A Low Wash Hullform and Pollutant Free Inland Waterways Leisure Craft

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Abstract: - This paper presents the development of an environmentally friendly leisure boat. The study seeks to choose an appropriate hull form configuration, propulsion system and material to minimize bank erosion and prevent air and water pollution. An asymmetric catamaran hull form configuration was selected and an electric motor with solar cell was chosen as propulsion system. GRP material was chosen to ensure ease of maintenance and corrosive resistance

Key-Words: environmentally friendly, leisure boat, asymmetric catamaran, electric motor, solar power.

1 Introduction

Various kinds of boats and ships are used in inland waterways, some for transport while others for leisure uses. Studies have shown these that vessels cause pollution to the environment [1], [2]. These vessels pollute the three components of the environment i.e. air, water and land-water interface [3].

1.1 Air

The use of fossil fuels in ships and boats has been identified as one of the main contributors to greenhouse gases and environmental pollution [4]. In leisure boat application, the exhaust gas will also cause discomfort to the users. For example, for a small-sized boat with tail wind, the exhaust fumes will be blown into the passenger cabin. This toxic gas exhaust fumes is an inconveniencer and can cause respiratory problems. The exhaust gas permeates and stains clothing as well as the boat. In addition, secondary effects from the engine in terms of heat and fumes can trigger a fire. The other problem with internal combustion engine is noise pollution. This noise causes discomfort to crews, passengers and other users, and will disturb the fauna when the boat is used in an eco-tourism setting.

1.2 Water

The internal combustion engine needs not only fuel in the form of petrol or diesel oil, but also lubricant. Leaks and spills are potential contaminants endangering aquatic and human lives. This polluted water discourages locals and tourists from engaging in waterborne recreation activities. Moreover, the paint used to protect wooden leisure boats can gradually dissolve and contaminate the water, hence endangering aquatic life and also increasing cost of water treatment process.

1.3 Land-water interface

Vessels generate wake wash which erodes the banks of rivers and lakes. This wake also rocks neighbouring crafts and causes unpleasant effects to anchored vessels and swimmers. Wake wash from a passing vessel can be regarded as a pollutant. Small boats also produce the adverse effects of wake wash, contributing to environmental damage, especially in inland waterways. According to [1], boat wake wash is often the dominant cause of local instability in tidal wetlands and along fringe wetlands in lakes. Johnson [2] reported that recreational boating on the Mississippi River main channel is the contributing influence most responsible for the documented high rate of shoreline erosion. Bauer et al. [5], estimated the boat wake wash-induced levee erosion at the San Joaquin River Delta of central California and shown that boat wake wash gradually erodes levee banks.

A lot of work has been carried out in developing low wake wash boats but they are mainly concerned with ferries and other high speed marine crafts. Not much work has been done in the field of slower, smaller speed crafts for inland waterway application, despite the fact that bank erosion is more critical in rivers and lakes compared to the seas.

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This paper presents a study on developing an environmentally friendly boat with low wake wash hull form for leisure boats. On top of that, the boat utilizes electric propulsion deriving its power from a bank of batteries powered by solar panels on its canopy.

2 Design Requirements

A survey was carried out among the inland leisure boats operators in Malaysia and the following were found to be desirable attributes for an environmentally friendly boat:-

- Low noise.
- Low wake wash to reduce bank erosion.
- Low maintenance.
- Low water and air pollution or if possible none at all.
- Relatively easy to handle.

With these attributes the team came with the following main specifications for the prototype as shown in Table 1.

<table>
<thead>
<tr>
<th>Hull Type</th>
<th>Asymmetric catamaran</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Overall (LOA)</td>
<td>5.10 m.</td>
</tr>
<tr>
<td>Length Waterline (LWL)</td>
<td>5.02 m.</td>
</tr>
<tr>
<td>Breadth moulded of demihull</td>
<td>0.33 m.</td>
</tr>
<tr>
<td>Beam Overall</td>
<td>2.65 m.</td>
</tr>
<tr>
<td>Draught</td>
<td>0.50 m.</td>
</tr>
<tr>
<td>Passengers</td>
<td>4 Persons</td>
</tr>
<tr>
<td>Crew</td>
<td>1 Person</td>
</tr>
<tr>
<td>Service Speed</td>
<td>3 Knots</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>6 Knots</td>
</tr>
<tr>
<td>Propulsion system</td>
<td>Electric motor, battery, solar cell.</td>
</tr>
<tr>
<td>Material</td>
<td>GRP</td>
</tr>
</tbody>
</table>

Fig. 1: Flow Chart of Parametric Study

Figures 2 and 3 show the wave contour of Flat Side Inwards (FSI) and Flat Side Outwards (FSO) configurations respectively, produced by the Computational Fluids Dynamics numerical simulation described in detail in [8]. The full results of the hullform development were reported in [8] and [9]. Examples of results for experimental and CFD studies are shown in Figures 4 and 5 which compare wave profiles of FSI and FSO configurations with the longitudinal wave cut location at the centreline as well the effect of demihull separation ratio (S/L) respectively. FSI configuration is presented with a dashed line and FSO configuration is presented with a continuous line.
3 Boat Material

The present inland waterway boats are mainly made using timber. Timber is a diminishing resource and the felling of trees causes untold damage to the environment. Coatings used on most inland waterway vessels react with the environment, leaching and polluting the water. To overcome this problem, Glass Reinforced Plastic (GRP) was chosen as the prototype material. There are many other advantages to using this material, since it is easy to process, low maintenance, as well as corrosion resistant. No secondary painting of the hull is needed.

4 Propulsion Systems

Electric motor was chosen as the propulsion system. Electric motors are highly efficient. They require no fuel or engine-oil maintenance. Motors contribute to the safety of the work environment, emitting no exhaust
fumes, and without flammable fuels. Moreover, for ecotourism, its quiet operation is a welcome bonus. Solar cell was chosen as the auxiliary power source to support the batteries. Solar cells are completely silent and non-polluting. As they have no moving parts they require little maintenance and have a long life. However, the problem of nocturnal downtimes means solar cells can only generate power during the day. The prototype was constructed and tested successfully, as shown in Figure 7. Although visually the wake wash seems to have diminished, actual measurement on the full-scale vessel has not been carried out to actually confirm the expectation.

![Fig. 7: Final Prototype Testing](image)

### 5 Conclusions

The final catamaran hull form i.e. an asymmetric demihull with outward-facing flat side configuration was selected as it generates low wake wash. The outboard electric motor is used in this prototype for its low noise and absence of gas emission and discharge. Solar cell was chosen as it is completely silent and non-polluting. Glass Reinforced Plastic (GRP) was chosen as prototype material, because it is easy to process, low maintenance, and corrosion resistant.

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### References:


