ENVIRONMENTAL IMPACT ASSESSMENT USING LIFE-CYCLE ANALYSIS

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ABSTRACT

Life cycle assessment (LCA) is a methodology used in evaluating the impact of environmental factors associated with all stages of a commercial product, process, or service life cycle. This paper sheds light on different techniques and processes and how they are applied during each phase of a product or process, right from the acquisition of raw materials to the end-of-life phase where assets are decommissioned. This project also uses a case study to explore economic and ecological life cycle outcomes as it relates to cost and financial bearing

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INTRODUCTION

The idea of Life cycle analysis (LCA) was derived from the increasing need to establish how the environment impacts products and processes, right from the design phase through the entire lifetime of the product or process, otherwise known as the lifecycle. LCA is a versatile methodology that can be applied to a procedure, an industrial process or a distinct product. The primary significance of an LCA study is to create a form of environmental consciousness within the industry, especially amongst professionals and duty holders (1).

A recommended practice is that companies should have the full knowledge of how the process of manufacturing is carried out, they must as well have the knowledge of evaluating utility and energy consumption, including emissions level during manufacturing, when the equipment is in service, and at the end, the total amount of generated or generating waste has to be established (2).

There are many pertinent analyses that have been used to quantify the lifecycle of a product or process, one of the most dominant methods is the “cradle to grave analysis”, which will be explained in detail as we proceed in this paper (1).

The LCA may be described over time with different names and terminologies but in whatever way it is described, it is an industrious tool which regulators use when they are in the process of creating legislation concerning environmental and industrial activities, this is also a helpful tool which guides the analysis of process and product improvement. The consumers are also not left out of the benefits of LCA as it directs them in making the right choices based on proven facts (2).

CRADLE-TO-GRAVE ANALYSIS

The environmental impact of a certain product or process can be established using the cradle to the grave analysis, which considers every stage in the life of a product from start to finish point. The starting point of the analysis is usually from the extraction of raw-materials phase, the steps involved in processing the raw materials, manufacturing it and through to the point where it is disposed or better still re-used by the process of recycling (3). LCA is then brought in to evaluate environmental concerns and impact through the following means outlined. Firstly, it involves the bringing together of material inputs. Secondly, it entails an assessment of impacts that are associated with the inputs identified. Thirdly, it brings to light an interpretation of drawn conclusions and results which helps in making enlightened decisions. Figure 1 below, shows the different stages of a cradle to grave analysis which is applied in LCA (3).

Figure 1: Showing the cradle to grave process (2)

LIFECYCLE OF A PRODUCT

There are different phases involved before and after a product has been deployed, since LCA is concerned with evaluating environmental impacts, it is important to define the phases in more detail. The following are the know phases in a product’s lifecycle (3).

The Acquisition Phase: This involves the acquisition of raw materials and the transportation of the acquired materials for usage in the manufacturing plant. This is generally known as the first phase (4).

Material-Processing: This is a lot more different from the first phase, this entails processing of the raw materials and moving them to the production site (4).

Manufacturing Stage: This stage involves the manufacturing, packaging and distribution of finished products for the use of the consumer. This phase in highly industrial and labour intensive, a significant amount of emission is recorded during this phase (4).

Useful life: This takes into account all that goes on during the usage of the product, i.e., the emissions, utility consumption and safety impact as a result of failures (4).

The End of Life: This stage is sometimes called the waste management stage also known as the waste disposal phase, it may involve landfilling and all forms of product and waste recycling (4).

STEPS OF LIFE CYCLE ANALYSIS

There are four (4) major steps in the LCA process. The first phase is to outline the scope and goal, followed by the life cycle inventory, life cycle impact assessment and finally the data interpretation. Figure 2 below shows a representation of the phases in the LCA process (5).

Figure 2: Showing the steps of the LCA process (7).

