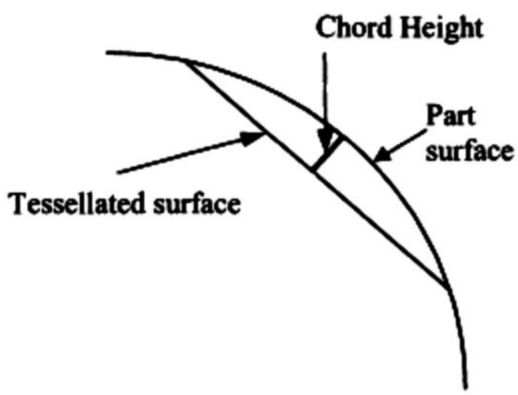
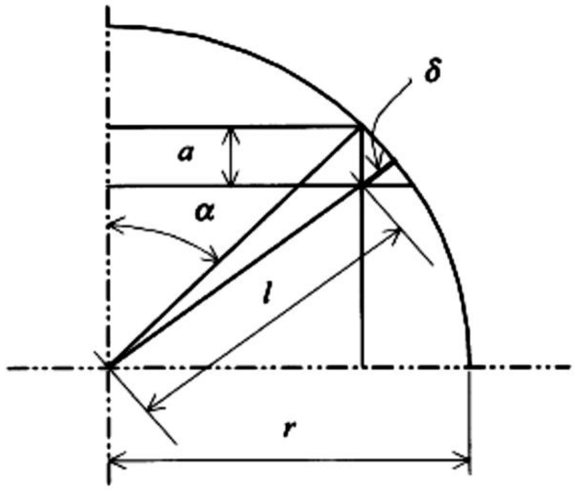
Internal Assessment Test -3/Improvement Test – May 2018

Solutions Key

Sub Code: 10ME837 **Semester** : 8

Subject: Rapid Prototyping **Course Instructor**: Prof.HManikandan

Q.No	Solution
1.	**Errors due to tessellation** Most RP systems employ standard STL input files. A STL file approximates the surface of the 3D CAD model by triangles. Errors caused by tessellation are usually ignored because of the belief that tessellation errors can be minimized by increasing the number of triangles. However, in practice the number of triangles cannot be increased indefinitely. The resolution of STL files can be controlled during their generation in a 3D CAD system through tessellation parameters. ***Chord Height.*** This parameter specifies the maximum distance between a chord and surface (Figure 1). **If** less deviation from the actual part surface is required, a smaller chord height should be specified. The lower bound for this parameter is a function of the CAD model accuracy. The upper bound depends on the model size.  ***Angle Control***. This parameter specifies the required definition level along curves with small radius. Specifically, it defines a threshold for the curve radius (ro) below which the curves should be tessellated: $r < r_0 = \frac{partsize}{10}$ **Errors due to slicing** RP processes have a stair-stepping problem that is found in all layer manufacturing technologies. Stair-stepping is a consequence of the addition of material in layers. As a result of this discrete layering, the shape of the original CAD models in the build direction (z) is approximated with stair-steps. This type of error is due to the working principles of RP processes, which can be assessed in data preparation.

