SIEMENS DIGITAL INDUSTRIES SOFTWARE

Five key steps to electric ship design

Executive summary

The United Nations Conference on Trade and Development reports that ships transport 80 percent of the world's commodities. This number is expected to grow further. Worldwide shipping produces a massive amount of exhaust gases, such as sulfur oxides, nitrogen oxides, soot particles and fine dust, as well as carbon dioxide. Maritime shipping accounts for two to three percent of the global greenhouse gas emissions. It is also estimated that shipping is responsible for about 15 percent of the nitrogen oxides (NO_X) and four to nine percent of sulfur oxides (SO_X) emissions globally. (source: Statista)

There is a sense of urgency for the shipping industry to become more environmentally friendly and sustainable. The white paper explores how shipbuilders can rely on an integrated suite of simulation tools to drive innovation in alternative fuel and propulsion systems design. From innovative drag-reducing hull forms, through electric motor and battery sizing, to noise and vibration simulations for passenger and crew comfort, shipbuilders can assess every aspect of the ship's performance before it is built.

Contents

Introduction

How can the maritime transportation industry minimize its environmental footprint? How will it meet the strict requirement for drastic emission reduction? There are no simple answers to these questions. The industry is actively assessing several options for reducing harmful emissions. These range from utilizing alternative fuels like LNG and ammonia to introducing new propulsion systems, such as hybrid electric, hydrogen fuel cell and fully electric propulsion systems, with a goal of a zero-carbon future.

This white paper will first review the key driving forces in the shipbuilding industry and briefly examine the pros and cons of alternative fuel sources. It exposes electrification as a reasonable design option for smaller-size recreational vehicles and coastal or close-to-shore ships such as ferries. Based on this observation, it presents a case study detailing the five key steps to electrifying a passenger vehicle ferry, using the appropriate software tool to achieve the right design directly.

Key trends affecting the shipbuilding industry

Three key trends affect the shipbuilding industry. The first is the move toward sustainable shipping, followed by a tendency to consolidate shipyards and customers' increasing requirements to integrate more advanced technologies into new ships.

With regard to sustainability, the International Marine Organization (IMO) has put forth strict emissions mandates for 2050 to reduce carbon dioxide ($CO2$) output by 50 percent. This significant reduction will be impossible to achieve without innovations. However, the volume of shipping is expected to grow rapidly as well. Even a 50 percent emission reduction for individual ships would lead to an overall increase in $CO2$ emissions. So, the 50 percent reduction is crucial, but it is more than likely that restrictions will tighten further in the near future.

The next observed trend is consolidation. In the recent past, there were many independent shipyards, some of being small in size and producing very few ships. In a highly competitive market, smaller shipyards struggle to survive and are often either going out of the business or being integrated into larger groups. Nowadays, the industry's twelve largest shipyard groups account for building approximately 75 percent of all new vessels.

The last trend is the integration of advanced technologies. As in other industries, connected, smart technologies also are making their way into the marine industry. Partially or fully autonomous ships, for example, are gradually being introduced to the market.

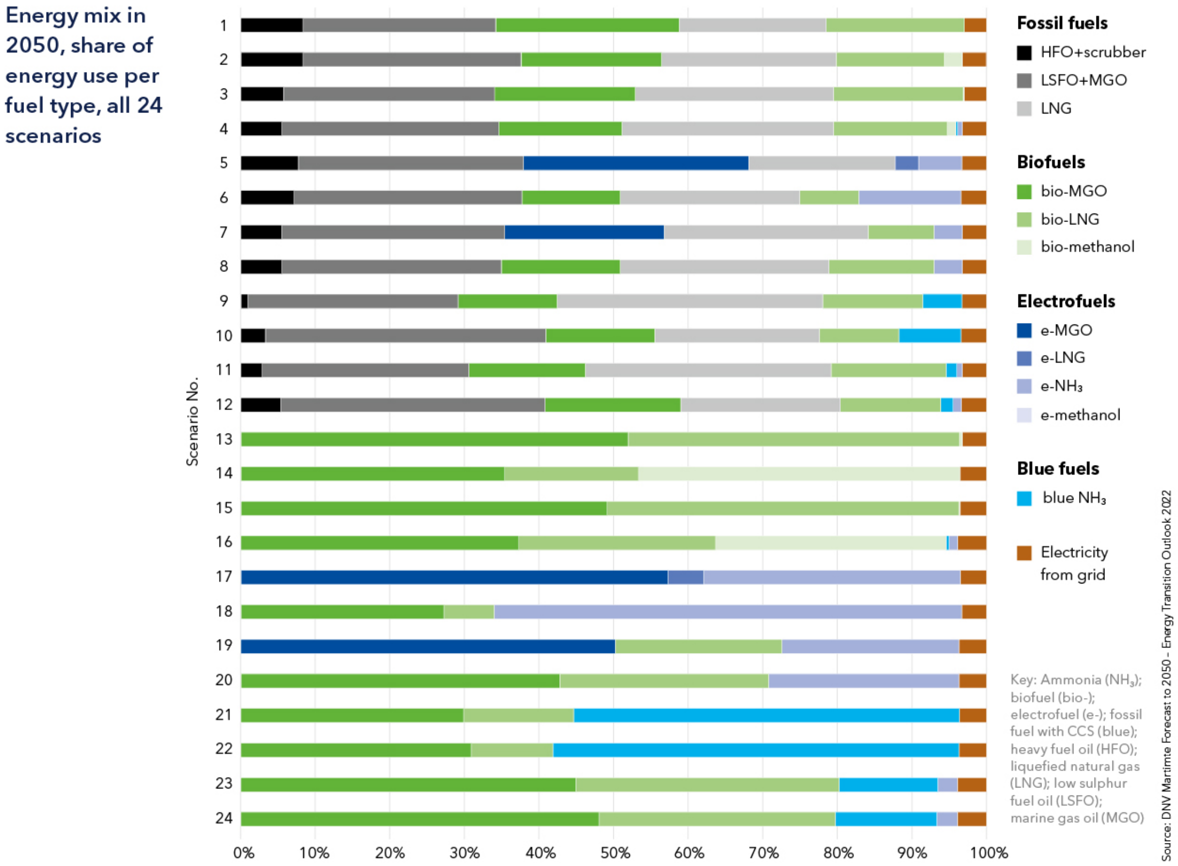
This white paper will explain how simulation software can be used to design more technologically advanced and sustainable ships. The focus will be on electrifying a ship's propulsion system to meet future greenhouse gas emission reduction targets.

Future marine propulsion systems

To reduce ships' harmful emissions, shipbuilders explore numerous ship design options; some of them integrate a different propulsion system or alternative fuel sources into the design.

The classification society DNV predicts that the usage of current low-sulfur fuel oil or marine gas oil will drastically decrease over the next 20 to 30 years. Liquefied natural gas and ammonia are the most promising fuel sources. Because of their limited range, fully electric ships are not expected to take a significant market share, except for smaller recreational boats and ferries. Ships are more likely to rely on hybrid powering solutions, using for example liquid natural gas (LNG) or ammonia as the main fuel source combined with batteries and electric propulsion. In a hybrid configuration, the ship will feature automated systems that will select the most appropriate propulsion scenario depending on the sea route and the sea conditions.

In the following section, we will review some of the advantages and disadvantages of selecting a particular fuel source and propulsion system.



Source: DNV Maritime Forecast to 2050 – Energy Transition Outlook 2022

Figure 1: The uptake in 2050 for each fuel type – expressed by the range from minimum to maximum across all scenarios within the pathways IMO ambitions and Decarbonization by 2050 (DC2050) (Source: DNV)

Liquefied natural gas

LNG carrier

Liquefied natural gas (LNG) is increasingly used to power sea-going vessels. LNG-fueled vessels reduce their nitric oxide and nitrogen dioxide (NO_x) emissions by up to 80 percent and almost eliminate their sulfur oxide (SO_x) and particulate matter emissions. Greenhouse gas emissions can be reduced by up to 23 percent with modern engine technologies. Methane leakage, however, is a concern. When released into the atmosphere, methane is more harmful to the environment than CO_2. The safety factor must be considered when designing ships.

