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## Shared electric push ship scheme based on "Internet +" in the Lake

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# Shared electric push ship scheme based on "Internet +" in the Lake

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**Abstract:** Aiming at the problems of current diesel engine pollution, water-powered ship promotion, and slow battery charging, this paper designs a shared electric pusher scheme for the "Internet +" lake area waters. Through the power transformation of agricultural ships on inland rivers and lakes, the original diesel engine ships were replaced by electric pushers. The design of shared batteries, different kinds of charging piles, information sharing network platform and operation mode are added. After the power transformation of the ship, the charging pile is used to provide a stable charging platform for the shared battery; The information sharing network platform is used to provide users with information about the location and usage of shared batteries and charging piles, and to provide managers and maintenance personnel with information about the frequency and location distribution of equipment, so as to realize online tracking of equipment. The operation mode is used to realize the operation of the entire shared electric push boat system.

## 1. Introduction

With the increasing age of diesel vessels in China's lake waters, the deterioration of ship conditions and the increasing emissions of marine diesel exhausts, it has a serious impact on the environment, which in turn harms people's health. Marine diesel exhaust not only contains a lot of carcinogens, but also puts great pressure on people's respiratory system<sup>[1]</sup>. In addition, the pollution of the lake waters by diesel engines is becoming more and more obvious.<sup>[2]</sup> Therefore, the demand for power transformation of ships is becoming more and more urgent, but due to the high cost of reconstruction and the slow charging speed of the battery, the speed of ship power transformation is slow. In addition, as the problems of mismatch between supply side and demand side, excess capacity on the supply side and limited effectiveness of demand side reform become increasingly prominent, China's economy has formed a new development direction focusing on supply-side structural reform. Under this background, the sharing economy uses "Internet +" technology to transfer temporarily the usufruct of idle resources owned by the supply side to create value for both the supply and demand side<sup>[3]</sup>. At the same time, it realizes the social circulation of production factors and the improvement of the utilization efficiency of stock assets.

Combined with the above points, aiming at the serious pollution of water body, the urgent need for ship power transformation and the slow charging speed of batteries, a scheme of sharing electric propulsion ship for the "Internet +" in lake area is put forward. Combined with the concept of sharing, the ship's batteries are set to be shared, and a reasonable and feasible scheme of sharing electric pusher in Lake area waters is designed. The feasibility of the scheme is verified by relevant analysis.



## 2. Design of shared electric push boat

First, the ship's power transformation is carried out, and the motor is replaced by a motor. And the charging pile is placed in the relevant area of the lake. When the electric boat is sailing on the lake and there is insufficient power, you can go to the nearest charging pile to pay and replace the battery.

### 2.1 Design of two charging piles

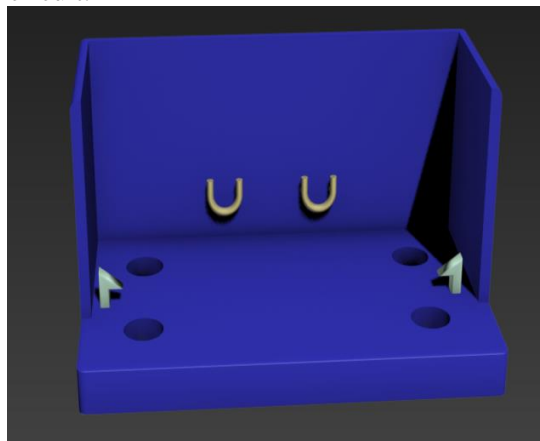
According to the actual use situation, the charging piles are placed at positions such as docks, lakesides, and frequent areas where ships are infested. The lake is planned and divided into various blocks, each of which guarantees at least a sufficient number of charging piles. Specifically:

- (1) Fixed charging piles will be placed in places where the water level difference does not change much, such as docks, lakes and markets;
- (2) Place a floating charging pile in a place where the drop in other water levels is relatively large.

**2.1.1 Structural design of fixed charging pile.** The fixed charging pile is mainly composed of a charging system, a charging device and a safety system.

(1) Charging system: When the user arrives at the charging pile, he first swipes the card or authenticates through the mobile APP. After system identification, the top cover of the battery cell will automatically open and unlock the full battery, and the user will take the full battery to the ship. Users put the batteries that need to be recharged into the battery cell for charging. After the cover of the battery cell is closed, the system will automatically detect the remaining power of the replacement battery. The cost of charging can be calculated. Users pay directly through the second card swipe or APP.

