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Pleasure boats : a future for pluggable hybrids

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Abstract

Electric boats using only batteries: Small electric boats are used for fishing or for trips of few persons for few hours. Large electric boats are used for transportation of many tens of persons for crossings of some kilometres. The users of pleasure boats even for a one day use, are hesitant because they want to be free and they are customers of fuel engine with quasi unlimited autonomy.
The pluggable hydrid solution : two french companies ECOVA and EVTRONIC propose an hybrid pleasure boat with the hope to promote electric boat propulsion.
The choice of the boat results of criteria such as a displacement hull, a medium capacity boat (10 to 20 persons), a well known boat (to be able to make comparisons).
The Pinasse of the Bassin d'Arcachon in the south west sea side of France responds to these criteria .

Keywords: pluggable hybrid boat, plug-in hybrid boat

1 Introduction

For over a century, research laboratories, constructors and suppliers, especially in the automotive industry, and, from time to time, the public authorities and the media, have been interested in electric propulsion and traction on land, and more recently, on water. Many specialists or futurists see in the development of these technologies, in particular with the arrival of the fuel cell, the universal remedy to certain evils from which our environment, our planet, and our societies, developed and undeveloped alike, of the five continents are all currently suffering.

Faced with such figures, the issue of the electric boat may well appear laughable. However...
Emissions into the air and water of closed aquatic environments or inland waterways from thermal engines have a substantial impact on the fauna and flora concerned. The life of a lake, a river, of their users or of the local population can be completely transformed when silence reigns supreme. Neighbouring towns and villages can spare their coffers by having to pay less for maintenance of the banks of those lakes and rivers, thanks to the generalised use of electric boats. Finally, the sheer pleasure of those on board an electric boat is multiplied tenfold by the absence of the noise, unpleasant smells and vibrations usually caused by thermal engines. They are all ample reasons which explain when many people see a sustainable opportunity of carving an easier wake than on land in terms of pollution free travel, more respectful of the various ecological systems and their delicate balance.

Simple or more sophisticated solutions exist. They have already produced extremely satisfactory practical results in the field of electric boats.

We shall first of all describe the state of the art at it stands today with the example of a pluggable hybrid boat.

2 Various sources of energy

The electric propulsion of boats uses various sources of energy:

- diesel-electric, where the energy is provided by petroleum or another fuel such as diester,
- the fuel cell, where hydrogen is used to produce energy,
- « solar-electric » where solar energy, converted by panels, is stored in buffer batteries,
- the « all-electric », where the energy of the network is stored in batteries.
- the « pluggable hybrids », that combines a conventional propulsion system with a rechargeable energy storage system.

2.1 Diesel-electric

The diesel-electric system combines one or several thermal energy generators with an electric motor. For powerful ships with the high torque on starting the electric motor required to overcome the inertia of the shafting, this solution offers the advantages of flexibility for manoeuvring in port and of enabling, at the design stage, the distribution and balancing of the weights of the diesel generators in the space available.

2.2 The fuel cell

This may well have a promising future in an appropriate context. It requires units for the production and storage of hydrogen or on-board production.

2.3 "Solar-electric": the Swiss example

In certain cases, solar energy, often considered as a back-up, can provide total autonomy for boats.

For example, the PlanetSolar project has a united goal: to be the first to circumnavigate the globe in a «solar» boat, i.e. one powered by a silent, pollution-free electrical engine, driven exclusively by solar energy.

2.4 The "all-electric"

The progress achieved in batteries developed for electric road vehicles is valuable for electric boats, but perfectly satisfactory levels of autonomy can already be reached with traditional lead or lead-gel batteries. In the case of displacement hulls, the boat is in fact the most suitable means for the transport of the greatest masses. Batteries, that can be installed intelligently in places where they can replace ballast, do not in fact represent any serious handicap, especially as the electric traction line is lighter than the "thermal line plus fuel tank" system.

On the other hand, the development of the « electric motor-variable speed unit », which converts the energy from the array of accumulators to the load formed by the propeller, must be specific. The solutions employed in large ships are not suitable for smaller boats. Moreover, the techniques implemented in electric road vehicles are difficult to transpose given the difference in the nature of the load between road traction and the propulsion of a boat.
For the moment, energy converting devices are borrowed from simpler systems found in fork lift trucks and light electric vehicles. There is, however, considerable room for research into solutions for variable speed units for electric boats, the objective being to ensure reliability in a marine environment at the lowest possible cost.

