke engines are the powerplant of choice for large marine vessels as they allow direct propeller drive without reduction gears and they deliver the highest achievable thermal efficiency of all internal combustion engines. However, the technical difficulties of turbocharging a two-stroke engine are significant. Indeed, the very simplicity of these engines reduces the potential for control and their layout – with intake ports for air delivery and poppet valves for exhaust – may be very straightforward but imposes restrictions.

Further, in contrast to four-stroke engines, charge air pressure and air mass flow through a two-stroke engine are not directly coupled. Two-stroke engines have a flow characteristic similar to an orifice in a gas pipe rather than a volumetric pump as is the case in four-stroke engines. This means that the pressure difference between the intake and exhaust of a two-stroke engine cannot be directly influenced by turbocharging. Therefore, a higher turbocharging system efficiency at unchanged intake air pressure leads mainly to a higher air mass flow through
the engine (increased scavenging). To enhance engine thermal efficiency within an NO\textsubscript{x} emissions driven cylinder pressure limit, additional measures on the engine side such as a reduction of intake port height must be considered.

**Power2® system for low-speed engine applications**

To exploit the potential of two-stage turbocharging in two-stroke engines, it was proposed in [1] to utilize the combination of high overall compressor pressure ratio and the high turbocharging system efficiency of two-stage turbocharging systems for engines with a power density elevated to a range between 25 and 30 bar, from today’s 21 bar.

Power2 is ABB Turbocharging’s newest dedicated two-stage turbocharging system for four-stroke engines. With an air pressure of up to 12 and turbocharging efficiency beyond 75 percent – compared to 65 percent efficiency of a conventional turbocharger – Power2 is a powerful energy multiplicator. Because of its operating characteristics, Power2 would be a suitable candidate for use in low-speed, two-stroke engines and for this reason the simulations described here are partly based on an adapted Power2 system. Simulations with single-stage turbochargers are also presented, for comparison purposes.

**Variability for air intake ports**

As a result of pressure to reduce emissions and fuel consumption, control features – ranging from variable injection timing (VIT) to variable exhaust valve timing – have been introduced on low-speed, two-stroke engines. However, intake ports are still passively controlled by piston movement. Is there perhaps a way to exploit variable intake port timing to achieve the engine control needed to allow two-stage turbocharging?

One approach is to use different timings for inlet port opening and closing. This gives an extended expansion stroke for higher thermal efficiency, while the intake duration would still be sufficiently long to achieve a high charge purity. This intake port variability can be achieved by the introduction of a movable sleeve able to cover the entire height and circumference of the intake port region within the cylinder liner. The necessary control functions can be integrated into the engine controller.

If the air intake duration is reduced, a higher turbocharger efficiency will be required, so it is worthwhile using a two-stage turbocharging system as a single-stage turbocharger may be underpowered.

**Asymmetric intake port timing**

With an actuator able to move the sleeve mechanism faster than the piston, asymmetric intake port timing can be achieved. The start of the scavenging phase can be delayed by late opening of intake ports – giving the extended expansion stroke that improves thermal engine efficiency. The duration of scavenging can be maintained with increased port height, i.e. later closing of intake ports if no surplus in turbocharging efficiency is available (which could be used for delivering similar scavenging performance with shorter intake opening duration). The sleeve preferably opens from the bottom, such that sleeve and piston move in opposite directions. Intake ports do not start to open before the edges of the piston and sleeve cross each other. If the air intake duration is reduced, a higher turbocharger efficiency will be required, so it is worthwhile using a two-stage turbocharging system as a single-stage turbocharger may be underpowered. This step is the key to enhancing fuel efficiency, while scavenging is still kept at the present performance (as can be seen from the diagram below).