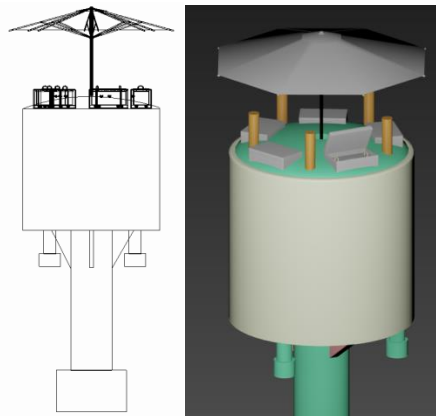
(2) Charging device: According to the location of charging piles, several charging pedestals are arranged around the charging piles. The charging seat is shown in Figure 1. When the battery is placed in the charging seat, the battery can be charged, and the charging pile is equipped with overload protection circuit and AC/DC conversion circuit.



**Fig.1** Charging seat

(3) Safety system: After the user puts the used battery into the battery holder, the system will make a determination, and when the system determines that the battery is in the charging state, the locking of the full battery is released.

**2.1.2 Structural design of floating charging pile.** The water level of the lake is not static, and its water level will change with the seasons. In this case, the fixed charging pile is not suitable for the lakeside where the water level falls. Therefore, the floating charging pile is designed. The floating charging pile consists of a floating platform, a bollard, an anchor chain, an anchor and an umbrella, as shown in Figure 2.



**Fig.2** Schematic diagram of the plane and three-dimensional structure

The function of the floating platform is to provide buoyancy for the entire device and to carry a charging system. A bollard is placed next to each battery slot to facilitate the user to dock the ship and play a role in assisting the ship to moor. The function of anchor and anchor chain is to fix the floating platform, prevent it from floating too far away, and make it fixed in a certain range of waters. The umbrella can prevent the rain from damaging the charging device on the floating platform, which provides a certain guarantee for the safety of the device.

## 2.2 Shared battery design

Considering the actual situation such as cost, service life, and weight of the battery under the same energy, it is finally decided to use a lithium battery (ternary<sup>[4]</sup>) and DC charging. According to the on-the-spot investigation of Dongjiang Lake, after replacing the diesel engine with the electric pusher, if it does not affect the normal use of the user, it is necessary to carry a battery of 6 kWh, and the lithium battery of each kWh is about 8 kg. So, a battery weighing 30 kilograms is designed. Two batteries are placed on each ship, one at the bow and the other at the stern. For one thing, it improves the self-stability of the ship. For another thing, it can make a battery enough to drive to the next charging pile for battery replacement.

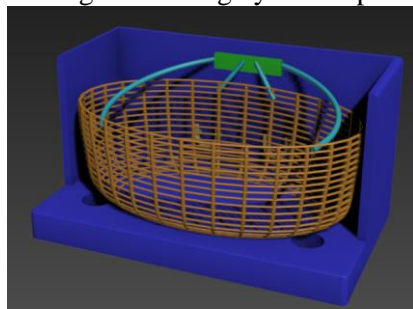
**2.2.1 Waterproof treatment of batteries.** Because the battery used in the ship after the power transformation is more or less exposed to water, the battery must be waterproofed. For this kind of situation, it is decided to adopt the Puwei waterproof technology with wide application and mature technology. The principle of its work is that in the state of water vapor, the water particles are very small, and according to the principle of capillary movement, the capillary can be smoothly infiltrated to the other side, thereby causing aeration phenomenon. When water vapor condenses into water droplets, the particles become larger. Due to the effect of surface tension of water droplets, water molecules cannot smoothly escape from water droplets and penetrate into another measurement, that is to say, water penetration is prevented, so that the permeable membrane has the function of waterproof.

**2.2.2 Design of Battery Tracking Management Based on IoT Network (LORA NB—IOT<sup>[5]</sup>).** In the context of the current sharing economy, many shared economic operators have full property rights to shared goods, and it is necessary and reasonable to carry out refined operation and maintenance. Especially in some durable goods market, the quantity of products will always approach the upper limit of market capacity for a certain period of time. At this time, the new revenue of product operators comes from refined operation and maintenance. For example, in the current situation of slowing macroeconomic growth and limited investment in fixed assets, the number of large-scale equipment in the construction machinery industry is limited, and equipment manufacturers mainly rely on new operation and maintenance methods. The durability of shared batteries determines that they are very suitable for new refined operation and maintenance methods.

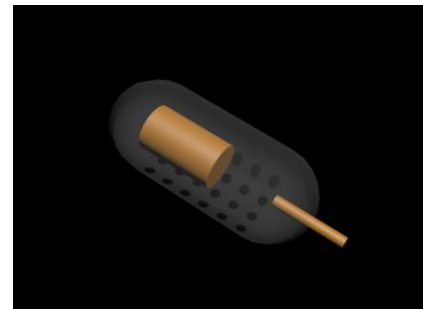
**2.2.3 Battery management.** Since all batteries are public, regular inspection and maintenance of the battery is necessary. The battery management personnel can carry out the position information of the battery through the positioning device on the battery, and regularly inspect and maintain the battery. During the inspection and maintenance process, the battery that has reached the end of its life and the battery that has not reached the service life but has problems due to non-human factors, such as accidental water ingress, cause short circuit, natural factors, etc., are recovered. For batteries damaged by human factors, find the person in charge of the damaged batteries, deduct the deposit and give warning, and let the person in charge fill the new batteries later.

