

The Analysis of Recovery Action in Case of Handling Equipment on the Example of Forklift Trucks Used in Seaport

Analiza reciklaže opreme za rukovanje na primjeru lučkih viljuškara

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Summary

Article presents the impact of forklift trucks used in seaports on the environment. Paper presents possibilities of application of recovery action for forklift trucks. Two types of component materials were analyzed and characterized.

KEY WORDS

forklift truck
recycling
recovery actions

Sažetak

U ovom se članku govori o utjecaju na okoliš viljuškara kojima se koristi u lukama. Prikazane su mogućnosti reciklaže lučkih viljuškara. Analizirana su i opisana dva tipa komponentnih materijala.

KLJUČNE RIJEČI

viljuškar
reciklaža
obnova

INTRODUCTION / Uvod

Seaports are the modal points in transport systems, in which there is a change of means of transport. The change is possible thanks to different handling equipment. Dynamic development of warehousing facilities in Poland is especially seen in seaports, which are expanded, modernized and upgraded year by year [4, 6, 19]. As a result of seaport development, the development of handling equipment is also seen. Especially the number of forklift trucks should be enlarged due to the fact that the number of logistic operators, storage facilities (such as cross dock, transshipping warehouses, logistics centers), suppliers in close proximity to the seaport are build thanks to the seaports development. It is also need to be stated that about 51-62% [21 - 25] of uploaded and unloaded products only in main seaports in Poland are in a group called piece-goods which are mostly handled by forklift trucks. Also the number of piece-goods handled in main polish seaports between 2009 and 2013 has been growing about 3-6% per year. It has to be stated

that increased use of these devices will not only increasing consumption of natural resources but also the formation of more and more waste. This waste can significantly impose the environment if they are not properly managed. Fig. 1 shows the impact of industrial trucks on the environment.

These wastes arise during the operation of the forklift trucks and after their withdrawal from service. In order to avoid contamination of the environment it is necessary to use proper waste management. Due to this fact it is necessary to identify the types of waste that are associated with the forklift trucks . These wastes can include [16]:

- Dispose of the premises impossible to reuse.
- Parts of the object suitable for reuse.
- Waste consumables, including fluids liquidated object.

Please note that the use and withdrawal of the object from the operation should take place with a minimum of environmental contamination [5]. The best solution in this

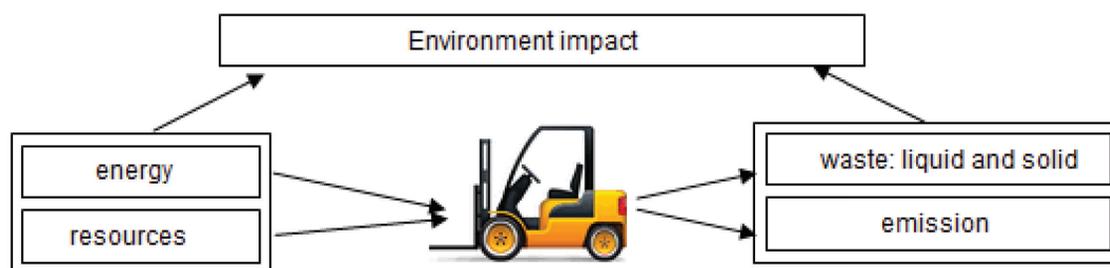


Figure 1. The impact of industrial trucks on the environment

Slika 1. Utjecaj industrijskih teških vozila na okoliš

regard is to undertake activities in the area of recovery actions.

Actions of recovery of different devices are nowadays not only compulsion but also a necessity. Compulsion result from low regulation which are establish by the UE, while the necessity should be understood for producers and users of devices that need to be aware of increasingly decreasing of natural resources in the environment. Unfortunately, in case of forklift trucks (not only in seaports), there are no law that consider the issue of withdrawal of the forklift trucks from service as a whole. Such provisions have been implemented only in the case of wasted vehicles and wasted electrical and electronic equipment (except internal transport equipment) [7, 8].