**Asymmetric intake port sequence**

1. Exhaust valve is fully opened.
2. Edge of piston crown reaches upper end of intake port.
3. Edge of sleeve reaches edge of piston crown.
4. Intake ports partly covered by sleeve; scavenging starts.
5. Intake ports no longer covered by sleeve.
Effect of BMEP, single and two-stage

To investigate the feasibility of the sleeve approach on low-speed, two-stroke engines, various simulations were carried out. The effect of asymmetric intake port timing was assessed at a BMEP (brake mean effective pressure) level of 25 bar. Full opening of intake ports was set to BDC (bottom dead center) for all considered cases. In all cases checked, it could be observed that asymmetric intake port timing has a linear effect on all major engine performance parameters, independent of BMEP (see figs. 1 and 2).

Conclusion

Asymmetric timing of intake ports based on a sleeve mechanism enables an extension of the expansion stroke in two-stroke engines without the adverse effects seen with a heavily reduced port height. The approach shows a consistent, linear effect on fuel consumption for the different cases considered with single-stage turbocharging at a BMEP of 21 bar and two-stage turbocharging at a BMEP of 25 bar, as long as the port height is well matched. Starting from a single-stage turbocharged engine at a BMEP of 21 bar with high-pressure tuning, savings in fuel consumption by a combination of two-stage turbocharging with asymmetric port timing may reach up to 7 g/kWh at 20 percent higher BMEP in the considered load range – though the power required to actuate the system will slightly reduce this saving.

In large marine engines, which can have up to 12 cylinders, higher BMEP could enable a reduction in the number of cylinders and thus a reduction in engine size – for the same, or better, efficiency.

Though no two-stage turbocharging system for low-speed, two-stroke engines currently exists, the calculations presented here point to one possible approach to developing such a turbocharger for the large market in marine applications.

Reference:

Raphael Ryser graduated from the Swiss Federal Institute of Technology (ETH) in Zurich in 2005 with a Master’s degree in Mechanical Engineering. After two years as a research assistant at the Paul Scherrer Institute in Switzerland, he spent five years with Wärtsilä Switzerland Ltd. working on two-stroke engine performance, in particular, two-stage turbocharging. Raphael joined ABB Turbo Systems in 2012 and is a Senior Expert, Turbocharging and Engine Technology.
ABB power, propulsion and automation for world’s most advanced port icebreaker

When Sir John Franklin searched for the North-West Passage in the mid-1800s, he could scarcely have imagined by just how much the polar sea ice would retreat in the following 150 years. Now, large ocean-going ships regularly ply sea routes along the north of Canada and Russia. These shipping lanes almost halve the time it takes to voyage between the Atlantic and the Pacific Oceans and the routes are remaining ice free for ever-longer periods, thus lengthening the shipping season.

Text Magdalena Okopska, Photography Aker Arctic
With this increased shipping presence comes the increased need for icebreakers both on the seas and in ports. Due to the nature of the job they do, icebreakers have to be of solid construction.

**Icebreaker design**

Thick ice is not often broken by ramming it, but in some cases by running the specially designed vessel bow up onto the ice and breaking it from above, using the propeller to crush it, or by moving ice floes in port as is in the case of a port icebreaker. In particular, an icebreaker’s hull differs from a normal hull in thickness, shape and material. The bow, stern and waterline are reinforced with thick steel especially chosen for its low-temperature performance; and the hull’s shape is designed to make the ship rise above the ice before falling and breaking through it. All these additional features mean that an icebreaker is much heavier than a normal ocean-going ship of similar size.

Moreover, due to the immense strength and often unpredictable nature of ice, icebreakers must be equipped to deal with a whole range of potential dangers. Pressurized air and heated water jets are forced out of the ship under the ice to help break it up. This water freezes, building up ice on the ships structure and causing its stability to change. Also, the rapid pumping of ballast water around the ship enables it to rock to further assist icebreaking.

**Powerful engines**

To make sure the maximum amount of power possible can be derived from the icebreakers’ marine engines, they are fitted with turbochargers. ABB has a wide range of turbocharger solutions for marine applications and are supplying turbochargers for the most advanced port icebreaker ever built — currently in planning for construction by the Vyborg Shipyards in Russia. ABB will also provide the power and automation capabilities for the vessel.

