M.Tech
Digital Manufacturing

BITS Pilani
Pilani Campus

Jayakrishnan J
Guest Faculty

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DMZG521- Design for Additive Manufacturing
Session 14 & Lecture 27-28

Difference in AM technologies

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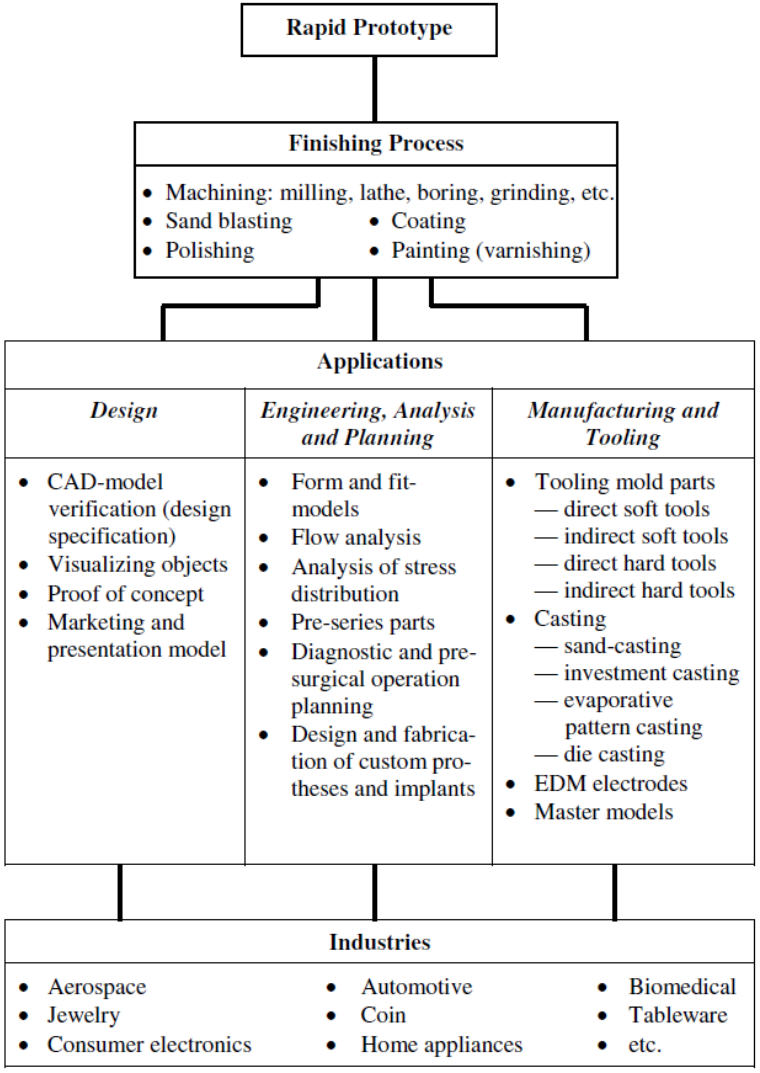
- Cost
- Range of materials
- Maintenance
- Speed
- Versatility
- Layer thickness
- Accuracy

Application Areas of AM



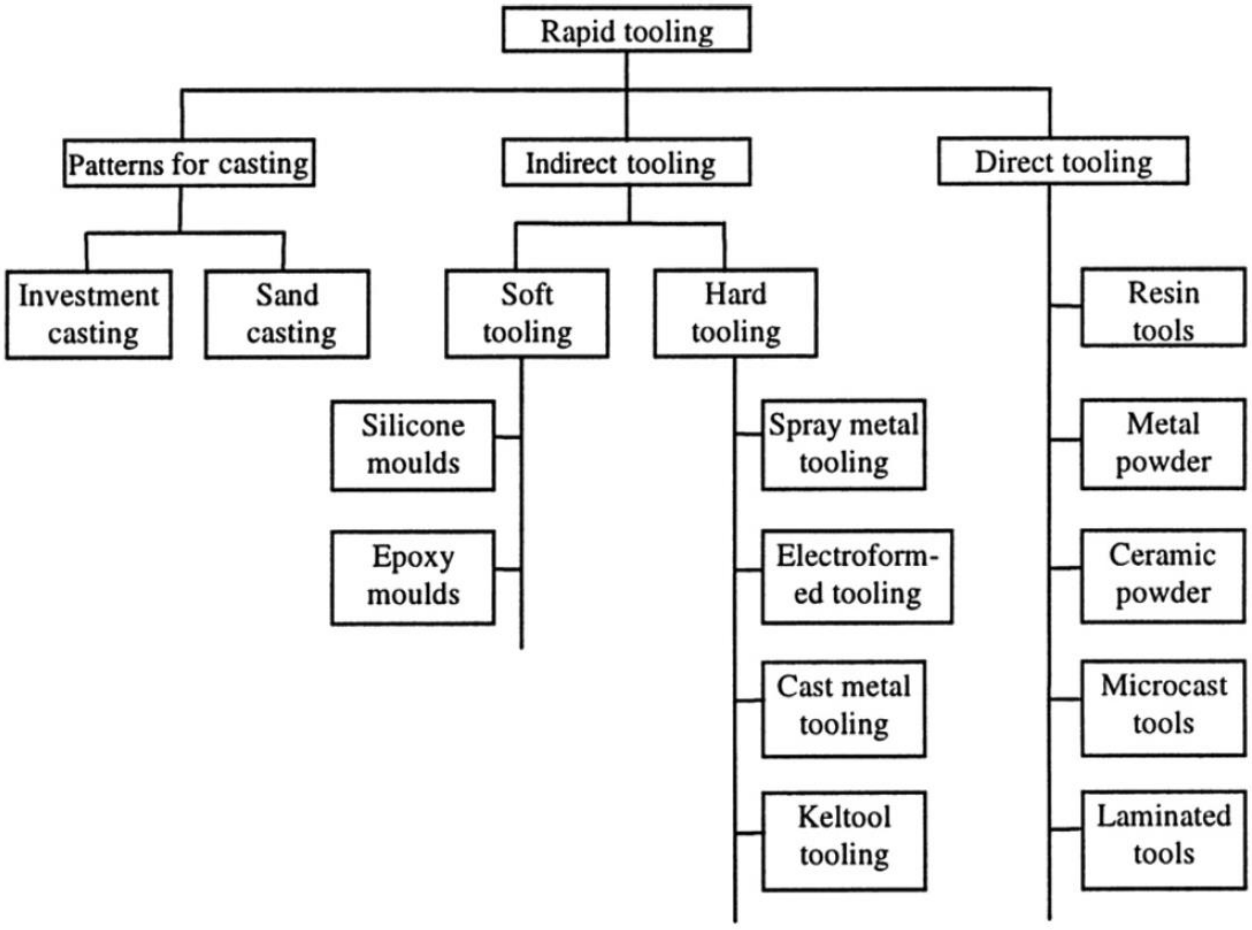
Application in Design

- CAD model verification
- Visualizing Objects
- Proof of concept
- Marketing and commercial application

Application in Engineering, Analysis and Planning

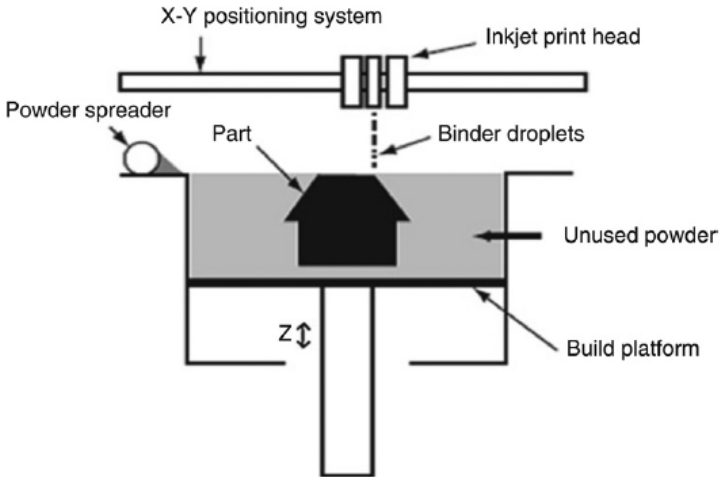
- Scaling
- Form and Fit
- Flow analysis
- Stress analysis
- Mock-up parts
- Pre-production parts
- Diagnostics and surgical operation planning
- Design and Fabrication of Custom Prosthesis and Implant

Applications in Manufacturing and Tooling

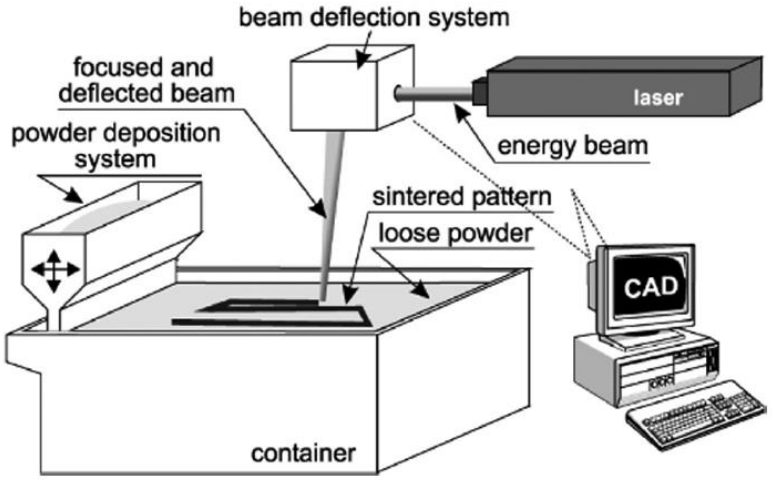


Rapid tooling

- Tool fabrication techniques that use layer wise Rapid Prototyping technologies - directly or indirectly.



