universitas
MALIKUSSALEH
The Blessing University

RAPID PROTOTYPING

Dr. M. Sayuti, ST.,M.Sc

JURUSAN TEKNIK INDUSTRI
FAKULTAS TEKNIK – UNIVERSITAS MALIKUSSALEH

2016

By *Dr. M. Sayuti, ST.,M.Sc*

CONTENTS

- OVERVIEW
- INTRODUCTION
- CLASSIFICATION
- METHODOLOGY
- TYPES OF RP
- APPLICATION
- PRODUCT EXAMPLE

Prototyping

- Prototyping or model making is one of the important steps to finalize a product design. It helps in conceptualization of a design.
- Before the start of full production, a prototype is usually fabricated and tested.
- Manual prototyping by a skilled craftsman has been an age-old practice for many centuries.
- Second phase of prototyping started around mid-1970s, when a soft prototype modeled by 3D curves, simulated and tested with exact material from other properties.
- The latest trend of prototyping, i.e., Rapid Prototyping (RP) layer-by-layer material deposition, started during early 1980s with the enormous growth in Computer Aided Design and Manufacturing (CAD/CAM) technologies.

By *Dr. M. Sayuti, ST.,M.Sc*

INTRODUCTION

What is Rapid Prototyping?

- The term rapid prototyping (RP) refers to a class of technologies that can automatically construct physical models from Computer-Aided Design (CAD) data.
- RP- can be defined as a group of techniques used to quickly fabricate a scale model of a part or assembly using three-dimensional CAD data.
- This CAD data may be generated by 3D CAD Modelers, CT and MRI scan data or model data created by 3D digitizing systems.
- RP - one of the fastest growing new technologies since its introduction in 1986.

Why Rapid Prototyping?

- To increase effective communication
- To decrease development time
- To decrease costly mistakes
- To minimize sustaining engineering changes
- Visualization of complex shapes not easily seen or understood on conventional drawings
- Allow design engineers to verify the form, fit, and function of a particular object

Classification of RP

Additive

Subtractive

What is Additive RP

- In additive prototyping, the machine reads data from a CAD drawing, and lays down layers of liquid plastic, powdered plastic or some other engineering material, and builds up the model from a long series of cross sections.
- These layers glued together or fused (often using a laser) automatically to create the final shape.
- Because RP technologies are being increasingly used in non-prototyping applications, such systems are also known by the general names
  - freeform fabrication (FFF)
  - solid freeform fabrication (SFF)
  - layered manufacturing.

Subtractive RP

- Subtractive: the machine starts out with a block of plastic or wax and uses a delicate cutting tool to carve away material, layer by layer to match the digital object.
- The subtractive method is older and less efficient.
- Similar to a computer numerical control (CNC) device such as a lathe or a milling machine.
- Complex shapes and forms with undercuts are more difficult to accomplish with the subtractive method

Limitations of RP

- What are the limitations?
- RP systems can't yet produce parts:
  - in a wide enough range of materials,
  - at a fast enough rate,
  - to match anywhere near the entire spectrum of requirements of industry and science.

