Exploring new frontiers

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From the editor

Being committed to continuously improving its products, ABB Turbocharging has a long and strong tradition of research and development – an excellent reason for charge! 1|15 to focus on its R&D activities. Christian Roduner, Head of Technology, and Volkmar Haueisen, Head of R&D Turbocharger, share insights on page 4.

One of our latest innovations based on R&D excellence is second-generation Power2. We are proud to announce its presentation at Nor-Shipping in Oslo, Norway (June 2 – 5), at ABB Turbocharging’s booth no. E02-13. Power2 is a genuine achievement. With clear benefits for the marine industry, it is the result of a fascinating technology development. Track the story of ABB’s two-stage turbocharging in this issue.

charge! 1|15 also covers outstanding two-stroke diesel turbocharging applications that go hand in hand with the rapidly increasing size of box ships. Turn to page 16 to find out why vessel size and economies of scale are converging.

A very important arm of our strategy is that we are geared to long-term relations and sustainability. An example is the strong relationship between ABB Turbocharging and AIDA Cruises underlined here in an interview with Jens Kohlmann, Director Yards & Strategic Projects at AIDA Cruises. ABB Turbocharging has been the turbocharger supplier to AIDA Cruises since 1996 and has always been committed to being a reliable partner in every area. Keywords here are reliability and environmental protection.

How ABB Turbocharging improves the performance of the engines and reduces fuel consumption through their upgrades is presented in the report on page 14. Karadeniz Energy Group, based in Turkey, has floating power plants called Powerships to provide power in regions where electricity is not always accessible. Finally, the recipe is inspired by and dedicated to Karadeniz, which in Turkish stands for “Black Sea region”.

Magdalena Okopska
Head of Market Communication
ABB Turbocharging

Focus on research and development
The Jungfrau test bed explores the limits of turbocharging technology.

CSCL Globe and MSC Oscar
ABB turbochargers on the world’s biggest box ships.
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Close-up of the Jungfrau test bed where the Power2® two-stage turbocharging system is currently being tested.
The constant search for improvement

Customers benefit when turbochargers become lighter or more compact. But how are these results achieved? And what role do Hercules and Imperial College play? The research and development (R&D) department at ABB Turbocharging invites charge! behind the scenes.

Text Tiziana Ossola Auf der Maur, Photography Michael Reinhard, ABB Turbo Systems Ltd

Ferries need to lower their emissions, container shipowners would like to reduce fuel consumption and power station operators want even shorter response times. These needs demand technical solutions. The path to them leads to the research and development department at ABB Turbocharging. It has one aim: developing turbochargers with benefits for the customer. Volkmar Haueisen, Head of the department R&D Turbocharger, cites an example: “If we want to increase efficiency by changing the shape of the compressor wheel, we must first work to acquire the necessary basic knowledge. That way we can be sure that the new blades are shaped and configured so that they function perfectly.”

Development processes

Developing an all-embracing R&D process for the blades involves a great deal. Measurements and investigations in the fields of mechanics, aerodynamics and materials science deliver precise data, creating the scientific prerequisites for the new design. Proof that a component both functions and benefits the overall system comes from a series of tests and qualifications. The knowledge acquisition process progresses step by step, culminating in new product release and industrial production.

ABB Turbocharging maintains global research partnerships with hand-picked academic institutions and industrial partners. The aim is clear: “We want the latest findings for the best performance,”
Haueisen says. The research presented in this edition of charge! – based on the Hercules study and work at Imperial College London – demonstrates what research delivers.

Hercules and two-stage turbocharging

R&D processes are more like marathons than sprints. Hercules is a ten-year study – an average timespan for an undertaking of this technical complexity. Forty partners from science and industry participated. “Hercules sets a milestone,” Head of Technology Christian Roduner notes, drawing a positive balance. “The research program delivered the proof that two-stage turbocharging on large engines is capable of achieving benefits such as improved fuel efficiency, higher power density and lower emissions. Among other things, Hercules has enabled us to quickly turn the idea into industrial hardware.” The second generation of Power2 two-stage turbocharging system today stands shortly before its product release.

The study at Imperial College in London was purely scientific, Haueisen explains. “We wanted to gain basic knowledge about the effects of pulsating exhaust flows on the turbine.” This has now been delivered. The “R” in R&D is completed. The “D” is undergoing testing. Haueisen: “What improves the response of the total system? A possible measure might be a new configuration of the turbine stage or parts of it.” With the emphasis on “might”. Do systematic adaptations make sense technically? And if so, will they also be economically viable? These are the questions that ABB Turbocharging’s developers take with them into the next stage of their work.

Who profits from research?

From the point of view of a cooperation partner at the forefront of science, ABB Turbocharging has available a unique fund of data and findings. “We have a whole constellation of information,” Haueisen says. The company’s research activities have, after all, been at a constantly high level for many decades. That is an inspiring starting point. “These data benefit the academic institutions we cooperate with because they can use them in their classes and hence enrich their research in this area, without ABB Turbocharging having to reveal any of its product know-how.”

The team makes the difference

From an engineer’s standpoint a turbocharger might look like a fairly straightforward piece of machinery, but as Roduner explains: “It is a piece of turbo-machinery which requires a great deal of research to get the best out of it.” Conducting R&D with all its ramifications is a matter of corporate culture. And it requires people to implement it. Roughly 200 research and development engineers, technicians and students on internships are at work on tomorrow’s turbochargers at ABB Turbocharging’s own R&D laboratories and test facilities in Baden, Switzerland. They know the technology of turbochargers inside out and exactly what research means. By embracing the spirit of invention, the team is making possible today what was inconceivable yesterday.
Simplicity is often complicated

ABB Turbocharging quantum leaps at a glance.
Comments from the technology department.

Second generation Power2 – high efficiency in a compact system
“Power2 achieves highest pressure ratios at highest efficiency, and high turbocharging efficiency translates into high engine efficiency. That means higher engine power with lower fuel consumption and massively reduced emissions. R&D focused closely on achieving a compact system. The components – especially the turbines and compressors – were developed from scratch. The high- and low-pressure turbochargers have been optimally tuned to each other. The service friendly cartridge concept is the result of a targeted reduction in complexity. It required high-tech solutions to turn the idea into hardware. Simplicity is often complicated.”

