**Academic Year 2017-18/ 8th Semester**
**Internal Assessment Test – 2**
Sub Code: 10ME837 **Solution Key**
Subject: Rapid Prototyping 16.04.2018

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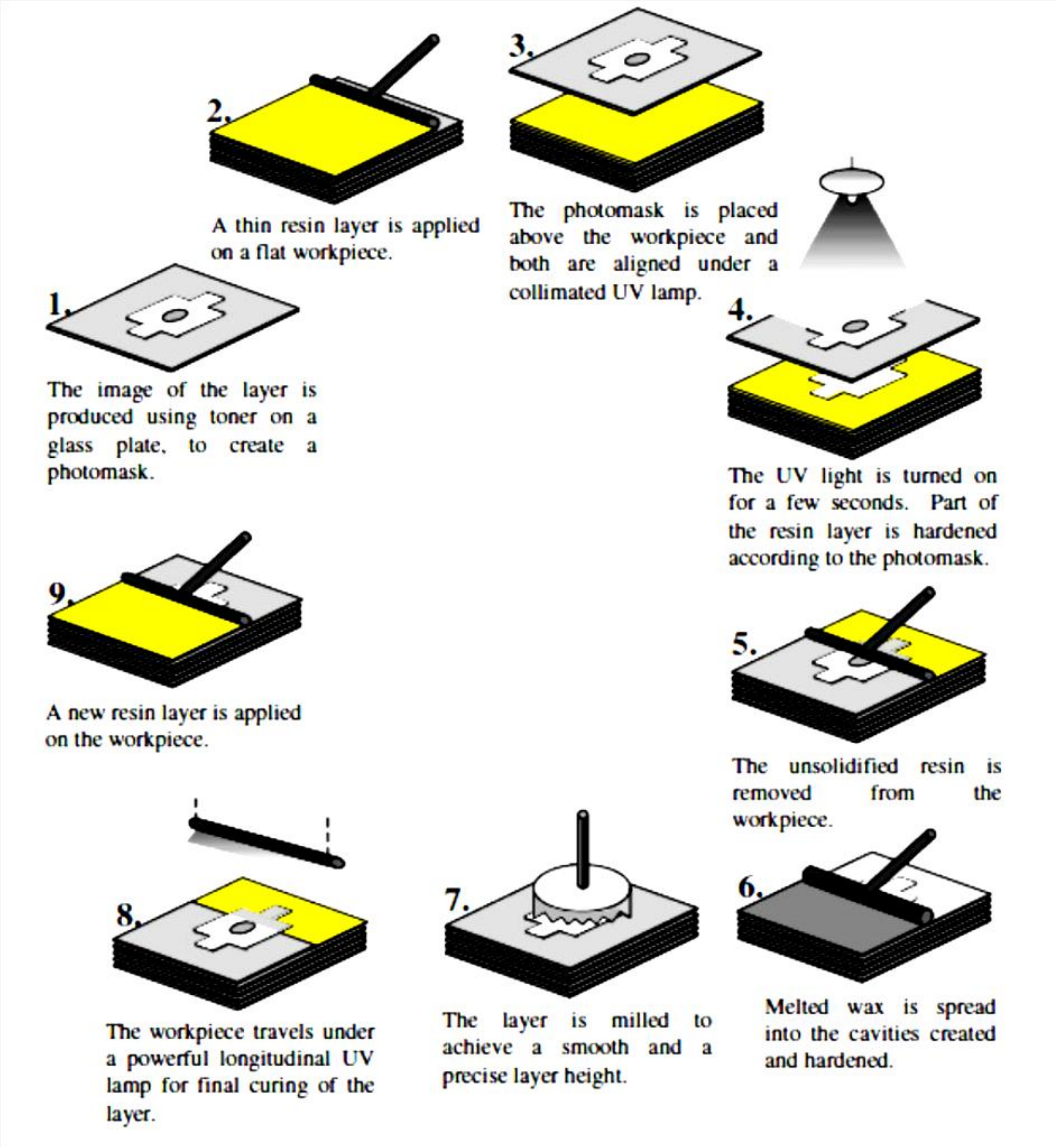
1. Solid Ground Curing


