BEN Buchele electric motor supports low-emission partial operation

Chicago: Hybrid Levelling Vessel for the Port of Hamburg

What started off as occasional one-off projects five to ten years ago has since become a genuine alternative in the shipping sector in the wake of the energy transition and the move towards more sustainable drive solutions: Hybrid powertrains featuring conventional diesel engines and state-of-the-art electric motors. Electric motor manufacturer BEN Buchele describes the requirements that the hybrid system developed by gearbox specialist REINTJES placed on the design of the auxiliary electric motors, using the joint 'Chicago' project as an example – a levelling vessel for the Port of Hamburg that entered service last October.

Image 1) The levelling vessel Chicago is fitted with a modern hybrid propulsion system comprising two diesel engines and two electric motors manufactured by BEN Buchele. The latter enable low-emission journeys within the port area.
Image: ©Reintjes GmbH

The levelling vessel, which shifts sediment in certain areas of the port so that it can be more easily reached and extracted by suction dredgers, is a twin-shaft vessel with two propellers and two prop shafts. Each prop shaft features a diesel engine as its main propulsion unit and an electric motor for low-emission partial operation. The electric drive is used to move the ship through the port to where it needs to be without creating excessive noise pollution and emissions. Once in place, the levelling vessel is switched back to its main engine and can get to work. With a frame size of 200, the electric motors each produce an output of 60 kW. Even when the ship is in electric mode, both propellers are still available, ensuring full manoeuvrability. Thanks to the redundancy built into the system, it is possible to use just one prop shaft should a propeller ever fail.

Hybrid Drive Systems from REINTJES

REINTJES, an experienced specialist in gearboxes for marine applications, is responsible for the overall hybrid system. REINTJES supplied the reverse gearbox, the electric motors, the flexible coupling between the electric motors and the gearbox, the frequency converters responsible for controlling the electric motors, and the vessel control system with its control lever and control cabinet.

The Chicago is the latest ship to have been built with a corresponding hybrid system in the past two years. REINTJES has extensive experience in this field and, as far back as 2012, fitted the research vessel Geo Focus with hybrid propulsion systems, and in 2016 fitted the Liinsand mudflat taxi with hybrid propulsion systems in collaboration with BEN Buchele, at a time when this kind of powertrain was still a novelty. In the Wadden Sea region in particular, there are strict regulations in place governing emissions, which were complied with thanks to the use of purely electric propulsion in certain zones. Electric propulsion is also very well suited to the research vessel's slow-speed voyages for collecting measurement data.

In certain areas of the port, emphasis is placed on the use of low-emission and low-noise vessels, which is another reason why REINTJES was brought on board. A hybrid system requires special fine-tuning for switching between propulsion modes. One way to change from electric operation to diesel power is by using the control lever: Moving the lever by a small amount manoeuvres the ship using electric power. Once the lever reaches a set position, the diesel engine kicks in. A simple button is another method of switching between modes – this was the solution implemented for the Chicago: If the lever is in neutral, the captain can select electric mode by pressing the button and continue to steer the ship using the control lever. Drive modes can be changed at any time, even when the ship is in motion and the propeller is turning.

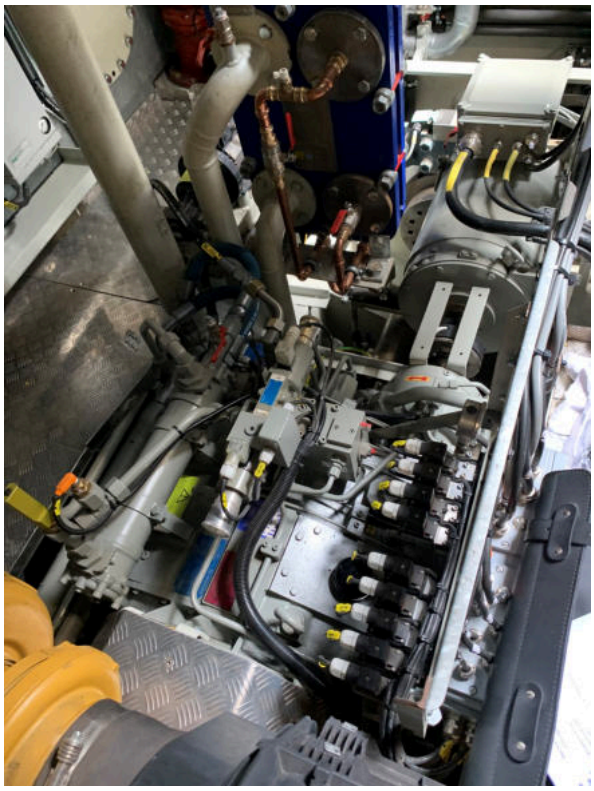

Image 2) At the heart of the engine room: The REINTJES reverse gearbox switches back and forth between electric and diesel operation at the touch of a button. In the top right-hand corner of the picture, you can see one of BEN Buchele's water-cooled electric motors, the compact size and low heat output of which are advantageous given the confined space in the engine room. Image: ©Reintjes GmbH

Water-cooled Electric Motor with High Rated Power

The electric motor was manufactured at BEN Buchele's electric motor workshop in Nuremberg, which specialises in custom-built machinery made to individual specifications. According to the specifications, the electric drive component had to enable fully electric power at a speed of up to 6 kn while also having the capacity to recharge the batteries with electricity generated while using the diesel engines.

