An Engineering Approach to Designing and Manufacturing a Reconfigurable Self-Locking Device Using 3D Printing

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Motivation

- Reconfigurable devices are becoming more desirable for consumers due to their convenience and lower cost
- Self-locking devices are innovative and new to the market and keyless boxes are becoming increasingly popular
- With an increase in the use of 3D modelling and printing for engineering prototypes, more research is needed to discover the benefits and risks of testing ideas with this technology

Objective

- Design a reconfigurable safety box that is self-locking, keyless, and appears difficult to open/unlock
- Reduce cost to manufacture while maintaining quality
- Choose materials based on ideal properties of device and capabilities of 3D printer (design for manufacture, assembly, and disassembly)
- Understand the tendencies of 3D printers in order to better design for and manufacture with them in the future

Background Research

Fused Deposition Modelling (FDM)

- Utilizes extrusion to adhere layers of heated thermoplastics to each other
- Most common type of 3D printing technology

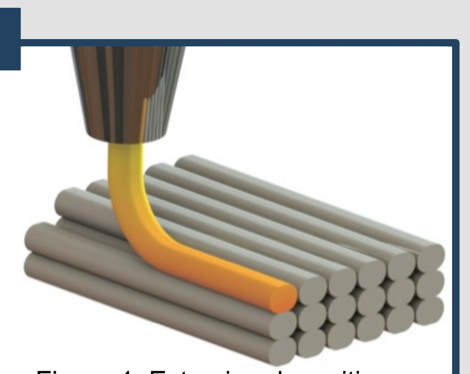

Figure 1: Extrusion deposition through FDM (additive3d.com)

Reconfigurability

- The ability of a system to undergo reversible physical changes in order to serve multiple purposes
- Results in fewer products being purchased and less space being used

Figure 2: Reconfigurable golf club (divnickgolf.com)

Self-Locking Devices

- Lock (and sometimes unlock) based on orientation
- Occasionally appear harder to open/unlock than in actuality
- Can be keyless depending on design

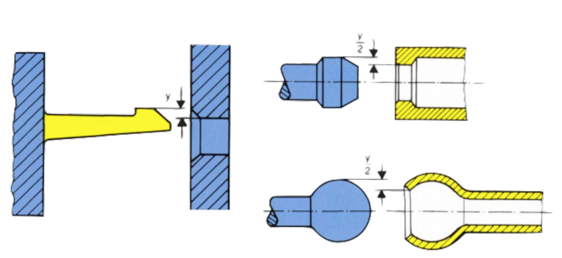

Figure 3: Self-locking cantilever and annular snap-fit joints (fab.cba.mit.edu)

Methodology

Step 1 — Ideas and Design Brief

Find needs to be filled

Step 2 — Task Clarification Phase

Choose one need and begin developing ideas to solve the problem

Step 3 — Concept Development

Create multiple "concepts"—designs that could be used to solve the problem
Select one

Step 4 — Detailed Design Phase

Begin modelling design and adding specific details
Dimensions, methods to create features, etc.

Step 5 — Manufacturing/3D Printing

Produce first prototype using specified guidelines
Material, supports, layer height, extrusion rate, infill percentage, shell thickness, heat of nozzle/print bed, etc.