In the case of forklift trucks (not only in seaports), which are largely structurally and operationally similar to the motor vehicles, there are provisions that apply only to individual components of the forklift truck. Modern motor vehicles consist of 90% same systems as forklift trucks. Common systems are: brake, hydraulic, power, control (steering), cooling, electric, power transmission, chassis and suspension. The forklift truck has one additional system which is connected with the main role of the forklift trucks in a sea port that is lifting, downloading, reloading, unloading the goods. This system is called the lifting system.

Due to the similarity of the systems it can be also assumed that there is a considerable similarity in materials from which forklift trucks are produced. Modern motor vehicles consist primarily of a variety of metals and alloys, glass, ceramics, polymers and plastics [14]. It can be assumed, therefore, that in the case of industrial trucks also in seaports used materials will be almost the same. Table 1 presents the contribution of individual materials in average motor vehicle [2, 3].

The table does not include the fluids that are not a part of a fixed structure, however, are in the operated forklift truck and in addition are very frequently replenished or exchanged, and its recovery is very difficult. During operation of the vehicle dozen or so liters of used liquids is produced (liquids represent about 1.5% of weight of the car), [18]. It is need to be stated that their final quantity in the process of withdrawal is much higher due to their periodic exchanges during operation.

Table 1. The contribution of individual materials in average motor vehicle and its recovery factor

Tablica 1. Udio pojedinih materijala u prosječnom motornom vozilu i njegov faktor reciklaže

Material	Contribution total mass [%]	Recovery factor
Steel, Cast Iron	55-85	70-100
Aluminum	1,5-14	70-90
Plastic	2-16	0-30
Tires, elastomers	2-8,5	30-50
Consumables	2,5-5	5-85

The variety of industrial trucks (including trucks in seaports) are not covered by the directives and laws concerning decommissioning (like in case of [7] and [8]), and are covered by the law related to the specific components of the equipment, and especially to the type of materials from which it was made.

Consequently in terms of environmental protection it becomes an important task to analyze:

- What are the possibilities of recovery action in case of

forklift trucks (also in seaports).

- What materials the forklift trucks (also in seaports) consist of.

What are the possibilities of its re-use.

The use of recycled materials and recover materials (both from production processes as well recyclable materials) is increasing especially due to the economic reasons. Recovery actions in case of forklift trucks (also in seaports) are shown in Fig. 2.

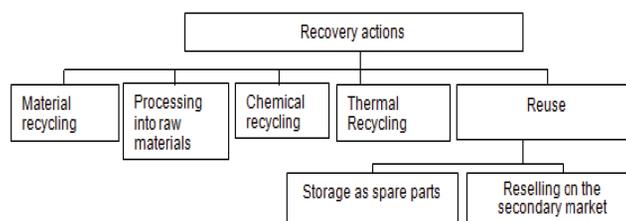


Figure 2. Recovery actions in case of forklift truck
Slika 2. Reciklaža viljuškara

The primary method for environment protection when the forklift truck in seaport get the end of life point is recovery action. The recovery action can be divided into a few processes presented in figure 2. Recycling is one of the method which is a way to reduce the consumption of natural resources and generation of waste [29].

Within the group of recycling actions the material recycling can be found. The material recycling can be defined as the repeated reprocessing of materials form the one product into a product of lower quality or value. In this case a new product has different purposes of existing than initially [1, 17]. In this regard, material recycling can be used for forklift trucks used in seaports, when there is an exchange of components (after the breakdown or planned replacement of the component and in the end of life point. Another recycling method is recycling action that involves the processing of waste materials and products to the form of raw materials from which these materials have been produced [17]. Further example of recycling activities is thermal recycling, which involves the production of energy contained in some materials by burning them [29]. The last method is chemical recycling, which involves the processing of waste materials for waste materials with different physico-chemical properties (e.g. the production of fuel oils, plastic , etc.) [29]. Different group of action is reuse action. First type of reuse action is reselling the whole forklift truck (or its parts) on the secondary market for warehousing companies in a seaport whose financial situation does not allow to purchase a new truck. Second type of reuse action is using parts of forklift trucks, which are possible to repair in a seaport that uses the forklift truck as spare parts.

The reuse action in the literature [1] is considered as the most efficient way of recovery action.

Taking into account the construction of the forklift truck used in seaports the components of the truck and the possibility of its recovery can be determined. Components and recovery action in case of forklift trucks used in seaports are presented in Table 2.