Binder Jetting



Selective Laser Sintering

Tooling accuracy

- Accuracy: Difference in dimensions between the molded part and the original CAD file
- Aspects of Accuracy
  - General accuracy
  - Accuracy across the parting line
  - Registration accuracy

Factors Affecting Accuracy

- Pattern Accuracy
  Accuracy of Finishing Process
- Shrink
  - Amount of Shrink to be Compensated
  - Number of Shrinks to be Accounted For
    - Plastic Shrink
    - Tooling Material Shrink
    - Intermediate Material Shrink

Factors Affecting Accuracy

- Phase Changes
  - Opportunities for Warpage and Distortion
- Number of Reverses
  - Losses in Accuracy with Each Reverse
  - Parting Line Mismatch
- Coefficient of Expansion
  - Mold May be Run at Different Temperature than it was Built

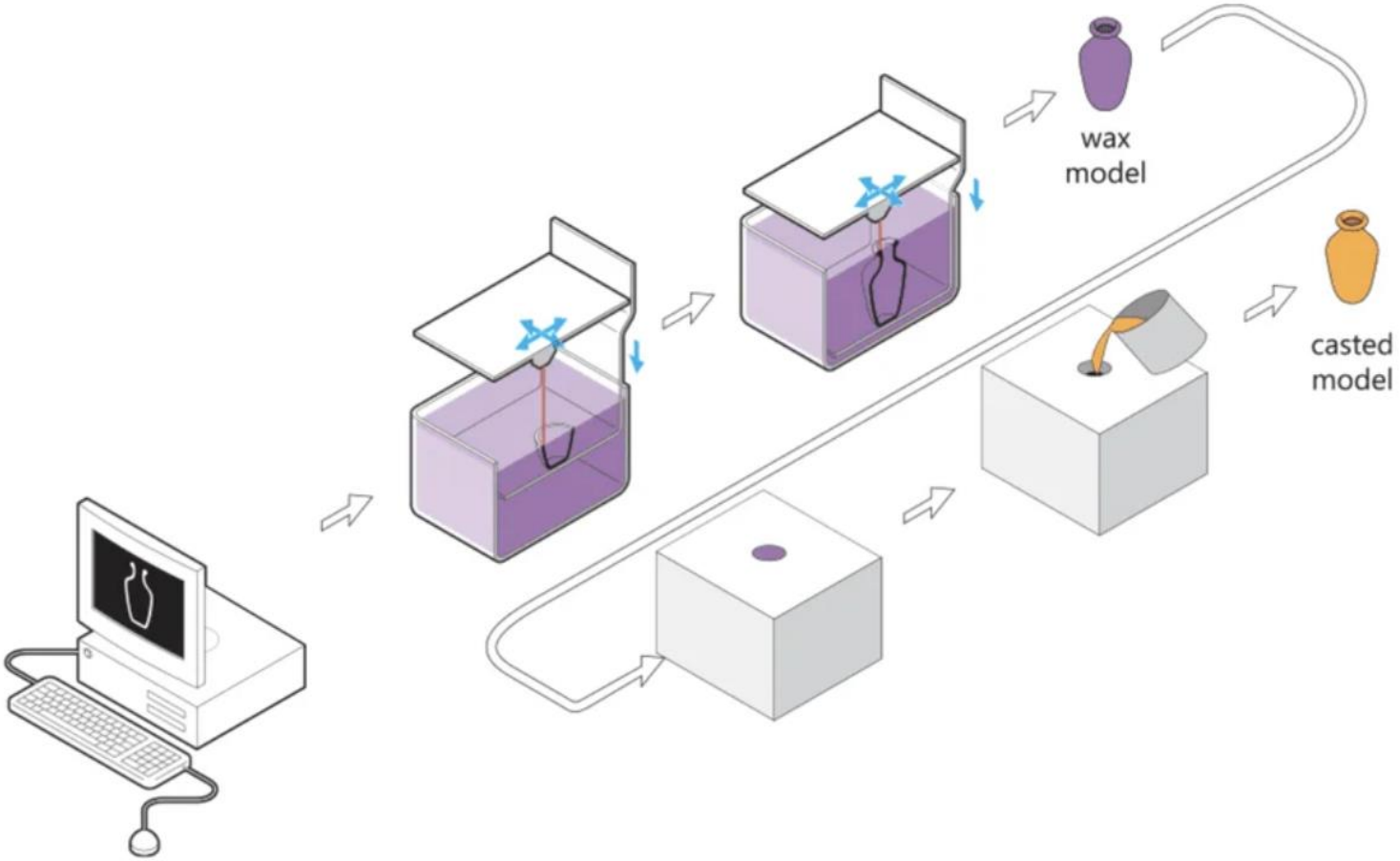
Factors Affecting Durability

- Strength of Surface Material
- Abrasion Resistance of Surface Material
- Strength of Backing Material
- Differential Rate of Expansion between Face Material and Backing Material

Investment Casting

- Ceramic slurry Prepared
- Pattern dipped and dried in the ceramic slurry, repeatedly
- Burn out the pattern; leave ceramic casting shell
- Cast molten metal
- Smooth finish, machine