To accommodate these features, the brief from REINTJES called for a weight-optimised, size-200, water-cooled motor from BEN Buchele with 60 kW of output, a rated speed of 2,130 rpm and frequency converter operation, suitable for continuous S1 operation.

When it comes to design and engineering, our aim is always to deliver the required speed as precisely as possible by minimising losses and striving for higher efficiency levels in order to achieve greater motor efficiency (IE2 or IE3).

If, for example, the brief requires 3,200 rpm, we design the motor to be slightly more powerful so that it can easily reach the required speed in operation. The use of higher-grade electrical steel for the stator and rotor cores enables us to reduce losses and increase efficiency.

“In order to be able to handle the various operating modes, the motor must be capable of correspondingly high speeds and be able to deliver this rated power across a wide range of speeds,” explains Louis Zander, Director of Sales & Service at REINTJES Hamburg. “Around double the rated speed was required for this project. As a result, the motors had to run at up to 4,300 rpm in PTO mode (generator mode) while also supplying the 60 kW of power at as low as 2,000 rpm so that they could operate at full capacity at the required speed of 6 kn in electric mode. As far as I’m aware, this kind of motor performance can only be achieved by BEN Buchele.”

Water Cooling for Reduced Heat Dissipation

Water cooling is another advantage that complements the thermal design for the engine room. All the power electronics, from the batteries to the frequency converter, generate a certain amount of waste heat. If the electric motors are water-cooled, this eliminates all further sources of heat in the engine room. Another key advantage of a water-cooled motor is its low weight and compact size, meaning it can be installed without taking up too much space. Yet it still delivers the same amount of power as a surface-cooled motor with a much larger frame size. In this variant, heat is dissipated over as large a surface area as possible to minimise losses, while in the water-cooled version, cooling takes place via the water jacket inside the motor. This allows the overall height to be kept relatively low.

Another advantage of BEN Buchele motors is their flexible multi-foot attachment, which allows the motor to be mounted in a variety of ways on the ship, depending on the circumstances. In this hybrid system, the electric motors are mounted directly on the reverse gearbox. There isn’t a great deal of space available for either motor, making the small and compact design ideal along with the multi-foot attachment, which enables lateral attachment with the foot facing the support beam.

BEN Buchele can also adjust the position of the terminal box – which is usually located on the right-hand side – at the customer’s request prior to installation. REINTJES opted to have the terminal box installed on top. Andreas Rödel, Deputy Sales Manager at BEN Buchele: “As long as the motor isn’t loaded onto the lorry yet, we can still make changes, such as modifying a terminal box. It’s always easier to let us do this than for the customer to open the terminal box themselves and reroute the cables.”

One additional component that has been fitted here is an incremental encoder, which is often required when operating a frequency converter as it provides feedback on the current speed. This ensures that the control unit receives sufficient data on how the motors are currently being operated.

One distinctive feature is the stand-alone solution via the DC link circuit. To feed power into the network, a standard frequency converter would connect to a ship’s existing electrical network in order to supply power to it. However, in the case of a PTO, if energy is fed into the system, a generator with a power output almost identical to that of the PTO would need to be running to prevent flickering lights or similar network disturbances. The advantage of the DC solution with islanded operation capacity is that it runs independently of the ship’s power supply. Electricity can be generated via the PTOs, and the on-board electrical network can then be fully powered by the DC network. The diesel generator, which is also available, is therefore intended for use in emergency situations.

Another advantage is the efficiency of the frequency converters, which is almost twice as high when operating on a DC network. As the ship's electrical system consumes significantly less power than the two generators can produce, the batteries are charged extremely efficiently during PTO operation.

Low-maintenance, Safe Operation

Hybrid solutions have so far proved their worth at REINTJES and BEN Buchele. On both the research vessel Geo Focus and the mudflat taxi, the auxiliary electric propulsion systems have been running without any breakdowns or major maintenance work since they went into operation. What sets BEN drives apart from comparable off-the-shelf motors is the focus on service that extends beyond the design itself. Experts from BEN Buchele remain at the disposal of REINTJES even after the motor has been delivered, should any problems arise during installation or while the motor is in operation.

Choosing an asynchronous motor, such as the one built by BEN Buchele, is also a safety consideration. Even when the electric motors are not energised – while operating in diesel mode – they simply keep on running without delivering any power, and therefore cannot cause a short circuit. A permanently energised motor would be inconceivable given the solution used here.