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Innovative Deck Redesign for Dinghies: Advancing Electric Boat Efficiency and Sustainability

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Abstract. The redesign of a dinghy deck aims to optimize the housing of batteries and onboard electronics, addressing the increasing demand for more efficient and sustainable solutions for electric boats. The design focuses on two key possible interventions: creating an external box specifically to house the batteries and electronics, suitable for retrofitting existing dinghy models, and, as alternative for custom boats, the functional and structural modification of the deck to accommodate the electric powertrain. The battery box is designed to house the batteries and the electronic components essential for the operation of the on-board system, including pumps and control devices. This solution enhances safety, provides protection against moisture and mechanical damage, and facilitates maintenance thanks to its modularity. At the same time, the project involves specific modifications to the rear part of the hull, near the stern, to integrate the battery box without compromising the boat's trim and performance. The design of the installation area was adapted to improve accessibility, reduce overall weight, and optimize the boat's balance while preserving stability and safety during navigation. The result of this redesign offers advantages in terms of both energy efficiency, by improving battery management and electronics, and reliability by facilitating the integration of advanced systems for boat electrification. This innovative approach represents an important step towards the ecological transition in the nautical sector.

Keywords. Dinghy, electric boats, battery box

1. Introduction

Technological developments and a growing focus on sustainability are transforming the nautical sector, particularly regarding electric boat propulsion.

The transition to greener, low-emission solutions is now a priority, resulting in a growing demand for electric boats. However, the realisation of fully electric boats entails several technical challenges, including efficient energy management and integration of electronic systems without compromising boat performance and safety. In this context, the redesign of a dinghy deck is an important response to the need to optimise space and improve the management of batteries and electronics. The project involves the creation of a modular battery box in which not only the batteries, but also the inverter and the oil and water pumps will be safely and securely housed. This solution integrates the main

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electronic components required to operate the system, ensuring greater efficiency and ease of maintenance. The modular design of the battery box allows optimal adaptation to existing boats, but also the possibility of structural modifications for customised models, improving energy efficiency, safety and long-term management of on-board systems [1]. This innovative approach contributes to the ecological transition in the boating sector, thus fostering the adoption of advanced technologies for boat electrification and optimising the management of on-board resources [2].

2. Technical description of the project

The electric dinghy is designed with a lightweight and durable structure. The battery box, the central element of the propulsion system, is completely watertight and made of fibreglass to reduce overall weight and improve structural rigidity [3]. It is fitted with 1 cm spacers to avoid direct contact with any water seepage and is anchored to the hull by means of threaded aluminium inserts, which prevent compression of the structural foam sandwich and facilitate maintenance. The power system includes a power harness connecting the batteries to the inverter and the electric motor, with protected passages inside a sealed corrugated conduit to prevent infiltration. Engine cooling is provided by a combined air-liquid system: seawater is used for direct cooling, while vents and fans improve heat dissipation inside the battery box. The control console includes throttle, hydraulic steering and inverter control system, providing an ergonomic and intuitive interface for the driver. In addition, a Wi-Fi monitoring system enables real-time collection and analysis of the dinghy's operational data. The entire design is developed in compliance with the technical regulations of the competition. Thanks to the CE certification, the dinghy will be exempt from certain technical inspections during the Monaco Energy Boat Challenge in which the following project will participate, simplifying the validation and commissioning process. In addition, all high-voltage components are positioned at a minimum distance of 1 metre from the pilots, meeting safety requirements [4].

3. From battery box sketch to three-dimensional design on cad software

The creation of a battery box starts with the sketching phase, a fundamental step in defining ideas and design specifications. The sketch usually done by hand or with digital drawing tools, allows us to explore the shapes, dimensions and technical constraints that the box will have to respect [5]. At this stage, variables such as the number and type of batteries to be housed, ventilation requirements, fastening systems and accessibility for maintenance are considered. Once the preliminary sketch is complete, we move on to digitisation using CAD (Computer-Aided Design) software, in the following case Creo Parametric was used [6], see Figure 1. The first step in CAD is the creation of precise two-dimensional sketches based on the proportions and measurements established in the initial sketch. These sketches are then extruded, cut and modelled to generate a three-dimensional representation faithful to reality. During this phase, the software allows rapid modifications, testing of different solutions and interference with other system components. A crucial aspect of the transition from manual drawing to CAD model is the verification of tolerances and mechanical specifications. Furthermore, the use of CAD enables the generation of production-ready files, whether based on 3D printing, laser cutting or injection moulding. Finally, the CAD model is used to create technical drawings and 3D renderings, which are essential for communicating the project with production teams and stakeholders. This iterative process ensures that the battery box is designed efficiently, meeting the technical and functional requirements.