A200-L – smaller and more compact
“The A200-L turbocharger is the result of a development trend which R&D has followed single-mindedly in recent years: steady increases in the specific flow capacity of the turbocharger while maintaining turbocharging efficiency. To this end we have developed more compact components and produced an altogether smaller turbocharger. For customers this means that the A200-L is more economical, both to buy and to use.”

Turbine washing for stable performance
“Turbines are fouling in operation, especially on engines burning heavy fuel oil (HFO). The answer is turbine washing and is the result of complex R&D work. Thanks to a sophisticated computer model developed in-house, we can analyze and verify the behavior of water streaming into the gas flow. Based on these findings, ABB Turbocharging has developed a turbine cleaning process which is very effective and easy to carry out. The “patient’s” response to the treatment is stable turbocharger performance, operational safety and longer service intervals.”
How can marine engines become more efficient?

The results from the Hercules long-term research project which began in 2004 have been especially important for ABB Turbocharging. The advantages of two-stage turbocharging on two- and four-stroke engines have been successfully proven.

**Text** Dr. Ennio Codan, **Photography** Michael Reinhard, Helsinki University of Technology

Since 1997 ABB Turbocharging has been involved in three European Union sponsored R&D projects. All of them brought together specialists from the worlds of industry and academia and resulted in an excellent mix of the theoretical and the experimental. Valuable information was gained regarding the computation and measurement of complex systems. Of special interest were measurements of the hydrodynamic resistance of ships and propeller characteristics in a test tank.

Projects like Hercules allow results to be achieved rapidly and efficiently.

**Simulations**

- Over the years, numerous additional new models were developed for the ABB Turbocharging simulation system:
  - Simulation of compressor surge.
  - Simulation of a complete marine propulsion system consisting of the ship, the engine, the propeller and the engine controller.
  - Fouling of compressor and turbine.

Power2 – the Hercules research project provided the basic knowledge for two-stage turbocharging.
Research and development (R&D)

Dr. Ennio Codan studied mechanical engineering in Trieste, Italy, and worked for nine years at Grandi Motori Trieste before joining ABB Turbo-charging in 1990. He headed the function R&D Turbocharging until 2007, contributed thereafter to the development of two-stage turbocharging in Power2. Since 2010 he is back in the R&D department for turbo-charging solutions as Senior Principal Engineer, expert for turbocharging, engine and system technologies.

Test engine at one of the Hercules partners, Helsinki University of Technology, Finland, showing some local inventiveness – sand as burst protection.

- Computation of radial turbines under pulse turbocharging taking into account losses due to uneven admission.
- Innovative 1-D compressor model for the simulation of jet-assist and pre-swirl control.

In parallel it was also possible to realize and test Controlled Pulse Turbocharging (CPT) and air injection into the charge air receiver as a means of improving engine load acceptance.

Hercules is the future

Under the leadership of Professor Nikolaos Kyrtatos, the laboratory for Marine Engineering at the University of Athens, Greece, has established itself as the authority in the research of marine propulsion systems. A project with high ambitions was launched: Higher Efficiency, Reduced Emissions, Increased Reliability and Lifetime, Engines for Ships (Hercules). Hercules has been under way from 2004 to 2014. With an overall budget of EUR 80 million the project consists of three sections and is operated by a consortium of over 40 partners, including engine builders MAN and Wärtsilä as well as component and systems suppliers, universities and research institutions, ship-owners and classification societies.

The role of ABB Turbocharging within Hercules involved the development and testing of new turbocharging concepts capable of making a substantial contribution to the overall aims of the project. These are higher engine efficiencies, lower emissions and increased reliability.

As part of the Hercules project, a turbocharger with very high pressure ratios was run on a test engine: 6.6 from a single-stage system (see picture above). Thereafter, two-stage turbocharging systems for a low-speed two-stroke engine and small and large medium-speed four-stroke engines were constructed and their performance measured. In the first version of an engine with two-stage turbocharging, it was possible to measure simultaneous improvements in engine efficiency of more than two percent and a reduction in NO\textsubscript{x} emissions of more than 40 percent.

High-pressure turbocharging is a central aspect of ABB Turbocharging’s research work. Projects like Hercules are thus an extremely valuable and fertile platform for the exchange of ideas among experts with very diverse areas of expertise. In addition, they allow results to be achieved rapidly and efficiently.

Working on solutions together

Collaborations with Imperial College (see article on page 10) and participation on EU projects are just two of numerous examples of how ABB Turbo Systems Ltd takes its R&D outside the company and is influenced by the external contacts it forges. Of great significance in this respect are also work within the FVV (Research Association for Combustion Engines e.V.), projects with ETH Zurich Switzerland and other academic institutions and, of course, the development work carried out with customers.
Far beyond the current state of the art

How does non-steady state admission influence mixed-flow turbine performance? A long-term research collaboration between ABB Turbocharging and Imperial College in London, UK, offers key insights.

Text Martin A. Seiler, Photography Imperial College London, Michael Reinhard
Turbine performance is an important factor in the success of ABB turbochargers. Professor Ricardo Martinez-Botas of Imperial College in London, UK, possesses extensive know-how on radial and mixed-flow turbines, as used in ABB’s TPS, A100-M and A100-H turbochargers. His team operates a special test bed on which non-steady state measurements can be carried out. This is significant for ABB Turbocharging since, in many applications, turbines are subject to pulsating admission.

Ricardo Martinez-Botas is internationally active, presenting papers at conferences like the ASME Turbo Expo or at the Institution of Mechanical Engineers in London, UK. As a result of his work, in 2005 a long-term collaboration was agreed on with ABB Turbocharging. Its aim was to expand the knowledge of the non-steady state admission of turbines. Two students at Imperial College, Colin Copeland and Peter Newton, made this the subject of their doctorates.