Step 6 — Revision of Design

Fix portions of design that fail in real life, repeat manufacturing

Step 7 — Post-processing

Remove support structures, smooth edges of print, add aesthetic features

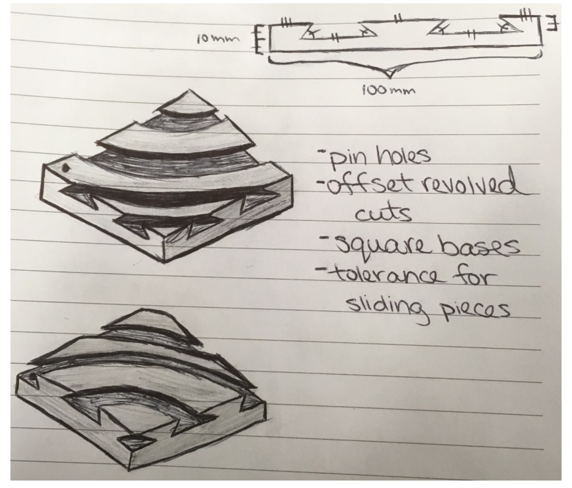

Figure 4: Sketch of First 3D Model
Idea 11, Concept 21

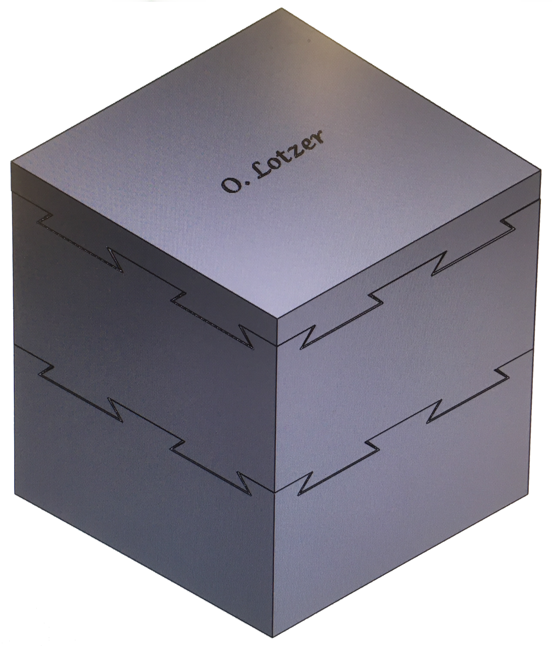

Figure 5: Collapsed View of 3D Model
Pieces 3, 19, 20, 31, 36. Assembly 15

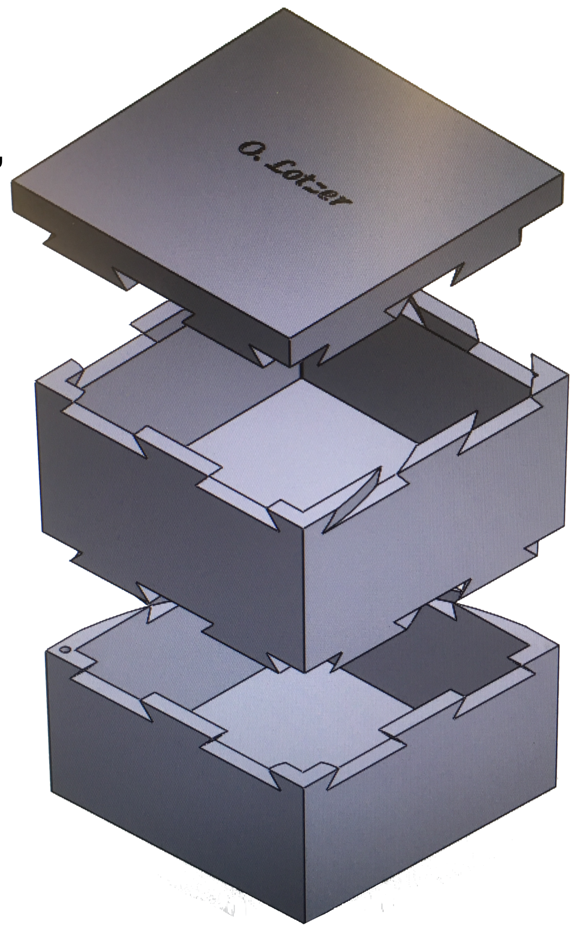

Figure 6: Exploded View of 3D Model

Progress and Results

- 3D model complete
- First prototype printed
- Post-processing in progress

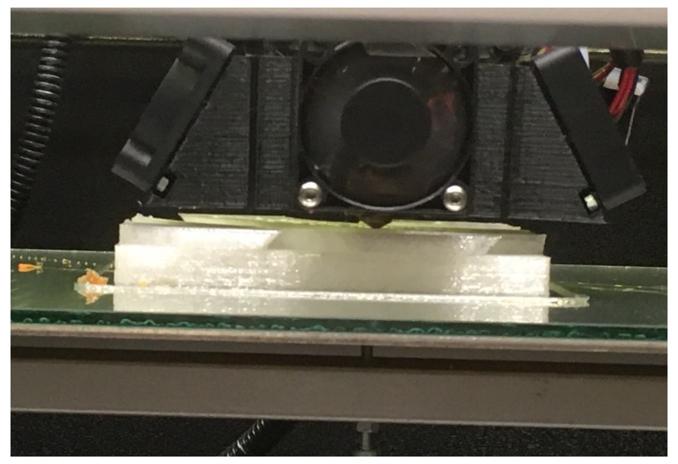

Figure 7: Prototype 1 during 3D printing