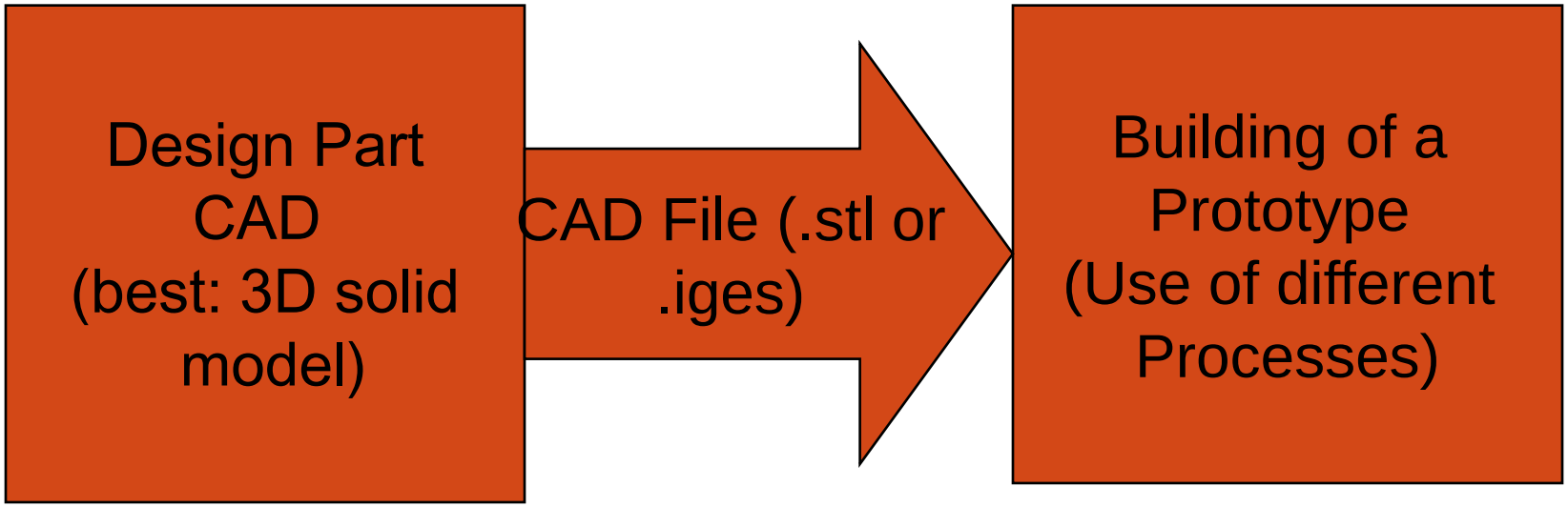
Methodology of RP

5 Basics Steps:

- Create a CAD model of the design
- Convert the CAD model to STL format
- Slice the STL file into thin cross-sectional layers
- Construct the model one layer atop another
- Clean and finish the model

CAD for RP

The first step in the Rapid Prototyping process is nearly identical for all of the various systems, this involves generating a 3-dimensional CAD model of the object.

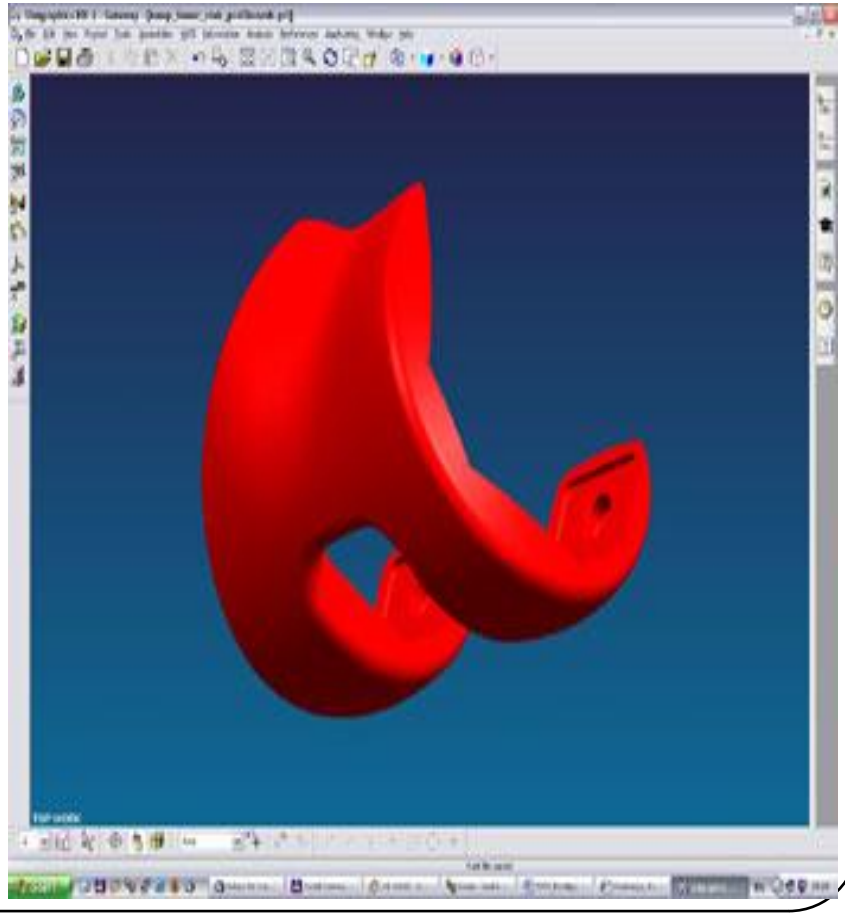


Create a CAD of Model Design

- Object must be a skin or solid
- STL (stereolithography files)
  - triangles connected at vertices
- SLC (Stereolithography contour files)
  - successive cross-sections taken at ascending Z direction intervals

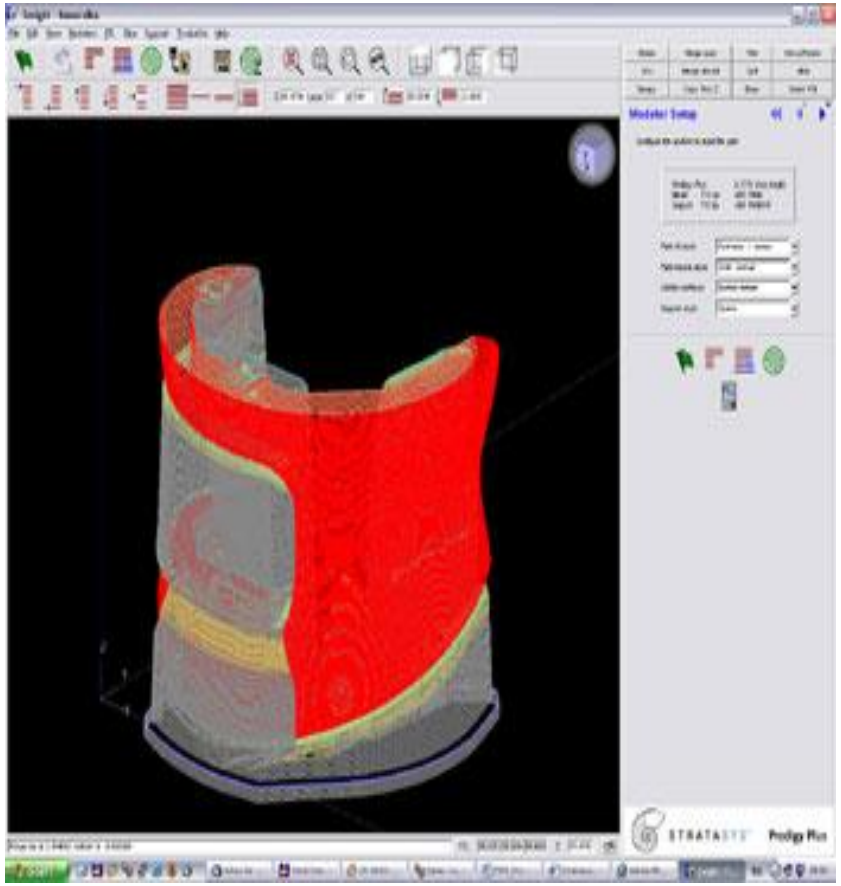
Example - CAD model of the knee replacement femoral component

