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Disposal of Worn Out Fiberglass Recreational Boats

Abstract

Mass production of fiberglass boats begun in the mid-50s of the 20th century. Over decades, a large number of such boats accumulated throughout the world. Since the lifespan of these boats is 30 to 50 years, at the moment many fiberglass boats simply arived to the end of their life and need to be appropriately disposed in a safe and environmentally friendly way. It is expected that the disposal of boats will become a more pronounced problem, in which the basic issue is the relatively high cost. The main problem is the fiberglass laminate which constitutes the major part of the boat. As of today, there are no economically viable methods. Many countries do not have special programs for the disposal of worn out fiberglass boats, which would undoubtedly provide the answers to many questions. The paper gives an overview of the disposal conditions of worn out recreational fiberglass boats over the world as well in the Republic of Croatia.

Keywords: worn-out fiberglass boats, disposal, overview

1. Introduction

In the recent decade in Europe and over the world, there is an increased interest in recreational boats that have reached the end of their life or are abandoned. Such boats can lead to environmental pollution, as well as to costs of removing from ports or marinas. These boats often represent a threat to waterways. The fact that a boat has reached the end of its life does not necessarily imply that it cannot sail anymore. It can mean that private owners wish to sell their boats, but can not find a buyer for a long time.

Fiberglass boats have been produced massively since the mid-50s of the 20th century, and to date, a quite large number of new fiberglass boats has been sold. The lifespan of fiberglass boats is between 30 and 50 years, meaning that a significant amount of such boats has been accumulated throughout the world over the years. The problem is that many fiberglass boats, mass-produced 60 years ago, are simply worn

out and need to be taken care of. Since it is expected that the number of such boats will increase, proper care will become an increasingly important issue. However, most countries do not have special programs for the disposal of worn out fiberglass boats.

In Europe, a two-year "Boat Dismantling Insight by Generating Environmental Safety Training - DIGEST" project study was conducted. It was funded by the European Boating Industry trade association. The study found that amongst 7 million pleasure boats, 95% were built of fiberglass. The vast majority is shorter than 8 m and has an average life of 35 years, [1]. The International Council of Marine Industry Associations - ICOMIA, an international umbrella association, has been gathering the nautical industry associations from many countries worldwide since 1966. According to its data, it is estimated that there are around 23 million boats in the world, and 16.4 million of them are in the US. It is estimated that 10% of these boats are no longer used regularly and that an additional 2% of boats will stop being used each year. Since the financial crisis in 2008, the number of abandoned boats increased. According to some other indicators, it is considered that there are around 40 million recreational boats in the world. If only 1% of boats annually become undesired, this means that about 400,000 boats should be taken care of annually in the world [2].

Recreational boats that have reached the end of their life must be taken care of in a safe and environmentally friendly way, which is not simple. The EU Directive 2008/98/EC bans the disposal of fiberglass in any waste landfill site starting in 2015 [3, 4] so other solutions need to be found. It is very difficult to reliably evaluate the total number of recreational boats in the world, and it is particularly difficult to estimate the number of boats that have been written-off or abandoned. The fact that many countries have no mandatory registration system for recreational boats represents another obstacle.

2. Disposal of worn out boats

There are two basic aspects to consider when discussing the regulations for the disposal of worn out boats. The first one is, who should be responsible for disposal of these boats. Secondly, how to classify a worn out boat: as communal waste (waste from households), technological waste (waste generated in production processes), or as something else. In some countries, the responsibility lies with the boat owners, who cannot just leave the boat or throw it off. Furthermore, since waste is not allowed to be disposed outdoors, the owner must not leave the boat in public areas. This also applies to places where the public has only a sight, including their own yard. However, it is legally permissible for such boats to be in boatyards. It can be expected that these boats will become an increasing problem in the near future, as more and more fiberglass boats will reach the end of their lifespan. Additionally, the boats built in last decades will have a shorter lifespan, since nowadays glass fiber laminates of smaller thickness are generally used in boat construction, as opposed to older boats that mostly have thicker laminate.