Testing at Imperial College

An ABB mixed-flow turbine stage with double entry housing was adapted for the test stand at Imperial College London. This turbine stage (see opposite page) was specially manufactured. The turbine wheel has an outside diameter of 85 mm and is, as such, about 35 percent smaller than even the turbine in the TPS 44, the smallest turbocharger in the TPS range. The turbine stage is operated “cold” – cold here meaning 70 °C instead of 650 °C. The transferability of results to full size ABB Turbocharging turbine stages is based on so-called similarity parameters, namely the Mach number. In addition, the complete turbine stage was computed using a CFD program. CFD stands for Computational Fluid Dynamics and refers to the calculation of flow processes on a computer. These calculations are extremely complex and, in certain cases, can occupy a powerful computer for up to 12 weeks.

On the test stand at Imperial College a wide range of data, such as pressures, temperatures, rotational speeds and torques, can be acquired at very high sampling rates. From these data important values such as intake flow capacity or efficiency can be ascertained. An example is shown in fig. 1, in which the measured and calculated patterns of the mass flow in the two gas inlets are represented. The processes take place within extremely short time spans of two hundredths of a second. This places very heavy demands on the measuring technology and computing processes used.

An excellent choice

As is customary when collaborating with universities, parts of the project work have been published as conference papers and articles in technical magazines. The published material has met with favorable response. In both 2009 and 2010, papers were honored with the ASME Turbomachinery Best Paper Award. This demonstrates that in Ricardo Martinez-Botas, ABB Turbocharging had gained a development partner of the highest caliber. At ASME Turbo Expo 2014, the major turbomachinery conference, ABB Turbocharging was again represented via a joint paper with Imperial College.

Industrialization is the goal

In cooperation with Ricardo Martinez-Botas of Imperial College London, ABB Turbocharging has been able to gain insights far beyond the current state of the art into the thermodynamic behavior of mixed flow turbine stages under non-steady state loading. The next step will be to determine, together with Ricardo Martinez-Botas, how the findings can be used in an improved turbine design.
Research and development (R&D)

Measurement data from the Jungfrau test bed.
Testing Power2 on the Jungfrau

The test bed evaluates the potential of two-stage turbocharging, taking it to its limits.

Text: ABB, Tiziana Ossola Auf der Maur. Photography: Michael Reinhard

In 2014, ABB Turbocharging in Baden, Switzerland, commissioned its Jungfrau test bed, designed to test two-stage turbocharging systems. Its performance data is impressive; turbine inlet pressures as high as 17 bar can be produced for the charging system being tested. This is taken care of by a combustion chamber that can produce hot gas temperatures of up to 750°C and thermal outputs of up to 13 MW. This level is needed in order to test ABB’s Power2 two-stage turbocharging system to its limits.

A series of complex ancillary systems are likewise part of the test bed’s configuration. These regulate the fuel for the combustion chamber, the atomizing air for combustion, the water for cooling and turbine washing and the lubricating oil for the turbocharger. They ensure that everything arrives in the right quantities and perfectly conditioned and include a reliable supply of electricity for all the electrical devices.

Thanks to its controllable combustion chamber concept and the numerous flaps and valves in the sophisticated system of hot air ducts, a wide range of load conditions can be generated. This is essential to complete a comprehensive qualification process with the turbocharging system at its performance limits.

Christian Roduner, Head of Technology ABB Turbocharging: “Jungfrau underlines the fact that we not only invest in the continuous improvement of our technology but are certainly also striving to achieve quantum leaps.” The launch of two-stage turbocharging on the market for large engines is proof of this. Roduner continues: “In the early stages we presented the benefits of two-stage turbocharging, and the market responded with keen interest. The results of the Hercules research project laid the foundations for the development of the first generation of two-stage turbocharging systems, and with lead customers we turned concepts into hardware. Currently the second generation of two-stage systems is being developed. We built the Jungfrau test bed to evaluate the potential of the system to its limits and to qualify it. With Jungfrau we are moving concertedly towards the industrial release of a system that will bring our customers great benefits.”

“With Jungfrau we are concertedly moving towards the industrial release of a system that will bring our customers great benefits.”

Power2 product release imminent

The product release of second-generation Power2 is planned for July, 2015. The two-stage turbocharging technology will be a cost-effective commercial solution covering the entire power range of large medium-speed engines. Two turbochargers arranged in series provide air pressure of up to 12 bar and a turbocharging efficiency of more than 75 percent. Both turbochargers have been designed specifically for the two-stage turbocharging system. Power2 800-M represents a compact, highly efficient and easy-to-service turbocharging solution enabling engine technology for reduced emissions and fuel consumption.
Powerships with raised performance

Thanks to turbocharger upgrades on its Powerships, Karadeniz Energy Group can significantly increase their power output and reduce fuel consumption.

Text Jonathan Walker, Photography Karadeniz Energy Group

The Turkish Local Business Unit of ABB Turbocharging is currently involved in a series of turbocharger upgrades on Karadeniz Powerships, floating power stations designed, built and operated by the Karadeniz Energy Group, based in Istanbul, Turkey. An ABB turbocharger upgrade entails the replacement of turbochargers or their components with more modern or further developed higher performance versions. With the aims of increasing the Powerships’ electrical output, reducing maintenance downtime and improving fuel consumption and emissions, the turbocharger upgrades are being carried out aboard Powerships located in Basra, Iraq.

Access to electrical power

Part of Karadeniz Holding Group, a heavy engineering specialist, the Karadeniz Energy Group was started in 1996 as a response to the global need for electrical power as various economies developed around the world. Recognizing that over one billion people worldwide have no access to electrical power and that capacity is overloaded and supply precarious in many regions, Karadeniz engineers came up with an elegant solution.

