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THE MANAGEMENT OF THE TECHNOLOGICAL PROCESS OF A PRODUCT ON THE EXAMPLE A SHRINK FILM IN THE ASPECT LIFE CYCLE ASSESSMENT

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Abstract: Nowadays Life Cycle Assessment is the most popular tool that can be used to see environmental load of a machine, a product or a process. LCA defines the impact throughout the life of a product, from the extraction or production of raw material from natural resources, through production, use and final disposal. This method focuses on the assessment of the impact of the tested object on the area of the ecosystem, human health and the resources use. LCA is a very helpful tool in the environmental assessment that is required and results from the current policy of the European Union, which requires the member states to minimize the harmful impact on the environment of every aspect of human life. The publication discusses the LCA life cycle assessment method as one of the methods allowing to estimate the environmental impact of a technological process or some product. The article shows also the history of LCA, the individual stages, advantages and disadvantage this method. This paper it is also an introduction to carry out LCA analysis on the example of a process with the use of the shrink film.
Keywords: management, technological process, LCA, impact

1. INTRODUCTION

Currently, one of the many problems that humanity try to stopped is too high negative impact of most of the produced products on the environment. Each product has a more or less complex impact on the environment throughout its entire complex life cycle. The scope of the product's impact depends on many factors, including the time of use and the amount of raw materials used in production. It is important to strive to minimize the impact at every stage of the product life, especially at the stage where this impact is the biggest. One of the most popular techniques that allows to conduct a comprehensive environmental impact assessment is Life Cycle Assessment (LCA). As part of the obligations imposed on the member states by the European Union

regarding the minimization of environmental impact, the LCA method becomes an indispensable tool used in solving this problem. Life Cycle Assessment (LCA) is also used for process management purposes. LCA indicates which steps of a given process are the most negative to the environment and allows to manage technological processes in such a way that they are as ecological as possible.

2. TECHNOLOGICAL PROCESS MANAGEMENT AND THE APPLICATION OF LCA

Nowadays, the world requires constant changes from companies to fight pollution. It is required that the processes are efficient and at the same time have the least negative impact. LCA is an important element in the management of technological processes. Carrying out LCA processes makes it possible to modernize or optimize them. This leads to the emergence of new or modernized and environmentally friendly technologies. The results of the LCA indicate which stage of the technological process under study is the most burdensome for the environment. The correct implementation of processes enables the company to achieve their goals. It has been known for a long time that correctly performed processes determine the economic condition and consequently, affect the ability of enterprises to develop. (Lesiuk et. al., 2012; Høgaas Eide, 2002)

Process management is an important element in every enterprise, because it gives the opportunity to improve the effectiveness and efficiency of activities, and at the same time to overcome competition on the market. Through the correct and appropriate implementation of processes, the company is able to achieve both economic and production goals. (Skrzypek and Hofman, 2010)

LCA can also be assigned as one element of the „Six Facets Model" (Fig. 1). Each aspect is related to each other and to technology management in this model.

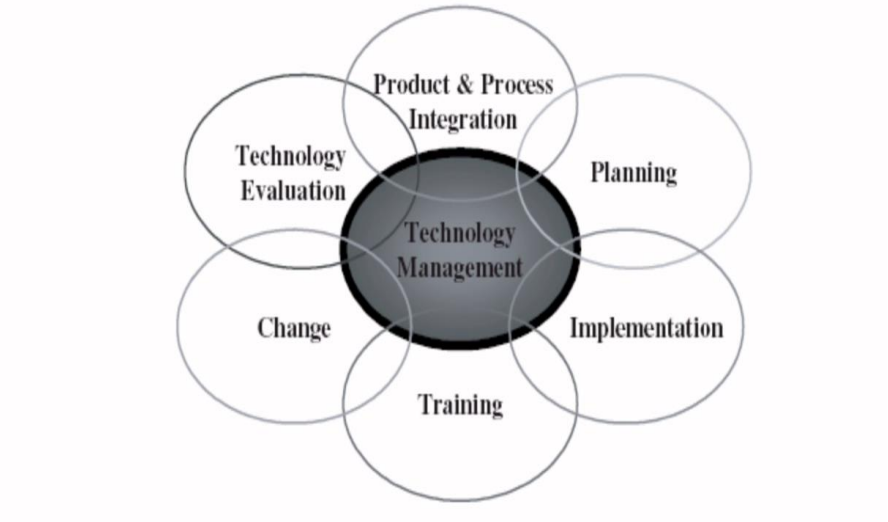

Fig. 1. The facets of Technology Management (Hull C. et al., 2005.)

