Life cycle assessment of an aircraft cabin element

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Abstract In the SINTEG research project, Fraunhofer IBP's GaBi department collaborated with Diehl Aircabin GmbH to calculate a LCA of an interior sidewall panel. The sidewall panel is used to separate the aircraft cabin from the load-bearing structure. It is a composite plastics sandwich construction. While the entire life cycle of the panel was generally taken into account, the production phase was the focus of attention. One important outcome was the relevance of incorporated materials. The single largest fraction of the total impact in any of the examined impact categories is related to the sandwich core, which accounts for less than 10% of the panel's mass. Broken down to an individual panel, the energy consumption for air conditioning of the production facilities accounts for another significant fraction of the total impact. The presentation shows the compilation of the inventory and highlights the most important results.

1 Introduction

Driven by societal and political pressure, the aviation industry is widening its understanding of environmental issues. Consequently, the interest for life cycle assessment (LCA) is growing in the industry. Not only airlines and aircraft manufacturers are realizing the potential of the method, but also their suppliers. In the course of the SINTEG research project funded by the German Federal Ministry of Economics and Technology (BMWi), Fraunhofer IBP's GaBi department collaborated with Diehl Aircabin GmbH to calculate a LCA of an interior sidewall panel.

2 Description of the product system

Sidewall panels like the one that is the subject of this article are used to separate the aircraft cabin interior from the load-bearing structure – in this case, in an Airbus A320. The panel is referred to as a “sandwich part”, because it basically consists of a sheet-like core covered in layers on both sides. The core is made of aramide and phenolic resin arranged in a hardened honeycomb-like structure. The covering layers are made of glass fibers reinforced plastic. Typically a thermosetting phenolic resin is used due to the high fire smoke and toxicity (FST) requirements. These layers are called “prepregs”, short for preimpregnated fibers. They are flexible like thick plastic sheets and harden when cured in the manufacturing process.

While the entire life cycle of the panel was generally taken into account, the production phase was the focus of attention. The panel is manufactured in five steps:

1) The core and the prepreg layers on both sides of it are bound together in a curing press. This is referred to as the “crushed core process” because the core is compressed.
2) The raw part is outfitted with a window including the conical frame and blinds.
3) A decorative layer is applied to one side. This decor defines the surface structure facing inside towards the passengers.
4) Thermal insulation is added to the backside of the panel.
5) The part is delivered to the customer, ready to be assembled into an aircraft.

The product system also includes the provision of energy (power and heat), as well as the production of materials and composite parts, most notably the core and the prepregs. The functional unit was defined as one piece of the specific wall panel.

3 Modelling

All manufacturing steps including material and energy provision, as well as disposal processes were modeled in the LCA software GaBi 4. Primary information about Diehl Aircabin’s in-house processes could be readily collected from the facility management and environmental departments, sometimes directly from machine operators in the factory. A mass consistency check revealed that

less than 10 g was not accounted for. Given that the entire part weighs about 5 kg, the inventory was practically complete from a material perspective.
Much of the information was given as overall figures which had to be broken down to individual parts and even individual processes. Especially in the case of power consumption for entire buildings with multiple production lines inside presented a challenge. Because some of the materials are temperature-sensitive and degrade over time, production facilities are air conditioned. It was decided to allocate such indirect consumption figures by the time a part spends in the building.
Information about the main materials (i.e. the core and the prepreg layers) could be retrieved from Diehl Aircabin's suppliers, who were very cooperative. The data was collected and compiled by their respective personnel.
LCA datasets for typical background processes such as power and heat provision, transport, and waste disposal were taken from the GaBi databases. Where representative datasets were not available, calculated estimates and proxy values were used.
The use phase of the panel basically consists of a fraction of the use phase of an aircraft. This decision was taken because (1) the use phase is not the focus of this study, so a quick and easy way of calculation inventory data was needed, and (2) because the added weight to the aircraft can be interpreted as a "side effect". The panel's primary function is to separate the cabin interior from the structure (visually, thermally, and acoustically). Ideally, it would be weightless, and though this is a physical impossibility, it represents the base line for assessment.

4 Results

The environmental impacts of the production phase were assessed in five impact categories, including global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), photochemical ozone creation potential (POCP), and fossil primary energy demand (PE_fossil). Figure 1 shows the relative contributions of each manufacturing step to the overall impact per category.
The manufacturing steps in the graph differ a bit from the description in section 2 because the results refer to the entire product system rather than only the manufacturing steps. "Crushed Core process" refers to the process itself, while "prepreg" and "honeycomb core" refer to the provision of the respective materials. "Other" includes processes related to the panel production but not explicitly mentioned (mostly disposal of material waste from cutting). "Decor" refers to the

provision of the surface layer and its application to the panel. “Assembly” includes the provision of solid parts (mostly parts related to the window such as the frame and blinds) and the assembly of the final product. General power consumption of the buildings is mainly due to air conditioning and is consequently labeled “facility HVAC”. “Delivery” covers the transport of the panel to the customer and the return trip of the empty delivery truck.