Extending the existing concept of the power barge – a set of large engine powered generators (generator sets or “gen-sets”) installed on barges which can be towed to where electricity is needed – Karadeniz decided to develop its innovative Powerships. These are ship mounted, purpose-built floating power plants designed and built under existing cargo ship conversion projects, which can sail much more quickly and safely under their own power to a suitable location, be connected to the local grid and provide power to it within hours of their arrival. The concept also includes specially designed barge-mounted Powerships, Gökhan Koçak, Powership Program Director at Karadeniz Energy Group notes.

To provide fuel flexibility, Karadeniz Energy Group has fitted its ships – there are currently seven, with more planned or under construction – with dual-fuel engines so that, where a supply is available, natural gas can be burnt, to the benefit of compliance with challenging exhaust emissions regulations.

“The Powerships represent a big future market for us,” Koçak confirms. “The concept is well established and we have recently won a contract with Ghana for 450 MW over ten years. We have, of course, already reserved our ABB turbocharger upgrades for future projects.”

Karadeniz had already planned for this upgrade two years ago, but had only started in 2014. To date, the ABB turbocharger upgrades have been executed on the third and fourth ships in the Karadeniz Energy Group’s Powership fleet: Karadeniz Powership (KPS) Doğan Bey, converted at Sedef Shipyard/Tuzla Istanbul with 126.4 MW of installed capacity, and KPS Rauf Bey, converted at the same shipyard in the same period, with 179.1 MW of installed capacity.

In total 22 turbochargers have been upgraded or are due to be upgraded on the engines of the eleven generator sets aboard the KPS Doğan Bey and KPS Rauf Bey. They are older Wärtsilä 12 cylinder, V-configuration 12V46 diesels designed for operation on heavy fuel (HFO) with a rating of 10,860 kW per engine.

Originally, the engines were fitted with two of ABB Turbocharging’s type VTR 454 turbochargers. However, in the course of this engine’s development program, during an uprating Wärtsilä began to specify ABB’s TPL 73-A30 turbochargers as a means of increasing power output, decreasing fuel consumption and emis-

ABB’s TPL 73-A30 turbochargers were specified as a means of increasing power output, decreasing fuel consumption and – importantly for the Karadeniz upgrades – improving ease-of-service.
At the same time, the reduction in exhaust gas temperature accompanying the increase in engine output is beneficial to stress on the cylinder head and its parts, and to engine reliability generally, especially when operating in the hotter climatic regions where Powerships are a popular solution.

Another distinct advantage of the upgrade to TPL turbochargers for an engine end user which manages its own servicing using ABB original parts is a 50 percent reduction in downtime for maintenance per turbocharger. “In the past, for the VTR turbochargers maintenance took between 10 and 12 hours, whereas after the TPL upgrades, downtime is now only between five and six hours,” Koçak notes.

For turbocharger servicing, each Powership has a dedicated crew of maintenance engineers capable of carrying out the turbocharger upgrades during scheduled overhauls, under supervision by and with training from ABB Service. ABB personnel also assisted with the turbocharger matching process, in which the air delivery characteristics of the turbochargers are fine-tuned to the engines’ demand for air, according to their operating profiles.

“This is an interesting upgrade case,” notes And Basak, Manager of ABB’s Local Business Unit in Istanbul. “The upgrade to newer turbocharger technology on older engines is an excellent way of getting considerably more power from the Powerships without making major modifications to the engines on their generator sets. It also reduces fuel consumption, emissions and servicing requirements. In this way the Karadeniz Energy Group is making savings in two vital areas of total operating costs. In particular, as we have seen, power output has been increased while operating on lower quality fuels,” he concludes.

And Basak also states that he was especially grateful for the extensive support of Regional Manager End User Sales Thomas Knüsel and the reliable calculations of Thomas Matt, Manager Sales and Application Engineering, both in Baden, Switzerland. “It was a unique experience in which Karadeniz Energy Group, ABB Turbo Systems Ltd in Baden and ABB Turbocharging Service Türkiye joined forces to make the project happen,” he adds. “Its great success has led to relations of the companies attaining a real partnership level.

Karadeniz Energy Group has seven Powerships completed and in operating condition and four more under construction. Total installed capacity of the Karadeniz Energy Group using medium-speed diesel engines is in excess of 1,800 MW, with engine and turbocharger populations close to 150 and 300, respectively.
CSCL Globe in Hamburg, Germany. It is 400 meters long, 58.6 meters wide and 30.5 meters deep.
Powering the giants of the sea

When launched, the 19,000 TEU CSCL Globe was able to claim the title of being the world’s biggest container ship. Less than two months later this title passed to MSC Oscar. Both box ships are turbocharged by ABB.

Text Alexa Christie, Tiziana Ossola Auf der Maur, Photography Christian Boldt Photography, Hans de Visser, Dominik Baur
January 2015 saw the then largest container ship to date complete its maiden voyage from China to Germany. CSCL Globe has generated worldwide news coverage, with some staggering statistics. With a length of 400 m, it is 74 m longer than the Eiffel Tower is high. Its width of 58.6 m and depth of 30.5 m means it can carry 19,000 TEU – enough capacity for 38,000 cars.

CSCL Globe, owned by China Shipping Container Lines, is equipped with MAN B&W two-stroke engines, each fitted with three A185-L turbochargers designed by ABB and produced under license in South Korea by Hyundai Heavy Industries Co. Ltd. It is the first of five 19,000 TEU container ships ordered by CSCL, all of which are to have the same engines and turbochargers. The auxiliary genset engines specified on CSCL Globe are also fitted with four ABB TPL 67-C turbochargers, produced and delivered by ABB Turbocharging in Baden, Switzerland.

The trend towards ever bigger container ships shows no sign of letting up. In January this year, within just two months of CSCL Globe’s delivery, Mediterranean Shipping Company’s MSC Oscar was delivered. Although at 395.4 m in length it is slightly shorter than CSCL Globe, MSC Oscar, with a TEU capacity of 19,224, has the edge in carrying capability.