- First, a computer model is created by means of Unigraphics - the CAD software package.
- The model is fully parametric; therefore it is possible to work with the model geometry in order to optimize the model and fulfill new requirements.



Example - CAD model of the knee replacement femoral component (cont.)

- Next, the CAD model is exported as STL data.
- The RP model is prepared by means of Insight software, which was provided with Prodigy Plus. The STL model is sliced into horizontal layers.
- Then the support structures and extrusion head trajectories are generated.



Example - CAD model of the knee replacement femoral component (cont.)

- As a result of working with Insight software, a file containing the control code for Prodigy Plus is obtained.
- Then Prodigy Plus, following through the control code, builds the RP model without any operator intervention

Prototype parts

Example - CAD model of the knee replacement femoral component (cont.)

- The RP model made of ABS thermoplastic is molded into silicon rubber and the tool obtained in this way is used to produce ceramic semi products by the cold isostatic pressing method

Final Product

Types of RP Systems

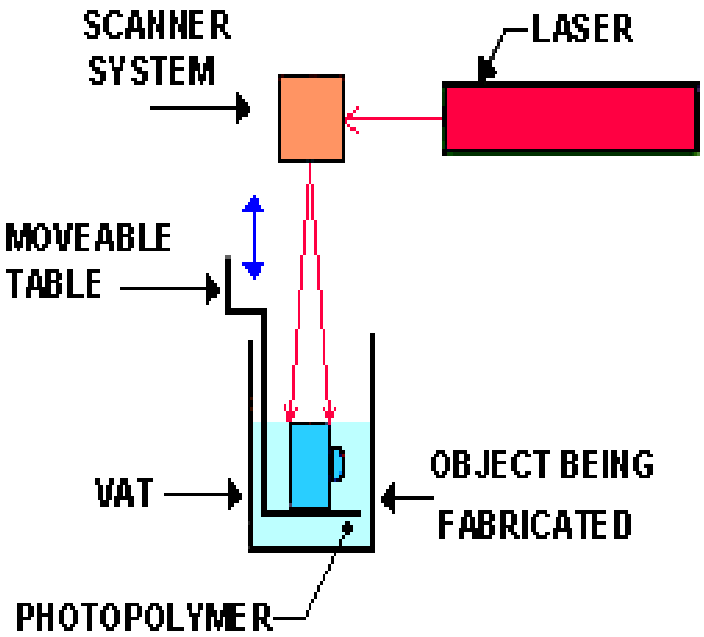
- Stereolithography (SLA)
- Fused Deposition Modeling (FDM)
- Three Dimensional Printing (3DP)
- Selective Laser Sintering (SLS)
- Laminated Object Manufacturing (LOM)
- Inkjet Systems (IJS)

Stereolithography (SLA)