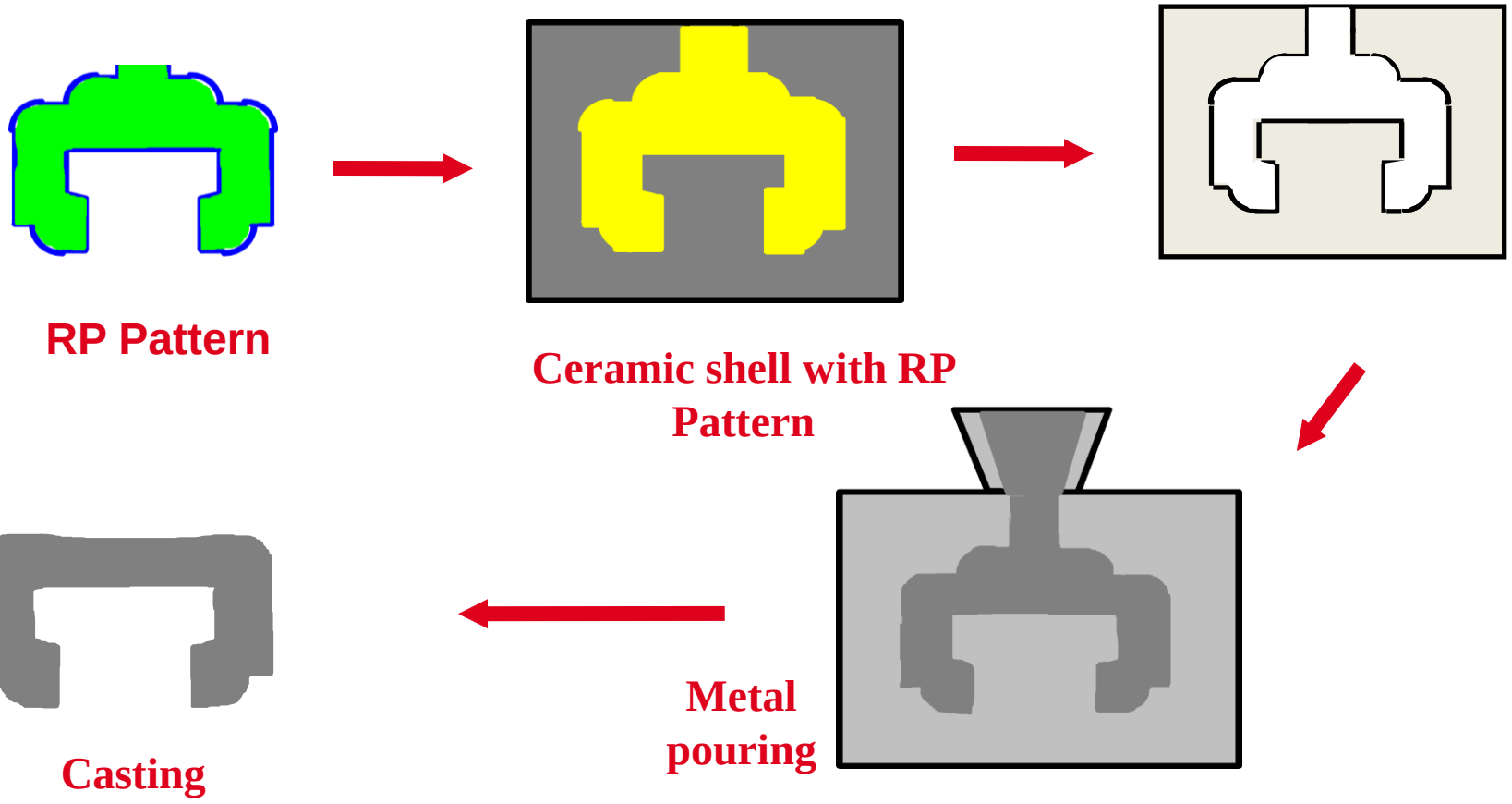
Schematic of wax 3D printing



Source: materialise.com

Multiple Functional Metal Components

- Investment Casting



Investment Casting- Case Study

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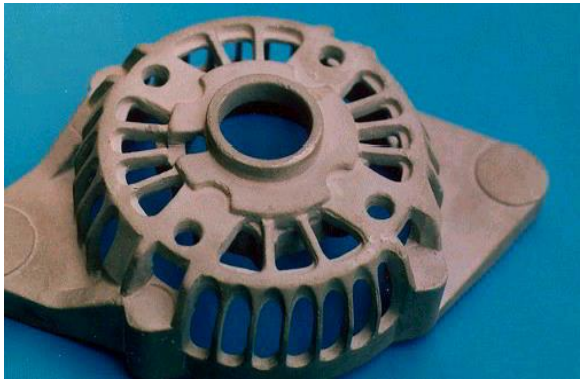
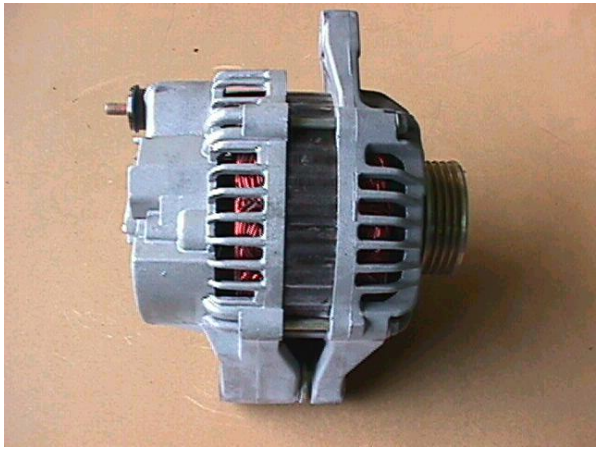
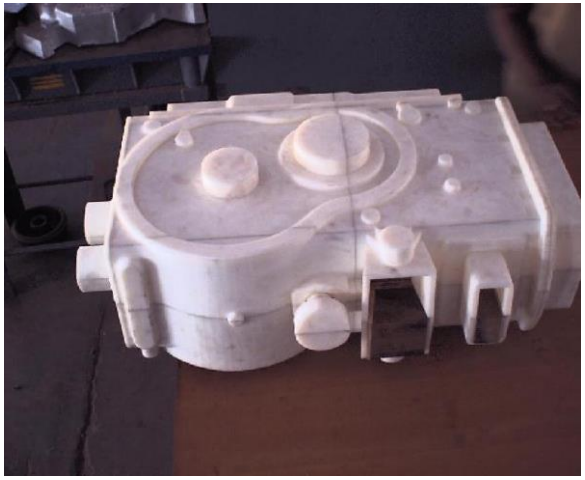
- A completely working alternator for live testing, too time consuming with machining.
- Masters of the housings were created and Investment casted in less than a week



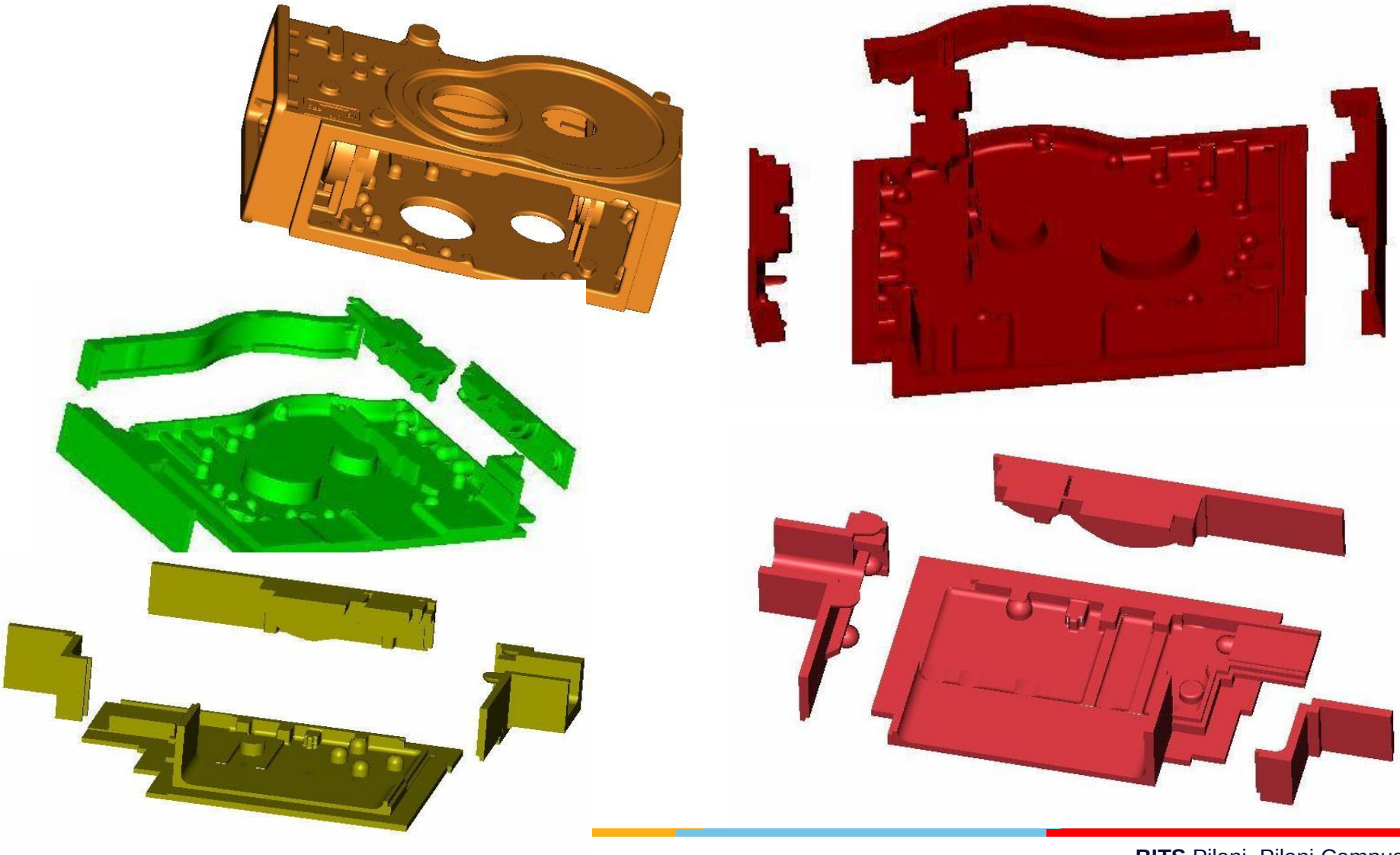


Process used by Tractor Manufacturer for Prototyping of Transmission Housing

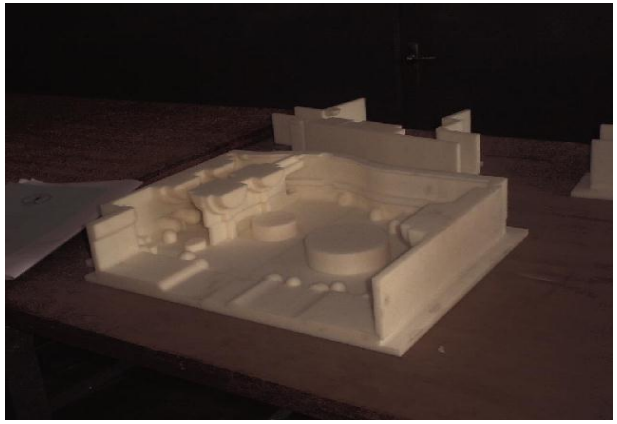
- Convert CAD design to Casting geometry
- Design core boxes in CAD
- Prototype ABS patterns and core boxes in the RP system
- Back the pattern with suitable material
- Sand Casting (normal green sand process) in material of choice.

