



# Perspective of Environment-Friendly Materials in Small Boats Manufactured in Vietnam

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**Abstract:** The using of new environmentally friendly materials in the small boat manufacturing is an appropriate direction, consistent with the general trend of the times, as well as the domestic transport demands and defense needs. This article presents the problems of the Copolymer Polypropylene (PPC) plastic materials as to apply on to the boat-building in Vietnam today.

**Keywords:** PPC Plastic Materials, Boat Building

## 1. Introduction

Vietnam has abundant and potential river system, with a total length of more than 41,900km, of which 2,360 km of the rivers' length, 3,260 km of coastline and more than 100 estuaries with a set of lakes, bays, marshes ... It is creating a system of waterways connecting the cities, provinces, residential areas and concentrated economic zones. There are about 33,789km of small canals that only allows vessels, which are under 50 tons of displacement, to exploit [1]. According to statistical data [2] in 2013, the national in-land waterway transport system has transported 144.7 from 2,844 millions turns of all the national transport system. Only in the Mekong delta region, the inland waterway transport system has carried 16.8% of the quantity of the passenger transported in this area [2].

Recently, the demand for small boats equipped for human's life and national defense purposes is great and varied, for examples patrol boats, relaxed fishing vessels, tourist ships in rivers, bays and lakes (figure 1).

Up to now, the materials used to build these above types of boats are still traditional materials (wood, steel, aluminum alloy, composite). According to practical data [3], among 137 tourist ships of small size (below 14m long, equipped with up to 45HP engines, carrying under 20 passengers), there are 120 ships with the hull made by wooden, 16 ships with the hull made by FRP and there is just only 1 steel ship (figure 2).

The used materials have following characters as: high cost (as aluminum alloy), or not environmentally friendly (as wood and composite) or short durable and high exploitation and/or maintenance fee (as steel).



Figure 1a. Canoes carrying tourists on canal of Mekong's downstream

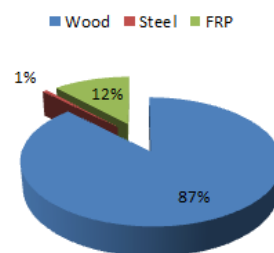


Figure 2. The quantity of small passenger boats by kinds of hull materials

The research in the boat design and manufacturing using environmentally friendly materials, as well as the application of the clean energy sources for the power systems and life serving systems on the ships are the big epochal problems, which have to be solved by the government and ship building managers in all the world, as in Viet Nam [4].

Small ships, made of PPC materials and welded connection, have been implemented since the early years of 2000s in some countries. Due to the outstanding advantages of this material, such as: healthy and safety for the workers; good collision resistance, long durable, good resistance to the weather conditions from -35 to +80 °C with good heat and noise isolation, capable of 100% recycling, light (910 g / liter), small friction, fuel savings, etc., it contributes to saving the fossil fuels and reducing CO<sub>2</sub> emissions, causing the greenhouse effect.

## 2. Evaluation of the Using of PPC Materials in the Boat Manufacturing

The using of PPC sheets in the industries are diversity, from tanks structure, pipes, liners to such vehicles' items as boats' hulls, trucks' containers, etc.

In recent years, some countries have developed the ship types made of PPC materials. The below figure 3 introduces the high-speed patrol boat "Patrol H39", with 11.8 meters long, 3.6 meters wide, 3.2 tons payload, equipped 2 engines Volvo penta 2x300HP for maximum speed of 50 knots. This ship has been built by 4.4 tons of plastic Polystone® P-Copolymer and hot plastic welding technology.



Figure 3. Patrol boat "Patrol H39", (Czech, 2011).

In addition to manufacturing boats, plastic Polystone ®P can also be used to fabricate the float pontoons well. Pontoons have been used as floating piers in the marina (Figure 4) and ferry stations, ...



Figure 4. Marina made of plastic Polystone ®P.

In Vietnam, PPC material was initially applied to fabrication of small boats [5]. Figure 5 introduces a patrol boat on the river (hull designing notation H29), which has the length of 8.5 m and equipped a 200HP Yanmar.