In the absence of proper programs for the disposal of worn out fiberglass boats, it is highly probable that the boats will remain in the yard, possibly be burnt, or eventually end up somewhere in nature or at the bottom of the sea, lakes or rivers. For the responsible owner, following the proper procedure of disposal can be quite expensive. The average cost in France ranges from 300 EUR for a small fiberglass boat up to 2,200 EUR for a 16-meter boat [2]. Generally, the highest cost is a transport. According to some studies [4], the average price for an ordinary boat with length of seven meters would cost around 800 EUR. The cost increases to some 1,500 EUR for boats of 10 to 12 meters in length and 15,000 EUR for boats longer than 15 meters. Costs are more associated with the boat volume than its length.

Some larger boat manufacturers believe that the problem could be solved by increasing the value of the boat throughout the entire disposal process. This could be achieved, for example, by changing the way the boats are built. In the automotive industry it has already been regulated. European Directive 2000/53/EC on waste vehicles requires that at least 85% of the average mass per vehicle per year is made of materials suitable for reuse or recycling [5]. Something like this is very unlikely to expect in the boat building industry in the near future.

3. Impact on the environment

The situation with fiberglass boats is a complex one. Almost all boats are now constructed with thermoset resins such as polyester, vinylester or epoxy. Once the resin hardens, it firmly bonds to glass reinforcements and the resulting laminate is almost indestructible. From the boatbuilder point of view, this kind of material is certainly desirable because the marine environment is far from being hospitable. From the recycling point of view, this is not so advantageous. Laminate can be mechanically chipped, but it is a small benefit of such material. In order to reuse the components of the laminate, it would be necessary to chemically separate the resin from the glass reinforcements. This is not economically viable at this time. Another problem is that such a boat does not consist only of laminates. The boat has a petrol or diesel engine that contains oil and coolant, there are fuels, batteries, explosive materials in fire extinguishers, etc. Many parts of worn out boats (e.g., engines, winches, anchors, tanks, masts), can be reused depending of their condition. Materials that are recognized as suitable for recycling are mainly metals such as lead, aluminum and stainless steel. Other parts that can be recycled with economic value are batteries and liquids such as oil, petrol or diesel fuel. Electronic equipment can be reused if not too old, but given the rapid progress in this area, probably there isn't a big market for such items.

Creative individuals find various uses for parts taken over from worn out boats. Thus, for example, bags can be made of sails. Other boat parts that can be separated and reused are kitchen stoves, toilets, windows, ropes, boat propellers, transmission gearboxes, etc. Most of the furniture on boats is made of wood, often expensive,

which, if not part of the fiberglass boat structure, could be further recycled in the wood industry or at least burnt as an energy source. The boat parts, materials, pollutants and the possibility of multiple uses or recycling according to today's methods are presented in Table 1.

Boat engines are similar to automotive engines and thus fit into the car recycling programs. After removing the engines and other parts, the fiberglass laminate represents the largest part of what remains of the boat. At present time there is no economically justified manner to recycle the fiberglass, therefore further development is needed in this area. The research project [1] has shown that fiberglass laminate in average makes about 35% of the mass of a fiberglass boat of about 7 to 7.5 meters in length. Wood makes about 26%, engine 12%, other metals 11%, furniture 3%, polyurethane 4% and other components about 9%. The other components include electrical and electronic equipment (3%), other fuels (2%), other non-ferrous materials (1%), polyvinyl chloride (2%) and hazardous materials (2%). Accordingly, main materials that could be recycled are fiberglass laminates and metals. The engine and other metals are the most valuable components of the boat.