The facets of Technology Management includes:

-Integration of products and processes through system thinking, development of the quality management system and benchmarking,

- technology evaluation (at the organizational, technical and personal level),
- planning (including strategic plans, work plans and environmental assessment),
- implementation of quality systems, documentation systems, organizational processes, software, project implementation, project planning and control,
- training and commitment to cultivate individual and organizational capabilities and promote workforce development,
- change management.

It shows that technology management is an integrative, multidisciplinary field focused on effective problem solving. (Hull et al., 2005; Brentrup et. al., 2004)

3. HISTORY OF LCA

The first texts on the LCA technique can be found in the work of Harold Smith, which concerned the production of various types of energy analyzed from the moment of obtaining raw materials to obtaining final products. In the same year 1969 Coca-Cola carried out tests to indicate the amount of materials, energy and waste used during the production and use of packaging. The energy crisis of the 1970s contributed to the development of the LCA method and was an inspiration for further research and analyzes based on the assumptions of the method. During the conference in Vermont, the first foundations of the LCA method were laid and also the term LCA was officially introduced. As a result, work began on standardizing the method around the world.

In the 1990s, the international ISO standardization organization developed a group of ISO standards of the 1404 series. On the basis of these documents, their Polish versions were prepared. Currently in Poland, the following are in force:

- PN-EN ISO 14040: 2009, Environmental management - Life cycle assessment - Principles and structure,
- PN-EN ISO 14044: 2009, Environmental management - Life cycle assessment - Requirements and guidelines.

These documents describe the principles and structures of the Life Cycle Assessment (LCA) and provide the requirements and procedures necessary for the Life Cycle Assessment (Kowalski et al., 2007).

4. ROLE IN THE CONCEPT OF THE CIRCULAR ECONOMY

The main goal of the circular economy is to recycle waste as much as possible in order to reduce the extraction of primary resources, especially fossil fuels. The circular economy system allows you to keep the product in circulation as long as possible and completely eliminate waste. The product does not end up in the bin or landfill at the end of its life but is reused through recovery and recycling. Product design turns out to be particularly important. In designing, it is assumed that the final product is to have the least possible impact on the environment throughout its entire life cycle and a smaller negative effect after its use.

Limiting the consumption of fossil fuels and reducing the negative impact on the environment are the main problems of the present times, which are the basis of the guidelines for the circular economy (Fig.2). People must reduce waste generation throughout the product life cycle. Therefore, it is important to conduct environmental analyzes throughout the life of the product. The LCA method allows to search for

solutions that minimize the negative impact on the environment (Burchart-Korol, 2016).

