Beta Prototype and Test Plan

Module 4B Importance of the Manufacturing Process

Motivation

Why is this module important?

- A prototype for evaluation by external users (including clients) is very different from a prototype for internal evaluation and product-development purposes
- Selecting inadequate manufacturing processes for the beta prototype used for external evaluation can result in conveying the wrong message to the client regarding whether the final product will meet their requirements

Module Outline

- Learning objectives
- Manufacturing process alternatives
  - —Factors that drive process selection
  - —Pros and cons of each process alternative
  - —Cost analysis guideline
- Rapid prototyping for accelerating the development of prototypes
- Case study of accelerating prototype development

Learning Objectives

- LO1. Interpret the manufacturing needs to ensure the accuracy of the finished product

Manufacturing Processes

Reminder

Factors that drive manufacturing process selection:

- Volume: how many prototypes are needed?
- Cost: costs associated with each process alternative
- Lead time: how long will it take to produce the prototype using each process alternative?

See Module 3C for more details on manufacturing processes

Manufacturing Processes

Comparison

Process Alternative	Pro's	Con's
Manual/skilled craftsman	• Very flexible • Typically high quality prototype • Direct communication between producer and designer	• High labor cost • Expensive to reflect design changes
Material removal processes (CNC)	• Tight tolerances • Inexpensive tooling	• Time investment in process plans • Limited geometric freedom • Not suitable for highly intricate parts or internal features
Material deformation processes (Injection molding)	• Suitable for high volumes • Tight tolerances	• Extremely expensive tooling • Not necessarily suitable for multiple design iterations or product development
Rapid prototyping processes (3D printing, additive manufacturing)	• No tooling cost (tool-less manufacturing) • Ease of design change • Reduced lead times • Arbitrary geometric freedom	• Limited choices of existing materials • Low part repeatability • Limited build envelopes and material deposition rates

Manufacturing Processes

Mindset for alpha versus beta prototype

- Producing an alpha prototype for internal assessment and product development is very different from producing a beta prototype for external assessment by the client or a third party
- In the alpha prototype stage, the focus is on quickly producing a prototype that can be used internally to provide input on design changes needed for the next iteration
- Consequently, selecting the manufacturing process for the beta prototype development stage requires a different mindset to develop selection criteria

In the beta prototype stage, more attention should be paid to details regarding:

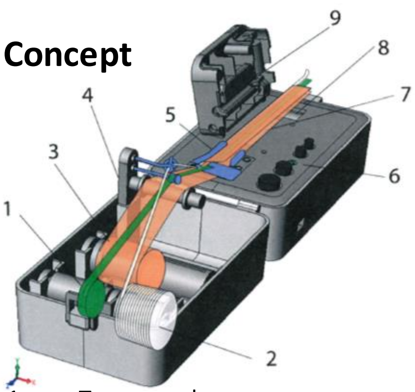
- Form and fit
- Function

Manufacturing Process

Example – Heat sealer for sewing industry

- Concept drawing to anticipate feature priority and part needs
- CAD for initial part design feasibility
- Several prototype for “works-like and “looks-like” testing
- Final production

Concept



1. Tape spool
2. Cord spool
3. Fabric spool
4. Guide feature
5. Front guide
6. Controls
7. Heating iron
8. Roller feeder
9. Magnetic clamp

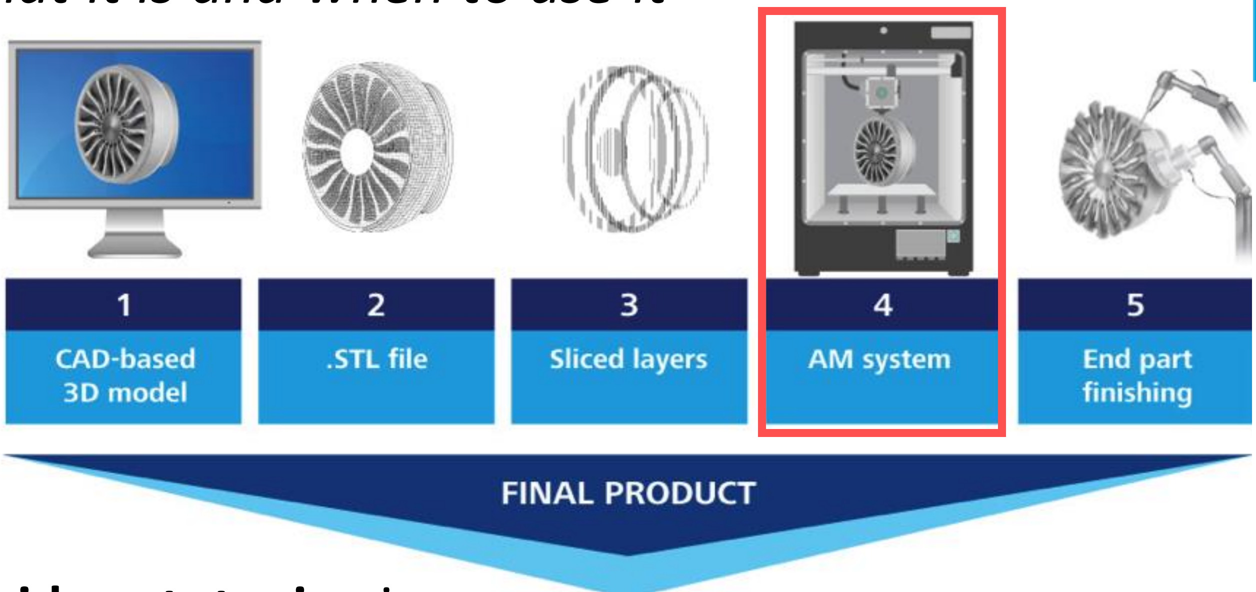
CAD

Rapid Prototype & Test

Final Production Product

Rapid Prototyping

What it is and when to use it



- **Rapid prototyping** is a method for reducing the time between the steps in the production of successive prototypes