Considering that the ship may tip over during navigation, the battery will fall into the water, so a battery emergency device is designed.

(1) Place a yellow net bag as shown in Figure 3 in the battery compartment on the ship. The net bag is connected to the green air bag by four ropes.



**Fig.3** Schematic diagram of battery emergency structure



**Fig.4** Airbag inflation starting device

(2) When the battery emergency device is activated, the green air bag will immediately start to inflate, and the air is completed in about 5 seconds. The air bag is lifted and the rope is tightened, and the battery is floated together.

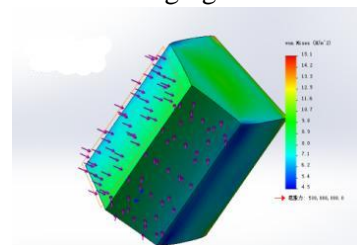
### 3. Feasibility analysis

#### 3.1 Strength Analysis of Floating Platform

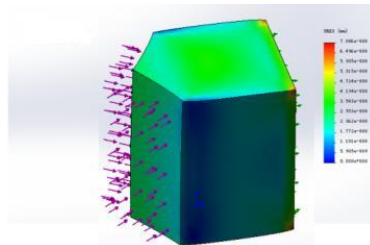
In order to check whether the strength of the floating platform is feasible, we use Solid works to build the model and match the corresponding materials. Through Solid works Simulation, the strength of the floating body is analyzed as shown in Fig.5 to Fig.7, and the conclusion is drawn:

(1) Material: The floating platform is made of FRP.

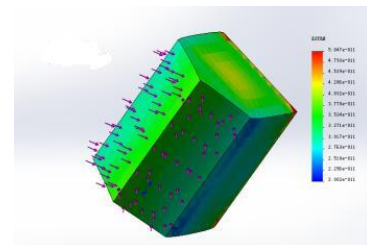
(2) Similar results can be obtained by simplifying the model, ignoring its internal structure and without changing its external constraints.



**Figure 5** Station stress map



**Figure 6** Station displacement map



**Figure 7** Station strain chart

Conclusion: (1) In terms of stress, the maximum stress of the floating platform designed by us is less than the yield force. (2) We obtain the deformation map of the floating platform at 50 times deformation ratio, which provides a clear and intuitive basis for the optimization of local strength in the future; (3) In terms of safety, standard engineering usually requires a safety factor of 1.5 or greater, and we set a safety factor of 2. Through analysis, the minimum safety factor is 1.2, the yield is not reached, and the overall safety factor is close to 2; In summary, the floating platform basically conforms to the design standards.

### 3.2 Feasibility of Battery Falling Water Emergency Plan

Water-soluble tablets have long been used in automatic inflatable devices of life jackets. After several tests, the water-soluble tablets will start the inflator after about 3 seconds of water contact. The airbag that provides 100KG buoyancy has an inflation time of less than 5 seconds, so the battery can quickly rise to the surface after accidentally falling into the water, effectively reducing the pollution of the battery to the lake at the same time, because the water inlet hole of the airbag starting device is below the device, water splashing on the device due to wind waves or other reasons is avoided.

## 4. Benefit Analysis

Taking Dongjiang Lake as an example, the benefits are analyzed from three aspects: energy conservation, emission reduction and economic benefits. Dongjiang Lake has 2,779 ships of various types, including about 2,500 agricultural vessels. These agricultural vessels work about 5 hours a day, assuming that the shared electric pusher completely replaces the original agricultural diesel vessels.

### 4.1 Energy efficiency

In terms of energy saving, the conversion of agricultural diesel engine ships to electric boats will completely avoid the oil consumption of ships. The fuel consumption that Dongjiang Lake can reduce in one year is:

$$S = M \times K \times P \times T = 2500 \times 200 \text{ g} / \text{kw.h} \times 6 \text{ wk.h} \times 5 \text{ h} \times 365 = 5475 \text{ t} \quad (1)$$

In the formula: S is the fuel consumption of the ship, M is the number of ships, K is the fuel consumption rate, P is the ship power, and T is the ship's sailing time. The power of an agricultural ship is about 6Kw·h, and the sailing time of one day is 5h. It can be inferred that after the ship is changed from oil to electricity, only the Dongjiang Lake ship can reduce fuel consumption by 5,475 tons a year. There are about 24,800 lakes distributed in China's vast land. If the agricultural oil-to-electricity plan is fully implemented, the annual fuel consumption can be reduced.