ABB has a wide range of turbocharger solutions for marine applications and are supplying turbochargers for the most advanced port icebreaker ever built.

Icebreakers will be needed increasingly as the North-West Passage is used more regularly by shipping.
Driving the development of new turbocharging solutions is the demand for highly efficient engines for such applications which require high power density and low operating costs in addition to compliance with today’s emissions requirements.

The main engines of this icebreaker will be fitted with Power2 800-M, the most advanced two-stage turbocharging system in the industry, enabling highest efficiency. Designed to set new standards in turbocharging performance, Power2 increases the efficiency of four-stroke engines and was developed specifically to support advanced engine concepts.

**Power2-800 M**

Many aspects of the design of Power2 800-M fit with the engine requirements of this new advanced vessel, in particular fuel efficiency and reliability. Icebreakers are fuel-intensive, which translates into high operating costs. An icebreaker running at full capacity through three meters thick ice can use more than 100 tons of fuel per day. Fuel efficiency is also important to eliminate the need for fuel refilling, which is challenging in ice-filled regions. Two-stage turbocharging is a key technology that facilitates a reduction in fuel consumption and emissions, while helping to increase power density.

Power2 800-M was entirely designed and optimized for the specific needs of two-stage turbocharging. Engine availability is a key factor here, so service and maintenance has been made easier and more cost efficient with the new extractable cartridge concept. This reduces the time for overhaul by approximately 30 percent, which is particularly important when twice the number of turbochargers are to be serviced.

**Two-stage turbocharging innovation**

The turbocharging system also takes up minimal space: it is 20 percent more compact than conventional two-stage turbocharging solutions. Such space saving is especially critical in an icebreaker as the extremely strong hull construction of the vessel leaves less internal space than would be available on an equivalent, ordinary ship.

In addition to enhanced fuel efficiency, the Power2 800-M turbocharging system is designed to operate across a wide range of load profiles, something that will further enable flexibility of operations. With up to 60 percent lower NOx emissions, it also substantially reduces air pollution – an important aspect for operation in the pure Arctic environment.

With a low-pressure and high-pressure stage, Power2 800-M provides higher air pressure ratios – up to 12 from eight in the previous generation. Whereas a single-stage turbocharger operates at 65–70 percent efficiency, Power2 800-M goes beyond 75 percent efficiency. It is the only system currently available across the large-engine industry with this capability.

Power2 800-M responds to the need for new marine engine technology to offer consistency of performance across conventional and newer marine fuel options. Once the icebreaker is constructed and operating in iced-up port waters, the capabilities of the turbocharging system will prove to be invaluable in providing the power to keep waters ice-free for shipping.

**Maximum flexibility**

The new vessel will also feature two pairs of Azipod thrusters and ABB’s Onboard DC Grid system. One of the crucial benefits of Azipod propulsion is that it turns 360 degrees, allowing the ship’s crew to maneuver the vessel to operate stern or bow first. The vessel will benefit from the DC Grid in that it provides space and weight savings whilst minimizing noise and vibration. Furthermore, the engines will be able to run at variable speeds, which is important when managing ice conditions. This flexibility can also cut fuel consumption and emissions.

Power2 800-M responds to the need for new marine engine technology to offer consistency of performance across conventional and newer marine fuel options.
Nozzle ring with new coating
Increased turbocharger availability and power output

A new surface coating for nozzle rings counters fast deposit buildup

Heavy fuel oil (HFO) is used extensively to power diesel engines in the continuous power generation market as it has a price advantage compared to diesel. However, HFO has a high level of contamination that causes deposits to form inside the turbocharger, in particular on the nozzle ring. These deposits can lead to partial clogging, which restricts the passage of exhaust gas and results in reduced turbine efficiency and performance, increased exhaust gas temperatures and higher charging and ignition pressures as the turbocharger speed rises.

Periodic wet cleaning can counteract these effects by removing deposit buildup, but this type of cleaning commonly has side effects such as thermal shocks that reduce turbine-side component lifetime. Other factors that have to be taken into account are the cost and effort of this additional maintenance performed by the crew and the reduced power output while the engine is deloaded to permit cleaning.