1. The image of the layer is produced using toner on a glass plate, to create a photomask.

2. A thin resin layer is applied on a flat workpiece.

3. The photomask is placed above the workpiece and both are aligned under a collimated UV lamp.

4. The UV light is turned on for a few seconds. Part of the resin layer is hardened according to the photomask.

5. The unsolidified resin is removed from the workpiece.

6. Melted wax is spread into the cavities created and hardened.

7. The layer is milled to achieve a smooth and a precise layer height.

8. The workpiece travels under a powerful longitudinal UV lamp for final curing of the layer.

9. A new resin layer is applied on the workpiece.

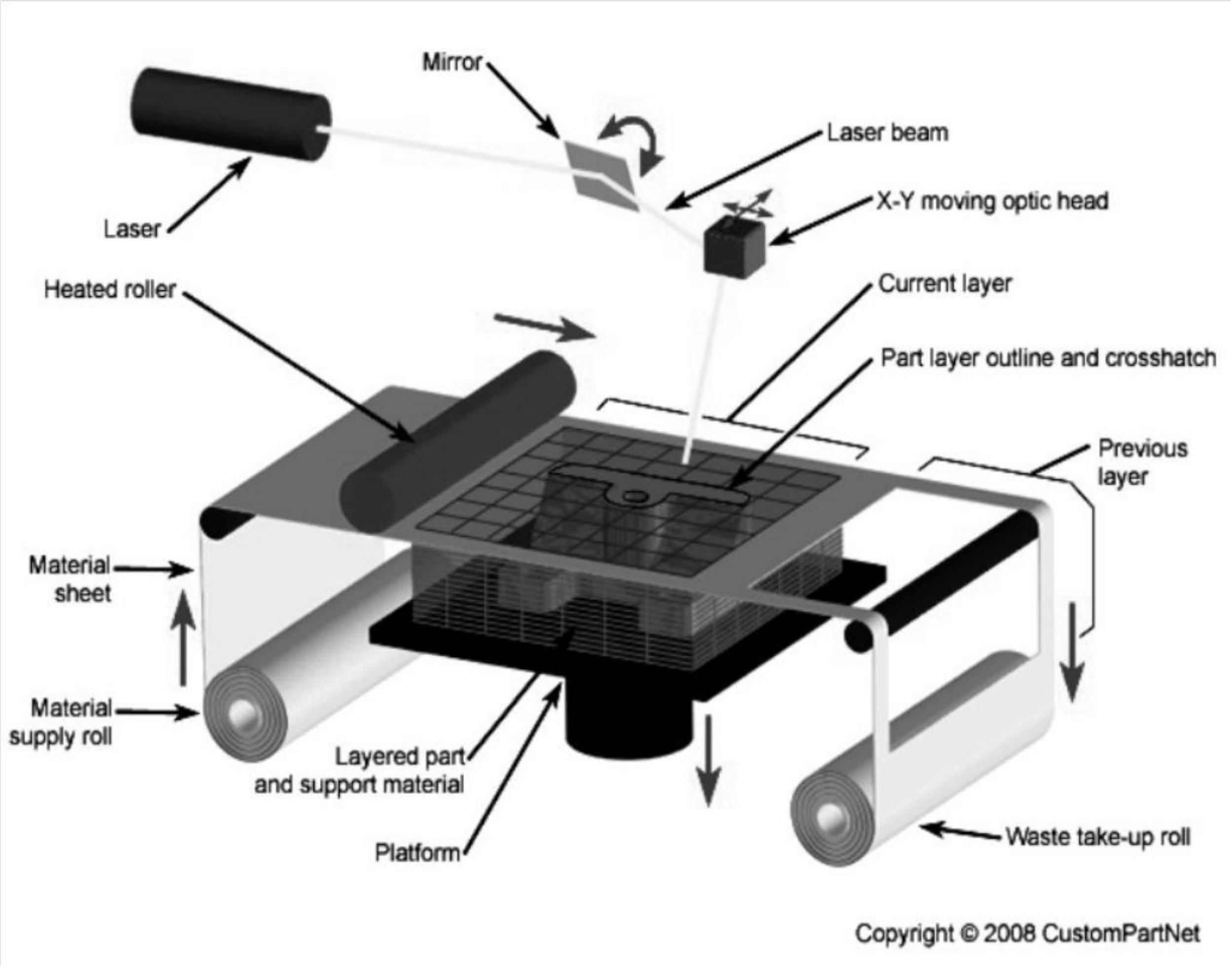
The Cubital's Solid Ground Curing process includes three main steps:

