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THE USE OF GREEN LOGISTICS ELEMENTS DURING THE CONSTRUCTION OF OFFSHORE VESSELS

Abstract

The article is aimed at the presentation referring to the use of green logistics elements during the construction of the offshore vessels in the following aspects: collection, removal and utilisation of any waste that is harmful for natural environment, elimination of the negative impact that such waste can have on natural environment and the search for the optimal solutions as regards these aspects.

Keywords: green logistics, offshore vessels, collection, removal and utilization

Introduction

In the 21st century the protection of natural environment has become an important element in the functioning of each industrial enterprise (Ficoń, 2009), including shipyards which provide various types of vessels.

Shipyard industry comes as an important and sensitive field of economy which produces modern vessels in which innovative technological solutions are applied (Blaik, 2010).

A significant aspect in the functioning of any shipyard in the world refers to environmental issues which directly or indirectly affect our natural environment (Sołtysik, 2000). Such elements include the following:

a) generation of hazardous waste (e.g. petroleum-derived waste generated during the cleaning of tanks, bilge water from sea-going vessels, containers or canisters with the residues of hazardous substances, oils) and others (e.g. abrasives – copper slag waste),
b) use of paint and emission of harmful volatile organic compounds into atmospheric air,
c) emission of pollutants generated during welding operations into atmospheric air,

d) emission of dust generated during the cleaning of the hulls and steel elements,
e) release of pre-treated waste generated during the cleaning of hulls into the surface water,
f) release of precipitation water into the shipyard basin water,
g) use of water.

The authors of the article focus their attention on the question of green logistics which appears to be an exceptionally significant aspect in the process of constructing offshore vessels and other types of vessels at shipyards. It mainly refers to the issues related to the protection of natural environment, water and soil, but also to the collection, disposal, removal, utilisation of any post-production hazardous waste from vessels, which may be burdensome for the environment.

Green Logistics is a concept ensuring proper delivery of logistic processes in a given enterprise, while limiting the negative impact of functioning of the company on natural environment (Altuntaş, Tuna, 2013).

It results from the drive at limiting the negative impact of the logistic systems on their surroundings. (McKinnon *et al.*, 2010). It also results from the fulfilment of international conventions and the resultant requirements towards governments and corporations (Sbihi, Eglese, 2007).

Green logistics describes all attempts to measure and minimize the ecological impact of logistics activities. This includes all activities of the forward and reverse flows of products, information and services between the point of origin and the point of consumption. It is the aim to create a sustainable company value using a balance of economic and environmental efficiency (Thiell *et al.*, 2011). Green logistics was a concept to characterize logistics systems and approaches that use advanced technology and equipment to minimize environmental damage during operations.

The research carried out by the authors refers to the one-month observation in a Polish shipyard in which five offshore vessels[1] have been constructed (each vessel has been at a different stage of construction).

Because of the restricted character of shipyard data, the authors were able to only present research results and their potential suggestions, without specifying the deadlines or revealing the information on the shipyard the research was conducted in.

The authors divide the research into two parts. The first part of the article presents the analysis of the protection of natural environment during the construction of offshore vessels, and the results of the observations carried out by the authors. The second part of the article refers to the logistics of waste storage during the construction of such vessels and it also includes the observations carried out by the authors.

[1] Offshore vessels are modern vessels of special purpose – they are exploited in exploration industry, oil drilling, mining and processing industry. The standard dimension specifications of such vessels are L=89.20 m, B=19 m, D=9 m. They are equipped with a Diesel Electric drive composed of four power generating sets which provide the total power of 6800 kWe. They are equipped with a dynamic positioning system which allows them to operate even in the toughest weather conditions. Another advantage of such vessels is the contract speed exceeding 14 knots.

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1.1. Characteristics of the construction process of an offshore vessel

The construction of an offshore vessel involves the assembly of single constructional elements into one unit which is referred to as a section/block (Plichta, 2013). The whole vessel is composed of such blocks which are assembled in accordance with the relevant construction specifications.

Therefore, in order to ensure the proper course of the assembly process and to meet specific requirements as regards the construction of the particular elements, internal instructions are developed by shipyards on the proper and comprehensive assembly process of the constructed sections. They include, among others, assembly stages and particular operations which must be subsequently performed to meet the constructional requirements defined by the relevant standards (Karpiński, 2004).