- Major advantage: "Tool-less" manufacturing

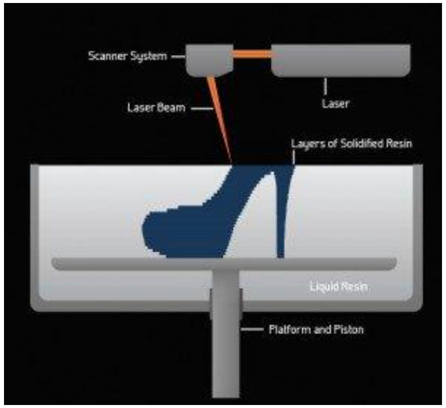
Rapid prototyping is a process that utilizes 3D printing and 'additive manufacturing' (AM) techniques (see red box)

Rapid Prototyping Processes

7 Key Methods

Stereolithography (SLA):

- Greatest material choice. Very high detail resolution. Single layer development process requires support struts that can be tricky to remove. Considered expensive but fast. Final part can be machined, used as a master mold.



Selective Laser Sintering (SLS):

- Thermoplastic material with comparable result to injection molding. Direct Metal Laser Sintering (DMLS) is the metal version but both use a “powder bed” process. No support struts but not as detailed as SLA and may require secondary machining. Part is not fully dense so will wear.

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Rapid Prototyping Processes

7 Key Methods (cont.)

Fused Deposition Modeling (FDM):

- Thermoforming filament is heated and passed through a nozzle to lay down successive layers. Machines are getting smaller and cheaper, with a variety of plastics. More than one kind of material can be printed during a single build. Too slow for large production runs but is ideal for rapid prototyping and very cost effective.

Multi Jet Modeling (MJM):

- A thermosetting polymer is used in an array of inkjet nozzles moving horizontally across the platform depositing a thin film for the 2D cross-sectional layer. Polymerization quickly solidifies the plastic in that layer, then the platform descends by one thickness and the process repeated.

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Rapid Prototyping Processes

7 Key Methods (cont.)

Selective Laser Melting (SLM):

- Create metal parts with a high powered laser used to weld and not merely sintered, producing a part that is fully dense.
- The build takes place inside a sealed chamber filled with an inert gas such as argon. This process is becoming more popular not only for rapid prototyping but also low volume production.
- It lends itself very well to complex engineering designs which have hidden pockets, conformal cooling channels and other internal features which can decrease the weight while increasing strength for demanding applications in aerospace, automotive, medical and other fields.

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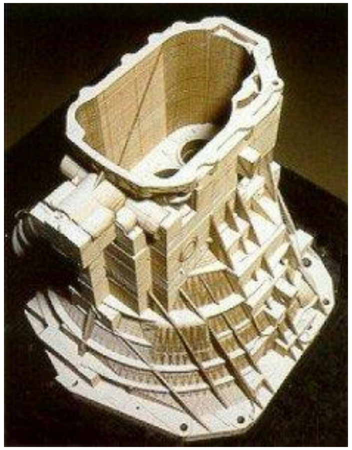
Rapid Prototyping Processes

7 Key Methods (cont.)

- **Laminated Object Manufacturing (LOM)**:
- A series of thin laminates layers are laid out on a build platform. The laminates can be paper, plastic sheet ormetal foil. A computer controlled laser cuts away material. The platform then drops by the thickness of one layer, a new laminate is glued on top and the process continues.



- This stacking process makes a finished part which is less sophisticated than a SLS or SLM equivalent, but it is cheaper and does not require especially controlled working conditions. Also, if paper is used as the laminate the finished part will be similar to solid wood and can be worked accordingly.

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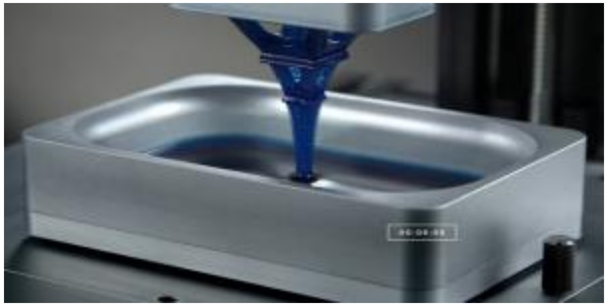
Rapid Prototyping Processes

7 Key Methods (cont.)

- **Digital Light Processing (DLP)**:
- Another variation on the polymerization of a curable resin, this process is very similar to SLA printing. It cures the resin with a more conventional light source, but it also requires support structures and post-build curing.



- The process is generally faster and a more shallow reservoir of photoresin can be used which also saves on cost. Like with SLA, the finished part has excellent dimensional tolerances and surface finish.