Ammonia

Ammonia is another alternative to traditional marine diesel oil. It is a zero-carbon fuel type. As there is no carbon atom in the ammonia molecule, it does not emit CO_2 during combustion. It offers a good energy density ratio. Its energy density is similar to methanol and more efficient than hydrogen. The synthesis of ammonia also comes at a relatively low cost. When synthesized from zero-carbon hydrogen, it is an efficient and easy-to-produce-at-scale fuel source. Ammonia has long-term potential. The decreasing cost of renewable energy will support the scalability of ammonia as a marine fuel. One major concern, however, is safety. Ammonia is highly toxic, flammable and corrosive. It poses a risk for humans and aquatic life in case of accidents and leakage.

Electrification

Electric propulsion is not a recent technology in the marine industry. Today, about 80 percent of oceangoing ships use a diesel-electric transmission system. Diesel generators generate electricity, which then drives the electric engine. This moves the ship's propeller.

With electrification, ships can achieve zero carbon emissions. Fully electric propulsion systems emit no CO_2. And if the electricity is sourced from a renewable energy supplier, the overall carbon footprint is minimal. However, the relatively low power density ratio of current batteries remains an issue. Fully electric propulsion will only prevail if the batteries that store the electricity become more efficient. Another issue with electric propulsion is the lack of charging infrastructure. Dockside charging facilities are still rare in ports.

Yet the positive impact of ship electrification on curbing climate change is significant. Studies show that electrifying boats rather than cars is ten times more efficient for reducing humanmade CO_2 emissions. The European continent is expected to see the largest growth of electrically propelled ships, in particular ferries and close-to-shore ships.

Five key steps to electric ferry design: case study

Whether fully electric or hybrid, it is expected that most ships will integrate some degree of electric propulsion in the future.

How can shipbuilders design the most efficient ship possible? This case study describes the process for developing a zero-emission, efficient vessel that meets the initial requirements set for it, using an integrated set of digital tools. This case study is a theoretical study based on existing data.

The objective is to design a fully electric ferry that transports road vehicles in the Great Lakes area in the United States. This ferry is tasked with making the crossing between Charlotte (Vermont) and Essex (New York state).

The ferry route covers about three miles (five kilometers). With current diesel-powered vessels, the crossing lasts around 25 minutes each way. The objective is to shorten the crossing time and get it down to about 15 minutes. To meet this requirement, the vessel should achieve a target speed of 10 knots. Additionally, the vessel will need to operate continuously for 14 hours and complete 20 crossings every day with uninterrupted service.

The primary goal of upgrading the ferry fleet to fully electric propulsion is to eliminate greenhouse gas emissions. But this should not come at the expense of optimized operation times and speed. The implications are that the electric batteries will need to deliver the power needed to reach an average speed of 10 knots while offering an autonomy of 14 hours a day. Additionally, the specifications require that the lifetime of the batteries lasts a minimum of 3000 cycles of charge.

In the following paragraphs, we propose a step-by-step process to evaluate every aspect of the ship design relating to its electrification and select the best design possible, using simulation tools. This process gives us confidence that the proposed ship design will meet the requirements as expected.

The proposed design for the ship hull is a double-ended ferry, as shown in figure 2 below.

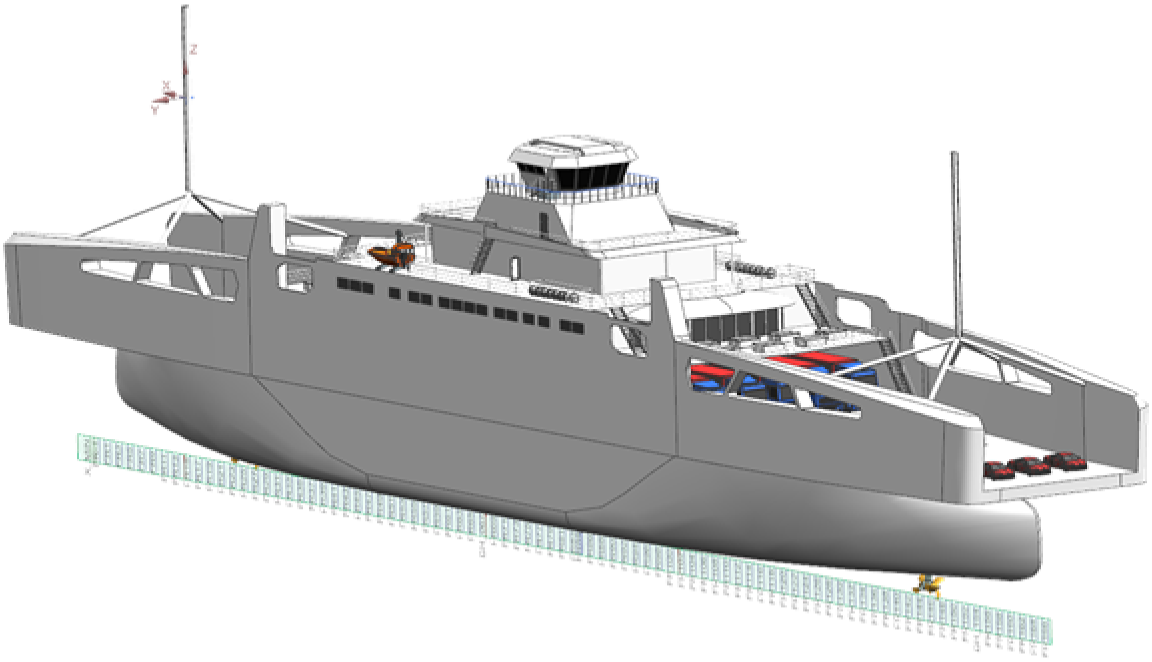


Figure 2: Geometry of the electric ferry (courtesy of DigitTread)

Step one: Calculate the hydrodynamics and resistance characteristics

Before designing the electric propulsion system, it is essential to understand how much power is needed to propel the ferry. The first property to assess is the resistance and power characteristics of the proposed ferry design. Only once the engineers obtain reliable and accurate information about the hydrodynamics and resistance properties of the design will they be able to properly size the electrical motor and the battery pack.

In our case study, the engineers use a high-fidelity computational fluid dynamics (CFD) simulation software to calculate a powering profile based on the current geometry. The software offers multi-physics simulation and can capture non-linear turbulent and viscous effects at full scale. It embeds automation tools to transform best practices into templated files that can run with just a few inputs.
The CFD template allows us to quickly analyze hull forms with high accuracy at full scale. The inputs for this simulation are the geometry, the target speed, and the draft corresponding to the maximum displacement.

The simulation runs automatically through different scenarios. The outcome is the resistance versus speed curve.