Key benefits of the A100-L turbochargers

Today, vessels like CSCL Globe and MSC Oscar are more energy efficient and produce fewer emissions than smaller vessels. Enhanced ship design and engine technology like an optimized hull form and larger propeller diameter enable important improvements. High efficiency turbochargers play a key role as well. The ABB A100-L type turbochargers installed on CSCL Globe and on MSC Oscar meet the specific requirements of ships of this type and size, while featuring technology widely proven on the smallest to the largest two-stroke marine diesel engines.

A key requirement of the turbocharger technology is fuel economy.
A key requirement of the turbocharging technology is fuel economy. Derating the main engine in combination with the A100-L turbochargers leads to a further fuel reduction. For CSCL Globe it has been calculated that at 75 percent engine load the fuel consumption is approximately 160 tons per 24 hours, more than five percent less than for a comparable engine several years ago.

Arie Smits, Senior General Manager ABB Turbocharging, comments: “The turbochargers that we have designed for CSCL Globe, its forthcoming sister vessels and for MSC Oscar combine a number of benefits, most importantly their role in increasing engine efficiency, which ultimately helps to reduce fuel consumption.”

Economy of scale and technology advances

The trend towards larger container ships has been relentless. Vessel size has roughly doubled in the past five years from 10,000 to over 19,000 TEU as shipping lines look for ways to increase their cargo volume and remain competitive. Arie Smits: “The increasing size of these vessels is driven by economies of scale. The ever larger container vessels being ordered have been enabled by technological advances in the field of marine propulsion that target the needs of shipowners looking to maximize operations in meeting supply and demand whilst managing their overall costs.”

Since 2011, ABB turbochargers have been specified on more than half of the container ship new buildings of 14,000 TEU and over.

ABB Turbocharging – fully committed to deploy the latest technology

Since 2011, ABB turbochargers have been specified on more than half of the container ship new buildings of 14,000 TEU and over. Smits again: “The fact that customers continue to specify our new generation turbochargers places us firmly at the cutting edge of the marine propulsion technology market. We remain fully committed to deploying the latest technology for improved performance. This is key as the container shipping industry manages the myriad challenges of competition, fuel prices, emission reduction and cost savings.”

Main engine equipment

CSCL Globe
- MAN 12S90ME-C Mark 9.2 produced under license from Hyundai Heavy Industries Co. Ltd.
- Three ABB A185-L turbochargers per engine, produced under license from Hyundai Heavy Industries Co. Ltd.

MSC Oscar
- MAN 11S90ME-C10.2 produced under license from Hyundai Heavy Industries Co. Ltd.
- Three ABB A180-L turbochargers per engine, produced under license from Hyundai Heavy Industries Co. Ltd.

The three turbochargers in the MSC Oscar engine room.
Cruising on LNG?

AIDAprima and her sister ship are the first cruise ships to have a dual-fuel engine. For these vessels, their 11th and 12th, AIDA Cruises have again chosen ABB turbochargers.

Text and interview: Tiziana Ossola Auf der Maur, Photography: AIDA Cruises, Michael Reinhard

Since 1996 ABB has been providing safe and reliable turbocharging on the main engines of AIDA cruise ships. The first to be equipped was AIDAcara, followed by all the cruise line’s subsequent vessels. This close, successful collaboration is now set to be continued with the coming generation of AIDA ships. AIDAprima, entering service in 2015, and its identical sister ship, due in 2016, will both have ABB turbochargers fitted.

The two ships are being built by Mitsubishi Heavy Industries Ltd. (MHI) in Japan. On 4th October 2015 AIDAprima will leave Yokohama on the first leg of its maiden voyage. On a 50 day cruise from Japan to Dubai, AIDA guests will experience 18 ports of call in eleven countries. On 20th November 2015 the 300 meters long, 37.6 meters wide ship will dock at Dubai. In the winter season, AIDAprima will depart from Dubai and Abu Dhabi for seven-day cruises to the Orient. The second leg of the maiden voyage starts on 18th March 2016. In 38 days AIDAprima will sail from Dubai to its future home port of Hamburg, Germany. As announced by AIDA Cruises, starting on 30th April 2016 and continuing throughout the year,
AIDAprimia will undertake weeklong cruises to some of Western Europe’s finest cities. London/Southampton, Paris/Le Havre, Brussels/Zeebrugge and Rotterdam are the stages on this journey.

AIDAprimia and the as yet unnamed sister ship can be distinguished from the remaining fleet by their vertical bows. They offer “holidays with a fine weather guarantee” according to AIDA Cruises. This is possible thanks to features of the ships’ architecture that make sport and recreation aboard independent of the weather. Among them is an expandable membrane roof above the Four Elements area with its climbing walls and water slides, and the ultraviolet-permeable plastic dome. This is spread almost invisibly above the Beach Club so that guests can enjoy a seaside environment on 365 days of the year.

**The dual-fuel engine**

There is also an innovation in the engine room. For the first time on a cruise ship, the well proven Caterpillar-MaK 12 cylinder diesel engines are joined by a 12 cylinder dual-fuel engine. It produces a power output of 900 kW per cylinder at 500 rpm in both its diesel and gas operating modes. For 40 percent of their time AIDA cruise ships are in harbor. Thanks to the dual-fuel engine, in harbors with the necessary supply infrastructure, the dual-fuel engine can run on liquefied natural gas (LNG), providing environmentally friendly electrical energy during the stay in port.

**Extensive experience**

Up until 2013, Klaus Heinrich was ABB Turbocharging’s manager responsible for business with Caterpillar-MaK. In the meantime Oliver Heinrich has taken over. Both are Senior Managers for Sales and Application Engineering. They advised AIDA on turbocharging technology and have overseen the latest contracts. Four-stroke medium-speed engines are their area of expertise. What does the new AIDAprimia engine concept mean for ABB Turbocharging? Oliver Heinrich: “Dual-fuel technology is familiar to us and our turbochargers are well tried and tested with all fuels, including gas, LNG, diesel oil and heavy fuel oil. Moreover, in terms of turbocharging it makes practically no difference whether the fuel is diesel or LNG. The basic challenge from
Applications

the turbocharging point of view lies within the combined operation of gaseous and liquid fuels.” Each of the three diesel engines and the dual-fuel engine is fitted with two TPL 71-C35 turbochargers.

