Life Cycle Analysis for Manufacturing Process Sustainability in the Aeronautical Industry

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1 INTRODUCTION

The growing concern to measure circularity and sustainability, as well as to properly integrate them in the development of products that respect the environment, economy and society, means that sustainability criteria are increasingly implemented. In the case of fuselage parts, previous research as Bachmann et at. (2017) states that there is a lack of information in the database when trying to evaluate the impact of using innovative materials (as materials of biological origin or recycled for use in aviation) which highlights the need for studies in this field of research.

It is essential that LCA methodology is integrated from the initial phases of the product as in this way, the evaluation of the different processes will be developed in the economic, environmental, and social dimensions. For this reason, previous studies such as Torres-Castillo et al, 2020, implemented a comparative LCA of two manufacturing process for an aircraft engine turbine blade. This study compared two processes: a conventional mechanization method and by additive manufacturing, concluding that the most impacted categories were: global warming potential (GWP), acidification potential (AP), ozone layer depletion potential (ODP), human toxicity potential (HTP) and human toxicity (HT) with carcinogenic effects and non-carcinogenic, consistent with the results of the present study.

The present work evaluates the process data of an aeronautical company that has been completely digitalized. The objective has been to analyze the digital data from the sensors and equipment to be incorporated into the inventory of the LCA system, and based on this, improve decision-making in the production process in the factory according to the impact observed by LCA data.

2 EXPERIMENTAL METHODOLOGY

Throughout the development of the present study, LCA methodology was applied to the manufacturing process of the aeronautical part **Cover PN 98M49008069000**. In the present research work, the boundaries of the system (see Fig. 1) include the procurement of primary resources, all manufacturing and transportation processes of product components and their raw materials, as well as all phases of the finished product life cycle, and LCA application develops a "From door to door" approach.

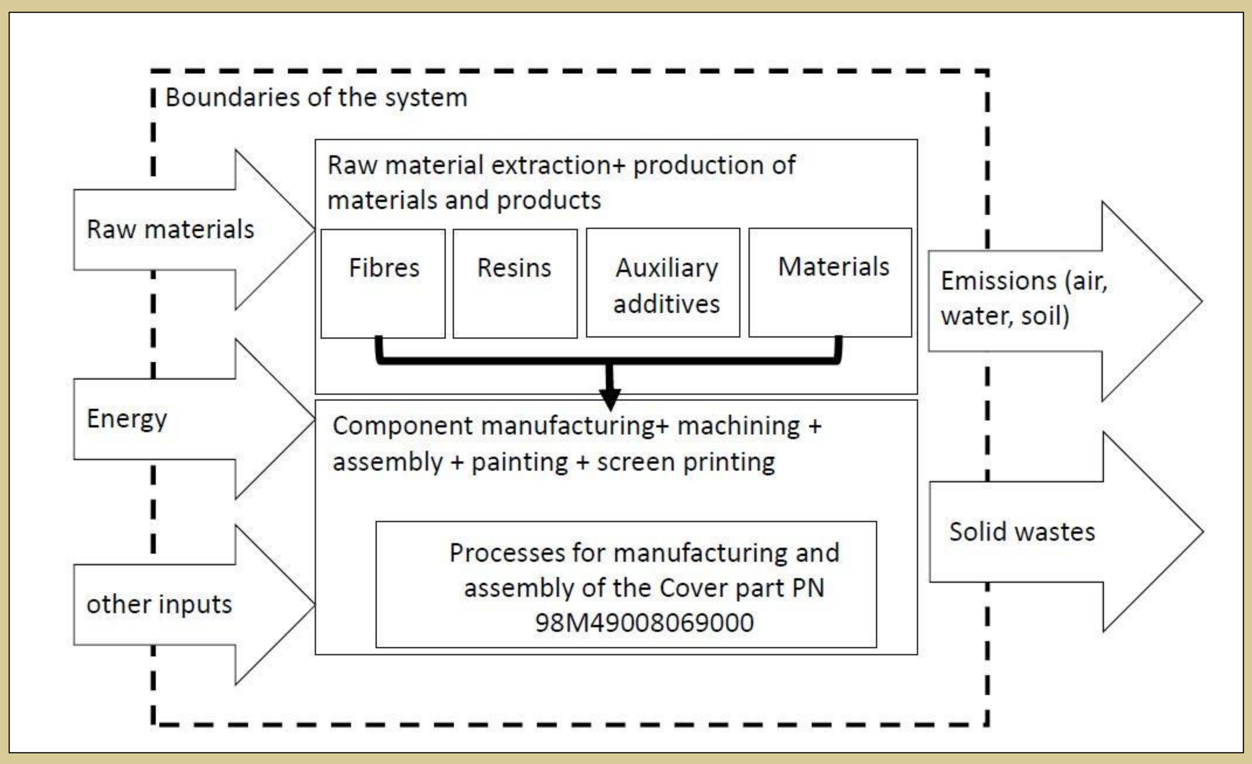

Figure 1. Boundaries of the system for production process of Cover PN 98M49008069000

Based on scientific articles and previous research such as those carried out in Sweden by the CHALMERS UNIVERSITY OF TECHNOLOGY (Gothenburg, Sweden) the optimal impact categories for this type of products are selected. These categories have been categorized according to CML, an impact method developed by the Center of Environmental Sciences of Netherlands, based on the studies of Dassault Systemes, 2017. Therefore, combining the different references mentioned in Table 1 are shows the 10 impact categories selected for the LCA system:

Impact categories	Midpoint reference substance	Impact categories	Midpoint reference substance
Aquatic acidification, AQ	kg SO2 eq	Abiotic Depletion - elements	kg Sb eq
Aquatic eutrophication, EUQ	kg PO4 eq	Marine aquatic ecotoxicity	Kg 1,4-DB eq
Global Warming Potential, GWP	kg CO2 eq	Fresh water aquatic ecotoxicity	Kg 1.4-DB eq
Photochemical potential	kg C2H4 eq	Terrestrial ecotoxicity	Kg DCB eq
Ozone layer depletion, ODP	kg CFC-11 eq	Human toxicity	Kg 1.4-DB eq.

Table 1. Environmental impact categories applied to the present study in IMPACT 2002+.

3 CONCLUSIONS

In general, according to previous analysis, it can be stated that the manufacturing of aeronautical parts contributes to GHG emissions, with energy consumption being a critical point, being necessary to quantify the environmental impacts of the treatment of solid wastes, paints and for machining equipment resulting from the process.

The present study demonstrates the need to take data in situ in the factory itself, since using real data has an impact on the quality of the LCA application. The data came from a factory located in the south of Spain and it is concluded that these real data from the equipment and sensors for digitizing the processes gave rise to maximum reliability of the inventory, facilitating decision making from the point of view of sustainability of the processes.

4 REFERENCES

Bachmann, J., Hidalgo, C., & Bricout, S. (2017). Environmental analysis of innovative sustainable composites with potential use in the aviation sector—A life cycle assessment review. Science China Technological Sciences, 60, 1301-1317.
Torres-Castillo et al, 2020

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