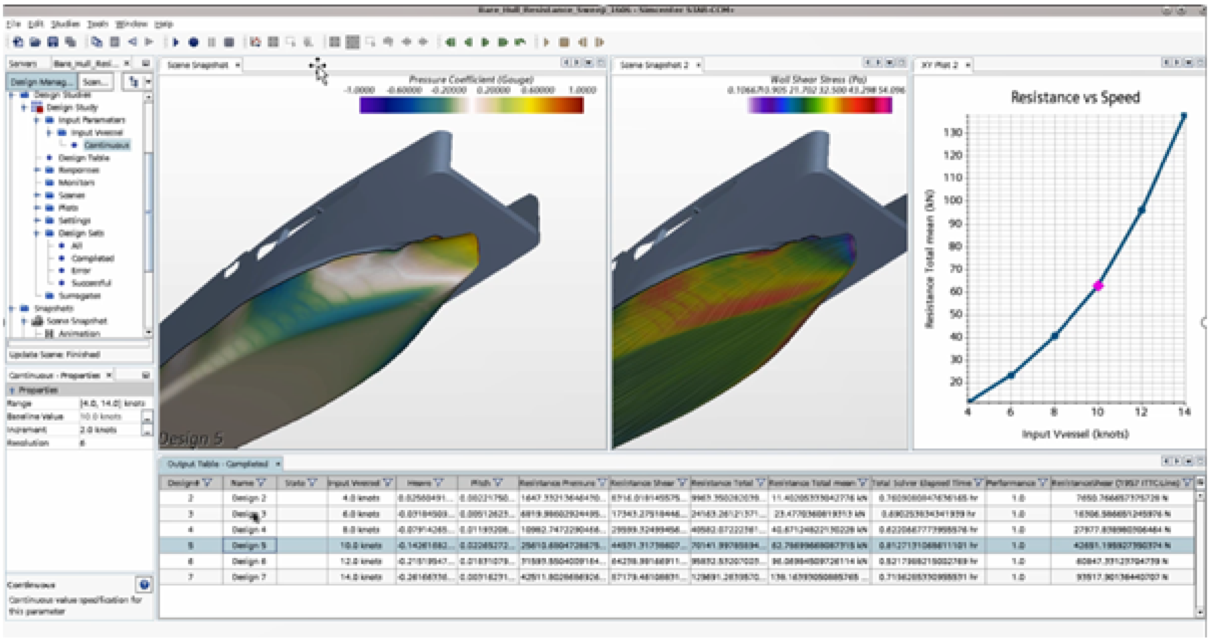


Figure 3: Using Simcenter STAR-CCM+ to generate a resistance versus speed curve.

This curve data will be used to define the battery and motor requirements. From the CFD simulation tool, the data is transferred to a system simulation tool. The integrated toolset permits the seamless transfer of up-to-date data.

Step two: Estimate the absorbed power

The system simulation engineers will now perform an estimation of the absorbed power. They add the ship's hydrodynamic resistance data and the propeller data to the software to obtain the absorbed power estimate. This corresponds to the power required to propel the ship at the required speed.

The result of the simulation is displayed in figure 4 below.

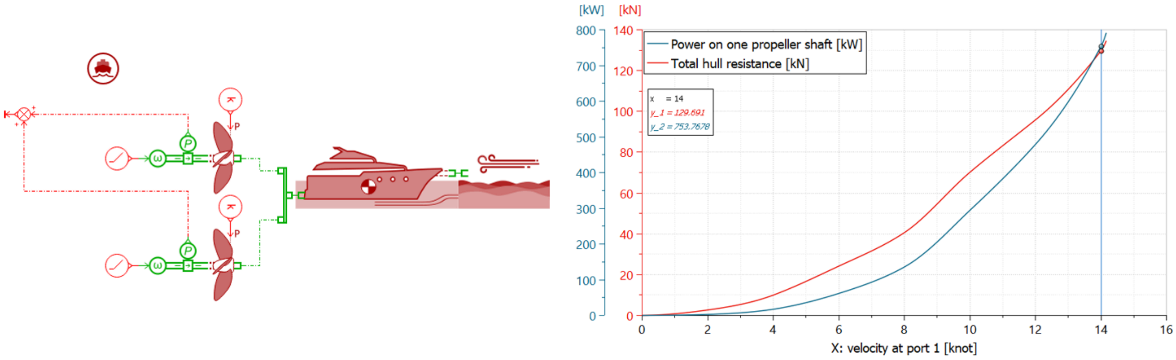


Figure 4: Estimation of the absorbed power using Simcenter System Simulation

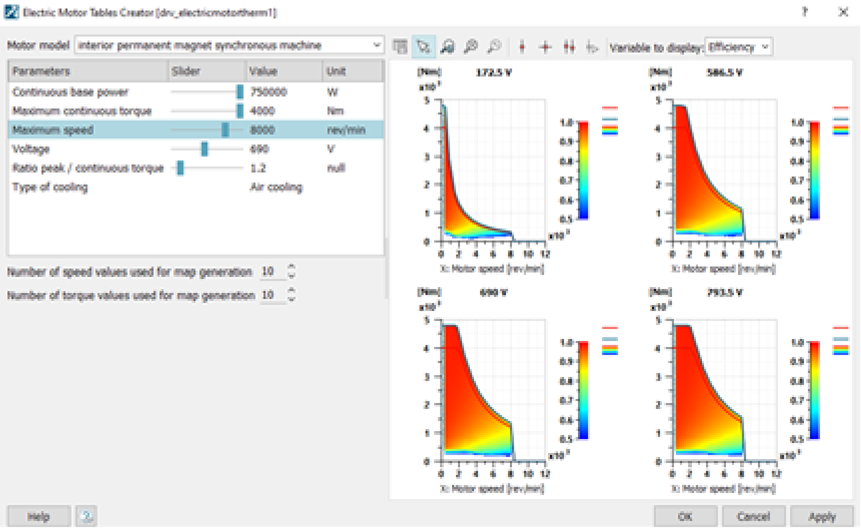
The red curve shows the hull resistance, while the blue curve displays the power distributed by one propeller shaft. Looking at the curve, there is a clear need to augment the power distribution to achieve a velocity of ten knots.

Step three: Size the electric motor and the battery pack

How can the desired speed be met? The engineering team will now perform a pre-sizing exercise to estimate the required size of the electric motor and the battery pack.

Size the e-motor

They will use the same system simulation software to size the required powering capacity. To start with, they put in the parameters required for the electric motors. The software will automatically create performance plots based on the entered parameters, as shown in figure 5. This gives them a starting point to evaluate the performance and select the right motor size.



Electric Motor Tables Creator [drv_electricmotortherm1]

Motor model: interior permanent magnet synchronous machine

Parameters	Slider	Value	Unit
Continuous base power		750000	W
Maximum continuous torque		4000	Nm
Maximum speed		8000	rev/min
Voltage		690	V
Ratio peak / continuous torque		1.2	null
Type of cooling		Air cooling	

Number of speed values used for map generation: 10

Number of torque values used for map generation: 10

Variable to display: Efficiency

Figure 5: Setting the required values to automatically create the performance plots in Simcenter Motorsolve

Size the battery pack

The team then performs a similar simulation to estimate the required battery size. It already estimated the battery power or energy needed to power the ship. The outcome of the estimation is added to the software to calculate the required size. The simulation model is shown in figure 6 below.

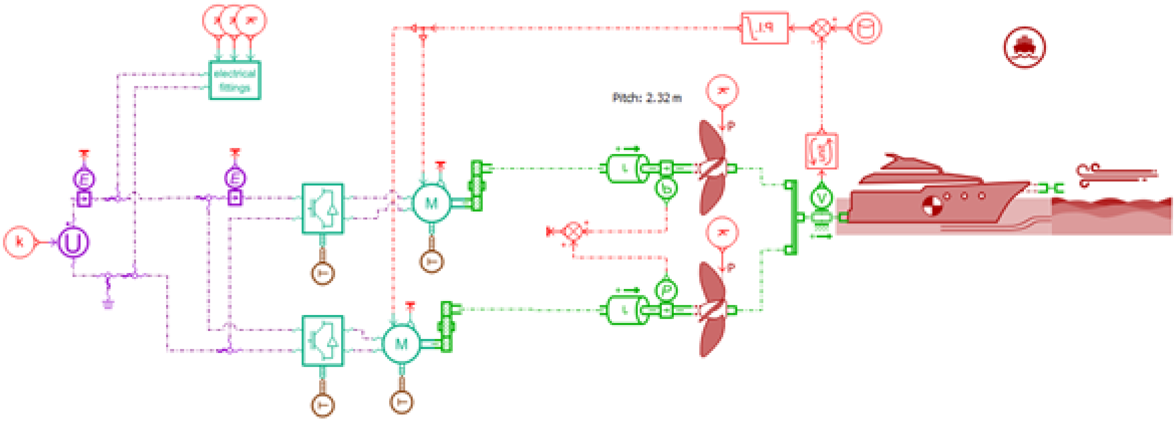


Figure 6: Battery sizing simulation model using Simcenter System Simulation

The outcome of the simulation appears in figure 7. In this simulation, the state of charge (SoC) is an important data point. It reveals how much charge is left in the battery. On one hand, the SoC must not go too low, as the batteries will then not deliver the power required to propel the ship.

