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Reflection

This thesis aims to find the extent to which rPET and additive manufacturing can be used to create a connector designed for disassembly. The final product consists of a thesis and a final design. The first stage of the research focused on creating a clear foundation, then the topic was further researched through a literature study, an analysis of the designs within the field was made and based on requirements formulated through the literature study and the analysis a set of prototypes were designed and one was chosen to further optimize.

The literature study creates a clear understanding of the definitions Additive Manufacturing, Circular Building Products and Design for Disassembly and relations between them. Within the analysis a clear understanding of the state of the art for additively manufactured circular building products was created and the research gap for circular connectors for additively manufactured circular building products was found. Through research through prototyping, several design variants were developed for connectors designed for disassembly and through a decision model consisting of requirements the prototypes were further improved and one was chosen as final design.

The potential of using additive manufacturing for the development of circular thermoplastic façade elements has been researched, and prototypes of AM thermoplastic façade elements have been made. However, a gap has been identified in the development of AM connectors that can be disassembled. Research into this topic has the potential to improve the circular potential of AM thermoplastic façade elements. For this reason, this thesis goes into the design of DfD connectors.

The first approach was taken too broad, it aimed to design a circular product, without clearly defining circularity and the criteria related to it. This meant the circularity of the design could not be measured. After researching the different circularity approaches a more rigid structure was worked out in the form of a decision model containing design requirements. This meant the circularity could be tested and the designs variants could be compared to each other.

Since each design variant led to new design problems to solve, the results were not expected. Although for the first round each design led to a new approach for connectors, the improved designs each have a similar approach. Although the form of the designs were different than expected, they did lead to the desired functioning.

The structure of the thesis where a literature study and analysis of a design form the basis for a decision model that informs the design, is an approach that could be used for similar scenarios where a design needs to be improved or used for another field of study, like in this case circular building products.

The research mostly influences the design. The research forms the basis for the requirements that inform the design variants. Although the design principles, which were set at the start of the thesis also influence the direction of design. For example, the use of the Spong3D block at the basis of the connector design informed the structured analysis of the circularity of the block.

The feedback given at the P2 was about finding focus and direction within my work, although this has been slow going since choosing the most relevant approach always asks for more research, I have stayed focused on narrowing down as much as possible. A strategy to attain this focus was to zoom out frequently, this allows for the possibility of reflection and assessment of the relevance of my work and methods.

Decision making in the design process is something I learned from going through the process of making a thesis. A decision is always based on both research and assumption. How a structured decision can be made while also taking into consideration my own judgment is something that has to be learned through experience. While at every design step more unknowns are created by the added knowledge on the topic, it is important to stay focused on the end goal for the design.

The final part of the graduation will be focused on improving the final design to the requirements. New prototypes will be made and sketch designs of the corner and bottom and top solutions will be made. Besides, the literature study of the definitions will be improved.

This thesis topic is part of the ongoing research project 'living in a bottle' into building mono-material translucent building products through additive manufacturing, it will add relevant information on the circularity of the manufacturing method. The ongoing project has a research method of prototyping, which is in line with the method of this thesis.

This thesis in line with two of the chairs within Building Technology, Façade & Product design and Design Informatics, in that it aims to develop a circular connector for a mono-material façade panel through additive manufacturing. The design of a circular building product is directly learned from the master track and the ability to learn new skills for design, like in this case 3D printing, is something often taught at the Building Technology track. The relation to the

Societal impact

The project is still at a proof of concept stage, so although it is not yet applicable in practice, it will add to a knowledge base about additive manufactured mono-material façade blocks and additive manufacturing for circular building products. Although the focus in this thesis lies on the design of a connector, the basis for the design, the Spong3D panel, should be developed further to be more efficient in working and production in order for it to be suitable to take into practice. The connector itself should also be developed to work for corner solutions and horizontal connectors, besides extensive testing into watertightness, strength and durability should be conducted.

As the design of a additive manufactured connector that is designed for disassembly has not been extensively researched, the product achieves a level of innovation. It is a combination of circular building products and AM which should be investigated further, since AM shows clear potential in that it, among other things, allows for standardized products, complex shapes and material optimization. As mentioned in the previous paragraph, the connector design should undergo testing to make a conclusion on the functionalities of the product.

Part of the knowledge base it adds to is in sustainable development. The objective of this thesis is to improve the circular potential of additive manufactured façade blocks, by designing a DfD connector, which has the potential to bring new solutions for circular façade products. It also opens up the possibility for discussion about novel building methods and innovative building resources.

Being about sustainable development a moral dilemma is encountered during the process. The research finds that reduced waste is preferable and for the production of virgin plastic considerably more CO_2 is emitted than for recycled plastic. However within the timeframe and scope of the project it is not possible to use (only) recycled plastic and create no waste with the production of prototypes. This brings up the question whether this is morally acceptable, however it is important we move to a more sustainable and circular economy as fast as possible. The more solutions are known, the easier it is for people to make sustainable choices, because there are more solutions that fit peoples preference. So by speeding the process up by working less sustainable on a small scale, when the project moves to a larger scale it can have a larger impact.

Although the working on a larger scale should also be discussed. Aesthetically and functionally the building product is not like any other regular façade, so if the product can succeed

through testing, the question remains whether it has the potential to be applied in the building industry that remains traditional and is relatively slow compared to other industries. A more proven and used façade material will easily be chosen over a relatively unknown material. Although it also adds a lot of visual interest because of the translucency of the material and the pattern the connectors add to the overall design. Using AM for manufacturing also opens up the possibility of local manufacturing, however this would require restructuring the building process. The combination of different layers in the skin of the building into a mono-material block also has a large impact on the building, it would simplify the building process, but might ask for a different form of maintenance, this would also have a large impact on the building industry.

Overall the value of this thesis lies in the academic field, it mainly adds to a knowledge base on circular building methods and products since the product itself remains at the prototype stage. It still has the potential to add societal value in the future if it can be fully developed into the building industry, this would mean a novel method and façade element is added to the industry.

The final design is easily transferrable since all design steps were made based on a structured decision model that was created from the literature study and analysis. Although its design is based on the Spong3D façade block, the connector can be used for other AM thermoplastic façade elements.