BUTTERFLIES Project

Bio-Polymers & Additive Manufacturing

Newsletter II

Towards sustainable additive manufacturing processes: a LCA approach

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Towards sustainable additive manufacturing processes: a LCA approach

The growing environmental pressure imposed by conventional manufacturing models has significantly accelerated the development of more sustainable production processes. In this context, the synergetic use of additive manufacturing (AM) and bio-based polymers can represent a frontier of particular interest for circular and low-emission manufacturing.

The BUTTERFLIES project aims at adapting and optimizing an established AM process (Binder jet printing - BJT) with chitin nanocrystals (ChNCs) and chitosan as the primary binder components. Chitin, a biopolymer extracted primarily from crustacean exoskeletons, insects, and fungal cell walls, can be used for application in the biomedical and pharmaceutical industry, as in the case of customized medical devices and advanced tissue-engineering structures.

Since environmental indicators for this emerging technology are poorly documented, life cycle engineering was applied with the aim of evaluating the sustainability of the BJT with these novel bio-based feedstocks.

Life cycle assessment (LCA) has been carried out for a biomedical orthotic device (i.e. orthotic thumb immobilizer) produced via binder jetting using bio-based chitin powder and a chitin/chitosan binder. This system is compared to the same device obtained through a conventional Powder Bed Fusion (PBF) (i.e. Multi Jet Fusion - MJF) approach with polyamide (PA) powder. Both studies have been carried out using the ReCiPe 2016 method and SimaPro Craft software, following a cradle-to-grave approach.

Life cycle inventory (LCI) data for the conventional route was filled with data both from partners and literature, mapping raw materials extraction and preparation, productions steps, distribution and use phase, as well as end-of-life considerations. The LCA model of the conventional scenario, based on MJF approach with PA, is presented in Fig. 1.

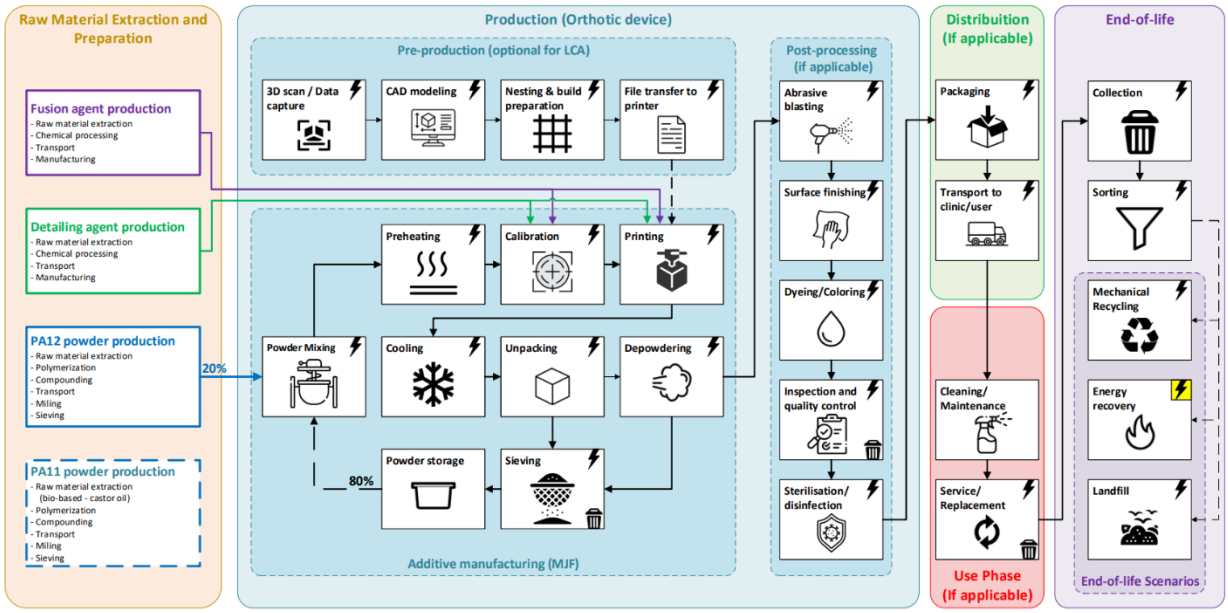

Figure 1: LCA phases of the conventional scenario of an orthotic device produced through Multi Jet Fusion (MJF) with a polymeric (polyamide) powder.

For the chitin/chitosan binder jetting route, the work is currently ongoing, centered on the compilation and analysis of relevant literature, input from project partners and primary experimental data collection.

Preliminary results point out that chitin-based binder jetting can outperform the polyamide MJF benchmark in climate change and fossil resource indicators, although the magnitude of the benefit will also depend on process efficiency, post-processing requirements and reactants being used in the production the ChNCs. the

Future research is ongoing for the optimization of the BJT with ChNCs and chitosan. The application of green synthesis routes for the formulation of the biopolymers, the enhancement of energy efficiency in the AM process, and the optimization of recycling and waste management strategies after the in-service life of device can further improve the sustainability and circularity of this innovative manufacturing model.