Currently, some 1,100 turbochargers are running reliably and efficiently on over 700 engines. The first dual-fuel applications were on stationary engines in electrical power plants. Their use in propulsion and onboard power generation came later, and for some time now marine dual-fuel engines burning LNG have been experiencing a veritable boom. Commenting on dual-fuel engines at sea, Oliver Heinrich notes that their first application was a very good technical solution. “They increased the efficient use of boil-off gas by some 50 percent.

Both of AIDA’s new-generation ships are fitted with three diesel engines and one dual-fuel engine (three Caterpillar-MaK 12 M 43 C plus one 12 M 46 DF). Using dual-fuel engines on cruise ships is new. Was it a technological challenge?

Every pilot project brings its share of challenges – of every kind, including the technical ones. The use of dual-fuel technology on AIDAprima is an absolute first in the cruise industry. The first installation of a liquid gas supply system and all the associated safety systems on a cruise ship was an exacting technological process. But not only that. Dual-fuel technology had an all-pervading influence on the design of the ship.

What developments were necessary on the engine side?

Dual-fuel engines are already well established on smaller passenger ships, where they operate successfully. Thus, it was only on the engine side that a limited amount of development work was needed.

According to AIDA, it will take a while before dual-fuel engines are used when the ships are at sea. Why is that?

Our new ships have no LNG tanks on board. They are designed to be supplied by gas from an external, shoreside gas supply in the harbor. That came about because at the design stage the classification societies had not yet finalized rules for the installation of gas tanks on passenger ships of this size. In addition, the infrastructure for the supply of LNG in harbors is still a work-in-progress globally. Nonetheless, by installing dual-fuel engines on AIDAprima and her sister ship, we have sent out a strong signal in terms of environmental protection and hope to spur on the expansion of LNG supply facilities at harbors with our move.

So, is the chosen engine configuration the future for cruise ships? And if not, why not?

None of us can look into a crystal ball and say with certainty which technology will dominate tomorrow. But we see great potential in the use of natural gas aboard ships as a clean-burning fuel. In the long term, the greatest challenge will be to create enough storage capacity aboard ship. LNG tanks take up more space than conventional liquid fuel tanks and their installation is more complicated. Dual-fuel engines, with their fuel flexibility, are thus an ideal solution.

What future does dual-fuel technology have in the cruise industry?

Jens Kohlmann, Director Yards & Strategic Projects at AIDA Cruises, discusses the use of LNG technology in the cruise industry.

TPL 71-C35 turbocharger used on AIDAprima and her sister ship.
by replacing steam turbines aboard LNG carriers.” Their applications in the four-stroke engine market are now numerous (see passenger ferry Viking Grace in charge! 2|14). “A major advantage of propelling ships and generating onboard electrical power using LNG is a significant reduction in emissions of both noxious gases (NOx, SOx) and the greenhouse gas CO2 as well as a completely smokeless exhaust,” he adds. The low emissions that result from burning LNG are a real plus against a background of tightening emissions limits and increasing environmental awareness. (More about the significance of LNG can be found in the interview with Jens Kohlmann, Director Yards & Strategic Projects at AIDA Cruises.)

Successful conclusion
Oliver Heinrich and his predecessor Klaus Heinrich oversaw the fulfillment of the AIDA order together with their colleagues on the spot, Sales Engineer OEM Ludger Pieper and Head of End User Sales Frank Leskow at ABB Turbocharging in Germany. Following a well-proven pattern, after the installation of the turbochargers on the Caterpillar-MaK lab engines there followed test runs and, finally, the customer release of the turbocharger type. Then came the manufacture of AIDA’s engines, the installation of the series-produced turbochargers and the final testing of the finished engines on the assembly test stand in Rostock, Germany. These processes, which preceded the installation of the engine in the ship, take place about a year before the launch of the vessel, meaning that ABB Turbocharging’s part in the process is already successfully concluded.

Currently some 1,100 turbochargers are running reliably and efficiently on over 700 dual-fuel engines.

What progress are you making with the development of the LNG hybrid barge – the floating power station for supplying your ships with electricity from LNG in harbors?
The first LNG hybrid barge in the world, belonging to Becker Marine Systems, was named Hummel on 18th October 2014, at a ceremony in the Hamburg Hafencity. The plan is, at the start of the new cruise season in the spring of 2015, to supply AIDAsol for the first time with electricity produced from LNG during her laydays in Hamburg harbor, on a trial basis.

Ever since 1996, when you commissioned your first ship, AIDAcara, ABB Turbocharging has been a partner for new turbochargers and service. What is the secret of the successful long-term cooperation? From the start ABB Turbocharging was a dependable partner and won us over with products that were always state-of-the-art and with outstanding service. We appreciate very much that ABB Turbocharging’s people always give us competent advice on technical matters and readily pass on their experience to us.

Looking at the cruise industry of the future, what demands does AIDA expect to place on engine turbochargers?
The critical criteria for us are, above all, reliability and a high margin of safety. Beyond that, they should play their part in enabling increases in performance, efficiency and emissions reduction for every new generation of engine.
“Working at Height” is one of ABB Turbocharging’s training programs for service personnel.
Arming a workforce for change

Targeting safe working practices on a global level has become a key focus of ABB Turbocharging in recent years. One major aim has been employee safety when working on customer sites.

ABB Turbocharging is present with its service business in over one hundred locations, in more than forty countries. Each of these sites has a highly skilled and dedicated workforce, trained to carry out all levels of service on ABB Turbocharging products. But what happens when a product is not in the controlled environment of a factory or workshop? How can the same level of service and short engine downtime be ensured when a turbocharger is installed in an engine room with limited lifting possibilities, or positioned on an engine two to three meters off the ground? These challenges are something which are faced by ABB Turbocharging personnel on a regular basis.

To target high risk activities and assist its global service employees in conducting safer and more efficient field service operations for customers, ABB Turbocharging has implemented two new training programs. Called “Safe Lifting” and “Working at Height”, these programs are delivered to more than six hundred service personnel worldwide.