ABB’s solution

The best way to combat the problem of deposit buildup is to hinder the deposit in the first place. ABB has successfully achieved this by developing a new anti-deposit coating for nozzle rings.

This innovative solution significantly reduces the frequency of required maintenance interventions. It also enables greater turbocharger power output and efficiency, thus allowing further cost savings. Experience in the field has shown that, with the new nozzle rings, the interval between wet cleanings can be increased by about four to six times. For example, on a 153 MW power plant in the Caribbean, the turbochargers of nine engines were recently upgraded during scheduled maintenance (no additional downtime was needed to upgrade). Intervals between cleaning were extended from 50 to 300 running hours, which represents 17,100 MWh of power that would otherwise be lost annually.

Nozzle rings with the new coating are offered for specific ABB turbochargers as an upgrade solution for customers who want to limit the impact of burning HFO. More on the subject of possible coatings can be found in “Tips for the operator”, beginning on page 24.
Classification societies give second-generation Power2 the green light

Milestone. Power2 800-M, the latest generation two-stage turbocharging system from ABB, reached a new milestone in May 2016 with the successful completion of type testing. As with all new engine components, the two turbochargers within the system underwent the type test ahead of their first installation. The nine classification societies and representatives of the Japanese government invited to carry out the thorough testing of the system traveled to Baden, Switzerland, for two days, and in conclusion confirmed that Power2 800-M passed the type test.

The process involved the system’s two turbochargers being run on a test rig where they could be measured in operation at the very highest permissible speed and highest permissible temperature. Following this, they were dismantled and checked for any possible damage which may have occurred during the test.

The agreement between all participants that the turbochargers passed the test confirms that the product is fully ready for application on an engine, a critical step for all engine components, particularly in the marine industry where specific regulations are in place to ensure that a ship and all its equipment meet the requirements of marine usage.

The type test is one major step towards the Type Approval Certificate, which confirms conformity of the Power2 800-M system with the classes’ technical rules. The Type Approval Certificate is the basis for delivery of class certified serial Power2 800-M systems to ABB customers.

Dr. Klaus Heinrich, Manager Classification Societies at ABB Turbocharging, commented: “Our reputation has long been influenced by the quality of products that we design and manufacture for efficiency, uptime and safe operation. This is underlined by the news that our highly efficient, new generation two-stage turbocharging system is now approved for commercial operation. Strict marine regulations make type certification for marine applications especially thorough, so to have this completed on schedule as we look forward to the first application of Power2 within the next 12 months is indeed a notable success.”

Although ABB turbochargers are always designed to fulfill the relevant industry requirements, passing of the test is still a significant milestone. It is the latest advancement in a series of announcements after Power2 800-M was officially launched to the market in mid-2015, offering unrivaled pressure ratios of up to 12 and turbocharging efficiency beyond 75 percent. Later that year, it was announced that the first commercial application of Power2 will be on the most advanced four-stroke medium-speed engine set to power a state-of-the-art new generation icebreaker currently under construction in Russia and expected to be in operation from 2017.
A100-M – the turbocharger of choice for advanced marine icebreaker applications

A100-M. ABB’s A100 turbochargers designed for medium-speed engines will be installed on the forthcoming icebreaker vessel commissioned by the Polar Research Institute of China. Established in 1989, the Polar Research Institute is a public welfare organization and the sole scientific research and guarantee service center for China specialized in polar research. Strengthening this capability will be the launch of this new icebreaking vessel, the first of its type to be built in China.

Expected to be in service by 2017, this vessel will become the sister ship of the MV. Xue Long, another Chinese icebreaker built in the Ukraine and now owned by the Polar Research Institute dedicated to undertaking expeditions in the Arctic and Antarctic Seas. Xue Long is equipped with two ABB TPL turbochargers and three TPS turbochargers. The new ship will benefit from the combination of higher turbocharging efficiency and high compressor pressure ratios of the newer generation A100-M. Since the A100-M launched, ABB has delivered 3,400 units to date.