2.5 The "pluggable hybrids"

A hybrid electric boat is a boat that combines a conventional propulsion system with a rechargeable energy storage system (RESS) to achieve better fuel economy than a conventional boat. Its secondary propulsion system, additional to the electric motors, means that it does not require regular visits to a charging unit as a battery electric vehicle (BEV) does.

In addition to hybrid electric boat, the plug-in hybrid electric boat can be recharged from the electrical power grid and do not require conventional fuel for short trips.

In our opinion, the plug-in hybrid electric boat solution seems the most safe and economical at the moment.

3 The current "Plug-in hybrid boat": GOELANE

3.1 The boat

The long, narrow-beamed, lightweight oyster boat is used since 19th century in the Bay of Arcachon and along the Gascony coastline, in France. It is now used exclusively for pleasure boating.

The ECOVA polyester hull boat, 10.5 m long and 2.9 m wide, with a total weight of 3.8 tons and a height of 1.85 m, is ideally suited to plug-in hybrid motorisation, given that it requires the presence of ballast that is replaced in this case by the batteries.

3.1.1 Energy

One pack of lead-acid batteries provided by SODETREL, with a capacity of 460 A.h with 48 V, produce a power of 22 kWh for a total weight of nearly 500 kg.

The batteries are recharged in 6 hours with a D.C current of 16A using a charger connected to the 240 V A.C. grid of the French Electricity Board (EDF).

3.1.2 The motor

The propulsion motor is a permanent magnet motor with a nominal power of 10 kW, or approximately 14 HP. The output speed of the motor is adapted to that of the propeller without reduction unit.

3.1.3 The current chopper

The motor is controlled by the combination of a current chopper. This chopper, developed by EVTRONIC, makes it possible to adjust the revolutions of the motor.

3.1.4 The transmission

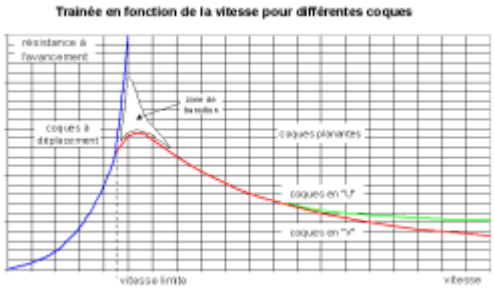
The mechanical energy from the motor is transmitted to the propeller through the stern tube. The first plug-in hybrid boat GOELANE was equipped with a variable pitch propeller making it possible to adjust the angle of attack of the propeller blades according to the revolutions. The purpose is to operate the motor at a constant rating with maximum torque, the speed of the boat depending on the pitch of the propeller. The experiment allowed to define an optimum fixed-pitch propeller.

3.1.5 The autonomy

The GOELANE pleasure boat has an autonomy of approximately 4 hours at 6 knots (11.1 km/hr) in full electric mode, enabling it to cover 24 nautical miles (45 km). The current consumed at that speed is 80 A at 48 V. The propeller turns at

470 rpm. The maximum displacement speed of the GOELANE is 8.5 knots. Above that top limit speed, as can be seen from the graph below, an enormous amount of power would be required to lift the boat out of the water and get it to higher speeds. At that top limit speed imposed by the shape of the hull, autonomy is about 1 hour. The distance the boat can cover in full electric mode is 9 nautical miles (16 km). The current absorbed by the motor reached 200A with the propeller running at close on 700 rpm.

The on-board generator provides infinite autonomy to the boat. Consumption is only 0.3 l / kW.h, this saves considerable fuel and is economically viable.



4 Conclusion

To maintain the nourishing characteristics of captive water (agriculture, fish-farming, domestic use) without its intrinsic qualities being degraded by boat traffic, it is impossible to consider that the effluent from internal combustion engines can be tipped into the water ad infinitum without severe deleterious effects.

Within the same logic, plug-in hybrid propulsion for boats ensures silence and comfort for those on board as well as for those living next to our lakes and rivers – a highly significant factor today for the quality of life and an important parameter for the implementation of policies for local development and/or the development of tourism.

Plug-in hybrid propulsion provides an advantageous and economically viable solution within the context of the production of electrical power in any country committed to a policy of sustainable development.

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