	 The error due to the replacement of a circular arc with stair-steps is $$\delta = r - l$$ where δ is the cusp height, *r* the radius and *l* the difference between *r* and δ. When *l* is at its minimum value, δ will reach its maximum value.
2.	**Part Finishing Errors** The model accuracy after finishing operations is influenced mostly by two factors, the varying amount of material that has to be removed and the finishing technique adopted. These two factors determine to what extent the dimensional accuracy of RP models will be reduced during finishing. *Varying amount of material.* During the data preparation stage, the RP model shapes are approximated with the comers of the stair-steps. Each RP process reproduces the comers and the stair-steps with a different resolution. Hence, the amount of material that has to be removed to improve the surface finish will vary depending on the RP process employed. Also, the amount of material to be removed on surfaces of the same model can vary due to the selected part build orientation. *Finishing technique.* A number of processes can be employed to finish RP models, for example, wet and dry sanding, sand blasting, coating, spraying, infiltration with special solutions, machining, etc. Each technique has specific technological capabilities and can be characterized by the achievable dimensional accuracy and surface roughness. The techniques that assure better dimensional control during the finishing operation will have less impact on model accuracy.
3.	**Part building errors in SL process** There are two main types of errors in the part building process, namely curing errors and control errors. Curing errors refer to those errors that are caused by over-curing and scanned line shape. Control errors are those errors caused by layer thickness an scan position control. Both types of errors affect part accuracy. *Over-curing.* Laser over-curing is necessary to adhere layers to form solid parts. However, it causes dimensional and positional errors to features. The overcured material in the bottom layer can be seen in Figure 4a, from which the unusual thickness of the bottom layer can be noted. This causes a dimensional change in the z direction along the lower feature boundary. As a result, the feature shape is deformed and the feature centre position is shifted. Figure 4b

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<tr><td></td><td>shows part of a deformed boundary of what should have been a circular feature.

Scanned line shape. A scanned line is created when a laser beam scans the resin surface. The cross section of the scanned line is referred to as the scanned line shape.. Note that the shape deviates from the theoretically predicted parabola.

The actual shape is determined by the properties of the resin and laser. The part building process is assumed to be a stacking up of rectangular shaped blocks. However, the actual process employs different shaped blocks. As a result of the shape of scanned lines, a supposedly vertical edge is not a straight line, but is rather jagged.</td></tr>
<tr><td>4.</td><td>Copper Polyamide tools

Copper PA is a new metal plasticcomposite designed for short-run tooling applications involving several hundred parts (100-400 parts) from common plastics. Tooling inserts are produced directly in the SLS machine with a layer thickness of 75μm and only subsequent finishing is necessary before their integration in the tool base. No furnace cycle is required and unfinished tool inserts can be produced in a day.

During the CAD stage, Copper PA inserts are shelled and cooling lines, ejector pin guides, gates, and runners are included in the design and built directly during the SLS process . Then, the insert surfaces are sealed with epoxy and finished with sandpaper, and finally the shell inserts are backed up with a metal alloy.

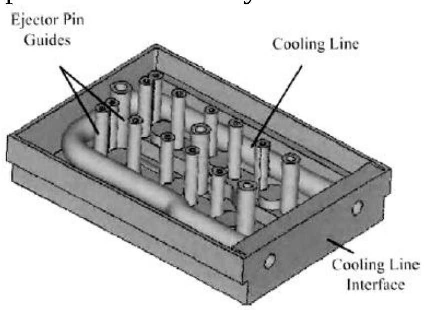

Fig 1 Back surface of an insert

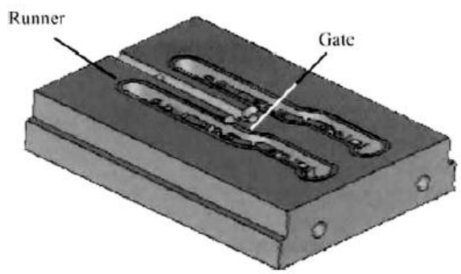

Fig 2 Working surface of an insert</td></tr>
<tr><td>5.</td><td>Quick cast process

QuickCast, a 3D Systems proprietary process, replaces traditional wax patterns for investment casting with stereolithography (SLA) patterns created in a robust, durable material, without tooling and without delay. The net result is QuickCast patterns in as little as 2 to 4 days and quality metal castings in 1 to 4 weeks.

The QuickCast part resembles a beehive hatch pattern and ends up being about 80% hollow. It will burn out in the investment casting process with very little residue. This hollow build style is important, as it allows the pattern to collapse inward during the autoclave and shell burnout phases of the casting process and thus prevents expansion forces from cracking the shell. The mostly hollow build style also reduces the amount of material necessary to burnout.