Figure 5. High-speed patrol vessel "H29"

## 3. PPC Plastic Materials

### 3.1. An overview of PPC Plastic Materials

Polypropylene (acronymed as PP) is a synthetic plastic material for common using. This is a product of polymerization of propylene. Chemical nomenclature: poly (1-methylethylene). Molecular formula of PP is (C<sub>3</sub>H<sub>6</sub>)<sub>x</sub>, (Figure 6) [6].

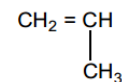
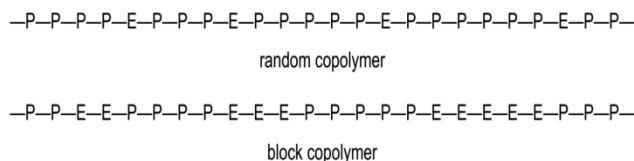


Figure 6. Propylene monomer

PP plastic, used in the industry, graded to two main categories:

- Homopolymer PP (acronymed as PPH) is made by polymerizing propylene with the catalyst cube - structure. Materials in this class have outstanding durability, hardness, resistance to high temperatures without deformation.
- Copolymer (acronymed as PPC) is slightly softer than Homopolymer but has good impact resistance, more supple, anti-stress cracking and works well in cold conditions than Homopolymer. Depending on the type

and levels of participation coincidence that there are two basic types (Figure 7):



**Figure 7.** Molecular structure of PP Random Copolymer and Block Copolymer.

- **Block (impact) copolymers:** It is a grade material PP mixed of (5 ÷ 15)% ethylene to improve impact resistance at temperatures as low as -20 ° C. Their toughness is enhanced by the addition of the elastomeric material. Their acronym is Impact PPC.
- **Random copolymers** is grade PP material composed of single molecules arranged randomly along the long molecular chains of polypropylene. This type usually contains from (1 ÷ 7)% ethylene. The name stands for Random PPC.

Each grade PP material is selected based on the consideration of the application area, cost, and processing methods. PPC materials is often chosen for applications requiring high impact toughness. The main applications of PPC sheets are varied in industry, from structural tanks, piping, liners, to vehicles such as boats, truck, etc.

### 3.2. PPC Materials for Boat Building

The lightweight material, had characterized mechanical and physical properties, chemical suit operating conditions in seawater environment, has long been a concern of the shipbuilding industry. PPC plastic partly meet the rigorous requirements that [7], [8], [9] namely:

- Impact resistance
- Resistance to UV and heated
- Resistance to chemicals
- Mechanical Properties
- Color reliability
- Environmentally friendly
- The suitability of materials for shipbuilding PPC

#### 3.2.1. The Pendulum Impact

PPC has better impact toughness and durability than PPH. Materials PPC likely under stress crack resistance and toughness at low temperatures better.

#### 3.2.2. Resistance to UV and Heat

PPC materials are sustainable for ultraviolet. This enables vessels to work directly under sunlight without degradation, deformation

#### 3.2.3. Resistance to Chemicals

PPC are superior materials when are used in corrosive environment of inorganic acids, alkalis, salt (sea), organic solvents, grease reducing agent, and impact resistant galvanic corrosion. The regular cleaning and disinfection with

chemicals are not harmful for PPC materials. Materials PPC are also neutral materials for fresh water and food.

#### 3.2.4. Mechanical Properties

Even through, PPC have impact resistance ability lower than polyethylene (PE), PPC have superior working temperature and tensile strength. Tensile strength values from (18.1÷30.2) MPa. Izod pendulum impact from (8÷140) kJ / m<sup>2</sup>. Materials PPC can withstand temperatures in the range of (-35÷70)<sup>0</sup>C

#### 3.2.5. Color Stability

Variety of colors due to the chemicals coloring are added during manufacturing, materials PPC have aesthetic value by keeping the color when affected by sunlight (mostly UV) and chemicals.