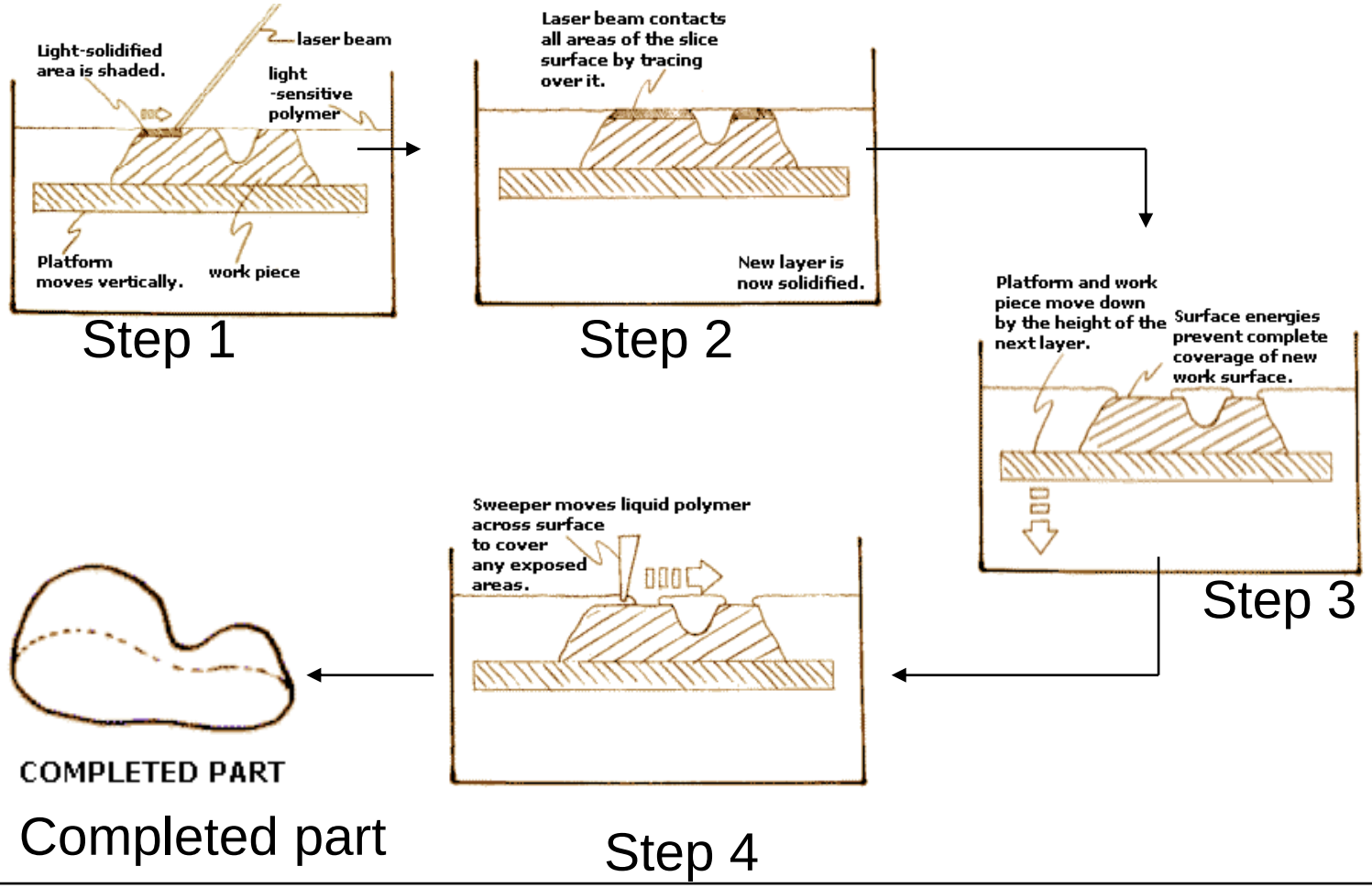
- A layered manufacturing method that utilizes a photo-curable liquid resin in combination with an ultraviolet laser
- Most widely used rapid manufacturing and rapid prototyping technologies

How SLA works?

1. SLA involves building of objects a layer at a time.
2. By tracing laser beam on surface of liquid photopolymer.
3. The photopolymer is solidified by the laser light.
4. Once each layer is completely traced, it is lowered exactly one layers thickness allowing fresh polymer to flow in.
5. Self-adhesive material property bonds it to one another
6. Eventually form a complete 3D object.
7. A complete 3D model is formed by combining many layers.