Table 1. Boat parts, materials, pollutants and the possibility of multiple uses or recycling according to today's methods

Part of the boat	**Material**	**Pollutant**	**Multiple Use / Recycling**
Hull	Antifouling paints Gelcoat	Tributylin (TBT), copper, irgarol, diuron, lead, zinc, zineb	No All listed pollutants are poisonous and need to be removed prior to disposal of the fiberglass hull
	Fiberglass laminate		Commercially justified technology does not exist Low energy value
	Thermoplastics	Pigments with cadmium and lead for paint stabilization	Material recycling can be limited depending on actual levels
	Wood	PCB (polychlorinated biphenyl) from paints and bonding materials	Materials which contain PCB should not be recycled
	Zinc anodes	Zinc, cadmium	Zinc anodes often contain cadmium in traces, which should be considered in the recycling process

Superstructure	Deck		Energy (if made of wood)
	Fenders	Lead in PVC (polyvinyl chloride) plastics	PVC is not suitable for recycling
	Sandwich construction with foam core	CFC (chlorofluorochrome) and HCFC (chlorofluorocarbons) gases	Not suitable for recycling
	Mast		If metal – yes If wooden – for energy
	Sails		If plastic material – maybe If textile – yes
	Ropes		If plastic materials – yes If natural materials – no
	Windows	PCB in sealing	Materials which contain PCB should not be recycled
Furnishing	Textiles	Flame retardants	
	Wood	White paint may contain lead	Energy
	Paint	White paint may contain lead	No
	Toilet		May be removed and reused
	Stove/oven		May be removed and reused
Engine	Engine parts		Yes
	Starter		May be removed and reused
	Batteries	Acid and lead	Yes
	Iron parts		Yes
	Oil	PAH (polycyclic aromatic hydrocarbons)	No
	Boat propeller		May be removed and reused
	Boat transmision gearbox		May be removed and reused
Electronic equipment	GPS receiver, chartplotter, radio station	Flame retardants	Maybe

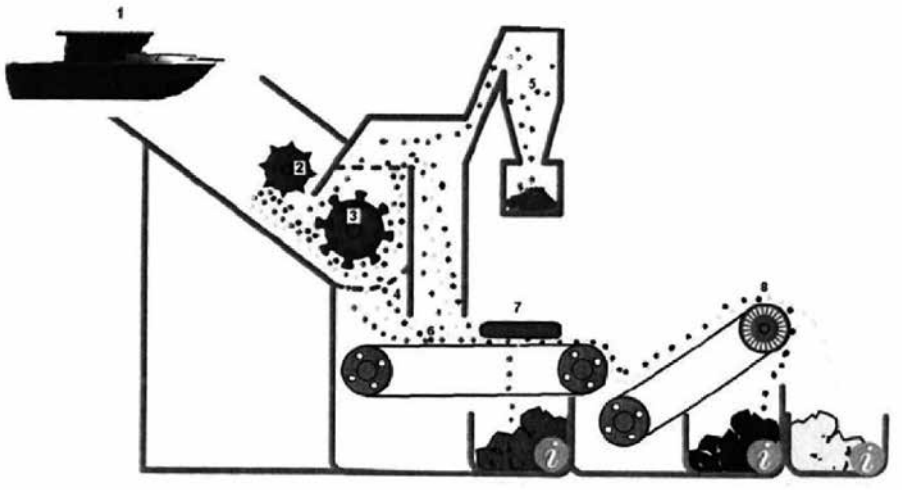
In the process of disassembling worn out fiberglass boats, attention and appropriate measures must be taken in order to avoid health risks and prevent the spread of pollutants into the environment. One of the main recommendations is that the cleaning and disassembly of boats must be carried out by qualified personnel from certified companies, ensuring that the health risks are minimized and the procedure is conducted in an environmentally friendly manner.

Most of the boat hulls are coated with anti-fouling paints. It is recommended to remove them before the further processing of the boat. These paints contain toxic substances that can contaminate the environment during the disposal process, and many of these substances are the priority hazardous substances (Tetrabutyl Titanate - TBT, lead). According to the Directive 2000/60/EC [6], these substances should be banned as soon as possible.

Nowaays, the fiberglass laminate can be crushed and grinded into smaller parts which can then be used as filler in concrete. Deck and superstructure parts that are in good condition can be reused. Wooden furniture is usually coated with problematic organic substances or white paints containing lead. Before reuse, the engine should be cleaned of oil, fuel and coolant. The impact of electrical and electronic equipment on the environment is the same for all types of such equipment, including the gadgets generally used in everyday life. Electrical and electronic equipment from boats must be collected within existing systems of appropriate waste management. Substances such as heavy metals, organic compounds, and brominated flame retardants can undoubtedly contaminate the environment. To avoid that, these substances should be handled according to safety instructions.