#### 3.2.6. Environmentally Friendly

PPC are the materials fullrecycling capable. Ecologically, the production and processing of PPC materials do not generate toxic substances to the environment and health

#### 3.2.7. The Suitability of PPC Materials for Shipbuilding

PPC are clean materials with no corrosion, no rust. The cleaning simply uses high-pressure water hose and brush /sponge to clean. PPC materials are not stucked at the bottom and hull boat by aquatic by aquatic species (oysters and moss), so this materials can save maintenance fees compared to traditional materials. Due to diluting paraffin components are waterproof and aquatic species non-adhesive, PPC materials could decrease hydraulic resistance and reduce fuel consumption by more than 30%. PPC are the lightweight materials. Due to the elastic and toughness of PPC, this materials can against hard bumps and resists penetration. PPC materials are also suitable for building structures such as floating marine, freshwater tanks at sea and islands.

#### 3.2.8. Other Notes

As a thermoplastic resin (nhựa nhiệt dẻo), PPC has some limitations:

- Susceptible to oxidation and thermal aging;
- Difficulty bonding with the solvent;
- Flammable;
- Be less abrasive;
- Liberation organic compounds volatile VOC (Volatile Organic Compounds).

These limitations need to be noted to design, manufacture and appropriately use of products.

Some represent types of boats and floating structures use synthetic material PPC:

- Boats, small boats carrying people and goods;
- Patrol vessels for the armed forces, customs, fishery control, etc.
- Floating structures for the archipelago as well, public houses, floating storage, water storage tanks;
- Vessel salvage and rescue;
- Sport boats, recreational fishing, floating dock,

## 4. Proposal Products

Some of the perspective products will be made in the plan of Viet-Czech Technology Jointstock Company [10], such as follows.

Multipurpose river catamaran with upto 50HP engine (Figure 8.)

Coastal patrol boat with upto 12 passengers plus 04 crews and 3 days of continuous traveling (figure 9).

River servicing fast boat (Figure 10) with a front-door.

Floating riverway navigation signal (Figure 11).



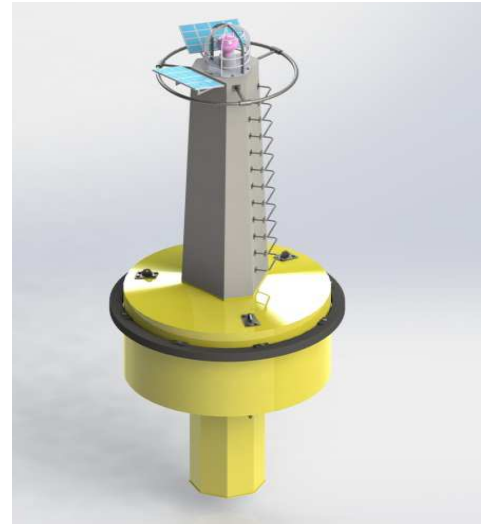
*Figure 8. Multipurpose river catamaran with upto 50HP engine*



*Figure 9. Coastal patrol boat*



*Figure 10. Servicing boat on riverway*



*Figure 11. A floating riverway navigation signal*

## 5. Conclusions and Recommendations

Materials selection manufactured boats fit current needs is significant scientifically and practically, bring efficiency and practical economic in exploitation of water means.

Considering the development of boat types using PPC material, in the last decade, the number and types of boat using PPC material is increasing. That is consistent with the trend of the times when using materials with environmentally friendly, reduce maintenance costs, maintenance, save energy, reduce CO<sub>2</sub> emissions causing the greenhouse effect.

The research about applications of PPC resin material (polypropylene copolymer Polystone®) into manufacture small vessels is an appropriate way, consistent with the general trend of the times, practical contribution to environmental protection.

Currently there is no high set of international laws for this kind of shipbuilding materials. The research vessels manufacturing with PPC materials in Vietnam is just initially deployed [11]. Need to invest in research, building regulations registration system for all kinds of canoes, boats produced by using new materials in order for canoes and boats which are produce by manufacturing enterprises to be able to activate eligibly.

Within this report, only present practical needs of using synthetic plastic materials in order to manufacture boats and vehicles, transportation equipment; thermoplastic resin welding technology is suitable in manufacturing boats; some preliminary results on small boats manufacture with plastic material synthesis PPC.

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