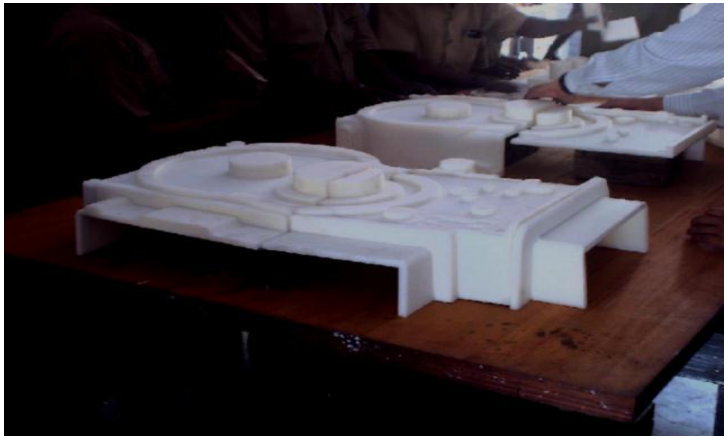


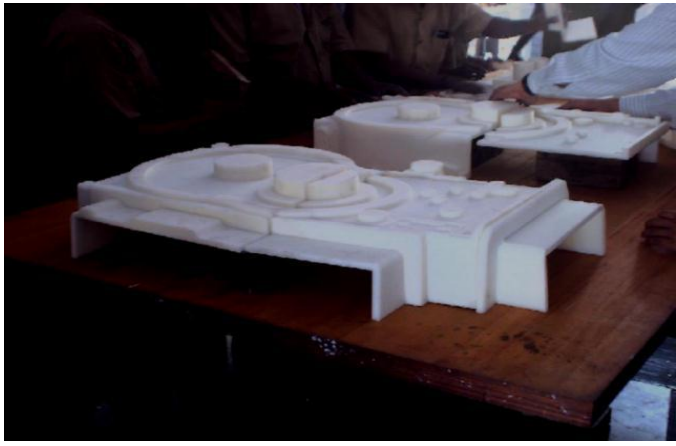
Extraction of Core Boxes using CAD System