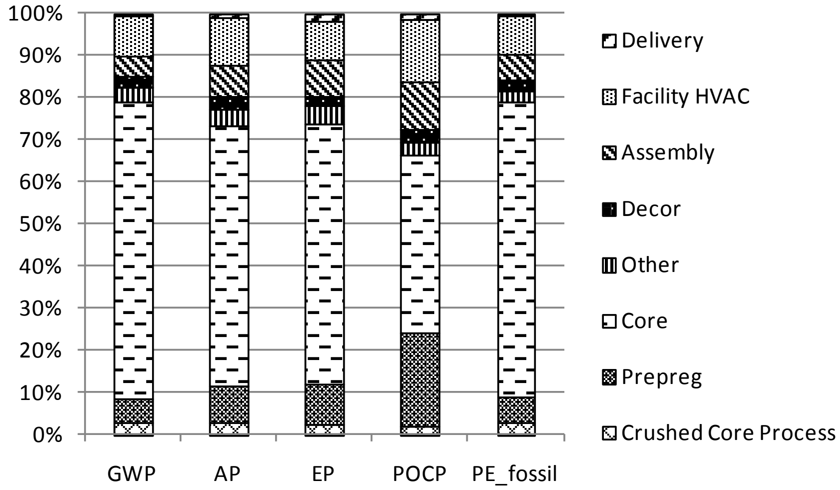

Fig. 1: LCA results, given as relative contribution per impact category

The single largest fraction of the total impact in any of the examined impact categories is related to the sandwich core. Depending on category, the contribution varies between 40% and 70%. Given that the core accounts for less than 10% of the panel’s mass, this is a surprising find. Most of the remaining impact can be attributed to the provision of prepregs and inserted parts (window frames, blinds etc.), all of which are made from high tech materials. Energy provision for crafting the structure contributes only a minor share of the impact. Broken down to an individual panel, the energy consumption for air conditioning accounts for between 10% and 15% of the total impact.

Indicative calculation of the use phase impact of the panel shows that its mass is the decisive factor. This is not surprising, because the use phase inventory is calculated based on the use phase of an entire aircraft allocated to the panel on a mass basis. Since the panel does not interfere with the aircraft’s aerodynamics or other properties relevant to fuel consumption, that leaves added weight as the only factor.

5 Conclusions

The results were discussed with Diehl Aircabin's development, environmental and facility management experts. The relevance of the product's mass for the use phase was very well known. An outcome that yielded new information was the relevance of incorporated materials, especially in relation to on-site energy use. The single largest fraction of the total impact in any of the examined impact categories is related to the sandwich core, which accounts for less than 10% of the panel's mass. Broken down to an individual panel, the energy consumption for air conditioning accounts for another significant fraction of the total impact. Even though the consumption figures for air conditioning were known, the relevance in contrast to the other manufacturing steps was new information.

It should be noted that the use phase impacts are far greater than the production phase impacts of the panel. Nevertheless, it was decided to keep the focus of the study on manufacturing. The decision was drawn for a number of reasons. Diehl Aircabin is interested in improving the environmental profile of their products wherever there is a notable degree of control, and that degree of control is mostly given in the production phase. Also, given the pace at which life cycle thinking and corresponding product labeling schemes are spreading in other industry branches, it is only a matter of time until major aircraft manufacturers are going to request LCA data from their suppliers. And last but not least, as the use phase of aircraft is likely to be less burdensome in the future due to efficiency gains and use of biofuels, the relative importance of the production phase is set to rise.

Following the use phase discussion, a guidance rule for future panels could be that they should not be heavier. This is so much in line with the general direction of the aviation industry that it borders on trivial, but beyond this rule, further recommendations could be derived. The results seem to suggest efforts to reduce the environmental burden of the core. On the other hand, it is especially the core that allows the construction of the panel as such a lightweight sandwich part. Alternative materials would most likely be heavier, which would contradict the overall rule of mass reduction. If a material with comparable structural properties could be found that would not increase the overall mass of the panel, it would be worth examining.

The burden from the general power consumption of the facilities (mainly for air conditioning) presents more of an opportunity for development. It may be possible to speed up the processing steps, which would result in less time of the part spent inside the facility and less air conditioning per part. Alternatively, there may be materials which are less temperature-sensitive and would allow dropping the air conditioning entirely.

On the other hand, it became obvious which manufacturing steps are of minor environmental importance. These include e.g. the provision of the decor material, assembly, and delivery. Not only does this mean that efforts for environmental improvement are better spent elsewhere. It also means that designers of future products with similar characteristics (and corresponding processes) have a certain degree of freedom. They can make choices regarding aesthetic and technical properties without critically endangering the environmental performance of their products.

6 Outlook

The results presented are merely a snapshot of information from an ongoing project. Thoroughly collected inventory data allows for a rather detailed breakdown of results. The relevance of materials and processes, even diffuse use of power, is made accessible for designers, technical personnel and decision-makers. Awareness about environmental issues (as well as non-issues) allows these people to include ecological considerations in their everyday decisions. The results were met with great interest in the company. It remains to be seen to what extent Diehl Aircabin is going to embrace life cycle thinking in general and LCA in specific.

7 Acknowledgement

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