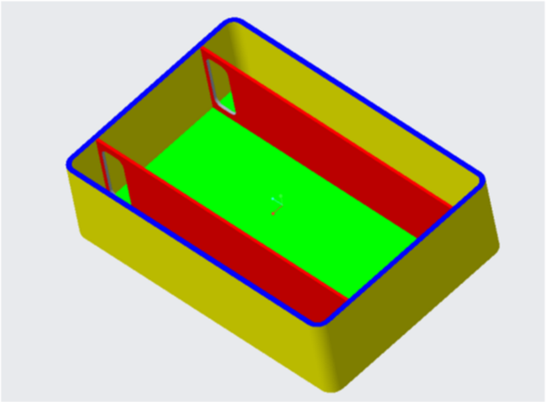

Figure 1. Battery box creation done with Creo Parametric software.

The battery box was manufactured by sheet metal stamping and has a striker flange, highlighted in blue in figure 2, with a width of 20 mm, achieved by means of a sheet metal striker integrated into the mould.

4. Modifying the hull to integrate batteries

Redesigning the hull is necessary to adapt it to electric propulsion, as batteries require secure, ventilated housings that are protected from infiltration and shocks. To dampen shocks and reduce vibrations, the use of vibration dampers is also planned.

Traditional dinghies do not have dedicated spaces for battery boxes, and the weight of the batteries can alter trim and stability. In addition, it is essential to ensure safety, protection from the elements, and adequate thermal management. The redesign allows for improved safety, balance, range, and maintenance, with two main strategies: the use of an external battery box or the modification of the hull to integrate components. In this specific case, Focchi's 510 Sailing dinghy [7] did not allow our battery box (1200 x 829.98 x 337 mm) to be placed easily on the stern, necessitating a redesign that involved removing a structural part. See Figures 2 and 3.

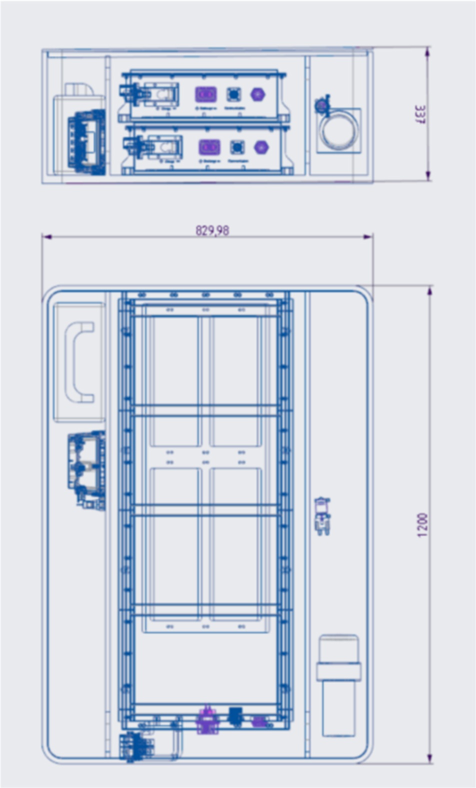

Figure 2. Battery box dimensions with all components inside.

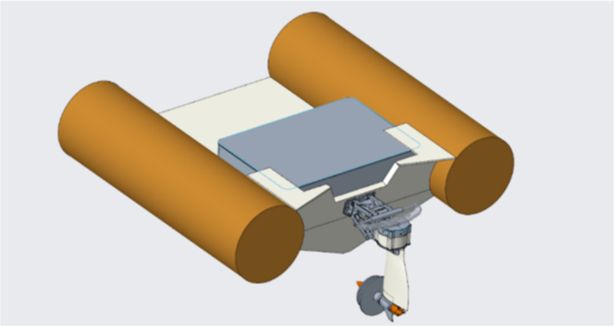

Figure 3. No match between the battery box size and how the stern is made in the original dinghy.

5. External battery box

The external battery box solution involves housing the batteries in a separate, completely watertight, and impact-resistant box attached to the deck or the stern of the dinghy. This option offers several advantages, including easy installation that does not require invasive structural modifications, simplified maintenance, and the possibility of converting a conventional dinghy to electric without a complex hull redesign. However, it also has some disadvantages, such as a possible impact on the hydrodynamic balance due to the addition of an external element, which could affect stability, especially in rough sea conditions. Furthermore, despite the watertight protection, the case remains more exposed to shocks, splashes, and mechanical stresses than a solution integrated into the hull. Finally, the additional bulk could reduce the useful space on board or interfere with other components of the dinghy, limiting freedom of movement or the installation of other accessories. Inside the battery box are the battery packs, which provide the necessary energy for the electric propulsion system. These are two 96 V 100 Ah batteries. These packs are securely fixed to prevent unwanted movement and protected with insulating materials to prevent short circuits or damage due to shock and vibration. In addition, the box includes a Battery Management System (BMS), which monitors the state of charge, temperature and cell balancing to ensure safe and efficient operation. For safety, the box is designed to be fully sealed and ventilated, with air vents or cooling systems to dissipate the heat generated by the batteries. There are also fuses and safety switches to protect the system from overloads or short circuits. Finally, sensors can be integrated for remote monitoring of the battery status, facilitating real-time maintenance and control. Inside the box, as mentioned earlier, are the water and oil pumps, but also the battery charger, the inverter and a small box containing the 12 V battery, as can be seen in the Figure 4.