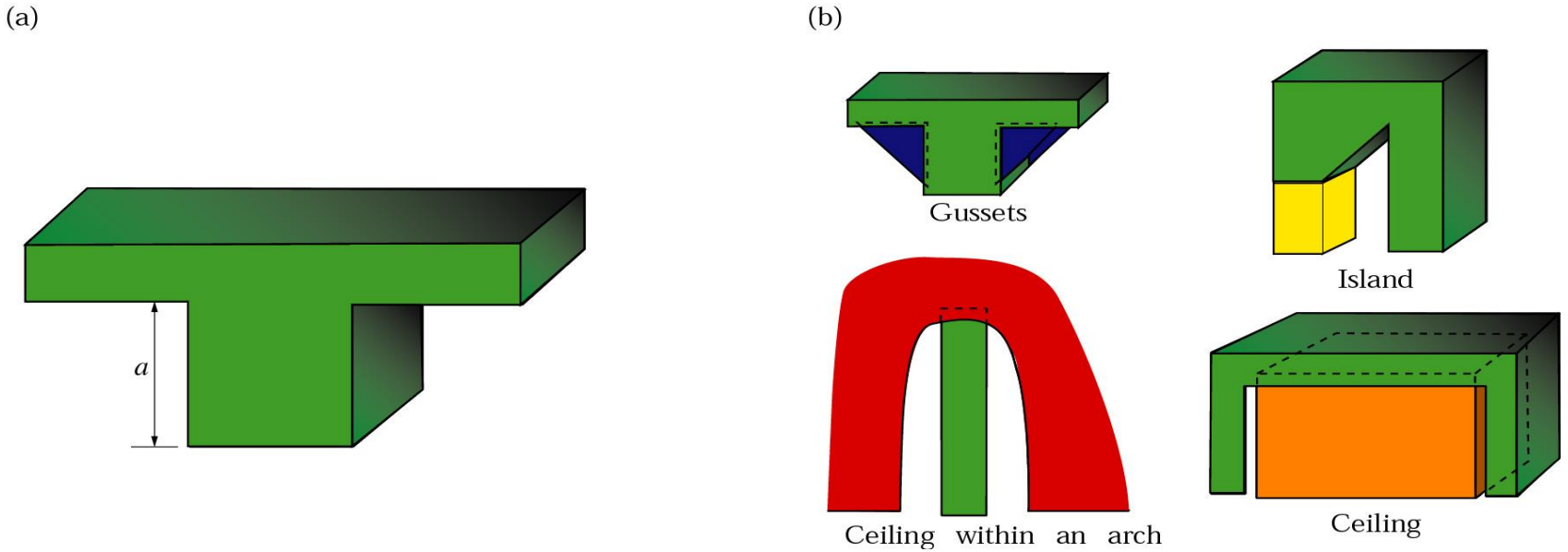


Schematic Diagram of SLA



Stereolithography (SLA)

- Why support is necessary?
- During fabrication, support is required if extremities of the part becomes too weak.



Stereolithography (SLA)

- Advantage
  - Capable of produce extremely accurate parts with very good surface finish.
  - Suitable for a wide range of applications, from form and fit to actual testing
  - Repeatability

- Drawback / Limitation
  - Capital investment
  - Cannot be installed in a typical office environment (handling liquid polymers)
  - require manual processes for removal

Stereolithography (SLA)

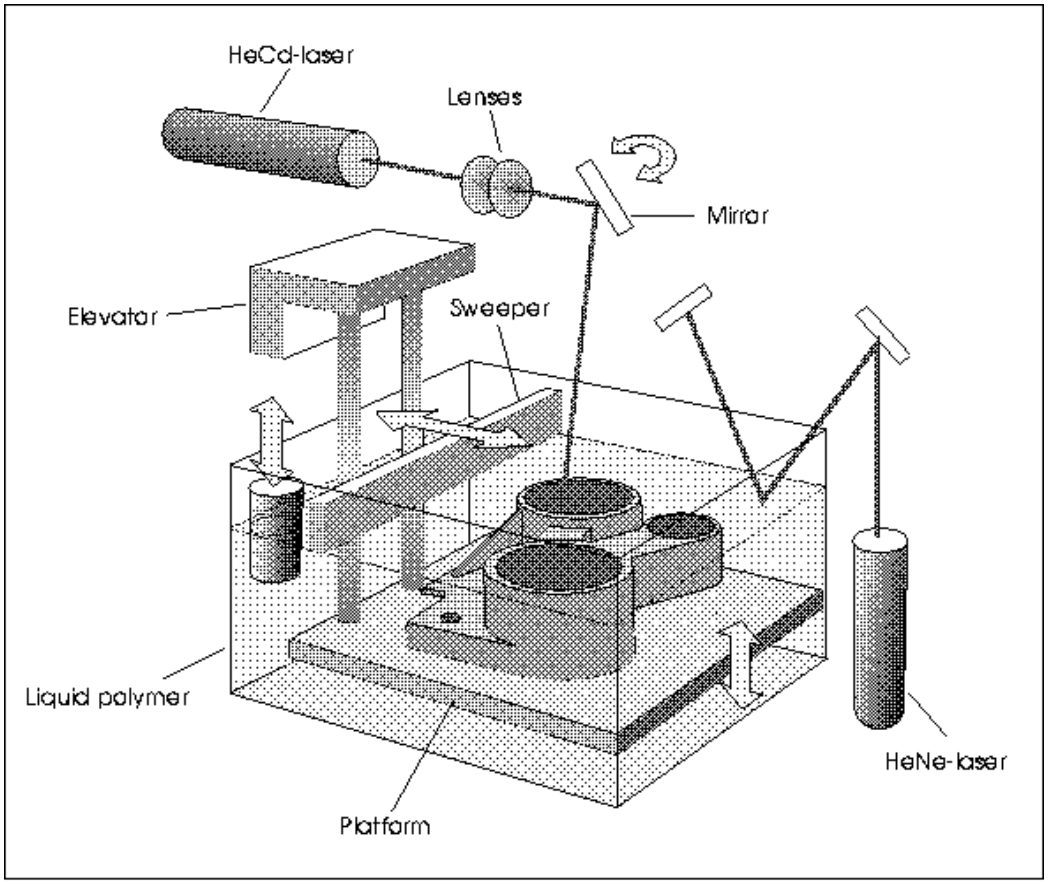


FIGURE 1. A schematic drawing of an SLA.