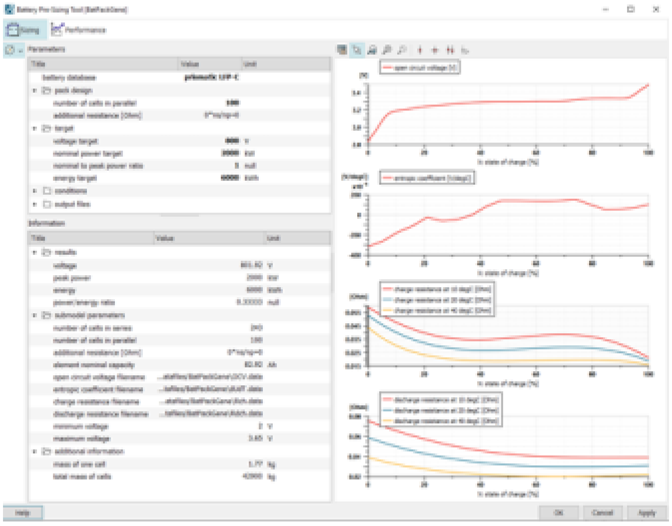


Figure 7: Battery sizing simulation results in Simcenter System Simulation

On the other hand, overcharging a battery is also damaging since the battery could overheat. This means that the state of charge should be kept within reasonable safety limits to avoid damages while meeting the power requirements.

Assess the results

According to the calculation, the battery low voltage limit is reached after 10h25 min of operation. This means that a battery of this size will power the ship for a little over 10 hours of operation. However, the requirements stated a need for 14 hours of uninterrupted battery operation.

The team of engineers will now evaluate different scenarios and find the most favorable one, where the operation time meets the requirements.

One option is to adjust the requirements. If the battery size is limited by other constraints such as costs, weight, or dimensions (restrictions which could apply in this case study as the ship is a relatively small coastal ferry), the ship owner or operator could envision an adjusted operation mode where the ferry’s batteries charge whenever the ferry is docked, for example when unloading and loading passengers. Charging the battery during each stop is a viable solution to avoid oversizing the battery pack or reducing the ship’s performance. This is called opportunity charging.

Other adjustments, such as additional cooling of the battery pack, can also help improve the operational range. For example, the performance of a passive air-cooled battery can be improved by adding forced air cooling with a fan or by adding a liquid cooling jacket around the battery that will absorb the heat.

Pre-sizing summary

In the present case study, the outcome of the pre-sizing characteristic yields the following characteristics. The battery should have a capacity of 6 megawatt hour (MWh); its weight is quite high, estimated at 43 tons. The motor is a brushless permanent magnet synchronous motor with a maximum speed of 4000 rotations per minute (RPM) and a maximum torque of 3000 Newton meters. The cost of the battery is estimated at $1.2 million, based on the estimates of a capacity of 600 and a cost of $200 per kWh.

Step four: Build the motor's virtual prototype

Now that our engineering team has sized the electric motor and battery pack, the next step consists of improving the design of the electric motor itself.

Build the digital twin

Using the simulation, the engineers assess several motor designs. After reviewing several design alternatives, they find a suitable candidate that meets the specifications.

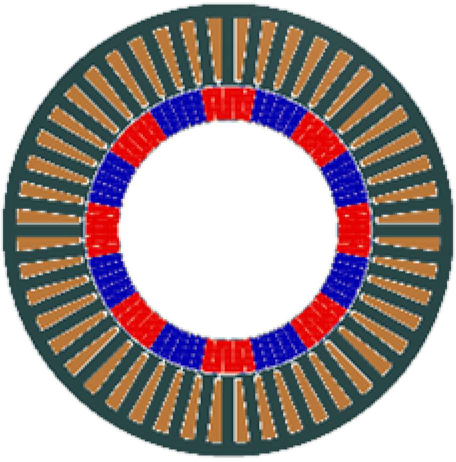
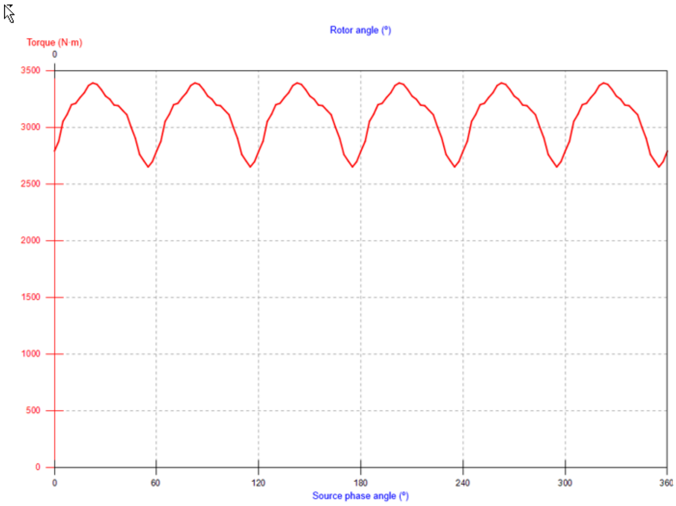


Figure 8: Selected motor design (Simcenter Motorsolve)

The selected design has a 16-pole Rotor, with a Halbach array for the magnets. The segmented magnets are made of NdFeB. For safety, the magnets are encapsulated in a nonmagnetic, non-conductive sleeve. Due to the nature of a Halbach array, there are no interior magnetic fields. A rotor core is not necessary, its volume and weight characteristics are removed from the design.

The design includes a 48-slot Stator, with laminations made of M19 steel. The stator is wound with a rectangular copper conductor in a three-phase Wye connection. The size of the motor's outer diameter is 550 millimeters, and the stack height is 200 millimeters.



	Base Design
Torgue (N·m)	3093.39571
RMS torque ripple (N·m)	231.426347
Input power (W)	1319408.66
Output power (W)	1295758.56
Efficiency (%)	98.2075228
RMS line-to-line voltage (V)	482.215781
RMS line current (A)	1600
RMS current density (A/mm²)	5.55555556
Power factor	0.953045831
Torque per unit rotor volume (TRV) (kN·m/m³)	160.760561
Loss - Total (W)	24934.1352
Loss – Winding (W)	3427.77383
Loss – Stator back iron hysteresis (W)	2831.86166
Loss – Stator back iron eddy current (W)	3195.27636
Loss – Stator teeth hysteresis (W)	5693.57283
Loss – Stator teeth eddy current (W)	9785.61908

Figure 9: Left, transient torque response of the motor – right, time-averaged response

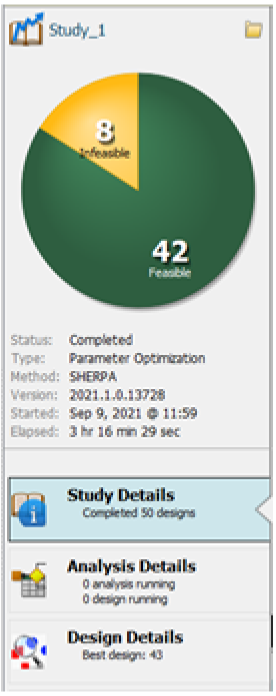
The required torque for the ferry is met as the motor delivers a little more than the 3,000 Newton-meter (N.m). The amplitude of the torque ripple for this proposed design is too high. Therefore, the simulation engineers continue their efforts and initiate a design exploration of the motor. The aim is to reduce the torque ripple of the motor to less than 5% and to maximize the torque while minimizing the ripple.

