From initial enquiry to the perfect custom motor design

Pump Motor for the Bilge

When designing electric motors, specific requirements can quickly exceed the capabilities of standard motors with certain standard parameters. These scenarios require drives that are precisely tailored to the specific application and installation situation. Electric motor manufacturer BEN Buchele specialises in custom-built machinery and, in this case study, demonstrates how a pump motor on a ship was designed to pump out the bilge in the event of flooding.

A shipbuilder got in touch with BEN Buchele. His request: an electric motor for a pump that could quickly remove water from the engine room of the ship. Other specifications included a power output of 36 kW and a speed of 3,600 rpm. S1 continuous operation was specified as the operating mode, as the motor is in permanent use when large quantities of water need to be pumped out. In addition, the customer required protection level IP68, meaning that the motor had to be absolutely watertight, as the motor itself could be submerged in water and therefore had to be suitable for underwater use.

A Powerful Motor for Emergencies

It is normal for water to penetrate the hull and collect at the lowest point in the bilge – including when waves crash over the deck in rougher waters. Ships such as ferries or cargo ships almost always feature some open areas through which water can get below deck. In the event of heavy flooding, a pump is required to remove the water quickly. One factor was crucial when designing the motor: namely, that the motor is not in constant use, but only needs to spring into action in the case of emergencies. When it comes to new orders, BEN Buchele places an emphasis on establishing all the parameters and influencing factors that could be relevant to the design. So the company researched how often this kind of flooding was likely to occur. It is not possible to quantify these cases, as the frequency and severity of flooding depend on the weather and the location. After some research, it became clear that, should such an emergency arise, the motor must be capable of running at full power in continuous operation while simultaneously meeting the required output parameters, complying with the protection levels and dissipating any heat generated during continuous operation.

Another key factor BEN Buchele's team needed to find out was the motor's installation position. Pump motors are often installed horizontally directly on the pump; these are known as submersible pump motors.

Image 1) In rough seas, large volumes of water can wash over the deck and enter the bilge. A powerful motor is required for pumping; in an emergency, it must be able to continue operating even when submerged. Image: ©Image'in/stock.adobe.com

In this case, however, the customer specified vertical installation with the shaft projecting downwards. This design is advantageous for a fan-cooled motor, so BEN Buchele put it on the shortlist. The key challenge in the design was preventing the motor itself from being flooded, as it ideally needed to continue operating underwater. BEN Buchele proposed three motor options to the shipbuilder for the application in question:

Safe, Powerful and Compact: the Water-cooled Motor

The most elegant and reliable solution proved to be a water-cooled motor, which is very compact and therefore takes up little space while delivering high output and – thanks to the water cooling – does not release any heat into the surrounding environment. Water-cooled motors are fully protected against water ingress and continue to operate reliably even when submerged. A water-cooled motor always requires a cooling unit, which entails a little more cost and effort. BEN Buchele suggested that the motor could be integrated into an existing water circulation system on board, which would reduce the work involved to a certain extent. Another option was to connect the motor to an existing hydraulic system so that it could be cooled by oil. In this scenario, the motor would dissipate slightly less heat, as the oil would already have reached a certain initial temperature within the system and would no longer be able to absorb as much heat. As a result, the liquid-cooled motor would need to be designed with a slightly higher capacity to achieve the desired power output.

Image 2) Water-cooled motors are highly compact and powerful, and can continue to operate even when submerged, thereby ensuring continuous pump operation. However, an additional cooling unit is required. ©BEN Buchele Elektromotorenwerke GmbH

High Material Consumption with an Unventilated Motor

Alternatively, there was the option of installing an unventilated motor, which dissipates heat through the surrounding air and moisture in the ship. However, unventilated motors are considerably larger. A size 280 motor would have been required for this brief, which would have entailed using a lot of materials and therefore incurred higher costs. In addition, cooling through the ambient air does not work as well as fan or water cooling, especially as engine rooms can be hot environments. Nevertheless, as the ambient temperature specified by the customer was 45 degrees Celsius, BEN Buchele did consider an unventilated motor.