The whole process of an offshore vessel construction may be divided into the particular stages during which the following elements are constructed:

1) sub-sections – which include constructional elements and which are provided as a result of the assembly and welding operations. These are the elements which are mounted into the plating panel sections, e.g. web frames, web beams, floor, girders;
2) flat sections – are the constructional elements composed of a plating panels and its stiffening construction. These are the elements of the side shell plating section which may be also used in deck sections;
3) block sections – are the constructional elements of vessels which are composed of several assembled flat sections. They form particular components or parts of the hull, such as wing tanks or double bottom.

1.2. Construction of flat sections

The whole construction process of an offshore vessel can be divided into three main stages which are presented in the figures below:

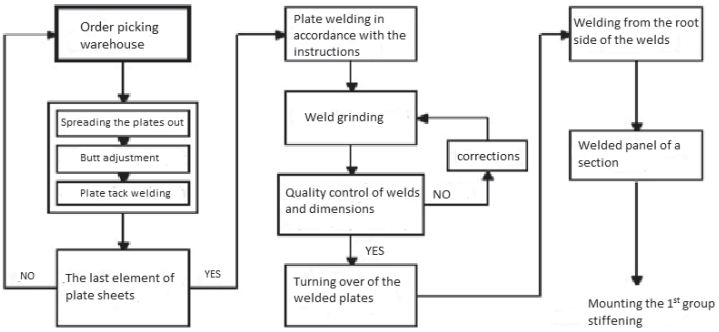

Figure 1. The first stage of the construction of a section for an offshore vessel
Source: (the authors' own study based on the documents provided by the shipyard)

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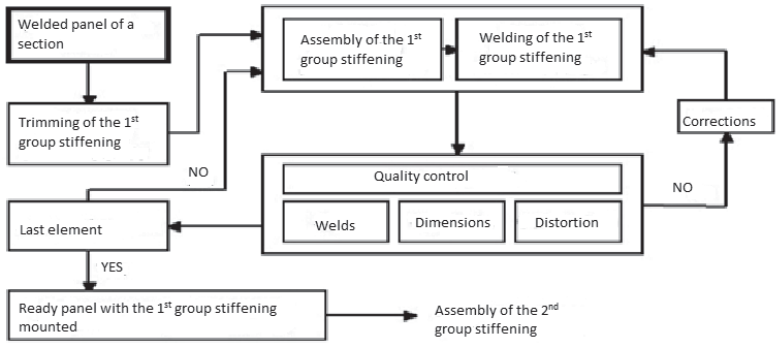

Figure 2. The second stage of the construction of a section for an offshore vessel
Source: (the authors' own study based on the documents provided by the shipyard)

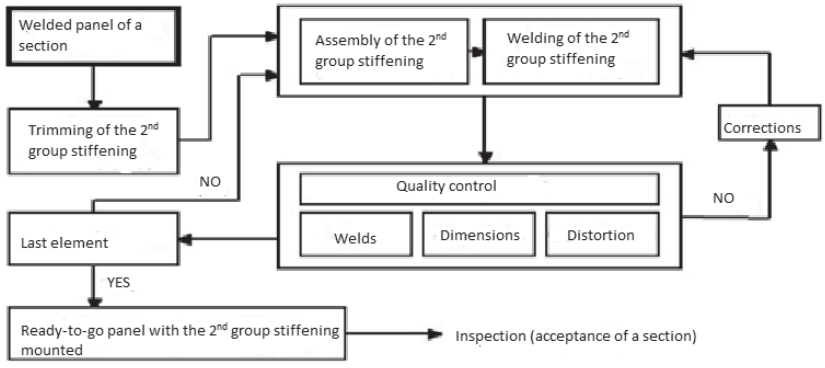

Figure 3. The third stage of the construction of a section for an offshore vessel
Source: (the authors' own study based on the documents provided by the shipyard)

At each stage which has been mentioned above and which is involved in the process of an offshore vessel construction, a considerable threat of natural environment contamination appears through:

a) hazardous waste generated during the process of the assembly of the vessel blocks,
b) exceeded limits of pollutants which are emitted into atmospheric air during the process of welding,
c) exceeded limits of dust emission generated during the cleaning of hulls and steel elements before painting,
d) excessive use of paint and emission of volatile organic compounds into atmospheric air,
e) improper discharge of pre-treated waste generated during the cleaning of hulls into water.