After reading table 2 it can be stated that greater part of the mass of a forklift truck used in a seaports consists of scrap and can be subjected to best forms of recycling which is material recycling or to reuse.

Table 2. Components of the forklift trucks used in seaport and recovery actions possible to implement

Tablica 2. Dijelovi lučkih viljuškara i reciklaža koja se može primjeniti

		Material recycling	Thermal recycling	Processing into raw materials	Chemical recycling	Reuse
Scrap	Motor*, gearbox, radiator*, starter, suppresor, exhaust pipe, fan, distributor, frame cylinder, hydraulic hoses reinforced, electrical wiring, mast*, lifting chain, carriage*, forks*, body*, counterbalance, electronic control unit, fuel tank*, automotive instrument panel, suspension, tires*, steering system, lamps, electrical equipment, driver's seat*, engine cover with suppression*	X				X*
Płyny	Cooling, breaking	X	X			
Oleje	Motor, gear	X				
Szkło	Lamps	X				
Tworzywa sztuczne	Motor, gearbox, condenser, elastic leads, fan, pump and hydraulic oil tank, junction box, hydraulic slave servo, hydraulic hoses reinforced, electric al wiring, electronic control unit, fuel tank, automotive instrument panel, suspension, steering system, lamps, electrical equipment, driver's seat with seat bel	X	X			
Guma	Elastic leads*, tires*, lamps	X	X*			X*
Kompozyty	Motor, gearbox, alternator, starter, suppresor, fuel tank, automotive instrument panel, driver's seat, engine cover with suppression	X				
Mass of exemplary forklift truck used in seaports (duplex, 7 t.)		4001,5 g				

The "*" in the table means that object signed by the "*" in the group of other objects not only can be subjected to recovery action signed by the "X" mark in the table but also to the additional recovery action signed by the "X*". For instance in the group of scrap, object called motor can be subjected to the material recycling and reuse action, but for example electrical equipment can be subjected only to the material recycling.

The most difficult group of industrial waste in forklift trucks used in seaports are rubber and oil wastes, which are a group of hazardous waste.

RUBBER WASTE: TIRES / Gumeni otpad: gume

Poland is one of the biggest warehouses markets in East Europe. These warehouses in large quantities can be found in seaports or in their neighborhood. In places such as seaports forklifts trucks are used every day and due to this facts large quantities are consumed. According to the law, tires must not be stored in landfills (not in a tires form or even in a shredded form).

About 180 thousand tons is produced per year in Poland. Only 4% of tires on the market are used tires. During operation, tires are subjected to the process of weight losing (about 20-25% of weight is lost). Therefore it can be stated that after this loss there is 142-152 thousand tons of used tires to recover. In addition, about 10 thousand. tons of waste rubber is derived from dismantled gaskets, tubes, washers, hoses, cables and suspension components [31, 28].

Possible to implement recovery action in case of tires used in forklift trucks in Poland presents Fig. 3 [12].

Currently the most widely used method of recovery action is thermal recycling. There is a significant difference between the waste management of the tire in Poland and European Union countries. Level of retreading (reuse action) is almost the same (EU = 11%), but there is a significant gap in case of material