- a. Data preparation,
- b. Mask generation and
- c. Model making

## 2. LOM Process

LOM process consists of three phases

1. Pre-processing phase
2. Building phase
3. Post-processing phase



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***1. Pre-processing phase***

The pre-processing phase comprises several operations. The initial steps include generating an image from a CAD-derived STL file of the part to be manufactured, sorting input data, and creating secondary data structures. These are fully automated by LOMSlice, the LOM system software, which calculates and controls the slicing functions. Orienting and merging the part on the LOMTM system are done manually. These tasks are aided by LOMSliceTM, which provides a menu-driven interface to perform transformations (e.g., translation, scaling, and mirroring) as well as merges.

***2. Building Phase***

The build cycle has the following steps:

Step 1: LOMSlice creates a cross section of the 3D model measuring the exact height of the model and slices the horizontal plane accordingly. The software then images cross hatches which define the outer perimeter and convert these excess materials into a support structure.

Step 2: The computer generates precise calculations, which guide the focused laser beam to cut the cross sectional outline, the cross hatches and perimeter of the model. The laser beam power is designed to cut exactly the thickness of one layer of material at a time. After the perimeter is burned, everything within the model's boundary is freed from the remaining sheet.

Step 3: The platform with the stack of previously formed layers descends and a new section of material advances. The platform ascends and the heated roller laminates the material to the stack with a single reciprocal motion, thereby bonding it to the previous layer.

Step 4: The vertical encoder measures the height of the stack and relays the new height to LOMSlice, which calculates the cross section for the next layer as the laser cuts the model's current layer.

The above sequence continues till all the layers are built.

### *3. Post Processing Phase*

Step 1: The metal platform, home to the newly created part, is removed from the LOM machine. A forklift may be needed to remove the larger and heavier parts from the LOM

Step 2: Normally a hammer and a putty knife are all that is required to separate the LOM block from the platform. However, a live thin wire may also be used to slice through the double-sided foam tape, which serves as the connecting point between the LOMTM stack and the platform.

Step 3: The surrounding wall frame is lifted off the block to expose the crosshatched pieces of the excess material. Crosshatched pieces may then be separated from the part using wood carving tools.

## 3. Applications of LOM:

*1. Visualization*. Many companies utilize LOMTM's ability to produce exact dimensions of a potential product purely for visualization. LOMTM part's wood-like composition allows it to be painted or finished as a true replica of the product. As the LOMTM procedure is inexpensive several models can be created, giving sales and marketing executives opportunities to utilize these prototypes for consumer testing, marketing product introductions, packaging samples, and samples for vendor quotations.

*2. Form, fit and function*. LOMTM parts lend themselves well for design verification and performance evaluation. In low-stress environments LOMTM parts can withstand basic tests, giving manufacturers the opportunity to make changes as well as evaluate the aesthetic property of the prototype in its total environment.

3. *Manufacturing*. The LOMTM part's composition is such that, based on the sealant or finishing products used, it can be further tooled for use as a pattern or mold for most secondary tooling techniques including: investment casting, casting, sanding casting, injection molding, silicon rubber mold, vacuum forming and spray metal molding. LOMTM parts offer several advantages important for the secondary tooling process, namely: predictable level of accuracy across the entire part; stability and resistance to shrinkage, warpage and deformity; and the flexibility to create a master or a mold. In many industries the master created through secondary tooling, or even when the LOMTM part serves as the master (e.g., vacuum forming), withstands enough injections, wax shootings or vacuum pressure to produce a low production run from 5 to 1000 pieces.

4. *Rapid tooling*. Two part negative tooling is easily created with LOMTM systems. Since the material is solid and inexpensive, bulk complicated tools are cost effective to produce. These wood-like molds can be used for injection of wax, polyurethane, epoxy or other low pressure and

low temperature materials. Also, the tooling can be converted to aluminum or steel via the investment casting process for use in high temperature molding processes.

*Build materials used in LOM*

Potentially, any sheet material with adhesive backing can be utilized in Laminated Object Manufacturing. It has been demonstrated that plastics, metals, and even ceramic tapes can be used. However, the most popular material has been Kraft paper with a polyethylene-based heat seal adhesive system because it is widely available, cost-effective, and environmentally benign.