- Steps 1-5 complete
- Self-locking system to be printed at increased scale in further prototypes so that pieces are large enough to print precisely

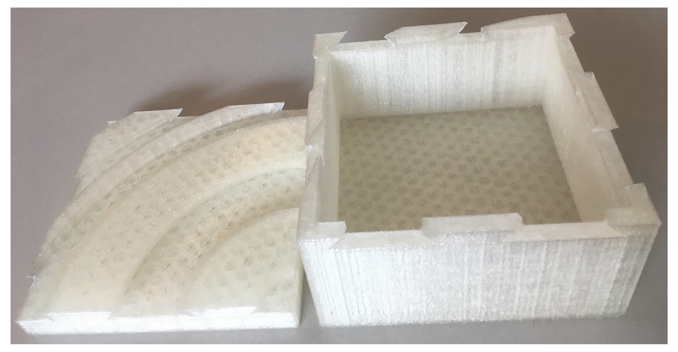

Figure 8: Pieces 3D printed for Prototype 1

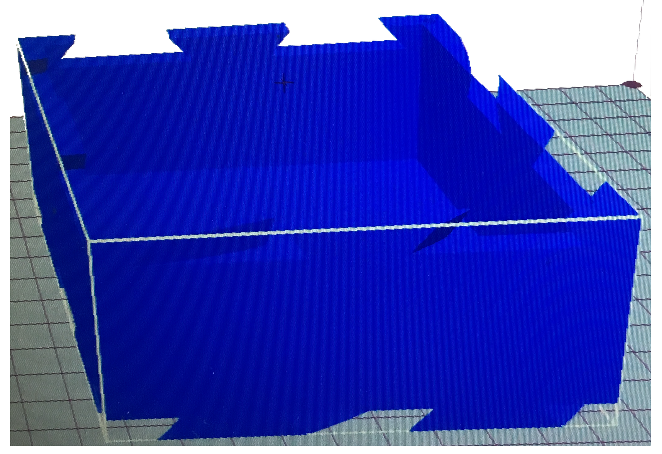

Figure 9: Sliced file of second print

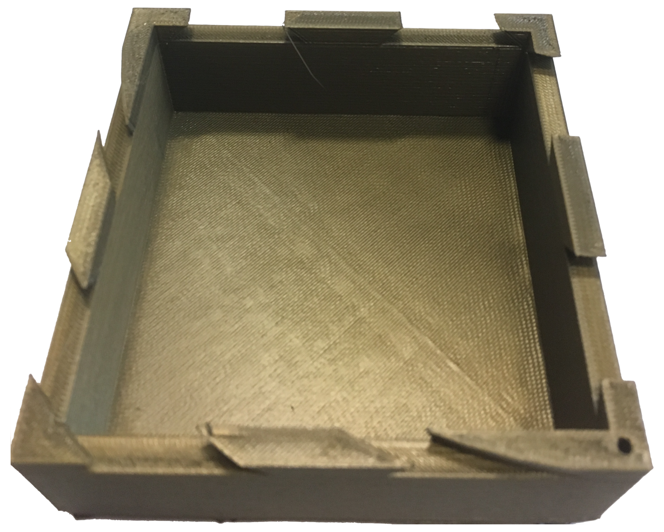

Figure 10: First print of middle piece

Future Research

- Testing optimal print settings for specific outcomes
- Improve upon self-locking system used
- Discover new reconfigurability patterns
- Redesign model for improved manufacturing, assembly, and disassembly

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