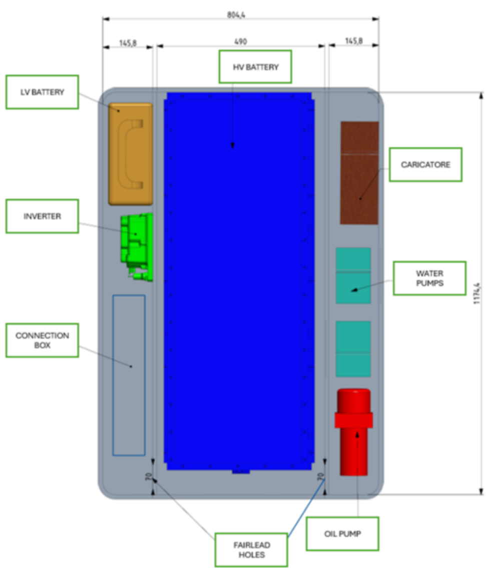

Figure 4. Components inside the battery box.

6. Plybook

The battery box is made of fibreglass and epoxy resin. The lamination of the battery box is designed to ensure an optimal balance between light weight, structural strength and safety. The side walls, with a total thickness of 12.8 mm, use a symmetrical layering of two 700 g/m² layers of woven glass fibre with 0/90° and ±45° orientations, combined with a 10 mm foam core, ensuring rigidity and reduced weight. The 15.6 mm thick cover maintains the same configuration but with a double layer of glass fibre for each ply, improving strength without compromising lightness, with additional reinforcement at the edges to ensure greater stability. The floor, 20.6 mm thick, replicates the layering of the lid, replacing the standard core with a 15 mm foam, improving its ability to absorb loads without adding excessive weight.

The 11.4 mm thick inner walls combine a single layer of 700 g/m² woven glass fibre with 0/90° orientation and a 10 mm Nomex core, ensuring high strength with minimal mass. To ensure a solid and reliable assembly, the box and inner walls are joined using a fibreglass prepreg resin-compatible structural adhesive, supported by the manual impregnation of dry fibreglass with resin, guaranteeing excellent cohesion and durability.

As for the battery box lid, it has the sandwich in the middle and the edge will be trimmed on the final box, so it can be laminated on a plate with a minimum size of 1200 x 900 mm.

For rolling, stainless-steel inserts were also considered. See Figure 5 for exact coordinates.

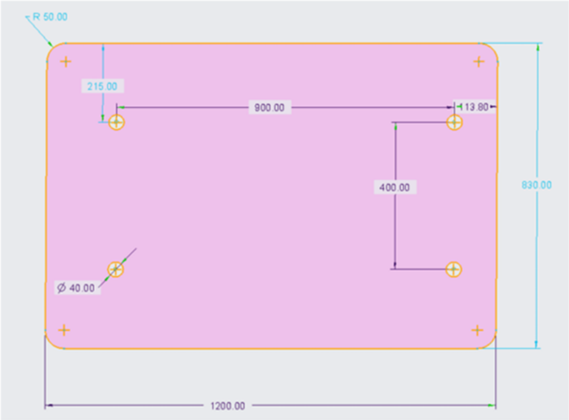

Figure 5. The coordinates of the inserts.

7. Future implications and potential for evolution

The electric dinghy project represents an important step forward in the innovation of sustainable mobility in the nautical field. The solutions adopted, such as the use of advanced materials, a highly efficient electric propulsion system, and an optimised cooling architecture, offer a solid basis for future design developments [8].

One potential development concerns the integration of high-energy density batteries, which could increase the range and improve overall performance. In addition, the adoption of fast charging systems and intelligent energy management solutions could make the dinghy even more efficient and versatile.

On the structural side, the use of advanced composites and even lighter materials could be explored to further reduce weight without compromising strength. Improved aerodynamics and hull could also help optimise glide and reduce energy consumption.

Another direction of development is the integration of autonomous or assisted driving technologies, which would allow safer and more intuitive navigation, with advanced control systems able to optimise course and performance according to environmental conditions.

Finally, the know-how acquired through this project could be applied to commercial or recreational nautical vehicles, facilitating a transition towards electrification in the maritime sector and contributing to the reduction of polluting emissions. The developed dinghy could become a benchmark for future competitions and the development of increasingly high-performance and sustainable electric boats.

8. Conclusions

The electric dinghy project represents an important milestone in sustainable propulsion and technological innovation in the nautical sector. The integration of advanced materials, an efficient electric propulsion system ,and an optimised structural architecture enabled the development of a high-performance boat that complies with safety regulations and competition requirements. The design of the fully sealed battery box, advanced mixed air-liquid cooling system, and optimised mass balance have made the dinghy highly reliable, safe, and high-performance, guaranteeing a stable cruising speed of 32 knots.

The integration of an ergonomic console with real-time monitoring and a modular architecture simplifies the management and maintenance of the system, making it an example of efficiency and innovation. The engineering solutions adopted not only offer a competitive advantage in the competition but also open up new perspectives for the evolution of the electric marine sector. The project demonstrates that the transition to zero-emission boats is possible without compromising performance, laying the foundations for future developments in the commercial and sporting sectors.

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