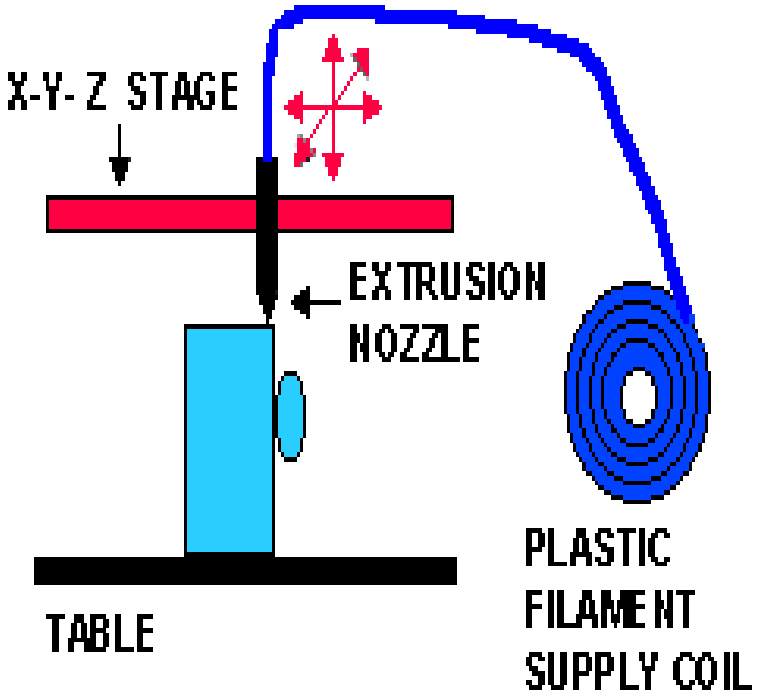
VIEW MOVIE

Fused Deposition Modeling (FDM)

- A layered manufacturing method that extrudes a thin bead of plastic, one layer at a time.
- Works on an "additive" principle by laying down material in layers
- Second most widely used RP technology, after stereolithography.
- Favored technology for prototyping plastic parts requiring strength

Fused Deposition Modeling (FDM)

1. Plastic filament supplies material to an extrusion nozzle
2. Heated nozzle melts the plastic
3. Deposits thin bead of extruded plastic as the nozzle is moved over the required geometry
4. Plastic hardens and bonds to the layer below
5. The entire system in chamber kept at temperature just below Tm of plastic.



Fused Deposition Modeling (FDM)

- Variety of nontoxic materials exist like wax, ABS and other types of elastomers.
- Acrylonitrile, Butadiene and Styrene.
- Polysulfone/ polycarbonate
- Custom colors are available.
- FDM = office-friendly/ quiet/ fast for tall, thin small parts/ slow for wide parts

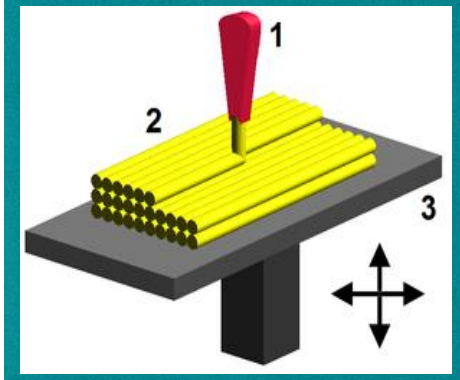
Fused Deposition Modeling (FDM)

- High accuracy
- Functional parts
- High quality parts with the finest details
- Water-soluble support structure
- Production materials
- Durable parts with great stability
- No post curing is required
- functional snap fit parts without the need of secondary processes

Fused Deposition Modeling (FDM)

- Advantages:
  - Operates unattended
  - Accommodates several users
  - Durable, functional, low cost materials
  - Capability to build hollow or honeycombed parts
- Limitations:
  - Small size of prototype parts and models
  - Limited material selection
  - Low dimensional accuracy/poor surface finish
  - Slow build speed