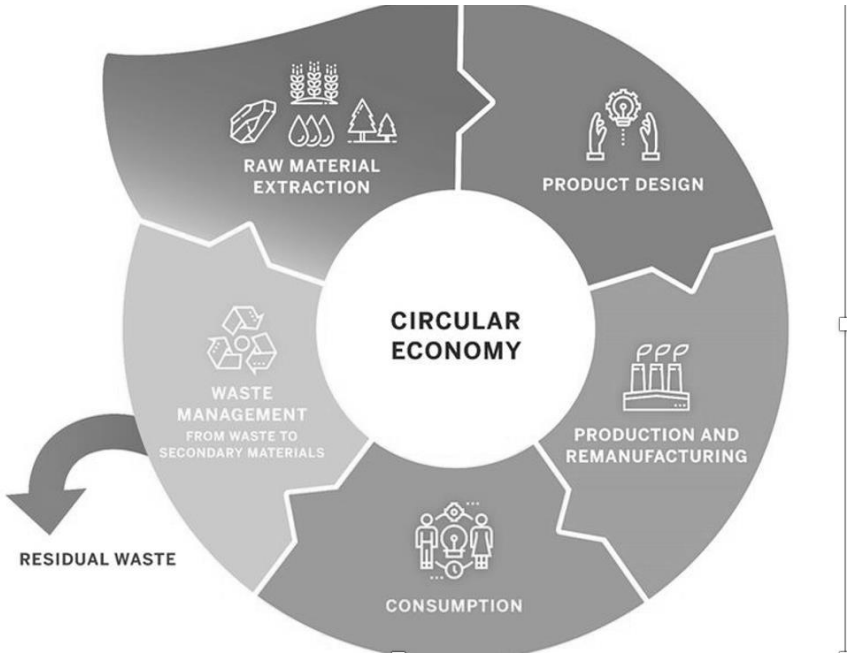

Fig. 2. Circular economy diagram (source: https://www.cencenelec.eu/news-and-events/news/2021/briefnews/2021-02-03-eu-circular-economy-action-plan/)

The use of LCA supports the management of natural resources and the optimization of technology, taking into account economic and environmental aspects. In order for LCA to be used in a circular economy, it should meet the following conditions:
- should cover the entire life cycle of the product, including reuse (cradle-to-cradle concept),
- should make it possible to evaluate the consumption of fossil fuels and minerals,
- should include a Product System Extension (CLCA) to assess different by-product management.

The "cradle to cradle" idea is to use the waste in the next manufacturing process. Used raw materials are constantly in circulation, thanks to which we limit the use of natural resources and thus reduce the amount of waste (Burchart-Korol, 2009; Basavaraj and Prakash, 2017).

5. IMPLEMENTATION PROCEDURE OF LCA

Now, Life Cycle Assessment (LCA) is the basis of a method used in design and development. Although it has complex procedures, LCA is a common method because it uses computer techniques. The LCA has several important stages of assessment, which are presented at the Fig. 3.

The first stage of the LCA is objection definition and scope. This is a key moment of the analysis, because it is at this stage that the detail of the analysis is determined. It is very important to correctly define the limits of the tested model. The scope of the research is mainly determined by characterizing the scope and type of collected data

and the system boundaries. It is also specified which life cycle stages will be covered by the study (Lesiuk, 2012; Burchart-Korol, 2009; Teixeira and Pax, 2011).