Perform design exploration

For the design exploration, the engineers let the software freely explore four different stator topology parameters. These are:

- Slot depth
- Slot opening width
- Tooth tip thickness
- Tooth width

These four parameters serve as the inputs to the design exploration.
Additionally, the engineers selected two outputs for our design exploration that define the success criteria. These outputs are a) maximizing the torque delivered by the motor and b) minimizing the ripple on the torque. As they set up the study for the design exploration, they allowed the software to explore a total of 50 distinctive design alternatives. These are summarized in the pie chart (figure 10).



Status: Completed
Type: Parameter Optimization
Method: SHERPA
Version: 2021.1.0.13728
Started: Sep 9, 2021 @ 11:59
Elapsed: 3 hr 16 min 29 sec

Study Details
Completed 50 designs

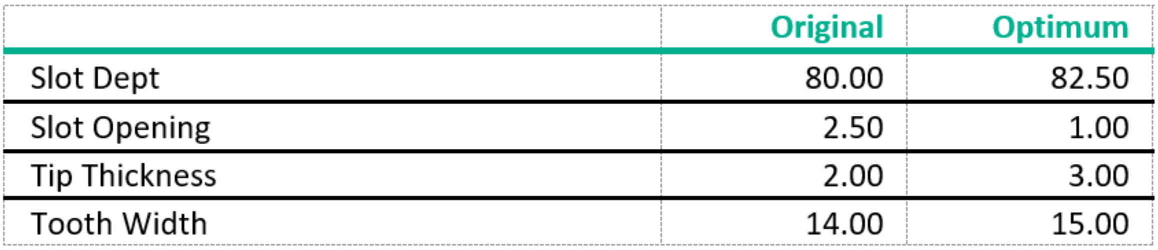
Analysis Details
0 analysis running
0 design running

Design Details
Best design: 43

Figure 10: Design exploration results in Simcenter HEEDS

Forty-two of the designs met the set criteria, while eight of the designs fell short. The elapsed computation time to explore all 50 designs was less than 200 minutes. After completing the study, the software chose design #43 as the best possible design.

The next step is to compare the original design with the optimum design determined by the software.



	Original	Optimum
Slot Dept	80.00	82.50
Slot Opening	2.50	1.00
Tip Thickness	2.00	3.00
Tooth Width	14.00	15.00

Figure 11: Different topologies of the designs

Figure 11 summarizes the topology differences between the two designs. Each topology parameter has a slight difference in its assigned value. How did these changes impact the motor's performance? Figure 12 is a graph of the transient torque for both designs.

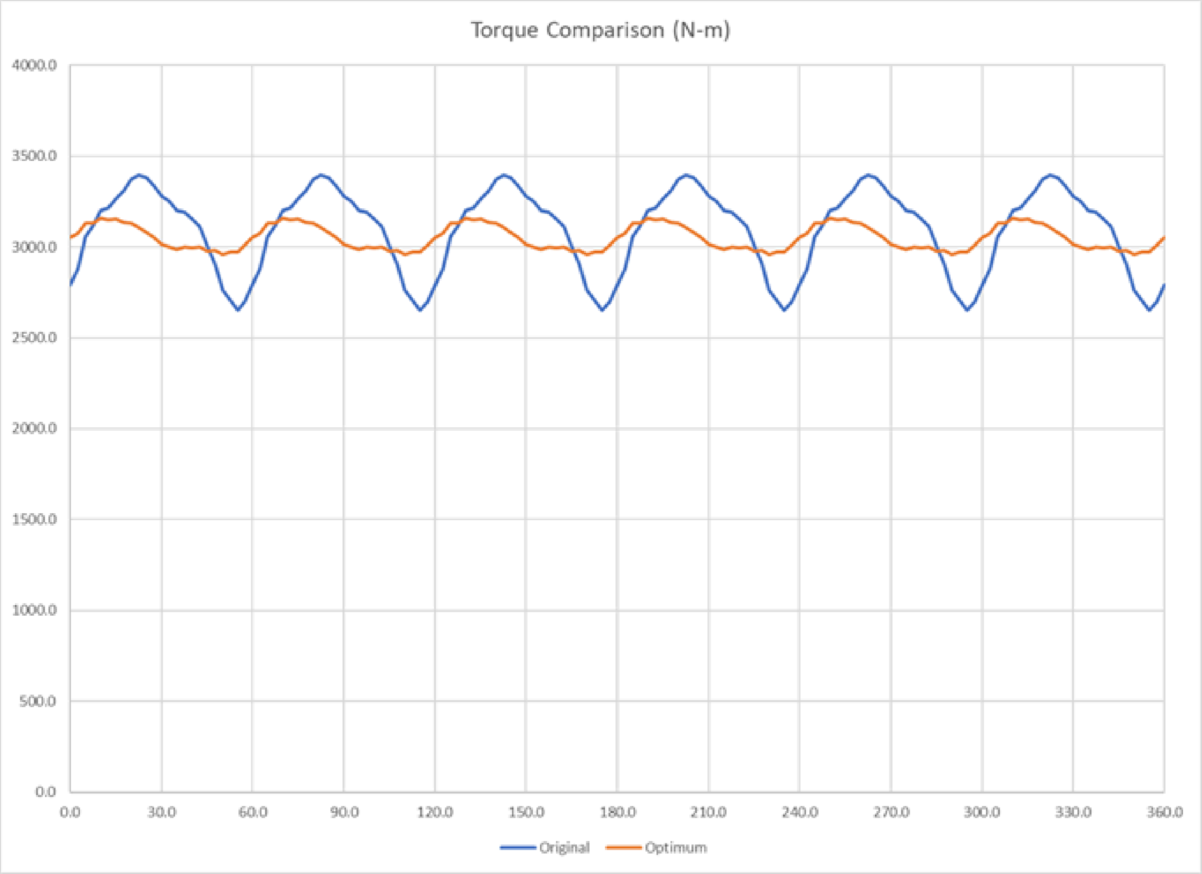


Figure 12: Comparison of the transient torque for each design

The torque curve for the original motor is blue, and the torque curve for the optimum motor is orange. Additionally, the time-averaged perspective of the motor's performance is summarized in the table in figure 13.

	Original	Optimum	
RMS line-to-line voltage (V)	482.22	482.22	
RMS line current (A)	1600	1600	
RMS current density (A/mm^2)	5.56	5.56	
Power factor	0.95	0.95	
Torque per unit rotor volume (TRV) (kN·m/m^3)	160.76	158.59	1.4%
Torgue (N·m)	3093.40	3051.53	1.4%
RMS torque ripple (N·m)	231.43	68.63	70.3%
Torque ripple %	7.5%	2.2%	
Input power (W)	1.32	1.30	1.3%
Output power (W)	1.30	1.28	1.4%
Efficiency (%)	98.21	98.17	0.0%
Loss - Total (kW)	24.93	24.03	3.6%
Loss – Winding (kW)	3.43	3.42	0.3%
Loss – Stator back iron hysteresis (kW)	2.83	2.79	1.4%
Loss – Stator back iron eddy current (kW)	3.20	3.22	-0.8%
Loss – Stator teeth hysteresis (kW)	5.69	5.84	-2.6%
Loss – Stator teeth eddy current (kW)	9.79	8.76	10.5%

Figure 13: Summary of the motors' expected performances

While maintaining the 3,000 N.m of torque required by the specifications, the new proposed design successfully reduces the torque ripple. It decreases by more than 70 percent compared to the original motor design, while the delivered torque only decreases by a little more than two percent.