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2. Protection of natural environment during the construction of offshore vessels

2.1. Identification of hazardous causes in protection of natural environment (the Ishikawa diagram)

Despite the fact that proper procedures and required standards are respected at the discussed shipyard, it is not always possible to prevent contamination of natural environment and direct exposure of shipyard workers to the consequences of such contamination.

The research carried out by the authors refers to one-month observation (from Monday to Friday – 20 days in total) which has taken place at the discussed shipyard during the production of five offshore vessels (each of them was at a different stage of the construction process). The research aims at the verification of all the observed incorrect factors which substantially affect the organisation of the protection of natural environment.

Considering the confidential nature of the shipyard data related to the type, the marking and the role of the discussed vessels, the authors are only allowed to present the results of their research and their own conclusions.

The research carried out by the authors indicates that the problem with the organisation of the protection of natural environment at the analysed shipyard is generated during the following processes:

a) the assembly of the particular constructional elements into larger sections – welding work,
b) the assembly of the elements included in the equipment of the vessels, e.g. engines (lubricants, oils, fuel, dirt),
c) painting of particular constructional elements of the vessels.

The results of the research indicate that the probability for a dangerous situation to occur and to threaten natural environment at the shipyard are considerably affected by:

a) chemical factors (the use of paints and emission of volatile organic compounds into atmospheric air) – 30% of the cases observed in the analysed vessels during 20-day observation,
b) welding work (emission of pollutants generated during welding operations into atmospheric air) – 25% of the cases observed in the analysed vessels during 20-day observation,
c) industrial dusts (emission of dust generated during the cleaning of hulls and steel elements), emission of dissolvents (volatile organic compounds) during painting – 20% of the cases observed in the analysed vessels during 20-day observation,
d) cleaning of hulls (discharge of pre-treated waste generated during the cleaning of hulls into the surface waters) – 15% of the cases observed in the analysed vessels during 20-day observation,

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e) the use of precipitation water (discharge of precipitation water from the cleaning of hulls into the shipyard basin water) – 10% of the cases observed in the analysed vessels during 20-day observation.

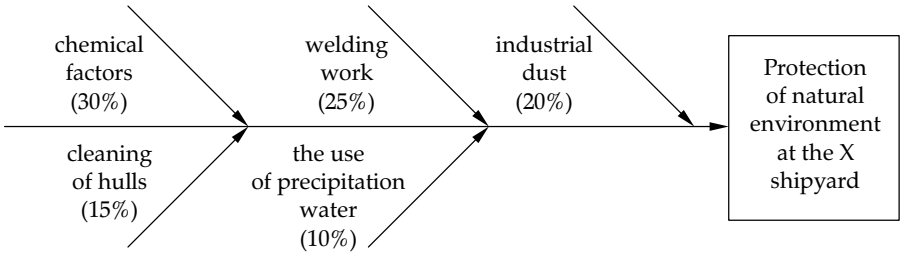

Figure 4. The Ishikawa diagram for the X shipyard, based on the 20-day observation
Source: (the authors' own study)

2.2. Improvement measures

The analysed shipyard should constantly improve its operations as regards the protection of natural environment, with the consideration of its own technical and economic operational conditions. The impact of the shipyard on natural environment should be focused on meeting the requirements which result from the legal regulations and administrative decisions issued for the shipyard.

In order to limit any harmful impact on its natural environment, the shipyard should apply the methods of work and technical measures which shall prevent the emission of pollutants through:

a) compliance with the current legal requirements on natural environment in Poland,
b) limitation of any environmental burdens through the selection and application of environmentally-friendly technologies,
c) improvement in ecological awareness among the shipyard workers,
d) constant improvement of technical and organisational methods which help to decrease the negative impact on natural environment,
e) development of vessel production with the minimal emission of pollutants,
f) efficient use of energy resources,
g) economical and efficient use of material resources,
h) minimisation of generated waste, recycling and segregation of generated waste,
i) application and development of techniques and technologies which prevent the emission of pollutants,
j) consideration of needs related to the protection of natural environment at the stage of planning the production of offshore vessels and during the investment implementation,
k) operations which are aimed at the increase in the knowledge and awareness of shipyard workers and cooperators as regards the protection of natural environment.