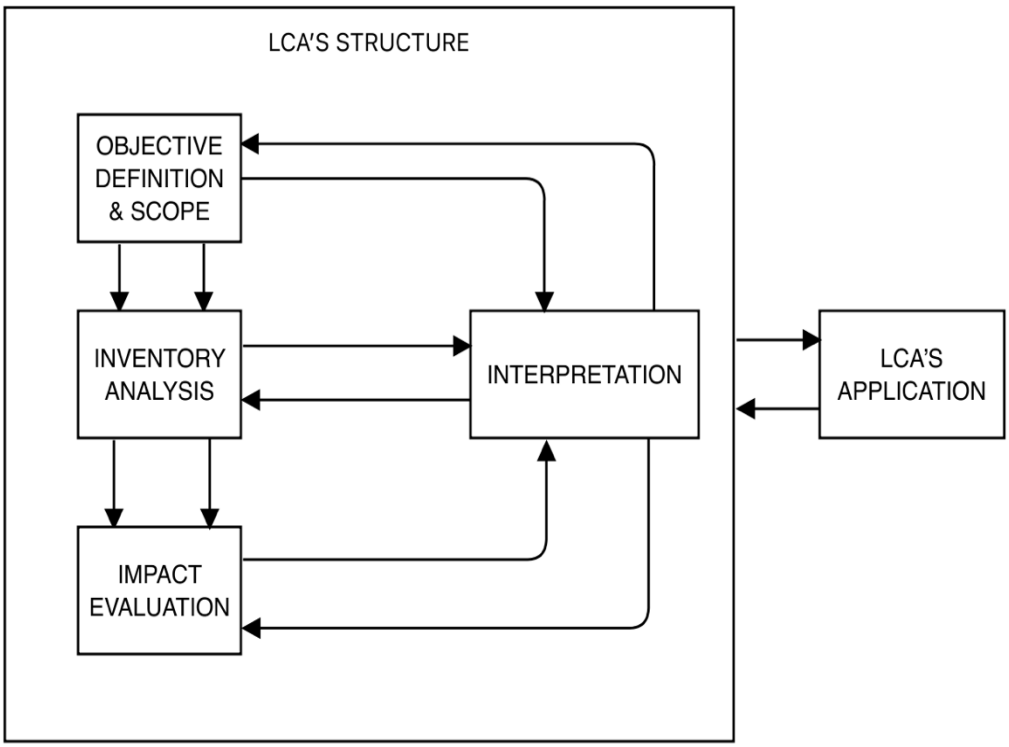

Fig. 3. LCA's structure (own study)

In the second stage – inventory analysis, the time period and technological area of the tested object are determined. The area of the system is defined because it allows for establishing the source of raw materials and energy. This stage also determines inputs and outputs in the manufacturing or processing process, transportation, the degree of use of all types of fuels and energy, use of technological waste and secondary raw materials, production of auxiliary materials, manufacturing, proper use and disposal of basic equipment and aspects related to additional devices or installations (lighting or heating).

In the next step, the impact of the life cycle on the environment is assessed. The impact category, the category index and the classification models are also selected. The task of these elements is to transform the results of the analysis into the results of indicators of the impact category.

The final step involves analyzing the results, explaining the limitations and providing any recommendations based on the results of the previous steps. The purpose of the interpretation is to formulate conclusions and define recommendations aimed at limiting the harmful effects on the environment. Based on these conclusions, decisions are made to minimize the negative impact (Lesiuk et. al., 2012; Żakowska, 2008; Filimonau, 2016).

6. ADVANTAGES AND DISADVANTAGES OF LCA

LCA is a method that assesses the effects of a process or product on the environment. This method aims at efficient use of resources while reducing the load of environmental. The main advantages of LCA are:

- the fact that the assessment covers all life stages,
- the detailed description of the method is included in the ISO standards,
- this method shows the contamination in detail,
- the fact that LCA makes it possible to identify the most harmful to the environment stage of the process,
- the fact that, on the basis of the analysis, it is possible to develop conclusions on the possibilities and possible improvements.

On the other hand, one of the main disadvantages is that there are measurable effects that are difficult to measure and match the appropriate number (Kamińska, 2012; Kijeńska et. al.; 2016, Berlin and Uhlin, 2004).

7. LCA ON THE EXAMPLE A PROCESS WITH THE USE OF A SHRINK FILM

Shrink wrap is a popular type of polyethylene film. It is made of low-density polyethylene – LDPE in the form of granules (Fig. 4). It is most often used for collective packaging of products. Due to the properties of the polyethylene it is made of this film is physiologically neutral, so it is so popular among food packaging.

Fig. 4. LDPE granules and a shrink film
(source: https://www.kinvestments.pl/oferta/tworzywa-sztuczne)

The life cycle of the tested film was divided into stages in the first evaluation phase. A simplified diagram of the processes as well as the boundary at which the LCA was performed is shown in the Fig. 5. A simplified diagram shows stages like extraction and processing of raw materials, the formation of polyethylene granules, the production of film, using, waste collection, recycling or end of life and also transportation between all stages.