### 4.a) Indirect and direct Rapid tooling

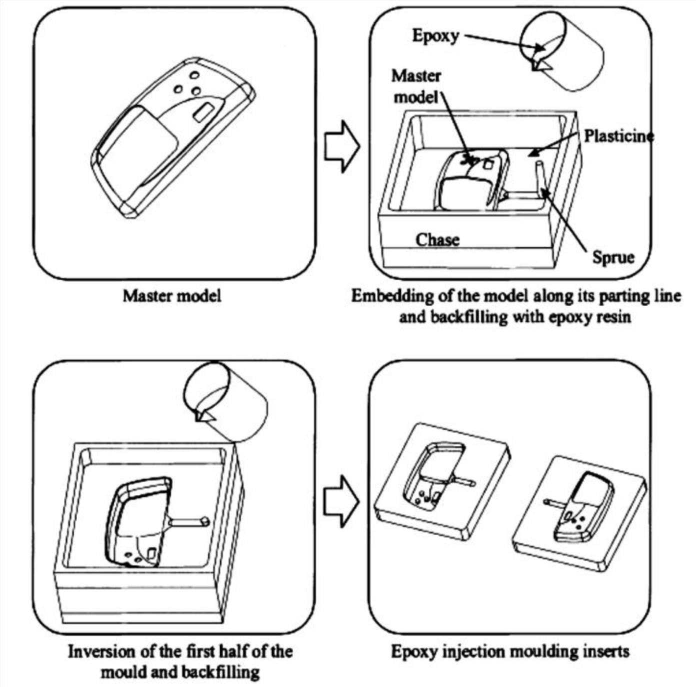
- Indirect RT methods are called indirect because they use RP pattern obtained by appropriate RP technique as a model for mould and die making.
- Soft tooling can be used to inject multiple wax or plastic parts using conventional injection-molding techniques.
- Traditional hard-tooling patterns are fabricated by machining either tool steel or aluminum into the negative shape of the desired component
- The most widely used indirect RT methods are to use RP masters to make silicon room temperature vulcanizing moulds for plastic parts and as sacrificial models or investment casting of metal parts. These processes are usually known as Soft Tooling Techniques.

### 4.b) Steps involved in Silicon rubber tooling

1. Producing a pattern. Any RP method can be employed.
2. Adding venting and gating to the pattern.
3. Setting-up the pattern in a mould box with a parting line provided in a plasticine.
4. Pouring silicone rubber to form one half of the mould.
5. Inverting the first half of the mould and removing the plasticine.
6. Pouring silicone rubber to produce the second half of the mould.

### 5. Aluminum Filled Epoxy tooling

1. The fabrication of the mould begins with the construction of a simple frame around the parting line of the RP model.
2. Sprue gates and runners can be added or cut later on, once the mould is finished.
3. The exposed surface of the model is coated with a release agent and epoxy is poured over the model.
4. Aluminium powder is usually added to the epoxy resin and copper hose cooling lines can also be placed at this stage to increase the thermal conductivity of the mould.
5. Once the epoxy has cured, the assembly is inverted and the parting line block is removed, leaving the pattern embedded in the side of the tool just cast.
6. Another frame is constructed and epoxy poured to form the other side of the tool.
7. When the second side of the tool is cured, the two halves of the tool are separated and the pattern is removed.



Master model

Embedding of the model along its parting line and backfilling with epoxy resin

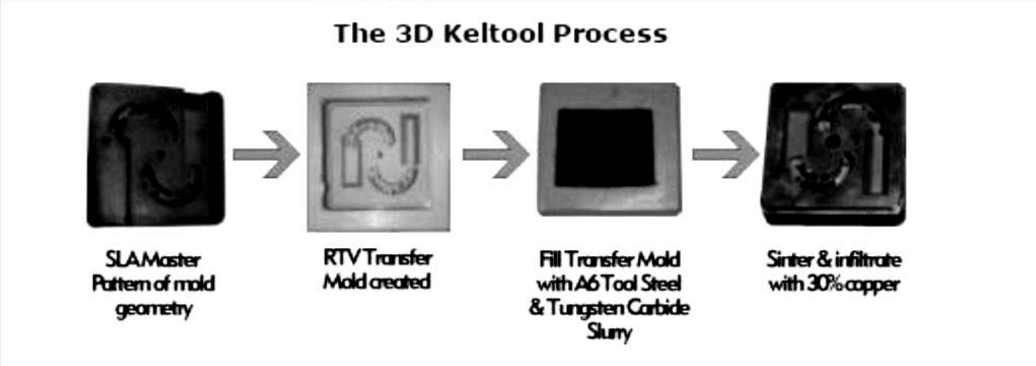
Inversion of the first half of the mould and backfilling