As with wax patterns, QuickCast patterns must be incorporated into a system that includes the pouring cup, sprue, runners and gates.. Creating an assembly with QuickCast patterns is similar to creating an assembly with wax patterns.

Process description
▪ A Stereolithography QuickCast pattern is created from an STL file.
▪ The pattern is leak tested to make sure it is air tight.
▪ An investment caster is chosen (based on experience & material required).</td></tr>
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	▪ QuickCast pattern is given to the caster. ▪ Caster puts part through ceramic coating process and performs firing procedure to burn out SLA pattern. ▪ Metal is poured into the fired ceramic shell. ▪ Ceramic shell is broken off to reveal metal part.
6.	**Rapid tool process** SLS is one of the rapid prototyping techniques widely used for direct tool production. Using SLS, DTM was one of the first companies to commercialise a rapid tooling technology, marketing it as the RapidTool™ process. The DTM RapidTool family of tooling products consists of three materials, RapidSteel l.0, RapidSteel 2.0 and Copper Polyamide. Rapid Steel 1.0 The first product, RapidSteel 1.0 powder, is made up of low-carbon steel particles with a mean diameter of 55µm. The particles are coated with a thermoplastic binder. The processing of Rapid steel 1.0 can be broken into three stages 1. Green part manufacture. 2. Cross linking 3. Furnace processing ***1. Green Part Manufacture (SLS Processing)*** The low melting point binder allows the material to be processed in the SLS machine without heating the feed and part bed. Tooling inserts in the "green" stage are built layer by layer through fusion of the binder. ***2. Cross-linking:*** During the subsequent furnace cycle, the thermoset binder coating would melt and would behave as a lubricant between the steel particles. To prevent distortion being caused in this way during the low temperature portion of the furnace cycle, the green part is infiltrated with an aqueous acrylic emulsion and dried in an oven at about *60°C*. The acrylic emulsion acts as a binding agent that provides strength to the green part when the polymer is burnt away in the furnace. The drying time is dependent upon the part size; for large parts, it can take up to 48h. ***3. Furnace processing:*** In this stage, the green part is converted into a fully dense metal part by infiltration with molten copper. To remove oxides from the steel surface, a mixture of hydrogen and nitrogen is used during the furnace cycle. Between 350 and *450°C*, the polymer evaporates. Then, the temperature is increased to 1000°C to allow the sintering of the steel powder. Finally, the part is heated up to *1120°C* where copper infiltration occurs driven by capillary action. The final RapidSteel 1.0 parts are 60% steel 40% copper fully dense parts which can be finished by any technique including surface grinding, milling, drilling, wire erosion, EDM, polishing and surface plating
7a)	**Advantages of DMLS** **High speed:** Because, no special tooling is required, parts can be built in a matter of hours. **Complex geometries:** Components can be designed with internal features and passages that cannot be cast or otherwise machined. **High quality:** DMLS creates parts with high accuracy and detailed resolution. Applications 1. Medical Field 2. Aerospace industries 3. Manufacturing

	4. Automotive
7b)	**LOM Tooling** The original LOM process produces parts with a wood like appearance using sheets of paper. Unfortunately, moulds built this way can only be used for low melting thermoplastics and are not suitable for injection moulding or blow moulding of common thermoplastics. For this reason, new materials based on epoxy or ceramic capable of withstanding harsh operating conditions have been developed. ***Polymer sheets:*** These sheets consist of glass and ceramic fibres in a B-staged epoxy matrix. Parts made with this material require postcuring at 175°C for one hour. Once fully cured, they have good compressive properties and a heat deflection temperature of 290°C. ***Ceramic sheets***: Two ceramic materials have been developed for LOM, a sinterable A1N ceramic and a silicon infiltratable SiC ceramic. Both materials are mixed with 55% by volume of polymeric binder.