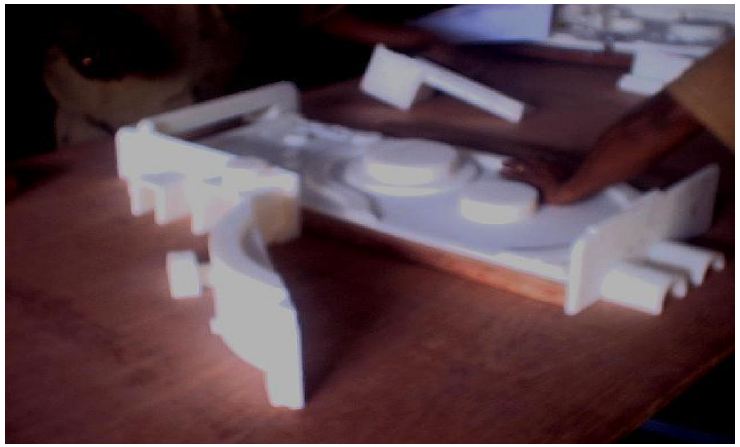
Joining of printed parts

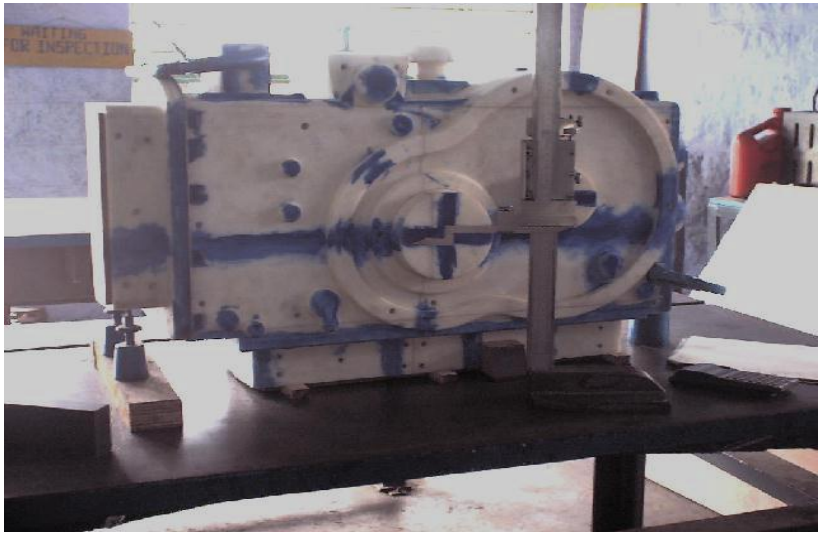


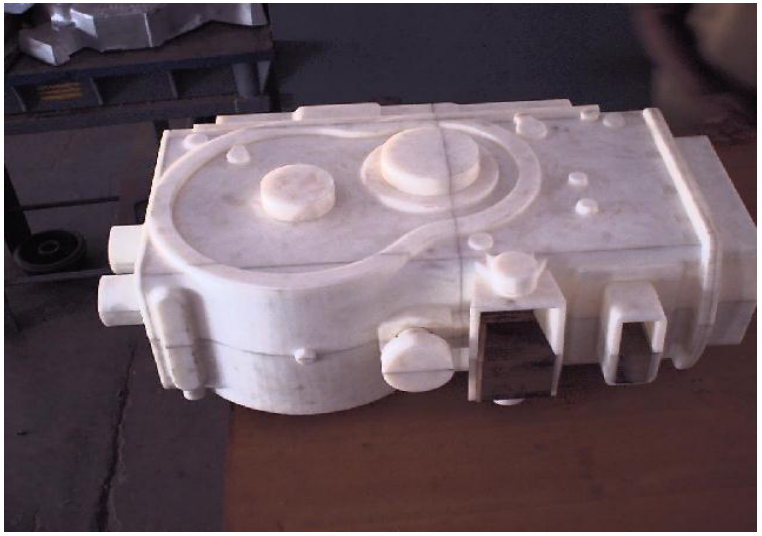




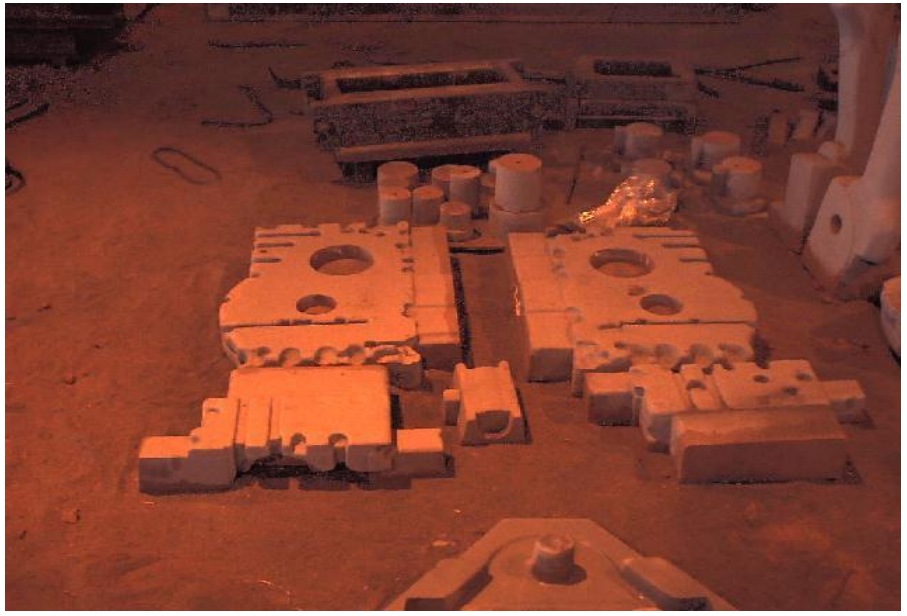
Backing-up of Patterns with Wood





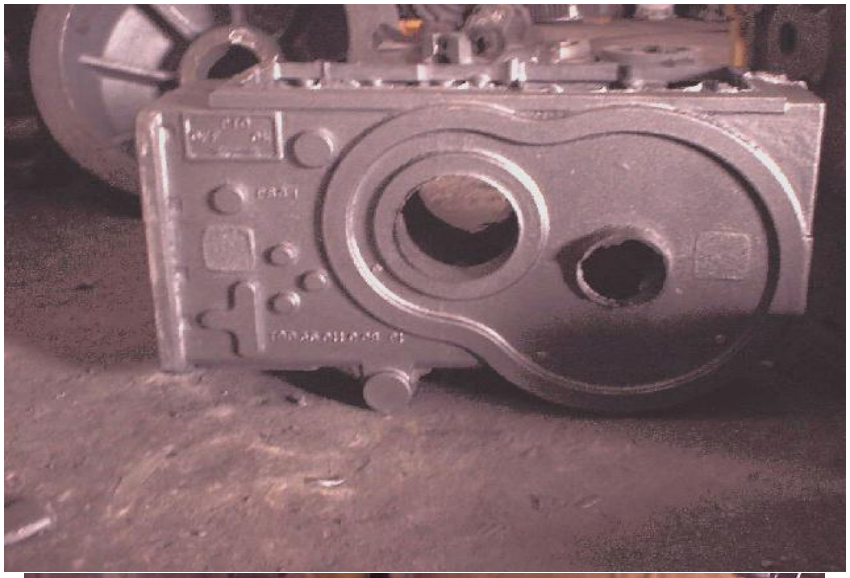


Sand Cores from FDM Patterns



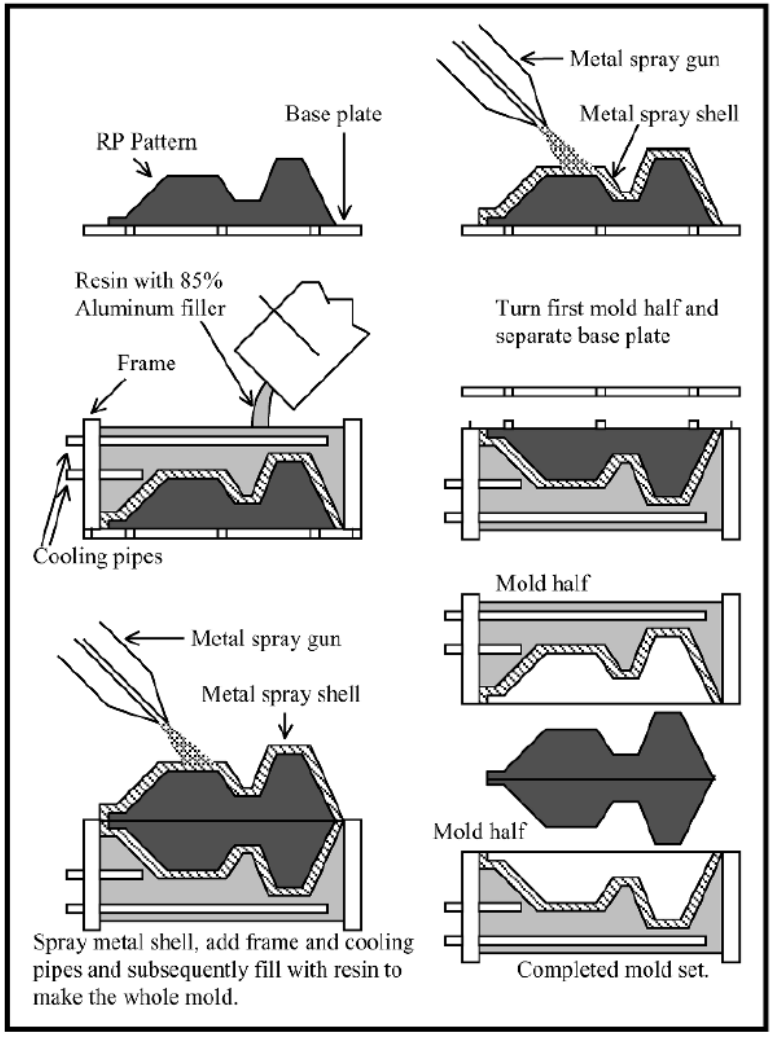
Metal Pouring

Grinding of Casting

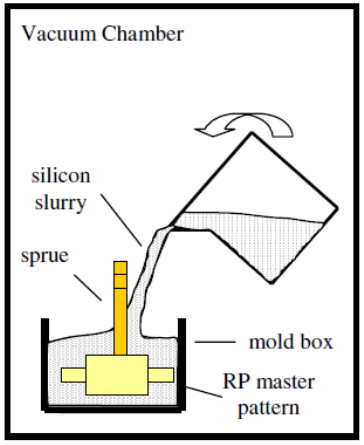


Other Indirect Tooling

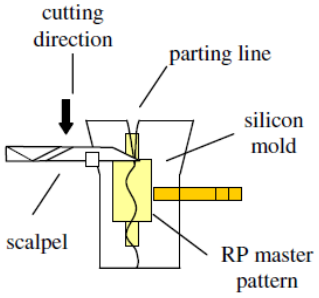
Arc Spray Metal Tooling



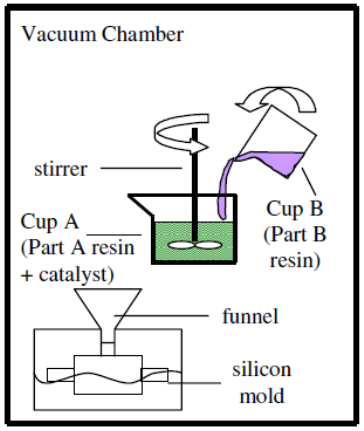
Spin Casting with Vulcanized Rubber Molds



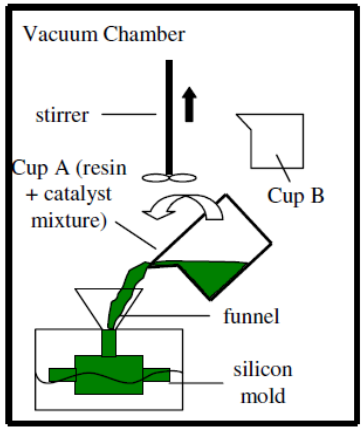
(a) Producing the silicon mold



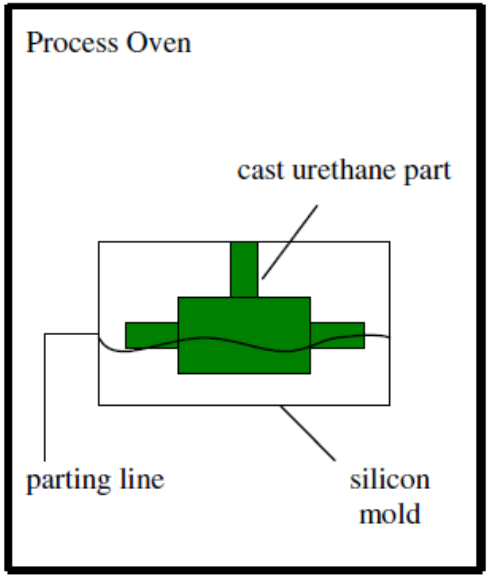
(b) Removing the RP master pattern



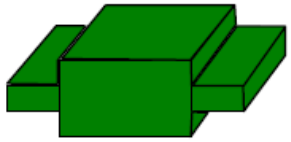
(c) Mixing the resin and catalyst



(d) Casting the polymer mixture



(e) Cast urethane part cured in a baking oven



(f) The final rapid tooled urethane part

Direct tooling

Direct laser sintered Metal Parts

Direct tooling of complex shapes

Rapid tooling benefits

- Versatility
  - Die casting
  - Thermoplastic injection molding
  - MIM (metal injection molding)
- Fast turnaround, low cost
  - 2 weeks from CAD file to part
- Mold hardness
  - Extended tool life
- Quick cavity duplication
  - Ideal for multi-cavity molds

Sand 3D Printing: Ex-One S-Max Pro

- Build envelope **1.800 X 1.000 X 700 mm/400**
- Volume **1260 L**
- Max Build Rate **100 – 135* L/h (depending o**
layer height 0.28/0.38 mm)
- Min layer height **0.26 – 0.38 mm**
- Fully automated printhead with printing speeds up to 135 l/h

Aerospace Industry

- Design Verification
- Prototyping for Air Inlet housing for Gas Turbine Engine
- Topologically Optimized Engine components
- Light weight structures manufacturing
- Part consolidation