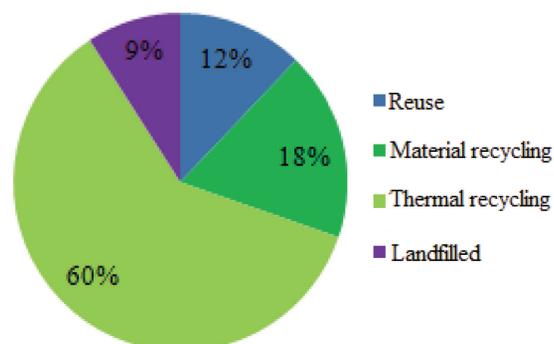


Figure 3. Recovery actions in case rubber tires in Poland

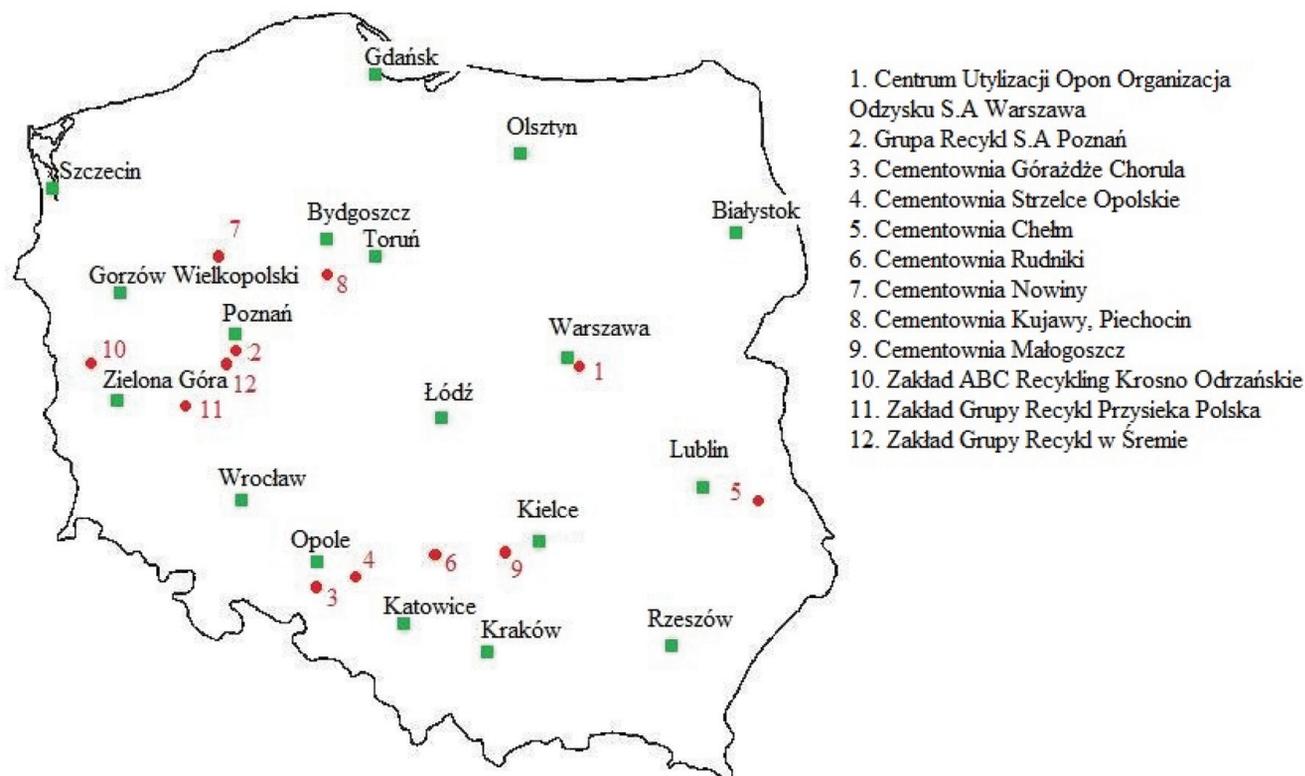
Slika 3. Reciklaža guma u Poljskoj

recycling (EU = 39%) and thermal recycling in for of incineration in cement plants, which in the EU stands at 39% [12].

Currently there are two entities involved in the creation of collection network and reprocessing of tires in Poland. These include: Centrum Utylizacji Opon, which has 65% market share and the Grupa Recykl S.A. with the 15% market share. In addition, the market consist of about 30 smaller entities that deal with the recovery of tires. These entities have about 20% of market shares. Currently there are three main material recyclers and about seven cement plants that use tires to generate energy (thermal recycling). Cement plants and material

Figure 4. Main recipients of rubber tires for material and energy recycling and main organizers of collection

Slika 4. Glavni preuzimatelji guma za reciklažu materijala i energije i glavni organizatori skupljanja



recyclers and the main actors that organizing the collection of tires is shown in Fig. 4.

Year after year the new companies whose business is to make recycled materials is formed, which include lately: Orzeł SA (near Lublin), Unirubber Sp. z o.o. (in Zielonka).