4. Disposal programs

Finland is a country where a program for disposal of waste fiberglass boats has been existing for over a decade and this program was the first of its kind in Europe [4]. In the summer 2005, a small ferry began sailing around the islands of the Turku archipelago and collected several hundreds of unwanted boats free of charge. The program was soon joined by Kuuaskoski Oyj, a leading recycling company in northern Europe. The method for crushing boats in the Kuusakoski system is shown in Figure 1. The program is still active today, the owners pay for their boats 10 EUR/m for boats shorter than 6 m and 150 EUR/tonne for larger boats.



1 - The boat is fed to the conveyor
2 - The feed roller feeds the boat towards the rotor
3 - The hammers attached to the rotor crush the boat when rotating at 600 rpm
4 - The sieves let through the particles that are at the defined size (40mm); larger particles stay in the crushing rotors
5 - During the crushing process dust is being sucked from the crusher to the cyclone, where it is being fed to the sludge scrubber and then on to waste
6 - The transfer conveyor moves the crush towards the separation plant
7 - The magnetic carpet is used to separate the magnetized crush from the overheads of the wind separator
8 - The eddy current separator separates aluminium from other metals and waste

Figure 1. The method for crushing boats in the Kuusakoski system, [4]

Similar programs were also conceived in the other countries. In Japan, for example, 6,000 boats have been recycled since 2006. The nautical industry associated with the cement industry and devised a way to use fiberglass as a concrete mixing aggregate. In France, the national landfill network was established in 2009 and about 4,000 boats have been removed from the 52 landfill sites along the coast since then. Sweden and Norway have also announced national programs for for disposal of waste boats.

Some stakeholder groups suggest to pass waste boat costs onto the new boat manufacturer, which means that the cost would already be included in the purchase price of the boat. Others would prefer to follow Japanese and German examples of recycling of fiberglass. The disposal of fiberglass on landfills has been banned since 2005 in Germany. In their recycling system, fiberglass waste is grinded into small pieces that are further mixed with thermoplastic waste. In this manner a cement-based material

is obtained. By burning in the furnace, the required heat energy is generated. The glass fibers are melted and mixed with other solid materials, creating a high quality cement. The European wind power industry sends 100% of its waste glass fiber to the German cement industry [4]. The recycling of 1,000 tonnes of profiles has been estimated to save up to 450 tonnes of coal, 200 tonnes of chalk, 200 tonnes of sand and 150 tonnes of aluminium oxide. And no dust, ash or other byproducts are formed in the process [8].

5. Current situation in the Republic of Croatia

In the Republic of Croatia there is an obligation to register all boats with a length above 2.5 m or a total propulsion power exceeding 5 kW. This makes it possible to identify the owner of an abandoned boat according to the registration number, if visible on the hull.

The boat is removed from the register if it is wrecked. Within 15 days from the date of the occurrence of the distress circumstances, the boat owner should inform a harbormasters' office in order to delete the boat from the register. However, the authorities do not ascertain whether the boat was actually wrecked and whether it was properly disposed of. Such a practice exists, for example, for cars or motorcycles for which a "Waste Handling Certificate" issued by the "Environmental Protection and Energy Efficiency Fund" is submitted for the unregistration.

The Republic of Croatia does not have a special program for the disposal of worn-out fiberglass boats. At the present moment it is not certain how many fiberglass boats need to be disposed of annually, but it can be guessed that a number is not large. The production of fiberglass boats in this region has begun later than in the world or in Europe. At the very beginning, only small boats had been produced and most of them are still in use.