Perform a multi-physic performance assessment

The optimum motor design is a promising candidate. But so far, the engineers have only considered one discipline of physics: electromagnetics. And they have considered it only at ambient temperature. What is needed now is a more thorough assessment of the performance. The next step is to perform a co-simulation between electromagnetic and thermal physics. The software can seamlessly connect 2D electromagnetics with 3D thermal physics. The engineers perform five phases of experimentation. These phases are described as:

- Phase 1 – Execute electromagnetic experiments at ambient temperature.
- Phase 2 – Execute thermal experiments using the electromagnetic losses as the form of heat to raise the temperatures.
- Phase 3 – Execute electromagnetic experiments at elevated temperatures from phase 2. The material properties for each component are automatically updated based on the local distribution of the temperature.
- Phase 4 – Execute thermal experiments after adding some form of cooling. Several forms of forced convection fluid cooling are available. The engineers chose to add spray cooling to the end region areas for both the rotor and the stator.
- Phase 5 – Execute electromagnetic experiments at new satisfactory temperature levels

to confirm the performance of the motor under operating conditions.

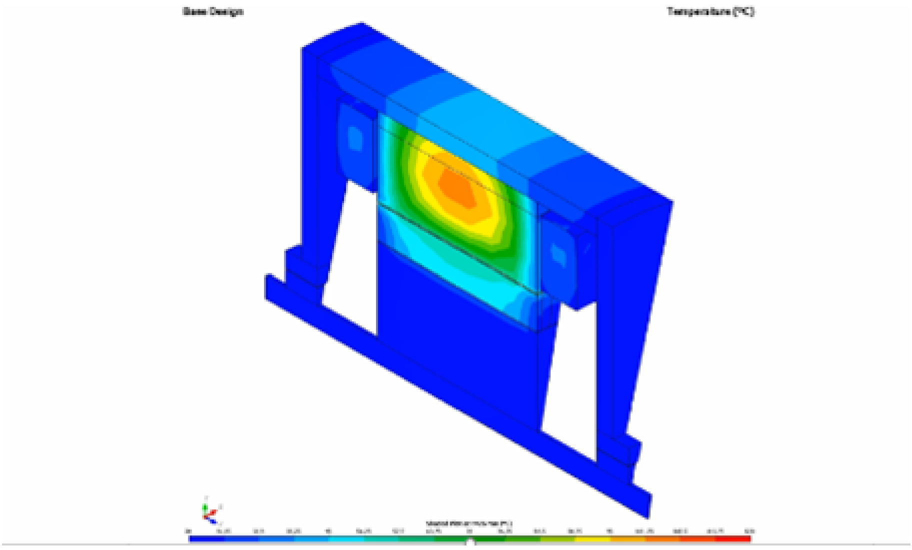


Figure 14: Shaded plot of the temperature response in Simcenter Motorsolve

Figure 14 is a shaded plot of the temperature response of the motor resulting from the 3D Thermal simulation. The local temperature distribution changes with each time-step.

In figure 15, the engineers compare the temperature data from the two thermal phases. Each experiment had the same 30-minute range of operation. The winding temperatures for the phase of no cooling are shown in pink, while the winding temperatures for the cooling phase are shown in red.

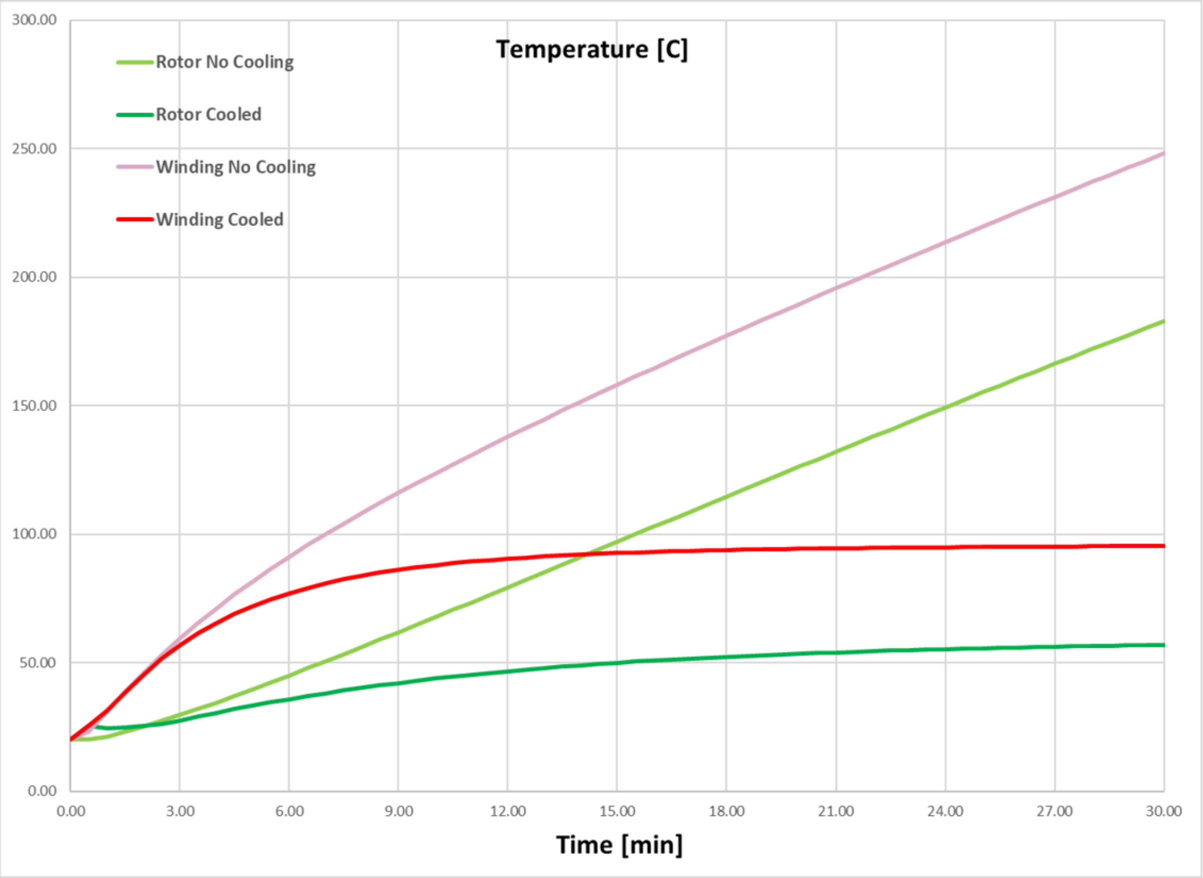


Figure 15: Comparison of temperatures for the different configurations

The parameters for the spray cooling configuration are adjusted until the component temperatures are reduced to acceptable values. This has the effect of removing a significant amount of thermal energy from the stator.

Similarly, the magnet temperatures for the phase of no cooling are shown in olive. The magnet temperatures for the cooling phase are shown in green. Spray cooling also removes sufficient thermal energy from the rotor.

The transient torque response from the three electromagnetic phases is summarized in figure 16.