Characteristics Favouring AM

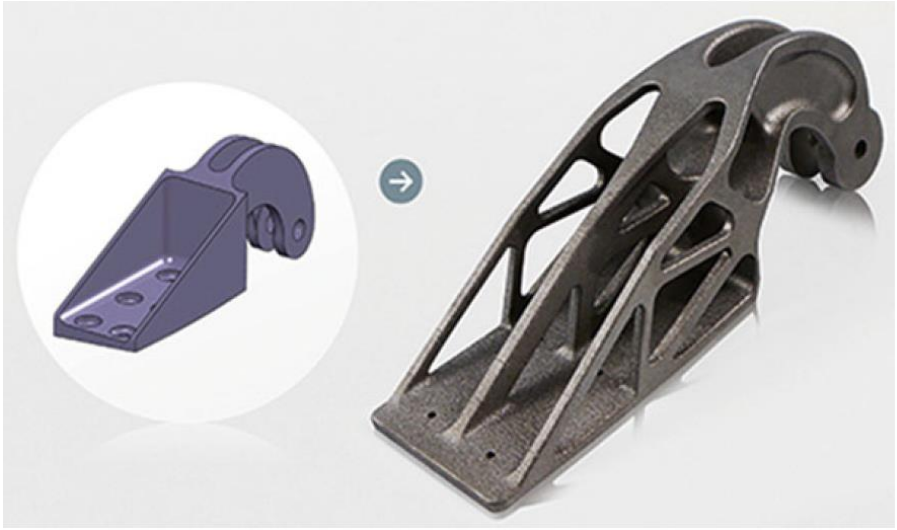
Lightweight

High temperature

Complex geometry

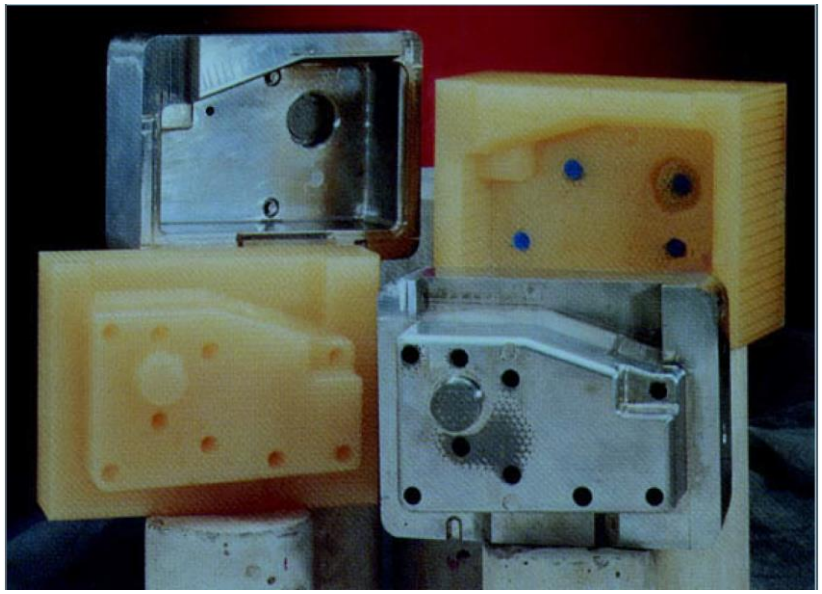
Economics

Digital spare parts

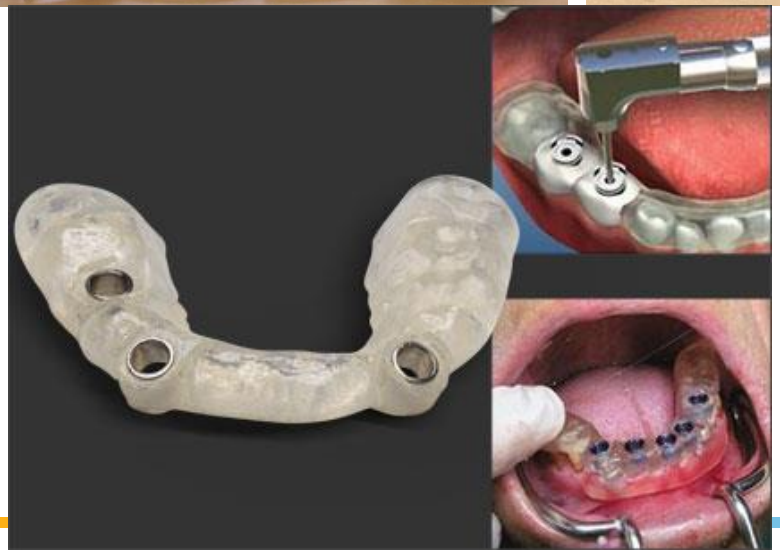


Automotive industry

- Prototyping Complex Gearbox
- Prototyping Advanced Driver Control System with SLA
- Creating Cast Metal Engine Block with RP Process
- Using SLA to Produce Production Tooling

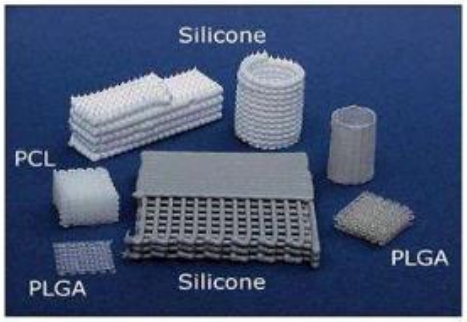


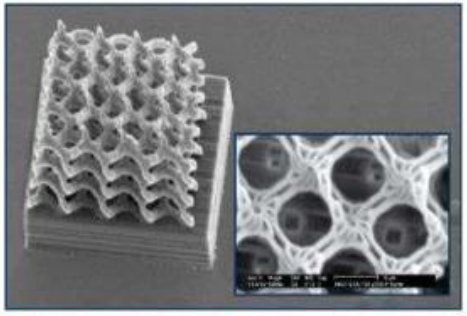
MEDICAL EQUIPMENTS

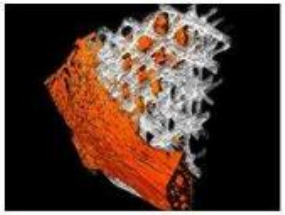


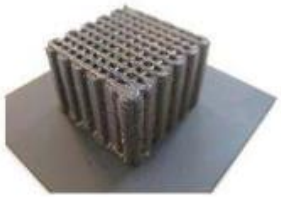
Biomedical Application

Tissue engineering scaffolds



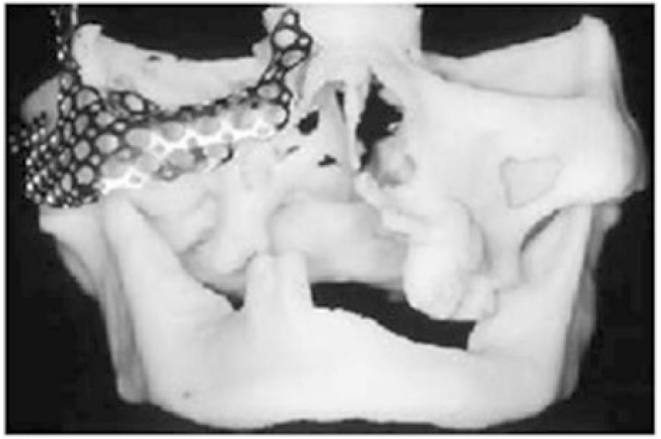




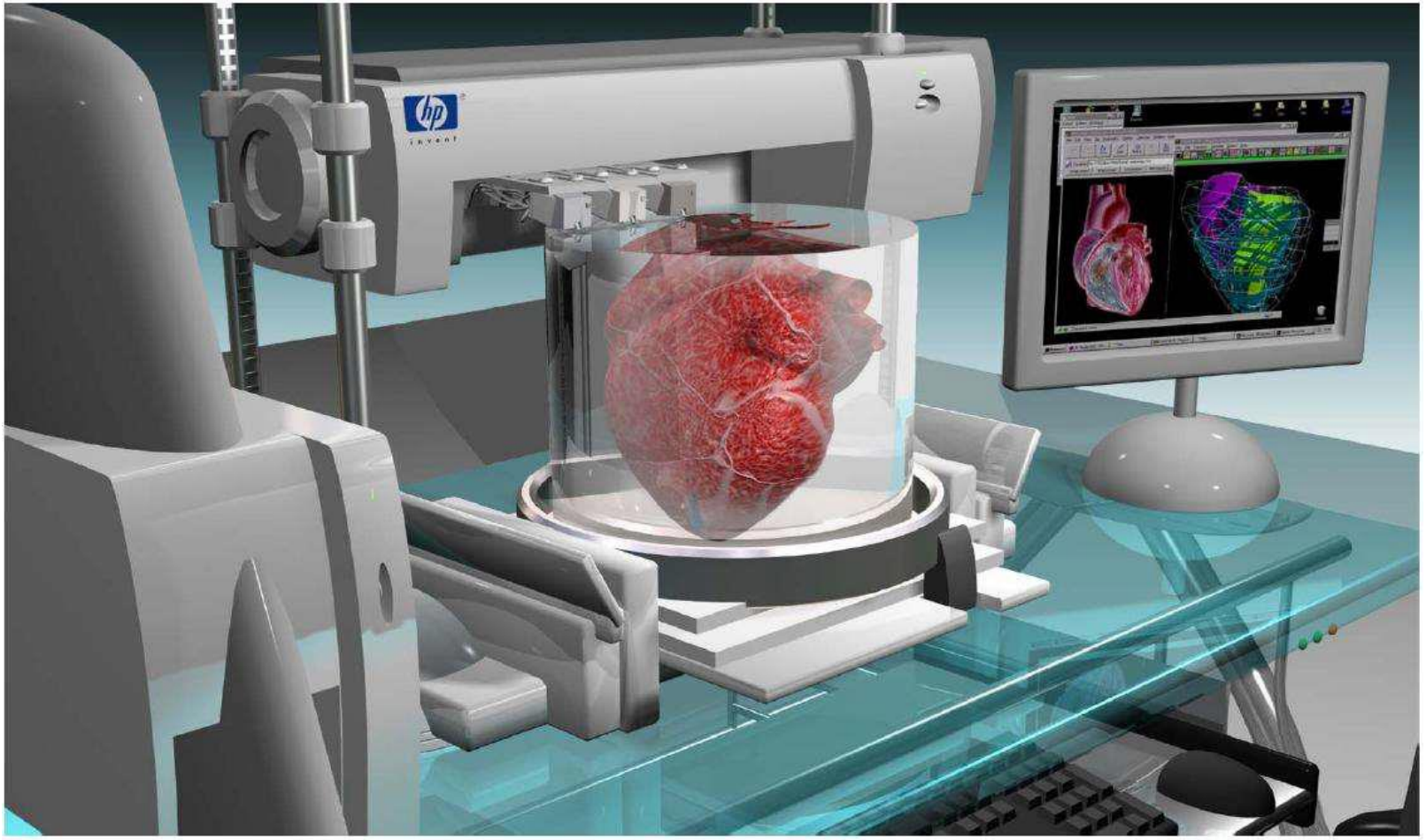


Printed organ

Prosthetic Development



3D Printed Heart



Organ Printing

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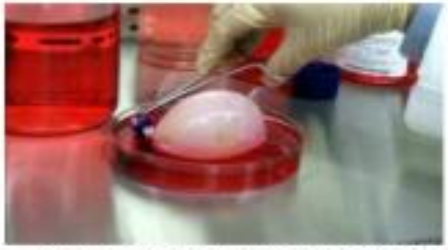
Additive Manufacturing: Organ printing