The proper way of disposal is regulated by a law. The "Act on sustainable waste management" ("Zakon o održivom gospodarenju otpadom" [9]), has established measures to prevent or reduce the harmful effects of waste on human health and the environment by reducing the amount of waste generated and/or produced. The law regulates waste management without using risky procedures for human health and the environment, with the utilization of valuable properties of waste. The "Waste management regulations" ("Pravilnik o gospodarenju otpadom" [10]) includes, among other things, conditions for waste management, duties of entities responsible for waste management, as well as the way the recycling yard works. According to the "Decree on categories, types and classification of waste with a waste catalog and a list of hazardous waste" ("Uredba o kategorijama, vrstama i klasifikaciji otpada s katalogom otpada i listom opasnog otpada" [11]), the "Environmental protection agency" ("Agencija za zaštitu okoliša") has issued a "Waste catalog" ("Katalog otpada" [11]). The Catalog classifies the waste into groups according to its properties and the place of origin, i.e. the activities and the processes which generate it. For example, the manufacturers

of fiberglass boats must take care of proper disposal of trimmings from fiberglass laminates. According to the "Catalog" this waste is classified under number "12 01 05". The group "12" refers to waste from shaping and physical-chemical surface treatment of metals and plastics, the subgroup "12 01" refers to waste from shaping and physical and mechanical processing of metals and plastics. The sub-subgroup "12 01 05" refers to plastic chips from planing and turning. Fiberglas laminate of old boats can not be classified in this manner since it is not pure and contains many pollutants.

6. Conclusion

Since ancient times people have been accumulating waste at sites that were not planned for that, and today this is becoming a worrying issue. Because of the negligence, soil, air and water are heavily affected and the human health, which is directly related to the environment, suffers a lot. There are many attempts to better handle and make use of the waste in order to avoid its disposal, which represents the last and least acceptable option. Since the production of waste is inevitable, it should be recycled and reused. Recycling, which is the process of collecting, sorting and converting waste into new materials, depends primarily on the type of waste. Many materials can be recycled, including those from worn-out boats, whether they are made of metal, wood or fiberglass. The efficiency of recycling metal or wooden boat is very high, in some cases almost one hundred percent, but fiberglass laminates are much harder to recycle.

Due to the fact that many boats built since the 60's of the last century are at the end of their lifetime, in the near future it is expected that the number of recreational fiberglass boats that will require proper disposal will increase. Boats must be disposed in a safe and environmentally friendly way, and this is challenging. There is no economically viable recycling method for the fiberglass laminate which represents the largest single piece of the boat. It is unrealistic to expect that boat laminate made of termoset resin will be replaced in the near future with some other materials that enable the recycling. For example, thermoplastic resins can be melted and shaped into something new. However, even if new materials were introduced tomorrow, there is still a need for disposal of a very large number of fiberglass boats produced in the previous decades. Disposal is generally associated with costs, and the permanent question is who will pay for it. The existence of special programs would certainly help to provide an answer to this question.

Finally, two methods can be mentioned as solutions for worn out boats, even though they are exclusively related to individual boats. One way could be to sink a boat in a controlled manner on previously carefully selected sites in order to create an artificial underwater habitat for marine organisms. The other way could be to do the restoration of a boat and provide it a new lifetime.

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Zbrinjavanje dotrajalih stakloplastičnih rekreacijskih plovila

Sažetak

Masovna proizvodnja stakloplastičnih plovila započela je sredinom 50-ih godina 20. stoljeća i u svijetu se tijekom godina nakupio veliki broj takvih plovila. S obzirom da ova plovila imaju trajnost od 30 do 50 godina, u ovom su trenutku mnoga stakloplastična plovila jednostavno dotrajala i potrebno ih je odgovarajuće zbrinuti na siguran i ekološki prihvatljiv način. Očekuje se da će zbrinjavanje postati sve jače izražen problem, a jedan od osnovnih problema su prilično visoki troškovi zbrinjavanja. Kao najveći problem pokazuje se zbrinjavanje stakloplastičnog laminata koji čini najveći pojedinačni dio plovila i za koji danas ne postoje ekonomski isplativi načini zbrinjavanja. Mnoge države nemaju uspostavljene posebne programe zbrinjavanja stakloplastičnih plovila koji bi nesumnjivo pomogli u davanju odgovora na mnoga pitanja. U radu se daje pregled stanja zbrinjavanja rekreacijskih stakloplastičnih plovila širom svijeta kao i u Republici Hrvatskoj.

Ključne riječi: dotrajala stakloplastična plovila, zbrinjavanje, pregled