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Each shipyard should have all the necessary permits and administrative decisions which refer to the exploitation of natural environment, required by the Polish law, namely:

a) permit to emit volatile organic compounds into atmospheric air (paint dissolvents),
b) permit to emit gases or dusts into atmospheric air (dusts generated during the process of cleaning and welding, welding gases, other substances which are released into atmospheric air during technological processes),
c) permit required under the Water Law Act for the intake of ground water,
d) permit required under the Water Law Act for the discharge of industrial waste to the sewerage system,
e) permit required under the Water Law Act for the discharge of precipitation water,
f) permit required under the Water Law Act for the discharge of water used for the cleaning of vessels into the shipyard basin water,
g) permit to generate waste.

3. Reverse logistics in the process of the construction of offshore vessels

3.1. Identification of hazardous causes in waste disposal

Despite the fact that the shipyard has already established its organisational units which are responsible for proper disposal and segregation of waste, the authors of the article have observed that there is a number of problems with the proper disposal of waste on the vessels, such as:

a) waste insulation (mineral wool, polystyrene foam),
b) waste paint (for external and internal use),
c) empty paint and dissolvent canisters,
d) waste oils, lubricants and valves,
e) abrasive waste,
f) scrap steel,
g) waste batteries,
h) waste fluorescent lamps,
i) waste cables and electrical wires,
j) waste pipes and fuel line end-pieces (steel and copper),
k) waste pipes and ventilation line end-pieces (ice water systems),
l) domestic waste from vessels,
ł) wooden reusable packaging, e.g. cable drums and pallets,
m) waste generated during tank cleaning,
n) containers and canisters containing the residues of hazardous substances (used to store paints and dissolvent).

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The above-mentioned waste materials may potentially damage and considerably affect natural environment in the area of the analysed shipyard, especially the soil, water and atmospheric air.

Furthermore, the damages to natural environment are caused by improper methods of storage and use of chemical substances and oils (e.g. overfilled containers) and by faulty equipment. The impact of such substances on natural environment depends on their characteristics (e.g. their decomposition time, state of matter, toxicity, concentration), the size of the spillage, efficiency of preventive actions and of the spillage collection.

During their research, the authors have considered the various construction stages of the offshore vessels and that fact has essentially conditioned the observed problems.

The authors of the article present the results of the one-month observation they have performed at the shipyard, during the construction of five offshore vessels in table 1.

Table 1. Improper disposal of waste at the place where offshore vessels are constructed

No.	Improper disposal of waste on the vessels	Marking of five constructed vessels (1–5)
1	waste insulation (mineral wool, polystyrene foam)	2
2	waste paint (for external and internal use)	1
3	empty paint and dissolvent canisters	4
4	waste oils, lubricants and valves	3
5	abrasive waste	1, 4
6	scrap steel	2, 3, 5
7	waste batteries	3, 5
8	waste fluorescent lamps	5
9	waste cables and electrical wires	4, 5
10	waste pipes and fuel line end-pieces (steel and copper)	3, 4, 5
11	waste pipes and ventilation line end-pieces (ice water systems)	2
12	domestic waste from vessels	1, 3
13	wooden reusable packaging, e.g. cable drums and pallets	1, 2, 3
14	waste generated during tank cleaning	2, 5
15	containers and canisters containing the residues of hazardous substances (used to store paints and dissolvents)	5

Source: (the authors' own study based on the research carried out at the analysed X shipyard)

3.2. Improvement measures

Improper disposal of waste during the construction of vessels comes as a serious problem at the discussed X shipyard and it may eventually result in:

a) heavy contamination of soil,
b) heavy contamination of water,

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c) heavy contamination of atmospheric air and unfavorable changes in natural environment.

Based on the observation carried out at the shipyard, the authors have noticed that at the initial stage of waste disposal, it is necessary to minimise the quantity of generated waste; then the waste should be segregated and disposed at the place where it has been generated.

According to the authors, in order to eliminate the discussed errors, it is advisable to implement the procedures which would make workers and sub-contractors who operate at the shipyard responsible for the proper waste disposal.

Each shipyard worker and sub-contractor should properly plan and organise their work in order to generate the least amount of waste which should be immediately segregated and disposed at the place where it has been generated.

Proper segregation of all the collected waste should be based on the division into main waste categories, namely: scrap metal, hazardous waste, waste for further segregation, mixed waste.