The FDM Extrusion Head



VIEW VIDEO

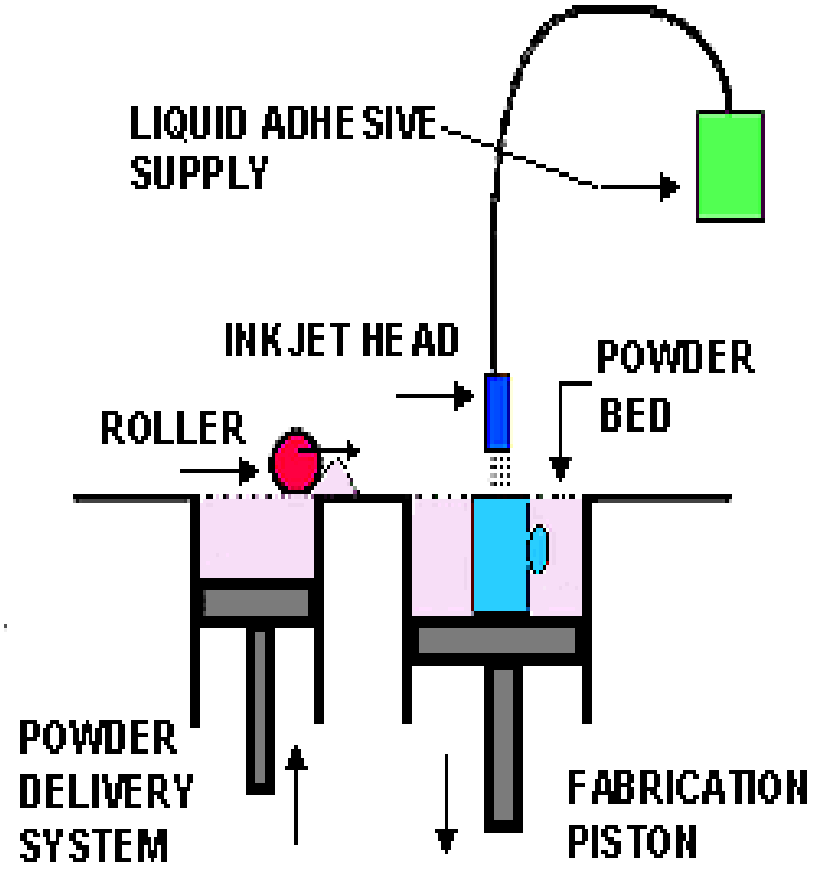
3-D Printing

- A rapid prototyping process developed at the Massachusetts Institute of Technology (MIT).
- Layers of powder are bonded by inkjet to form a part
- They are no larger than a photocopier, run just as cleanly and quietly.
- 3-D Printer 'prints' cross-sections of a model on a bed of plaster dust, using a sugar-water binding agent instead of ink.
- Advantages over other rapid prototyping techniques:
  - the machines have lower purchasing costs
  - parts are cheaper to construct

By *Dr. M. Sayuti, ST.,M.Sc*

How 3-D Printing works?

1. The 3D Printer spreads a thin layer of powder.
2. An ink-jet print head prints a binder in the cross-section of the part being created.
3. Build piston drops down, making room for the next layer, and the process is repeated.
4. Once the part is finished, it is surrounded and supported by loose powder, which is then shaken loose from the finished part.



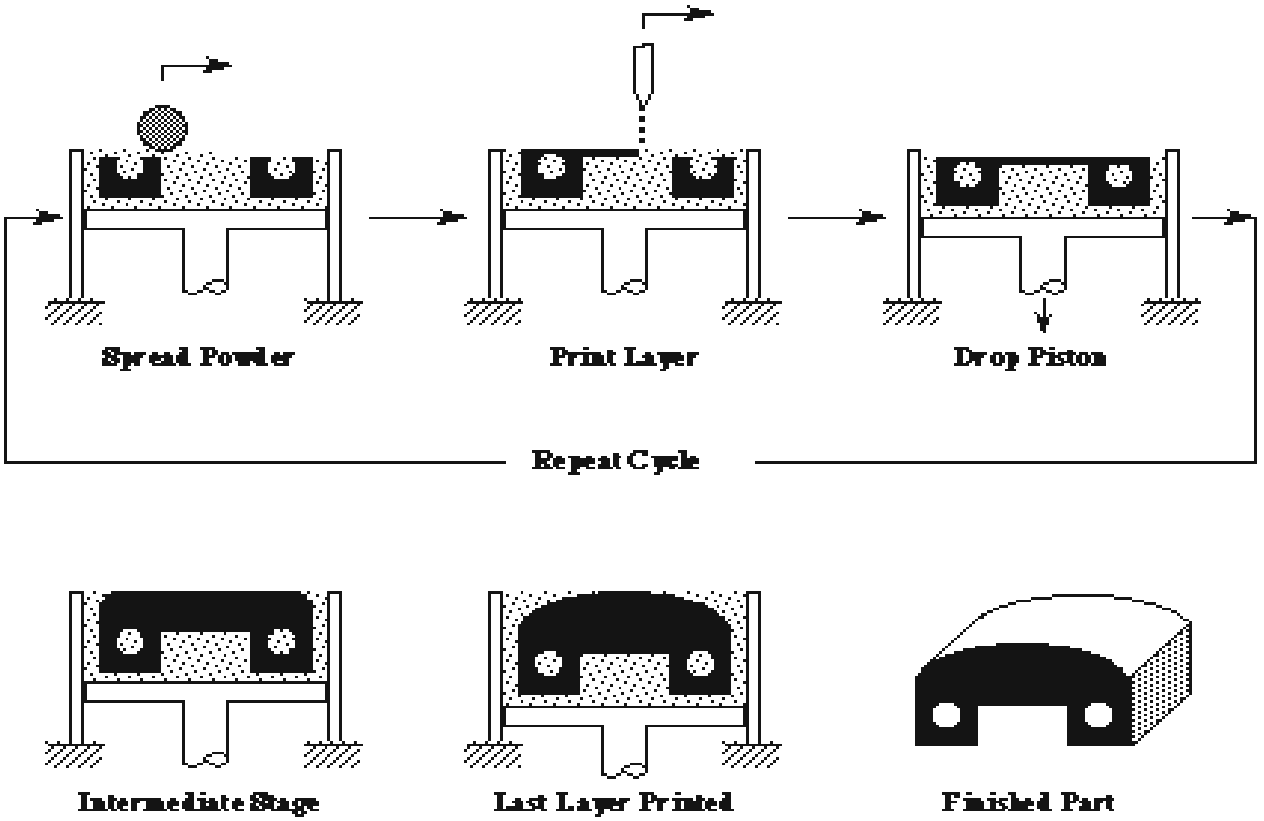
3-D Printing

- no external supports required
- speedy fabrication and low materials cost
- used as a direct manufacturing process and RP
- recently color output is available

3-D Printing

- Limitation
  - Models constructed using the 3D printer method are weak and can easily be damaged and distorted
  - Resolution and surface finish, and also available materials – depending on fine powder.

