Material and Energy Flow Modelling and Analysis in SMEs

Aya Osama Mohamed (*Materials Engineering)* and **Dr.Ing- Amna Ramzy** (*Engineering and Materials Science Faculty*)
Email: ayamelsayedd@gmail.com

MEFA

Material and energy flow analysis (MEFA) is a widely used effective tool that helps suggesting sustainable systems to replace wasteful ones. It is a systematic approach that is based on the law of conservation of matter and calculates a material balance for specific points in time within a given system. [1]

Literature Review

Humanity is currently facing one of its most critical and drastic challenges ever, which is climate change. The global ecological footprint of humans has significantly increased by 80% from 1960 to 2000. Currently, every year 1.2 times more resources are consumed than can be renewed in the world [3]which indicates that large quotas of the extracted raw materials are also being discarded after production as industrial waste, including material loss and operating materials being consumed during manufacturing, in addition to the increase of the emission of greenhouse gases.

Over the past years, the topic of sustainability and efficiency has gained a lot of attention, more specifically: material flow analysis (MFA) and life cycle assessment (LCA).

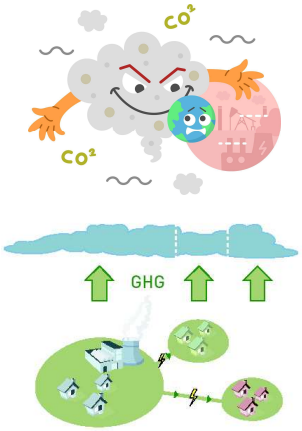
Nowadays, many software tools have been developed to evaluate all stages of a product's life which allows the estimation of the total environmental impacts resulting from all stages in the product life cycle, these tools not only facilitated the tasks and calculations instead of having to execute them manually, but also helped providing a comprehensive view of the environmental aspects of the product as well as a more realistic depiction of the underlying environmental trade-offs in product and process selection.

The food sector is undoubtedly one of the world's largest industrial sectors and therefore is a very large energy consumer which directly links it to the increase of the greenhouse gas emissions which resulted in global warming.

The food sector is undoubtedly one of the world's largest industrial sectors and therefore is a very large energy consumer which directly links it to the increase of the greenhouse gas emissions which resulted in global warming.

This calls for an urgent need to improve production systems and efficiency, thus, LCA.

LCA has been applied to a large variety of products in the food sector showing carbon footprint (CF) values for some common food items and indicating the most significant production stages with the highest impacts (hotspots) and suggesting better alternatives.

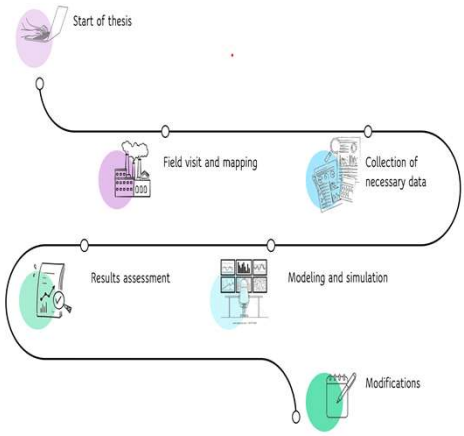


Problem Statement

It is not possible to totally eliminate waste in production; however, it can be minimized by taking a closer look at all the particularities and details of the processes following a systematic and coordinated approach with the help of software tools such as Umberto. UMBERTO software is a simulation tool that offers extensive modelling of production systems with a user-friendly interface, allowing better understanding of the material and energy flow systems, allowing us to test and implement different approaches to optimize the efficiency of the production process.

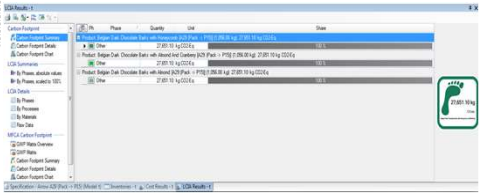
This will be an attempt to achieve the goal of minimizing wastes and improving production material flow efficiency by combining simulation using UMBERTO with MFA and LCA.

Methodology

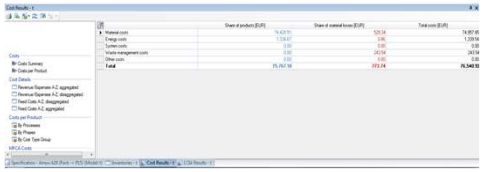


Results

- Carbon Footprint Analysis



- Cost Analysis



Conclusion

A sequence of processes are defined, of which, some stages exhibit considerable losses of material; this loss is only present in the honeycomb filled Scrunch chocolate product, as for every 990 kg of this chocolate product, we have 11.88 kg of honeycomb losses, which negatively affects the cost analysis results. Furthermore, for every 2970 kg of chocolate products, a value of 27651.10 kg CO_2 eq are emitted.

LCA has to be conducted to have better and more efficient production line by attempting to eliminate those losses.

References

[1] Kullmann, F., Markewitz, P., Stolten, D. et al. Combining the worlds of energy systems and material flow analysis: a review. Energ Sustain Soc 11, 13 (2021).

[2] image from: https://www.townofgypsum.com/community/utilities-public-works/recycling

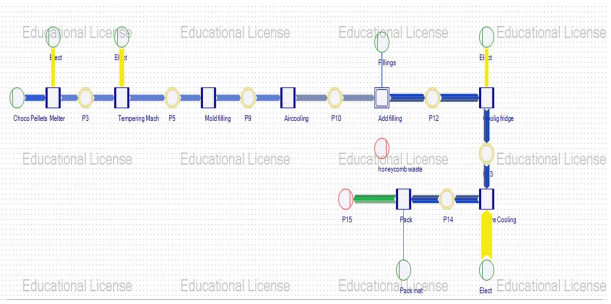
[3] A. R. &. P. Sharma, "A study on Life Cycle Assessment," *International Journal of Engineering and Advanced Technology (IJEAT)* , 2017.

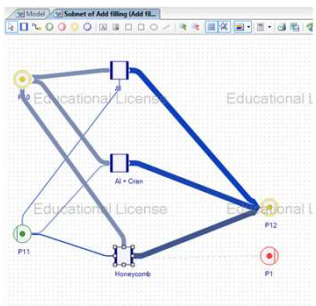
[4] image from: https://journals.openedition.org/sapiens/854

[5] image from: https://www.vecteezy.com/vector-art/3447442-greenhouse-gas-emissions-threatens-the-earth

[6] image from: https://aim2flourish.com/innovations/sustainability-gains-by-waste-reduction-process

Sankey Diagram of Chocolate products





GUC German University in Cairo

Prepared for Thesis Poster Display Conference

11th -12th June 2022

Faculty of Management Technology
THESIS Poster Display Conference 2022