Skill set for service personnel

Up until the release of the programs this year, most certified training schemes for safe lifting and working at height have been conducted by outside parties. These ensure a basic standard for each of the before mentioned activities, and are mostly focused on the risks or dangers foreseen in the building/construction industry.

ABB Turbocharging has now developed measures that prepare service personnel with the necessary skill set and procedures required when conducting difficult field operations on customers’
sites. Examples of such operations are navigating and manipulating turbocharger components around the engine rooms of power plants, transferring components from a shoreline to an offshore vessel, or safe multiple lifting sequences in restrictive environments, such as smaller fishing vessels or submarines.

During the preparation of the courses ABB Turbocharging committed to ensuring that only the latest state-of-the-art equipment and working procedures would be used in the training programs provided for its employees. Here, ABB Turbocharging was aided by the guidance and recommendations of specialist companies. These assisted in the development of the training programs, and helped with the simulation of the specific tasks faced by service personal during field operations.

Over the duration of the training courses – after first learning the theory underlying each subject – participants are required to demonstrate their practical competence. This involves being able to assess and plan safe lifting operations, i.e. to calculate the correct loading factors for the equipment used, identify adequate anchor points to support these loads for safe lifting and for attaching life lines for working at height. And they must understand the dangers of overloading or incorrect usage/installation of their equipment.

**Safe training environment**

The training program makes use of modular training apparatus, constructed out of scaffolding and engineered to withstand the various loading forces required during the practical exercises. This gives participants the advantage of being able to gain work experience in a safe, controlled environment in one of ABB Turbocharging’s global training hubs rather than on the job, as was historically the case.

With these new programs being delivered worldwide, ABB Turbocharging’s customers not only benefit from more efficient and safer work practices on future jobs. They also have the opportunity to contribute to the program’s success by contacting their local ABB Turbocharging service provider for an assessment of their facility before their next overhaul is due, and therefore further reducing the risk of an incident on site.
**New Service Point in the Arctic capital**

**Tromso.** ABB Turbocharging opened a Service Point in Tromso, Norway, in late 2014. This allows ABB Turbocharging to significantly reduce overhaul turnaround times by as much as one week, down to a day.

Truls-Magnus Lindseth, Head of ABB Turbocharging in Scandinavia: "With the launch of the Service Point located at Skattey Harbor in Tromso, we can complete most common service jobs for our customers within just 24 hours. It offers overhauls and repairs performed by experienced and certified ABB Turbocharging service engineers with Original ABB parts. It also features equipment for dynamic balancing, hardness testing, ultrasonic washing, sandblasting and high pressure cleaning equipment. This Service Point in Tromso is well positioned to cover the service needs throughout the greater Northern Region, including the northern part of the Gulf of Bothnia. With the large, well connected airport and the major harbor with its frequent marine traffic we can serve our customers in that area with increased speed and flexibility."

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**Caterpillar Platinum SQEP Award**

The award follows a Bronze Award in 2011 and Gold Award in 2013. The latest Platinum Award, however, has given the ABB Turbocharging team greater cause for celebration due to its special significance. Jonathan Hancock, Category Manager, Caterpillar Global Purchasing, explained that ABB Turbocharging is one of 28,000 suppliers, of which only one percent have achieved an SQEP Award. Within this top 280 group of suppliers, fewer than twenty hold a Platinum Award.

Richard NePaul, Vice President OEM Business North-America, ABB Inc. said, “Caterpillar’s SQEP Awards highlight their suppliers’ dedication to sustaining superior quality and world-class performance, and each member of our team has played a role in achieving this highest level of recognition for ABB. “To be included in such an exclusive group of suppliers to receive a Platinum Award lets us know that we are enabling Caterpillar to be more successful and demonstrates our team’s understanding of their business requirements. Our vision at ABB Turbocharging is to make a difference for our customers, so this award is very important to us all.”

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**Caterpillar Gold Award**

**Award.** In January 2015 ABB Turbo Systems Ltd received official recertification from Caterpillar Motoren GmbH for the Supplier Quality Excellence Process (SQEP) Gold Award for the year 2014.

The Gold Award was originally obtained in January 2014 by ABB Turbo Systems Ltd, following the initial Bronze Award gained in January 2012.

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**Image:** ABB Turbocharging Service Point in Tromso.

**Photo:** Richard NePaul, Vice President OEM Business North-America, ABB Inc. (left) with Jonathan Hancock, Category Manager Caterpillar Global Purchasing.
Dual-fuel engines in marine and stationary applications generally run most of the time in gas mode and some percentage of the time on diesel oil or heavy fuel oil (HFO). Normally, the lubricating oil used in these engines is the same as that used with standard HFO engines, where the Total Base Number (TBN) is typically 30 or higher.

Experience has shown that such lubricating oils, used together with HFO, create deposits when running in gas mode. The chemical composition of the high TBN lubricants reacts with the gas in the cylinders, resulting in the formation of substantial contamination on the turbine-side components.

Explanation of deposits build-up

One of the basic additives used in these lubricating oils to neutralize the acidic combustion products from heavy fuel compounds is calcium carbonate (CaCO$_3$). The chemical reaction that takes place between CaCO$_3$ and the combustion products from fuel and/or lubrication oil compounds, such as sulfur oxides, results in the neutralization product calcium sulfate (CaSO$_4$). Analysis of the deposits from turbine blades have shown the main constituents to be calcium (Ca) and sulfur (S) along with oxygen (O), mainly originating from the lubricating oil.

Under certain conditions the calcium sulfate could also react with moisture/water and form gypsum, calcium sulfate with crystal water CaSO$_4$·½H$_2$O, which can be very sticky and could contribute to the formation of hard deposits. This is a white/light gray colored Ca-compound which is typically found in gas engine exhaust system deposits.

Turbine Side Washing (TSW)

In general, how TSW is carried out will be based on the type of fuel used. A turbine wash interval of ~ 150 h can be used as default. The interval can be further extended up to 500 hours, being guided by experience.