The most important task of the first step is the collection of data, here the scope and goals of the project/process is clearly defined (6). The definition of the scope and goals is done to ensure that the LCA analysis is always performed in a consistent manner and according to the standards that are applicable to the process or product. During this phase, the system definition, allocation, and apportionment is done, followed by the definition of system boundaries and interphases. The environmental factors affecting them are outlined after thorough analysis.

The 2nd step is known as the life cycle inventory LCI, the most common way of completing this step is through the collection and recording of data after they have been properly assessed (7).

The third step is the life-cycle impact assessment (LCIA) which looks at the various categories of impacts, they can be further broken down into four simple steps, Characterization, Normalization and Weighting. The fourth and final step is where results and conclusions are drawn, and a sensitivity analysis is conducted (7).

CASE STUDY

Espresso is a famous drink and is bundled in an assortment of bundle designs, a Life Cycle Assessment (LCA) study was carried out where the accompanying famous packet designs were assessed, as shown in figure 3 (8). Figure 3 below shows the results of fossil fuel consumption greenhouse gas emissions and water usage for each type of packaging evaluated, including some of the key metrics that package designers consider when evaluating the environmental impact of a particular package. The eco impact software is used to compare packaging formats of different sizes by normalizing the data, based on functional units such as weight or usage (8).

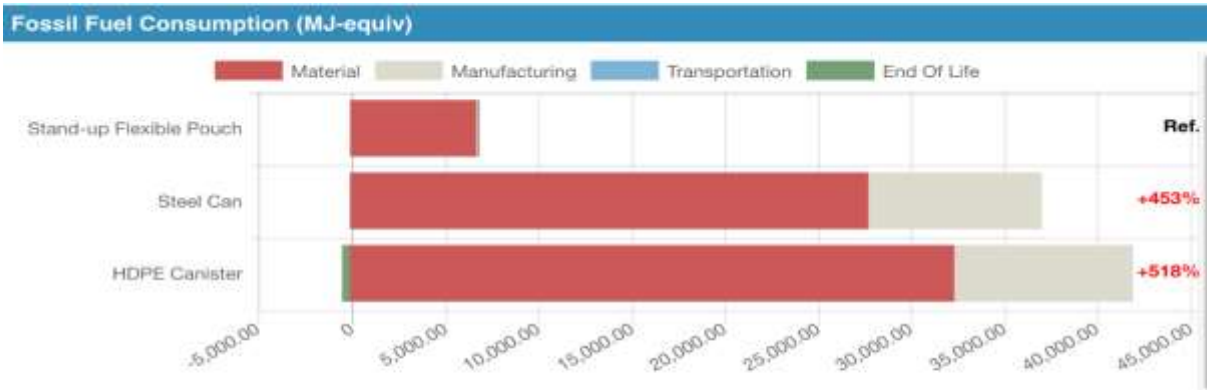

Figure 3. Coffee package comparison – Fossil Fuel Consumption (8)

The fossil fuel utilization graph shows that the use of steel cans and canisters have a much stronger impact on fossil fuels at the material and manufacturing stages (7). This is because it takes a lot of energy to produce resins in rigid packages such as plastic containers or steel cans. For example, in the HDPE canister production stage utilises injection molding, where plastic granules are melted and then injected into a mold to create a container (8). Stand-up flexible pouches, on the other hand, are a lamination process in which multiple layers of thin films are layered on top of each other, usually with adhesive. The additive process is much less energy demanding than injection molding and needs a lot of heat and fossil fuels (energy).

CONCLUSION

The four (4) main steps of the LCA should always be used as a standard for environmental impact assessment, it must serve as a guide to contain emissions and the release of hazardous substances to the environment. We all have a part to play, the industries, governments and anyone placed with the duty of keeping the environment safe, whether through direct or indirect involvement.

This report has been able to show, through the use of a case study, the need for Engineers to apply substantial effort during the process of material selection and ensuring that the materials and processes selected is best for the environment and protects the health and safety of the future generations.

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