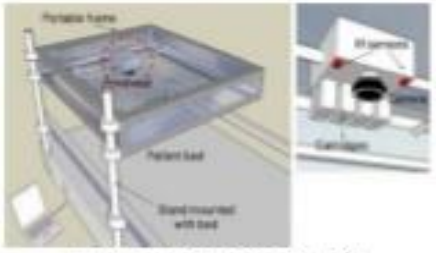
[Wake Forest University School of Medicine]

[Karolinska Institute in Stockholm]

[Wake Forest University School of Medicine]



[Wake Forest University School of Medicine]



[University of Manchester - UK]

[Wake Forest University School of Medicine]

Limitation of AM for Medical Application

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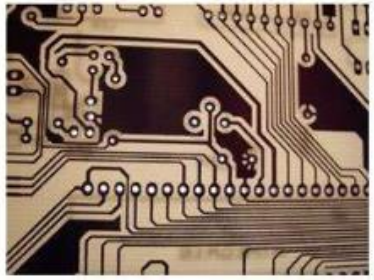
- Speed
- Cost
- Accuracy
- Materials
- Ease of use

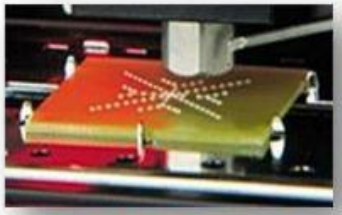
Electronic 3D printing

Inkjet Additive manufacturing :

(1) Fully Printed Thin Film Transistors
(2) Micro-optics / display mfg
(3) 3D Printed Electronics
(4) 3D Interconnects
(5) Clean energy
(6) Electronics manufacturing