Air-cooled Motor with a Slip Clutch

Option three was a much more compact size 200 motor with an integrated fan. On the whole, this option is the most cost-effective solution for the pump motor. The mass moment of inertia – namely the shaft with the rotor, which constitutes the moving mass – can be used to estimate the size of a motor. For size 200, the moment of inertia is only one third that of size 280. This ultimately saves money.

However, fan operation is risky if the water rises too high. In this particular case, the fan is located above the motor, so the water reaches it last. That being said, in an emergency situation the fan would have to work against the high resistance of the water and would cause power losses in the motor. The motor could overheat and fail despite the cold water surrounding it. To prevent this scenario, BEN Buchele devised a motor design featuring a fan and a slip clutch. The slip clutch is a safety device used on products such as conveyor belts. If forces occur that prevent the motor from continuing to operate smoothly, the slip clutch disengages and prevents the motor from overheating. With a fan-driven motor, the coupling is positioned between the shaft and the fan. It has friction surfaces that offer a certain amount of resistance. If the counter-resistance caused by the fan trying to rotate in the water becomes too great and reaches a certain torque, the friction surfaces slide apart and the fan disengages. The motor can continue to run without a fan, as the surrounding water has a cooling effect at this point. As slip clutches are standard products, the air-cooled motor remains competitively priced even with the additional slip clutch function, not least due to its smaller size and the correspondingly lower amount of material used.

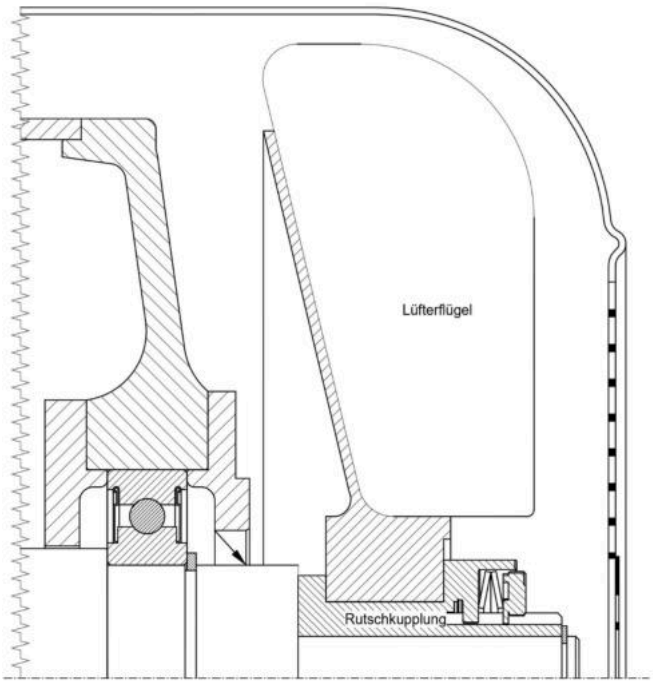

Image 3)

Image 4)

With a fan-cooled motor, a slip clutch (Image 4) can be installed between the shaft and the fan; this disengages the fan if rising water levels mean that resistance to fan-driven operation becomes too great.
Image 3) ©BEN Buchele Elektromotorenwerke GmbH; Image 4) ©Chr. Mayr GmbH + Co. KG

Additional Safety Features

Two additional safety monitoring tools are fitted as standard in every motor with this protection level (from IP56 upwards): an anti-condensation heater and a temperature sensor. Although the motors are airtight and watertight thanks to their housing (the sturdy grey cast iron housing is also resistant to contact with salt water and salty air), there is still a possibility that moisture could penetrate and cause winding failures. The anti-condensation heater ensures that the motor is kept warm even when not running, thereby preventing the build-up of condensation. A temperature sensor is also built into each motor to protect the winding from overheating. It reacts once the temperature reaches 155 degrees Celsius and triggers a cut-out, causing the motor to switch off.

The shipbuilder had to weigh up safety requirements, local conditions, the complexity of installation and, last but not least, costs, in order to determine which motor variant was best suited for emergency operation of the pump motor. Ultimately, the shipbuilder opted for the fan-cooled motor with integrated slip clutch. Given that emergencies that necessitate the use of the motor are likely to be infrequent, this option best met the technical and economic requirements.