### 4.2 Emission reduction benefit

In terms of emission reduction, some people have done statistics: 100 kinds of agricultural vessels in Dongjiang Lake are selected. These ships emit up to 5.6 tons of waste oil per year. Then the annual pollutant discharge of 2,500 agricultural vessels in Dongjiang Lake is:

$$\frac{5.6 \text{ t} \times 2500}{100} = 140 \text{ t} \quad (2)$$

After the ship's oil is changed to electricity, Dongjiang Lake will reduce 140 tons of slop oil emissions every year.

The consumption of agricultural vessels is diesel, and diesel combustion produces more CO, NO<sub>x</sub>, SO<sub>x</sub>, dispersed particulates and hydrocarbons. The annual emissions of Dongjiang Lake alone are:

$$F = M \cdot EF \quad (3)$$

In the formula, F is the annual emission based on fuel consumption, M is the annual fuel consumption of ships, EF is the emission factor based on fuel consumption.

**Table 1** Projected emission reductions in Dongjiang Lake

Polluted gas	M	EF	F
Carbon monoxide	5475t	6.13kg/t	33.56 t
Nitrogen oxide	5475t	76.55kg/t	419.11 t
Sulfur oxides	5475t	48.12kg/t	263.46 t
Diffuse particles	5475t	1296.51kg/t	7098.39 t
Hydrocarbon	5475t	2.24kg/t	12.26 t
Carbon dioxide	5475t	3165.63kg/t	17331.82t

In summary, the implementation of the oil-to-electricity conversion plan for ships will greatly reduce the oil consumption of ships, reduce the dependence on non-renewable energy sources, reduce the

emissions of dirty oil and polluted gases, and have considerable energy-saving and emission reduction benefits. If it is popularized nationwide, it will effectively improve the serious pollution situation of inland lakes in China.

#### 4.3 Economic benefit

In terms of economy, the current price of diesel No. 0 is about 7 yuan per liter, and that of one liter of diesel is about 0.85 kilograms. Diesel is a non-renewable energy source. With the shortage of petroleum resources, the price of diesel will continue to rise. At the same time, from the perspective of energy efficiency, the energy efficiency of diesel engines is about 30%-45%, and the energy utilization rate of electric pushers can reach 95%.

The annual diesel cost for a farm vessel is:

$$W_1 = \frac{K \times P \times T \times C_1}{0.85} = \frac{200g / kw.h \times 6kw.h \times 5h \times 365 \times 7RMB / L}{0.85} = 18035.3RMB \quad (4)$$

In the formula: K is the fuel consumption rate, P is the ship power, T is the ship's one-year sailing time, and C<sub>1</sub> is the No. 0 diesel price.

After the ship's oil is changed to electricity, the cost of sailing a farm vessel:

$$W_2 = P \times T \times C_2 \times \& = 6kw.h \times 5h \times 365 \times 2.5RMB / kw \times 0.4 = 10950RMB \quad (5)$$

In the formula: P is the ship power, T is the ship's one-year sailing time, C<sub>2</sub> is the shared battery price per kWh, and & is the relative energy utilization rate of the diesel engine and the electric pusher.

Through the comparison of the above data, we can know that the cost of ship navigation will be greatly reduced after the oil-to-electricity conversion, which will effectively alleviate the economic pressure of farmers. Shipowners will be more willing to change oil to electricity for ships, which has played a huge role in promoting the promotion of shared electric pusher.

## 5. Conclusion

In view of the serious water pollution, the urgent need for marine power transformation and the slow charging speed of batteries, a scheme of sharing electric propulsion ship for the "Internet +" in lake area is proposed. After analysis, the method has great feasibility, and it has certain reference significance for solving the problem of water pollution caused by the aging problem of diesel engines.

## Acknowledgement

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## Reference

- [1] Ma Shixue, Xu Kaifeng, Yu Yu. Emission Control Technology for Marine Diesel Engines [J]. Science and Technology, 2018 (33): 151.
- [2] Feng Zhuojin. Exhaust pollution of diesel engine and its treatment [J]. Urban Public Transport, 2000 (02): 20-21.
- [3] Xie Peng, Shi Yu. Development status and future trends of the sharing economy [J]. National Governance, 2017 (17): 29-37.
- [4] Han Li. Research on battery management system based on ternary lithium battery [D]. Chang'an University, 2018.
- [5] Shu Wenqiong. NB-IoT and LoRa have their own futures. The future will coexist for a long time [J]. Communication World, 2018 (28): 9.