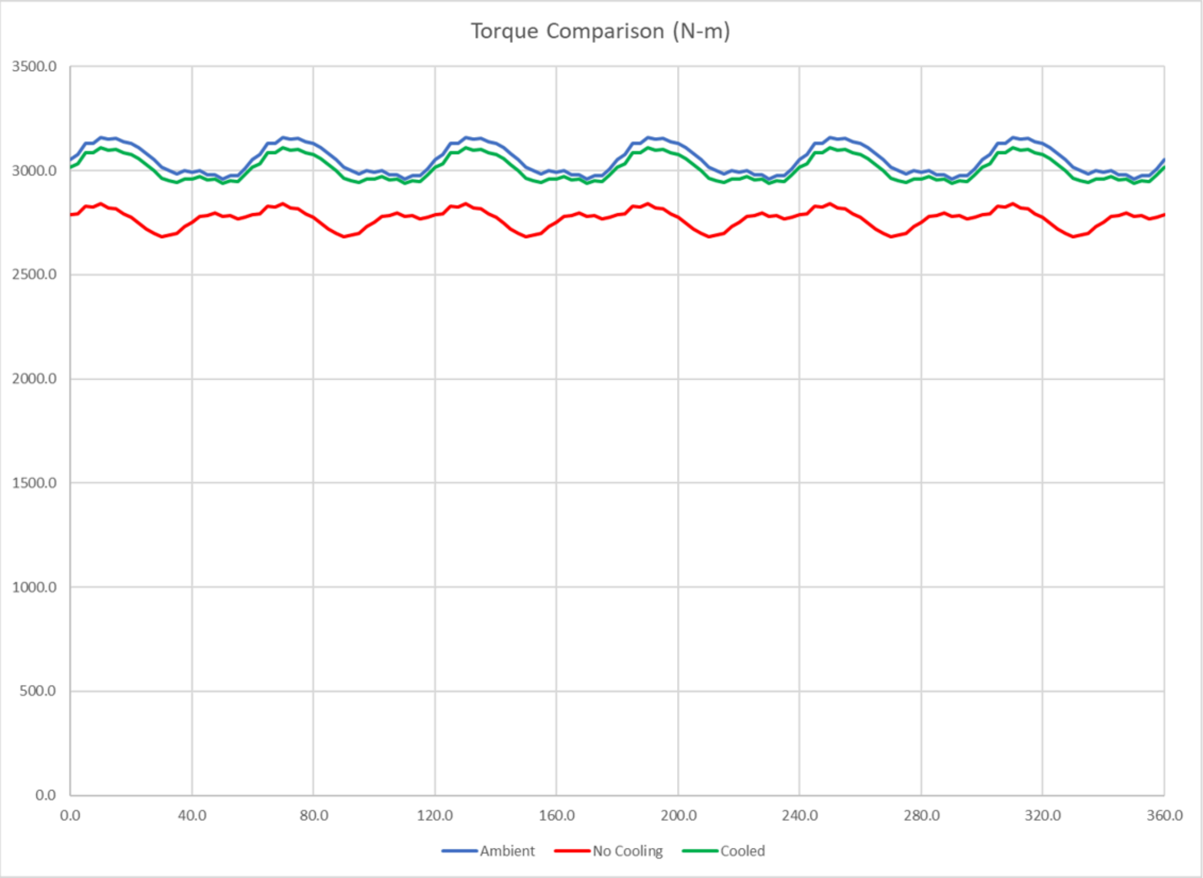


Figure 16: Comparison of the transient torque responses

The blue curve is the motor’s response at ambient temperature, while the red curve is the motor’s response during the phase of no cooling. Lastly, the green curve shows the motor’s response during the cooling phase.

The software offers various features to allow a refined assessment of the motor’s behavior. For example, the engineers can extract a shaded plot of the flux density within the components of the motor (figure 17). They can also review other electromagnetic constructs such as demagnetization, eddy current losses and hysteresis losses.

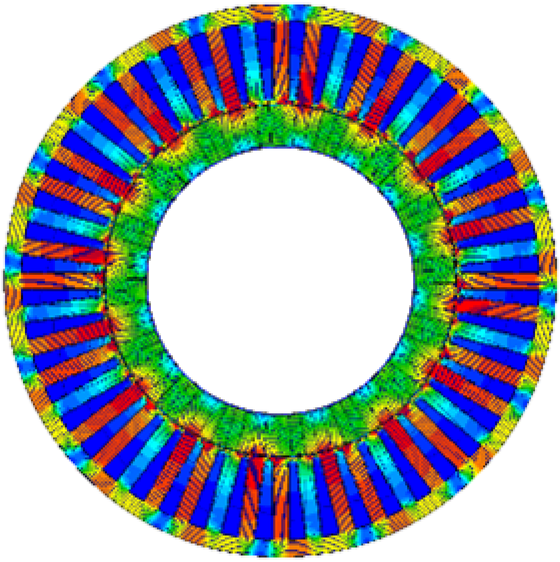


Figure 17: Shaded plot of the flux density in Simcenter Motorsolve

A final summary of the motor’s time-averaged performance is shown in this figure 18. When comparing it to the initial requirements, we see that the motor will deliver the required torque using 1,600 Amperes of current and at a reasonable level of voltage.

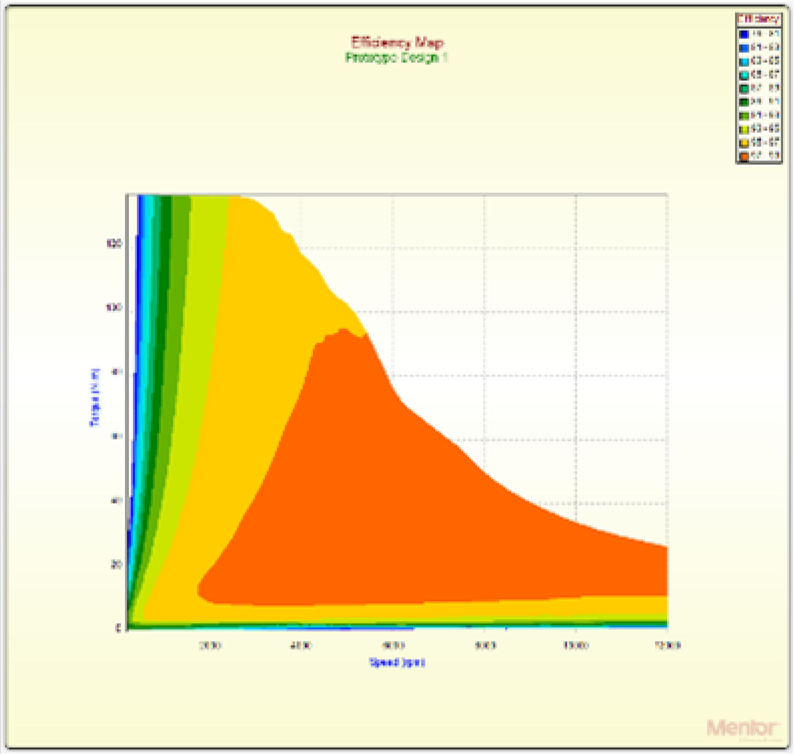


Figure 18: Summary of the motor design performance

Step five: Supplier data integration

Electric motor

Once the optimal motor specifications are defined, they can be shared with an electric motor manufacturer. The manufacturer will try to deliver a motor that is as close as possible to the required design.

Once the manufacturer has identified a design that meets the specification requirement, the characteristics of the actual motor design can be shared with the engineering team. When entering accurate supplier data into the simulation model, the engineers can quickly verify that the supplied motor will meet the performance requirements.

Battery aging evaluation and validation

The last step of supplier integration is understanding how batteries age. This step will help the engineering team select the right type of batteries that meet the ship's requirement. As part of that, they will need to look at how the batteries perform over time when running through many cycles. They set up a system simulation model to understand the aging process better. By entering the battery characteristics into the model, they can look at the aging effect.

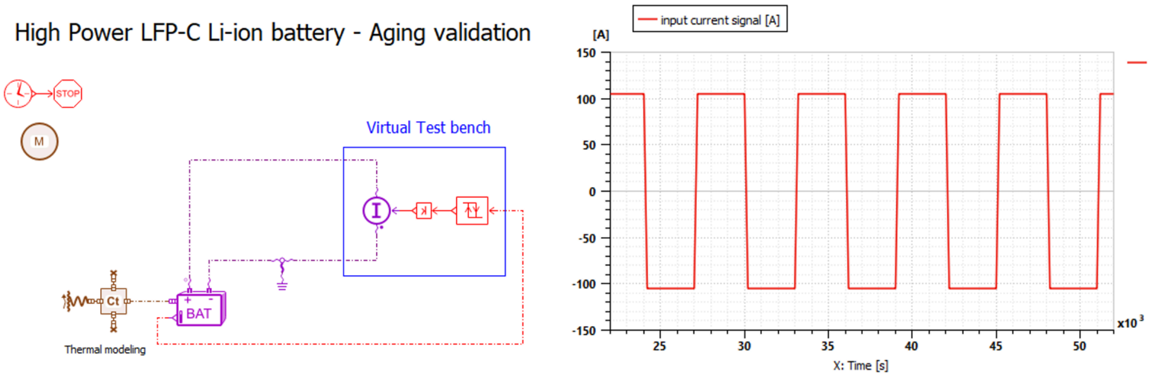


Figure 19: Validation of battery aging properties with Simcenter System Simulation

In figure 19, the red curve shows the outcome of system simulation, the number of cycles, and the power or the available power over time.