Flexibility for cutting through ice with a minimum thickness of 1.5 meters is critical for these vessels which also have a number of other unique traits, such as being much heavier for their size and requiring very powerful – usually diesel – engines. The A100-M enables excellent engine load response behavior for such applications in these extreme environmental conditions of sea and port ice-breaking.

The Xue Long was involved in the rescue operation of the crew onboard the Akademik Shokalskiy which became trapped in ice off the East Antarctic coast in December 2013. It then docked in Perth, Australia, where it was located in March 2014 when Malaysian Airlines flight 370 travelling from Kuala Lumpur to Beijing disappeared. Due to its proximity to the search site in the Indian Ocean, the Xue Long was dispatched as part of the multinational search operation.

ABB’s advanced A100-M turbochargers also power the engines of the world’s most environmentally friendly icebreaker, Polaris, the eighth in a fleet of icebreakers owned by the Finnish State Transport Agency. Delivered in early 2016, Polaris has been developed in line with a zero emissions principle of low sulfur fuel, and is the first icebreaker to operate on LNG, particularly challenging for the design of an icebreaker.

The main engines of another highly advanced newbuild icebreaker will use the newest generation of the two-stage turbocharging system from ABB for medium-speed engines: Power2 800-M. It will be built at Vyborg shipyard in Russia, and is described as the most advanced port icebreaker, developed specifically to handle heavy harbor ice conditions.

New Service Point in China

Fuzhou. ABB Turbocharging opened a new Service Point in Fuzhou, Fujian Province, China, in May 2016. The Service Point, at Fuzhou Huadong Shipyard, is the third ABB Turbocharging has set up in partnership with a local shipyard. The new facility features a full range of equipment, including a balancing machine and a sandblasting and high pressure cleaning machine. With it added to the south-eastern coast of China, ABB Turbocharging is better positioned to provide overhauls and repairs performed by experienced and certified ABB Turbocharging service engineers with Original Parts and serve customers in the area more quickly and flexibly.

Fuzhou Huadong Shipyard.
Nozzle ring erosion

The turbine components of turbochargers operating on engines burning HFO can be exposed to erosion. ABB has developed wear protection for the nozzle rings that substantially improves their durability.

Text Rolf Baechi, Photography iStockphoto, ABB Turbo Systems Ltd

Nozzle rings featuring wear protection are available for power plants and can also be beneficial for certain marine applications.
From a scientific aspect, erosion is a wear process in which surface damage is caused by the repeated application of high localized stresses. Erosion by solid particle impact is a problem of great practical significance that can result in component failures in, for example, turbines and energy conversion systems.

Turbochargers operating on engines that use heavy fuel oil can be exposed to erosion of turbine components, such as the nozzle ring (Fig. 1). Experience indicates that the potential wear occurs in the form of abrasion. This kind of erosion is caused by particles that are formed during the combustion process and conveyed to the turbocharger by the exhaust gas. The quantity and size of the particles depends on a number of factors, ranging from the properties of the fuel to engine operation. Factors with a major influence on particle formation are the fuel property CCAI (calculated carbon aromaticity index), and the asphaltene, vanadium and sulfur content of the fuel oil. Also, engine part loading, in particular, plays a major role in the formation of erosion-causing particles (Fig. 2).

Fuel additives are often used to keep the combustion chamber and other engine parts clean. Particles that would normally stick to the engine components leave the engine with the exhaust gas. This can lead to heavy wear. Chemicals in the fuel and/or additives may corrode components. The combination of corrosion and erosion can be very aggressive and have a significant impact on the components’ durability.

In view of the complexity of the issue, it is important to distinguish between ordinary and extraordinary wear and tear. Ordinary wear does not expose the turbocharger or the engine to hazardous operating conditions, but extreme wear can lead to a significant change in performance and durability, and a shorter replacement interval for turbocharger components.