3-D Printing


Spread Powder
Print Layer
Drop Piston
Repeat Cycle
Intermediate Stage
Last Layer Printed
Finished Part

VIEW MOVIE

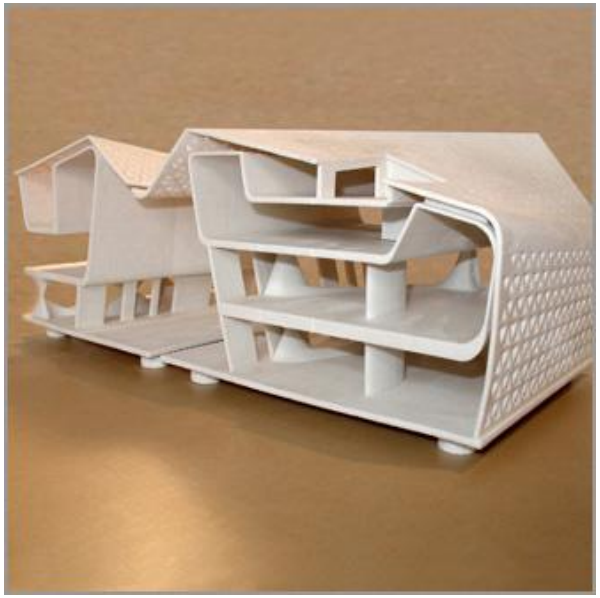
PEOPLE CHOOSE FOR RP?

Color variations.

Including white, which is the most frequently used colour, ABS comes in eight material colours. The colour options include blue, yellow, orange, red, green, black and grey. The medical grade ABSi offers translucency for applications such as automotive light lenses in clear, red or yellow.

Property Stability - FDM

- Unlike SLA and PolyJet resins, the material properties of the FDM materials do not change with time or environmental exposure. Just like their injection moulded counterparts, these materials retain their strength, toughness and colour in nearly any environment.



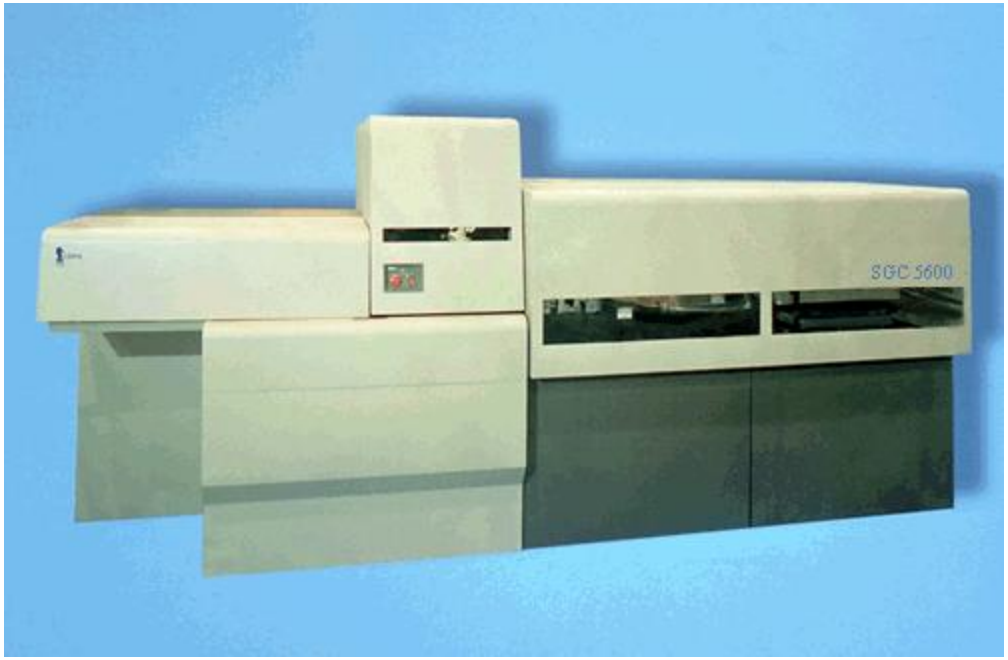
Current RP

- Object sizes range from microscopic to entire buildings.
- Materials range from paper and plastics, to metals and ceramics.
- Applications range from toys to aerospace and advanced medicine.

Examples of RP system

1. FDM® (fused deposition modeling) is a rapid prototyping process patented by

Examples of RP system



The SGC 5600, Cubital's Rapid Prototyping System.

Example prototype products of RP

Paintball mask by selective laser sintering (SLS)

A surgical planning model using fused deposition modeling (FDM)

THANK YOU