Recycled tires material may be used as [13, 28]:

- in the construction industry: a rubber mixture, cements, roofing pitches and playgrounds and paths runner, roofing,
- in the road: asphalt road, sleepers absorbing shock and vibration, sound-absorbing materials (sound barriers),
- in the manufacturing industry: car mats, rugs, mats farming, floor coverings, shoe soles, rubber boots, inactive fillers in the compositions of thermoplastic polyurethanes, seals, pigment for paint, varnishes, printing inks, black ink, rubber mixtures.

It is estimated that the mass of wasted tires will continue to grow at a rate proportional to the increase in the number of motor vehicles (Table 3).

Table 3. Forecast of waste tires
Tablica 3. Prognoza otpada guma

Year	2011	2014	2015	2016	2018	2019	2022
Waste tires mass in thousand tons	194,7	196,2	198,1	199,4	204,1	206,2	212,4

Source: Krajowy Plan Gospodarki Odpadami na rok 2014, Warszawa 2010

The increase of use of waste tires as an alternative fuel is projected [15].

OPERATING LIQUIDS / Tekućine koje se koriste za rad

Operating Liquids are one of the most widespread and dangerous in terms of environment form all of the liquids [27].

Liquids are used in various systems of forklift trucks used in seaports and are many times replaced. Their use is not therefore limited to a single use but to multiplied refilling or exchanging of all of the liquid in the system.

Operating liquids are classified as:

- fluids: cooling and brake,
- engine, gear, hydraulic,
- oils and lubricants.

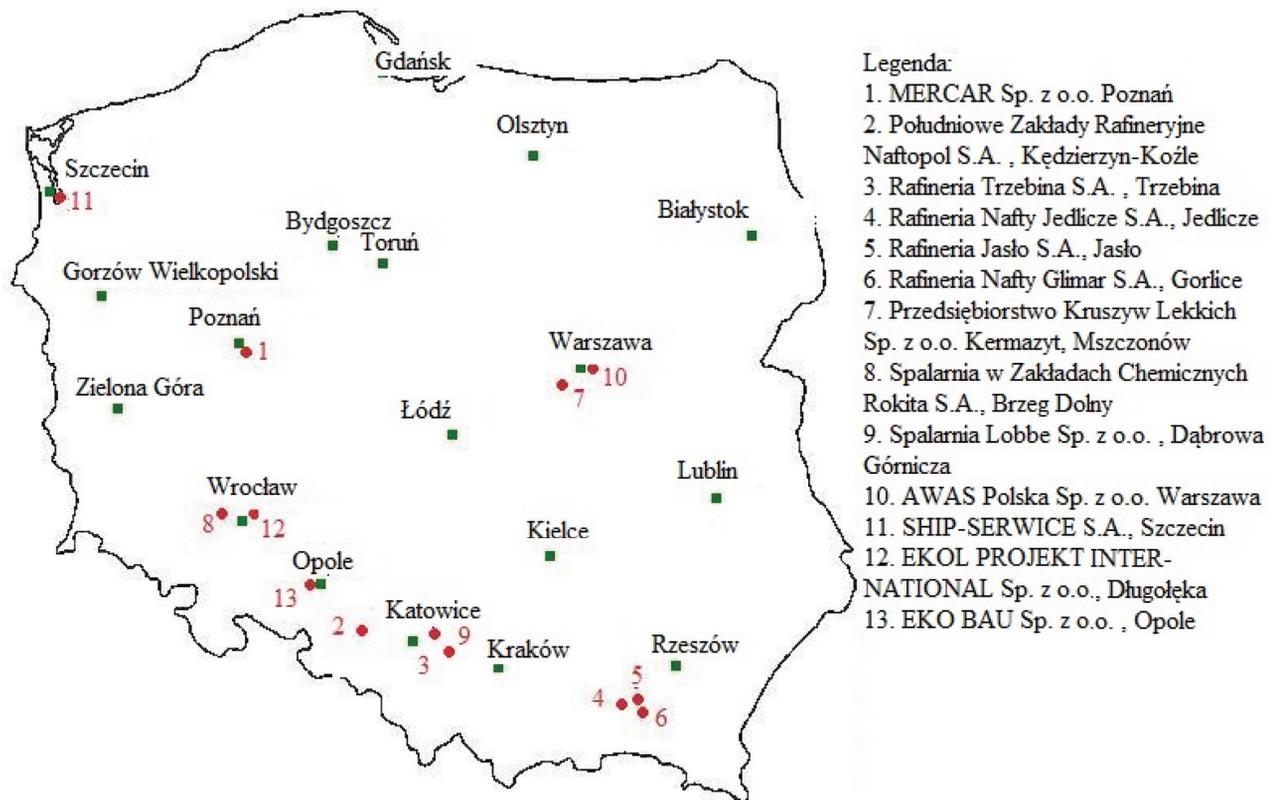
It is estimated that annually occurs environmental contamination by approximately 90 thousand tons of liquids in Poland. Those liquids contain very often about 14 thousand tones of variety additives, that often raising their toxicity [27].