An effective anti-erosion measure that can be controlled by the operator is to eliminate erosive particles from the exhaust gas by improving the fuel treatment and the combustion, or even burn better HFO quality. Another approach is to protect the components that are exposed to harsh conditions with wear protection. Consequently, new wear protection for the nozzle ring was developed, as introduced in ABB Service News 03/2015. This wear protection is available for several different types and sizes of ABB turbocharger.

Field experience has shown that durability can be significantly improved with a wear-protected nozzle ring. Contact your nearest ABB Service Station for more details.

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Rolf Bächi, who joined ABB in 2005, is a Senior Manager, Technical Service, who handles claims management and technical/breakdown investigations, project management of interdisciplinary teams, and technical support for end users and operators. Rolf also supports the ABB Turbocharging worldwide network. He holds an Advanced Federal Diploma of Higher Education in Mechanical Engineering and Business Engineering from the HF ABB technical school, Baden, Switzerland.
W e resisted the temptation to call Hamburg a "seaport" because although the city on the river Elbe is Germany’s undisputed gateway to the world, and after Rotterdam-Europoort the second busiest port in Europe, it is not actually on the sea. There are all of 70 miles (110 kilometers) for ships to sail from the mouth of the Elbe to the quays, cranes, dry-docks and ship maintenance facilities at the Port of Hamburg – ABB Turbocharging has one of its busiest service stations there.

But this does not stop Hamburg being a citadel of seafood cuisine. At the Fischerbörse, Fischmarkt, Fischereihafen, Old Commercial Room, and almost any other restaurant, Hamburg’s residents and visitors can enjoy virtually any type of fish or shellfish.

In fact, its abundance of seafood is one of the things that makes Hamburg one of the most attractive cities for visitors in northern Europe. But with that latitude and the closeness of the North Sea and Baltic goes a certain rawness of climate in the winter. The combined cold and damp – "nasskalt" the Germans say – mean it’s as well to eat heartily.

Scholle Finkenwerder Art, or Plaice Finkenwerder Style, is named after one of Hamburg’s western suburbs and fills the bill admirably. Like a number of German dishes it combines more than one source of protein – the flatfish plaice and diced bacon.

Alternatively, for the figure-conscious, by replacing the bacon with shrimps, the dish becomes Scholle Büsumer Art, or Plaice Büsum Style, named after a seaside town to the northwest which is a favorite summer excursion for Hamburger where shrimps are caught in abundance.

Better still, as any Hamburger will tell you, you are allowed to combine Finkenwerder and Büsum for a three-protein meal that will really stick to your ribs on a cold day!

Preparation is easy – both dishes can be cooked in the oven or in a frying pan – and ideal accompaniments are boiled or sautéed potatoes and green or mixed salad.
**Plaice Finkenwerder or Büsum Style**

![Plaice Finkenwerder or Büsum Style](image)

**Ingredients (serves four)**
- 4 filleted plaice (approx. 300 g each, with skin)
- 150 g smoked bacon rashers (for Finkenwerder style)
- 300 g peeled shrimps (for Büsum style)
- 100 g plain flour
- 50 g clarified butter (ghee)
- 2 to 3 lemons
- Salt and pepper to taste

**Preparation (frying pan)**
1. Wash the plaice and dry with kitchen paper.
2. Put three shallow (1 mm) diagonal cuts over the skin side of the plaice.
3. Press the juice of 1 or 2 of the lemons onto both sides of the plaice and season with salt and pepper.
4. Finely dice the bacon.
5. Dust the plaice finely with the flour and shake off the excess.
6. Melt some of the butter into a frying pan and fry each plaice for 4 minutes on the skin side and a further 3 minutes on the flesh side.
7. Put the plaice onto plates and keep warm in an oven.
8. Simultaneously with the last plaice, crisp up the diced bacon or shrimps in the butter in a smaller frying pan and sprinkle over the plaice fillets, followed by the fat/juice from the cooking.
9. Cut the remaining lemon(s) into slices to garnish the plaice.

Guten Appetit!
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