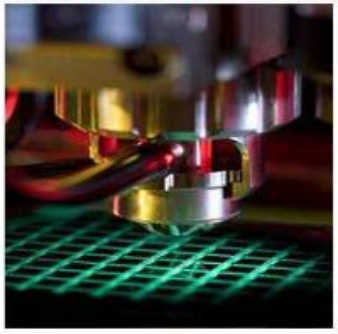


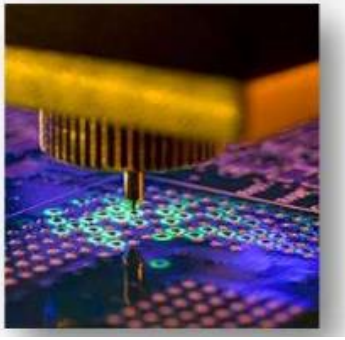
Inkjet 3D print



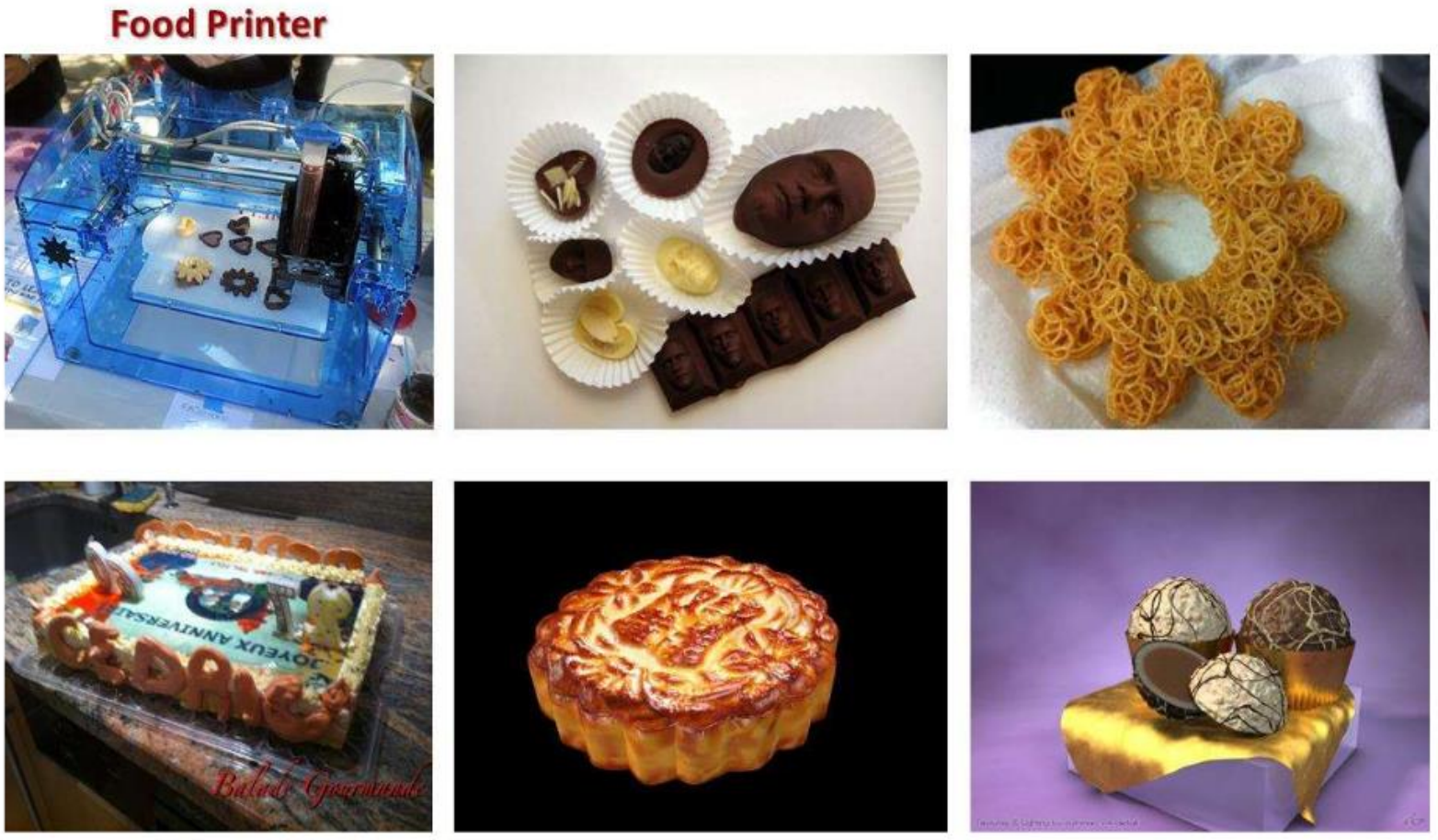
Conductive Materials

Thermal Compounds

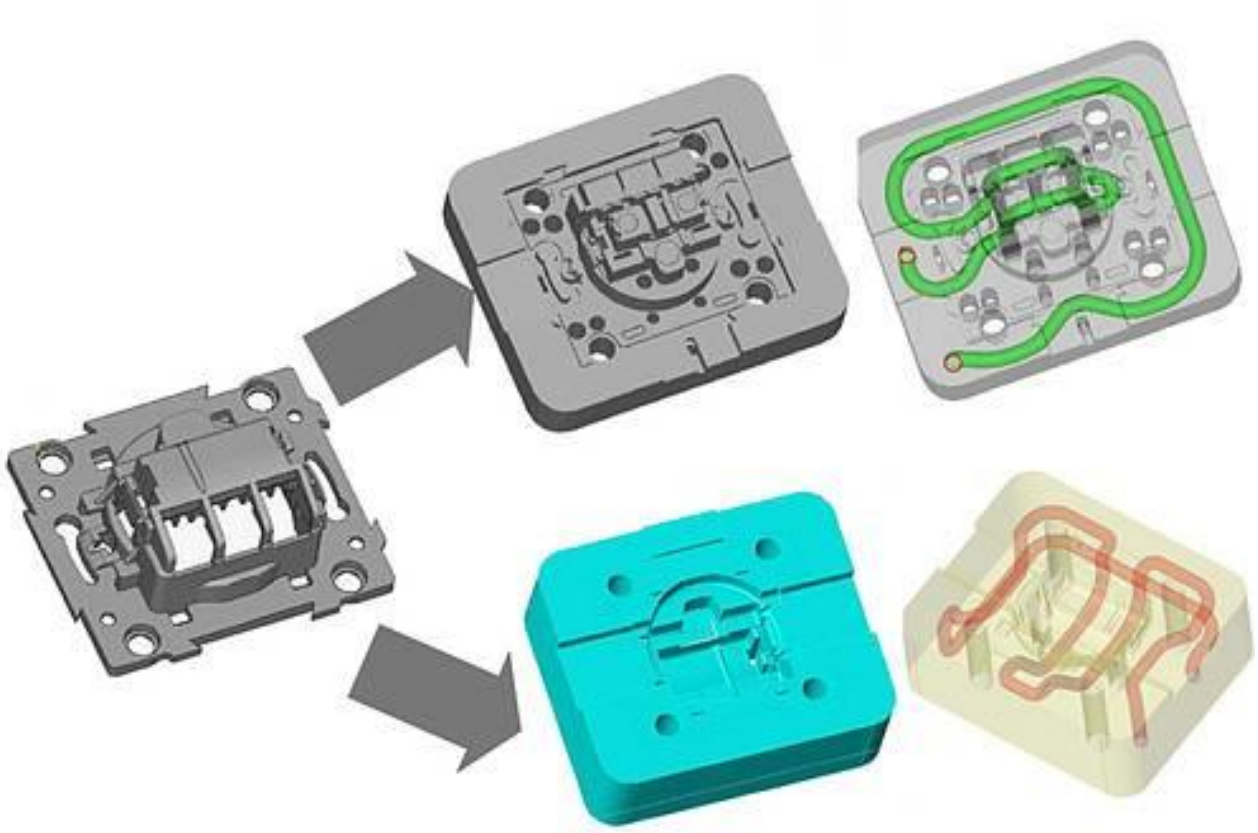




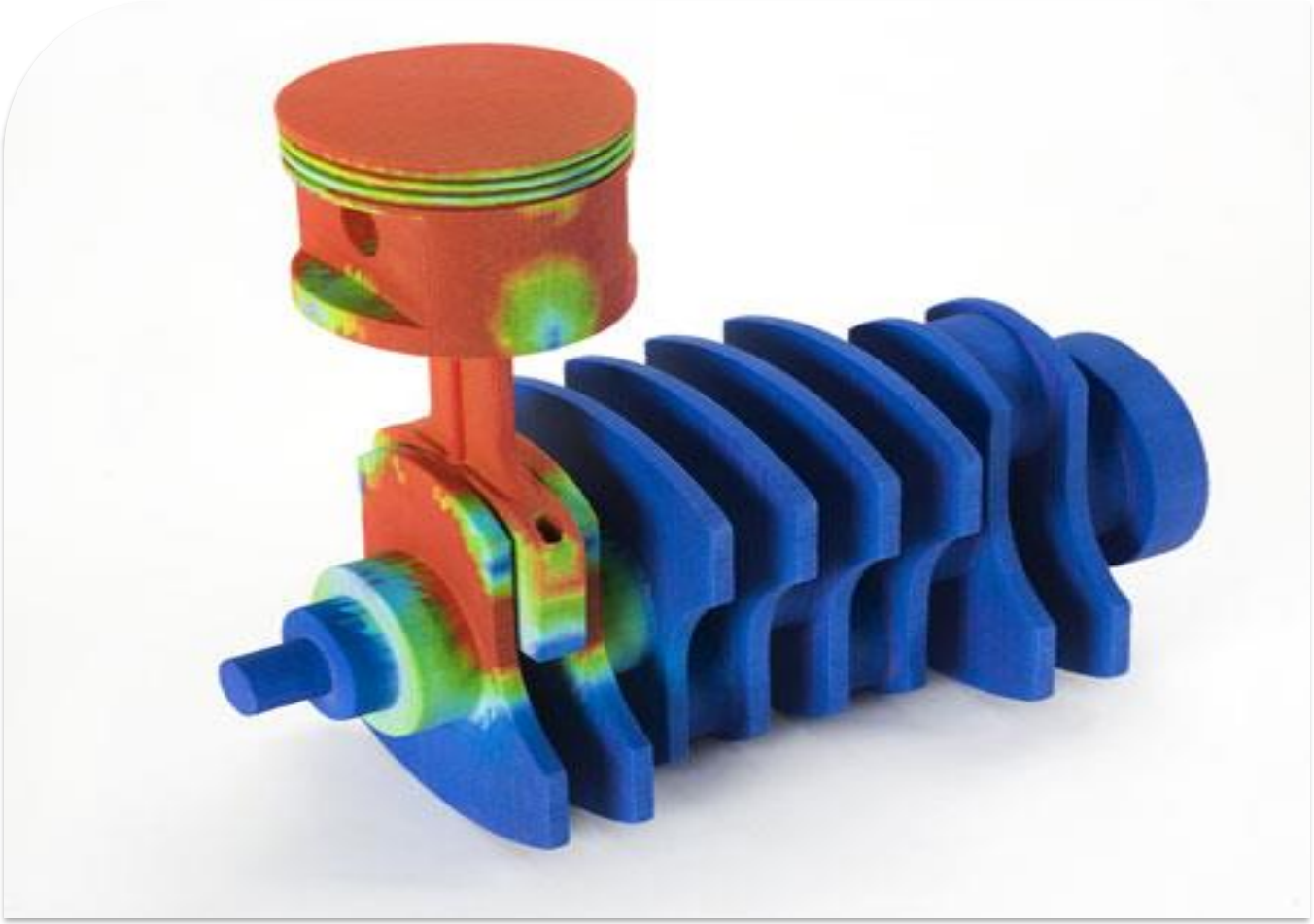
Food Printing



Conformal Cooling Channels

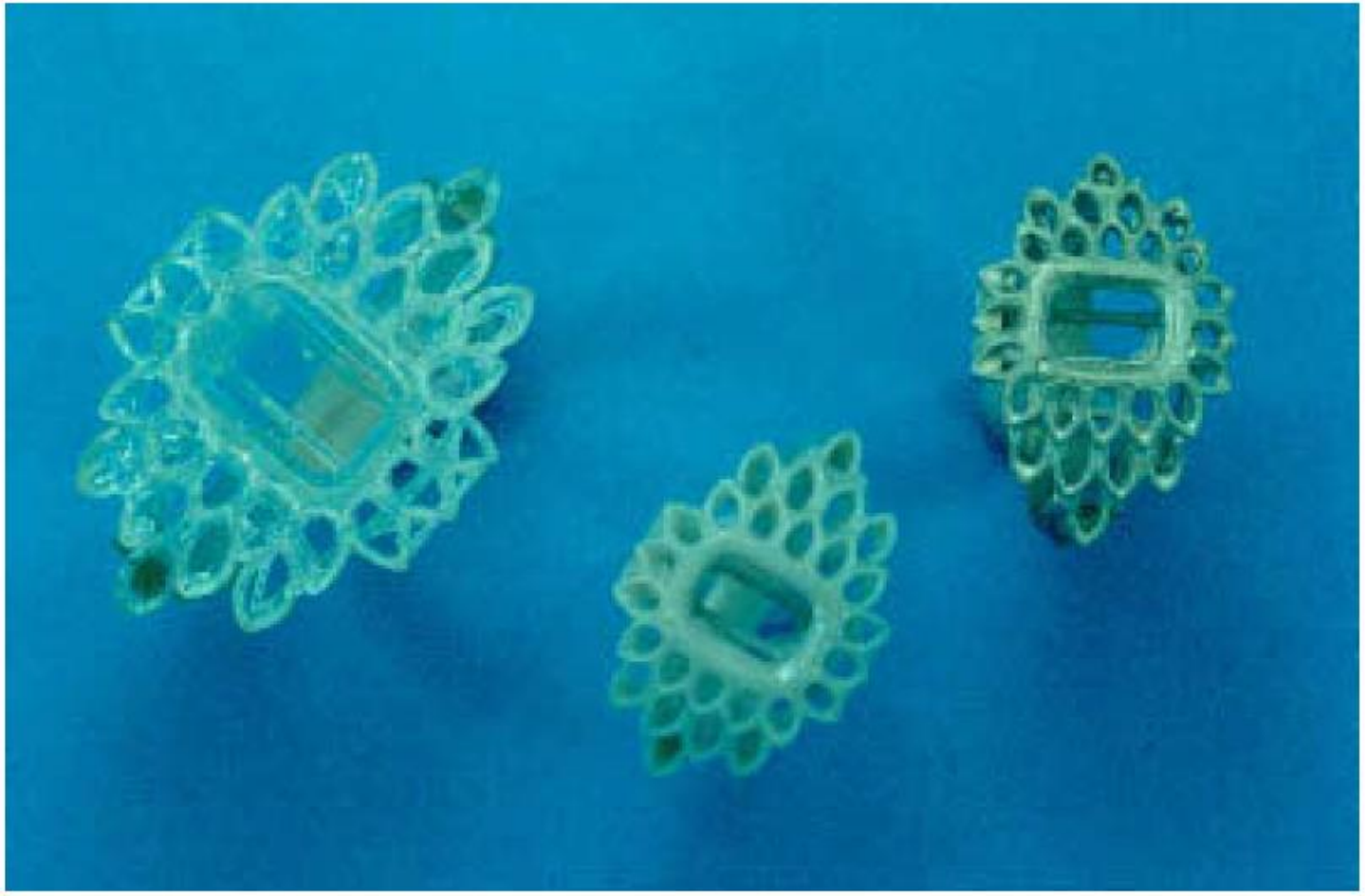


Data Visualization



Customized Households

Jewellery



Heterogenous Objects

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End of Session 14