The wash procedure is the same as when running on gas. Switching to diesel mode is recommended when starting the wash sequence.

The wash sequence

- Record turbocharger speed, temperatures and charge air pressure at normal output.
- Switch to diesel mode and reduce the load to achieve an exhaust gas temperature < 430 °C at the turbocharger inlet.
- Let the material temperature stabilize for at least 10 (preferably 15) minutes at < 430 °C.
- Start the water injection and adjust the water flow as needed:
  - TPL 67-C and TPL 69-A = 18 l/min per turbocharger
  - TPL 71-C and TPL 73-A = 24 l/min per turbocharger
  - TPL 76-C and TPL 77-A = 37 l/min per turbocharger
- Stop the water injection after 10 minutes.
- Let the engine run at the same low load for another 10 minutes before switching to gas mode and resuming normal load. As an alternative, switch to gas mode after the water injection but stay at low load for another 10 minutes.
- Repeat the speed, temperature and pressure readings after at least one hour at normal output. Use the readings to compare and judge the wash result.
Coated turbine blades

Since 2008 it has been possible to install 6 coated blades (dragons’ teeth) on the turbine as an option for ABB’s TPL-A and TPL-C turbochargers operating on HFO. The advantages of coated blades are multiple:

- They protect the standard blades from wear, thus avoiding the costly repair or renewal of the blades.
- The tip clearance is maintained within the tolerance limit, which helps to safeguard the high turbocharger efficiency.
- Thermal loading of the engine is reduced.
- Eventually, this results in fuel savings.

Contamination buildup on dual-fuel engines

Experience has shown that there is also some hard contamination buildup on the turbine diffuser of turbochargers installed on Wärtsilä dual-fuel engines. The formation of this layer may lead to wear on the turbine blade tip during operation. Dual-fuel engines, especially when operated in gas mode, are also sensitive to an increase in the tip clearance between the turbine blade tips and the turbine diffuser. Based on the positive experience from HFO operation, ABB Turbocharging also recommends installing coated blades for turbochargers on dual-fuel engines.

Although the turbine diffuser is highly resistant to deformation, it can deform if water is injected at too high a temperature, in other words when the cooling time is too short. It is therefore recommended that the turbine diffuser be checked for any ovalness before installing the coated blades. An oval turbine diffuser can cause rubbing of the turbine blades, which will result in the blade coating wearing away. An ABB Service Station would be able to assist you in measuring and assessing the reusability of the turbine diffuser.

Coated turbine blades

The coated blades feature a wear-resistant coating material at the blade tip. The coating material is also used in cutting tools and its application on the blade tip scrapes off the hard contamination buildup on the turbine diffuser.

On April 1, 2015 Shailesh Shirsekar took over as Regional Manager, Service Sales for the Asia Pacific region. In his previous position as senior manager technical service his main activities were claim management, breakdown investigation and feedbacks to the technical department for product improvement. He joined ABB Turbo Systems Ltd in April 2002. A marine engineer with an MBA, he worked until 2000 as chief engineer on ocean-going ships – mostly very large crude carriers.
A mariner’s legacy in Turkey

Mıhlama is a typical dish in the Black Sea region of Turkey. Karadeniz is significant in this context, and Columbus as well.

The Karadeniz Energy Group provided the turbocharger upgrade case study in this edition of charge! Karadeniz is also the keyword for international recipe number 10. It is a family name, but in Turkish also means “Black Sea.” “Karadeniz Bölgesi” denotes the geographic region that stretches from East to West along the Black Sea in the north of Turkey.

Today’s easy-to-cook culinary suggestion, Mıhlama (pronounced Machlama) is a typical staple dish from the Karadeniz. It consists mainly of cornmeal (ground maize, polenta). In some menus it is called Turkish Cheese Fondue, Black Sea Style. The description points to the second essential ingredient: melted cheese. That aside, Mıhlama has nothing to do with the Swiss national dish. The roots of this simple yet nourishing food lie firmly in the Black Sea region.

The climate in the Karadeniz region is warm and humid. Hazelnuts, tea, cherries and tobacco thrive. The coastal fringe of the Karadeniz is an important area of cultivation for maize. Likewise, cattle and sheep can be found in the extensive rural areas that stretch high into the mountains. For Mıhlama, the locals use traditional local cheese made from cows’ or sheeps’ milk.

Maize: What was that name again?

Maize is generally an important farm product in Turkey. Its relevance dates right back to the 16th century. Brought to the Old World on Columbus’ ships, maize was enthusiastically received and quickly incorporated into Turkey’s agricultural repertoire. Maize proved far easier to grow than other cereals and yielded larger crops. Where it came from soon didn’t matter. European growers, who saw it in Turkey and adopted it, called it “Turkish corn,” while the Turks themselves called it “Egyptian corn.”

Maize and cheese are now available everywhere and are as diverse as their strains and names. So, whether made with Turkish corn or maize from elsewhere: Mıhlama is easy to prepare and will taste a little different everywhere.
Mihlama

for two people

Ingredients

150 g cornmeal (e.g. easy-to-prepare polenta)
3 tbs. butter
200 g yellow cheese, grated. The original recipe uses a local artisanal cheese. Use any melting cheese but do not use white cheeses (like mozzarella)
4 dl hot water

Preparation

1. Melt the butter in a pan at medium heat.
2. Add the cornmeal and fry while stirring with a wooden spoon. Keep the heat at medium.
3. Add warm water slowly and continue stirring until the color changes.
4. When the mixture thickens add the cheese and cook for about 5 minutes.

Serve as a hot dip with bread.
An ABB turbocharging upgrade utilizes the latest technology to enhance your investment and your engine’s performance. Upgrading your turbocharger will increase your application’s efficiency, thereby saving fuel consumption significantly and increasing your productivity through an increase in your application’s speed margin. What’s more, an upgrade increases your engine’s operational life, the time between overhauls, thus reducing maintenance costs. Make the smart move to an upgrade.

www.abb.com/turbocharging