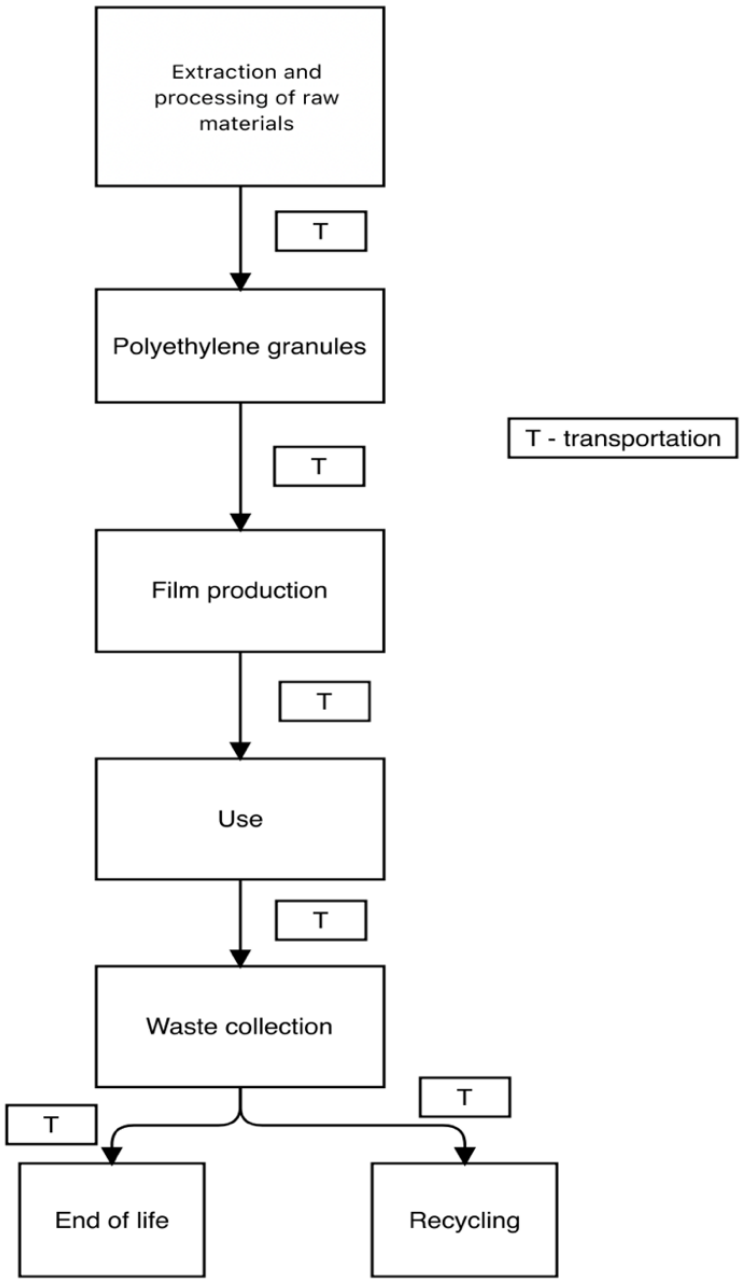

Fig. 5. A simplified diagram of the film's life cycle (own study)

Data structured in this way will be entered into the SimaPro program, which is currently the most popular computer program for conducting LCA. This program uses the eco-indicator method, but the losses are replaced by those damages caused by the negative impact of the process. The assessment includes an estimate of the loads broken down into categories which include human health, ecosystem quality and natural resource resources. The first category of human health covers the number and duration of diseases, premature deaths and obstructed breathing. The ecosystem quality category includes the impact on plant diversity, but also acidification and land exploitation. The last category concerns the energy needed to extract the raw material. The procedure for conducting research using the SimaPro program and its

results are part of a separate study, which is the second part of this article (Høgaas Eide, 2002).

8. CONCLUSION

Life Cycle Assessment (LCA) is a comprehensive method that allows you to define the most efficient resource management both economically and ecologically. Therefore, it is a good tool to develop a solution for reducing the use of natural resources and energy while maintaining an appropriate level of process efficiency. The most important stage of the LCA is to define the purpose and scope of the analysis. In this step, the exact purpose of the analysis is determined. If the purpose and scope of the analysis are correctly defined, correct and reliable results will be obtained. LCA can cover the entire life cycle of a process as just a single step. It can be used to design products and technologies, but also to improve the existing ones. The use of LCA allows to determine which stage in the life of the shrink film is the most harmful to the environment throughout its entire life cycle. The analysis will help to indicate the weakest stage of the technological process in terms of ecology (Filimonau, 2016; Burchart-Korol, 2009).

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