The above-mentioned people should properly collect and segregate waste, such as scrap metal, cables, wood, plastic, packaging, in order to ensure their most proper recycling later on. The authors have paid their particular attention to the fact that some reusable materials have been contaminated with other waste materials and, in that way, they could not be recycled, for example:

a) mixing hazardous waste with other types of waste,
b) pouring oil-derivative waste into:
   – publicly accessible bins and containers which are located on the wharfs and halls,
   – containers for scrap metal, slag and mixed waste (for segregation) from vessels.

In authors' opinion, efficient segregation of waste will contribute to a decrease in costs which are related to the recycling of waste generated during the construction of offshore vessels.

The lack of pro-ecological awareness in shipyard workers and cooperators who work at the shipyard has currently contributed to some serious damages which have been caused by:

a) improper storage and disposal of chemical substances and waste (overfilled containers which leak into the soil and water),
b) faulty equipment,
c) mixing hazardous waste with other types of waste,
d) discharging of oil-derivative substances from vessels into publicly accessible bins and containers located on the wharfs and halls and intended for the collection of scrap metal, slag and mixed waste (for segregation),

The impact of hazardous substances on natural environment depends on:

a) the size of the spillage into the soil and water,
b) the efficiency of preventive operations,
c) the efficiency of spillage collection,
d) the characteristics of the spillage substance: decomposition time, the state of matter, toxicity of concentration.

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The authors believe that it is necessary to appoint persons (or groups) who shall be responsible for the following issues at each vessel:

a) proper marking of places where all the waste generated on the vessels shall be disposed,
b) proper supervision over the storage of all the waste collected on the vessels by the shipyard workers and their cooperators,
c) instructions for the above-mentioned people on how to store hazardous waste,
d) proper response to the incorrect waste storage at the places which are not intended for such purposes.

Additionally, the assigned people would be responsible for the proper marking of hazardous waste and chemical substances, namely:

a) hazardous waste,
b) highly flammable substances,
c) substances hazardous for natural environment,
d) toxic substances,
e) explosives,
f) caustic substances,
g) biologically hazardous substances,
h) substances causing allergic response to the human respiratory system and sharp edges of scrap steel.

Conclusions

The article presents the most important problems referring to the protection of natural environment and reverse logistics related to waste disposal which are faced every day at the discussed shipyard during the construction of offshore vessels.

In their article, the authors present the process of constructing an offshore vessel. Some indispensable processes involved in such production at a shipyard are: welding, plate cutting, various types of beveling and chamfering operations, painting. All the presented problems affect green logistics, involving environmental aspects which directly or indirectly influence natural environment:

a) generation of hazardous waste during the assembly of hull sections,
b) excessive emission of pollutants generated during welding operations into atmospheric air;
c) excessive emission of dust generated during the cleaning of hulls and steel elements before painting,
d) excessive use of paint and increased emission of volatile organic compounds into atmospheric air; improper discharge of pre-treated waste generated during the cleaning of hulls into water.

The authors of the article believe that all the most significant changes in favour of natural environment in the discussed shipyard should be implemented through the level of the company management. It would facilitate the implementation of essential transformation in the ecological awareness of the shipyard workers

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as regards the protection of natural environment which is directly related to their work.

The management staff of the shipyard should also consider the fact that they are mainly responsible for the enhancement of ecological awareness at their workplace. They set an example for their employees and develop patterns of behaviour to be followed; as a result the production workers should follow the proper procedures during their work.

All the efforts listed in the article are aimed at the enhancement of ecological awareness. The management methods should be flexible so that they can be quickly adjusted to the current events. Such an assumption comes from the concept of constant improvement of systems in order to adjust them to the current regulations.

The authors point out that an important aspect in the elimination of the discussed drawbacks is making the shipyard workers and their cooperators responsible for their performance at work. It mainly refers to the planning and organisation of the employees' own work in order to limit the amount of waste generated during their operations, and the storage of all the generated waste which should be preceded by proper segregation at the proper places. In the authors' opinion, proper segregation of waste types, their marking and disposal in line with the ecological principles of green logistics shall considerably affect a decrease in the pollution of the soil, water and atmospheric air in the area of the shipyard.

In this work, the authors have used the following research methods and tools:

a) practical direct observations on offshore units,
b) interviews with the main technologist and production operators,
c) delphi method, i.e. employing the expert knowledge, experience, and opinions of practitioners in the shipyard field with whom the authors cooperated on the project,
d) results obtained by means of statistical methods.

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