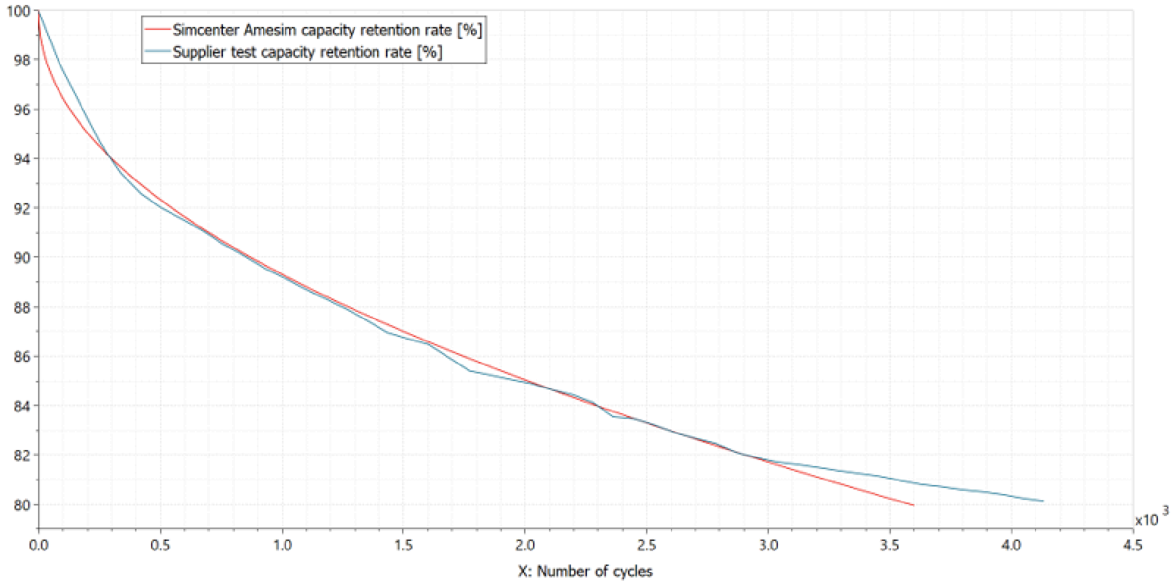


Figure 20: Battery aging simulation results

The simulation runs through thousands of cycles. After 3,500 cycles, 80 percent of the power is still available according to the model, while the manufacturer claims about 81 percent battery power. This proves the good correlation of the model predictions with the supplier's experimental data.

For the final requirements verification, the engineers now look at the performance of the battery versus the speed over time.

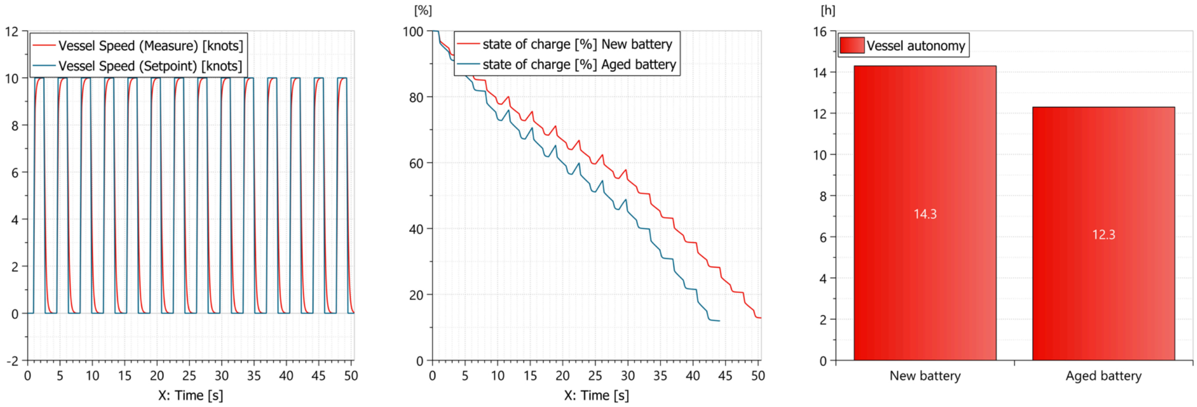


Figure 21: Battery performance versus vessel speed over time

On the left in figure 21, the blue line is the setpoint, the control system that shows the target speed. The middle graph displays the evolution of the state of charge as a function of time.

The simulation reveals that vessel autonomy will drop from slightly over 14 hours with a new battery to a little over 12 hours for the aged one. With this data, the shipbuilder can make an informed decision about integrating the battery into the ship.

Case study summary

The process described above is theoretical. Shipbuilders may adopt different approaches to vessel electrification. Some shipbuilders work directly with the battery manufacturers where they can give battery specifications. Others are going to buy batteries off the shelf. The process is going to be slightly different whether all the battery specifications are defined by the shipbuilder or by the battery supplier. Similarly, some ship integrators purchase single parts from different shipyards and build the ship by integrating all parts.

This theoretical case study describes a process where the shipbuilder builds the ship from the start. In practice, it is possible to either follow this entire process or just select the elements that are relevant to a company’s processes.

Address new noise and vibration issues

With ship electrification, new noise and vibration issues may arise. A diesel-powered ship has reciprocating engines with a repeated cyclical frequency from the engine cylinders, which causes vibration throughout the ship. Over the years, noise and vibration experts have learned to deal with these vibrations and minimize them. Electric motor noises have whistles or high-pitched noises that could be more irritating to the human ear. Engineers need to address these noise issues differently to optimize comfort and safety onboard.

Conclusion

The marine industry is under extreme pressure to evolve, to become a greener industry, due to the greenhouse gas emission reduction goals set by the IMO.

It can address the challenges in several ways, one of them being adopting alternative low- (or zero-) carbon fuels as energy sources to power the ships. In the short to mid-term, LNG and ammonia are interesting alternatives to traditional marine diesel oil for low-carbon ship propulsion. Nevertheless, they present risks and concerns as discussed in this paper.
Electrification is a likely solution for the long term, but technology advances, regarding battery technology in particular, will be required to permit its widespread adoption across the shipbuilding industry.
Cargo shipping and sea-faring ships cannot fully rely on electric power today. These ships travel long distances, and the battery technology is not yet offering enough capacity to become their primary source of power. The close-to-shore ships, such as ferries, are already adopting the technology, especially in Europe.

When designing a fully electric vessel, the primary challenge for shipbuilder is to determine the amount of power that will be required to propel the ship and to design a complete propulsion system that delivers the right amount of power over time. Rather than basing their decision on historical data, which is often missing or incomplete, shipbuilders can confidently rely on simulation to propose a design that will meet the set requirements. Additionally, they can use the same simulation toolset to optimize every aspect of the ship and make sure that it meets the highest standards for performance and quality.

Software integration is key when it comes to designing the best possible ship in the shortest possible timeframe. With an integrated toolset, engineers optimize team collaboration, minimize the risk of errors and maximize their productivity. Siemens offers the toolset that engineers need to create the ships of the future, from the initial concept to the ship’s delivery. The Simcenter™ software portfolio brings formerly siloed engineering disciplines together in a cohesive simulation environment. It challenges traditional design methods with a simulation-driven approach and gives engineers full confidence that innovative designs will perform according to the requirements. Simcenter is part of Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software.

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