Taking into account that there are many of entities in seaports that use forklift trucks it may be stated that those entities have considerable share of environmental contamination. What is more the nominal consumption of liquids is in forklift trucks (also those which works in seaports) is even dozen or several dozen lower than the real consumption. That fact makes the contamination even bigger [27].

Poland as a country belonging to the EU is obliged to respect and protect the environment in connection with the use of operating liquids. In terms of recycling, there is the main directive, which should be obliged by Poland. This directive is The Council Directive No. 94/31/EC of 27 June 1994 [10]. The directive applies to waste liquids. Processing of waste oils in addition also covered by other directives [11, 12].

From the point of view of the quantity of waste liquids, the

Figure 5. Main sites of oils waste disposal in Poland
 Slika 5. Glavna odlagališta naftnog otpada u Poljskoj



largest share has motor oils, (45% share). The consumption of such products in Poland is on the level of 400 thousand tons per year. Only 50% is totally consumed (degraded) during operation (data for 2002). Consequently approximately 200 thousand tons will be a waste in the form of the waste liquids. This product should be properly utilized. Currently, in case of requirements of the Directive, since 2007 the recovery and recycling of waste liquids is 70%. Consequently $\frac{3}{4}$ waste liquid that were not consumed during operation will have to be utilized [27]. Methods for recover waste liquids can the processes of [30]:

- cleaning, which result with the restoration of its original properties. Purified liquid can be re-used for its original purpose or as a lower-class quality liquid,
- re-treatment and reuse it as a fuel component,
- deep regeneration which is a re-refining process in order to obtain petrochemical raw material,
- recycling in order to produce high quality fuels and base oils,
- incineration and using it as fuel.

The most appropriate method for recovery activities is re-refining. This action poses no threat to the environment. A good way is also burning, but only in cement plants. During incineration released heavy metals bind in cement material and are not released to the atmosphere. In Poland, the operating liquids are subjected to disposal operations in fifteen locations that are shown in Fig. 5.

Companies marked on the map with the numbers 1 and 2 processes liquids by thermal cracking method. Companies marked points from 3 to 6 applies methods of re-refining or thermal cracking. The company with number 7 operates fluids as an additive to soften the clay used for the production of aggregates. The companies marked with numbers 8 and 9

incinerates liquids in waste incineration plants together with other waste. Furthermore, companies identified by numbers 10 and 11 cleans and dehydrates liquids. Conversely, companies numbered 12 and 13 bio-degrades liquids. The companies with numbers 14 and 15 makes chemical disposal.

Some of the waste liquids, however, is burnt in small incinerators that do not meet environmental requirements.

SUMMARY / Zaključak

The significance of recovery action in case of forklift trucks especially those one used in seaports is based on the fact that there is many entities that uses forklift trucks in seaports. As results the large quantity of waste parts and liquids from the forklift trucks that need to be recover derives from seaports. Forklift trucks in seaports are one of the main sources of industrial wastes and will be having a great impact on the environment. It should be also stated that in case of forklift trucks laws are not as much comprehensive as in case of waste vehicles or electric and electronic devices. But it should be also noticed that sustainability to recycling in case of forklift trucks is high (about 84%) [16] but without comprehensive laws It is hard to check if reuse, recovery and recycling level are the same as its sustainability to recycling. It is also worth mentioning that high level of sustainability to recycling gives proof that manufacturers try to design its goods properly. It must be also said that with increasing number of exchange in particular tires and liquids the level of possible recyclability can be lower.

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