Epoxy injection moulding inserts

## 6. 3D Keltool Process

The production of inserts employing the 3D Keltool™ process involves the following steps:

1. Fabricating the master patterns of the core and cavity.
2. Producing RTV Silicone rubber moulds from the patterns.
3. Filling the silicon rubber moulds with a metal mixture (Powdered steel, Tungsten Carbide and polymer binder with particle sizes of around 5μm) to produce “green” parts (powdered metal held together by polymer binder) duplicating the masters.
4. Firing the “green” parts in a furnace to remove the plastic binder and sintering the metal particles together.
5. Infiltrating the sintered parts (70% dense inserts) with copper in a second furnace cycle to fill the 30% void space.
6. Finishing the core and cavity.



## 7. Spray Metal tooling process

This technique is the most common metal deposition technique and can be divided in two main types: Gas Metal Spraying and Arc Metal Spraying. The former involves a low melting point alloy that passes through a nozzle similar to a paint sprayer. Metal wires, usually lead/tin, is melted by a conical jet of burning gas, atomized and propelled onto the substrate.

The second method, also known as the Tafa process, involves a gun in which an electric arc between two wires causes them to melt. The molten material (aluminum or zinc) is then atomized by a compressed gas that sprays it.

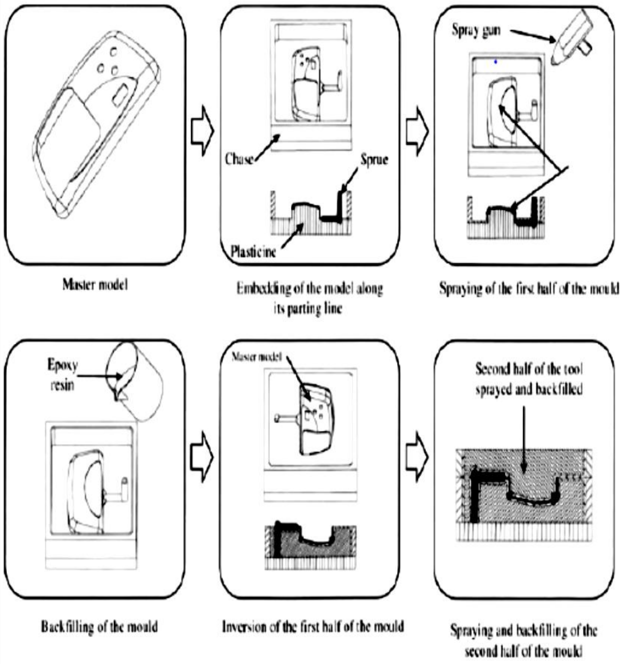
Spray metal tools can be used to mould up to 2000 parts in the exact production material. The tools are inexpensive, fast to produce, accurate and capable of handling abrasive materials.

Once a metallic shell has been created using the above method, water cooling lines can be added and the shell is backfilled with epoxy resin or ceramic to improve the strength of the mould.

These materials are selected because their coefficient of thermal expansion is close to that of the nickel or zinc the shells are made from. Aluminium powder is usually mixed with the epoxy resin or the ceramic to increase their thermal conductivity. After the backfilling material is cured, it is machined flat. The second half of the tool is built following the same procedure.

The main disadvantage of metal spraying is that it is not suitable where the part possesses features such as projections which partially block the metal spray configuration or where recesses may be too deep to spray into completely. For this reason, this process is restricted to models with large and gently curved surfaces.

Metal spraying produces economic tooling shells with good reproduction and dimensional qualities but low mechanical strength and high porosity. A way to improve the thermal conductivity of the moulds is to deposit a layer of metal with a higher melting point but better thermal properties over the shell



Master model

Embedding of the model along its parting line

Spraying of the first half of the mould

Backfilling of the mould

Inversion of the first half of the mould

Spraying and backfilling of the second half of the mould

**Figure 6.1** Spray Metal Deposition Mould