

* UNIT-3 *

* Powder Based Rapid prototype systems:

Since most starting materials for tissue engineering are in powder form, using Powder-Based additive manufacturing methods is attractive and practical. Selective layer sintering (SLS) and inkjet 3D printing (3DP) are two powerful and versatile RP techniques which are applicable to powder-based material systems.

Advantages:

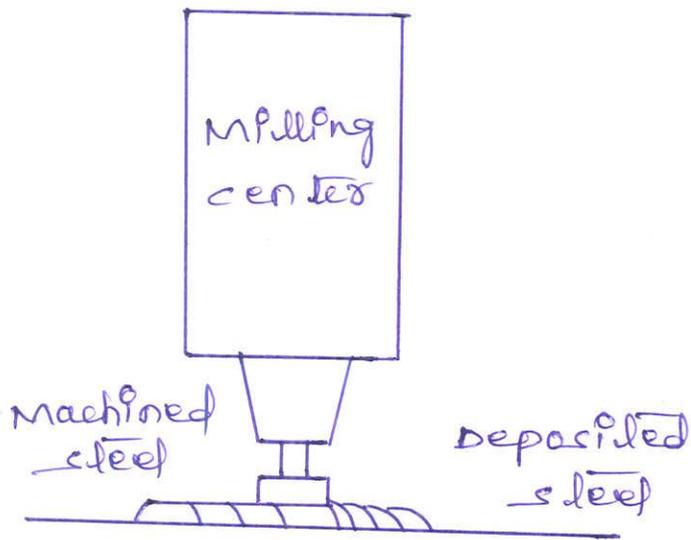
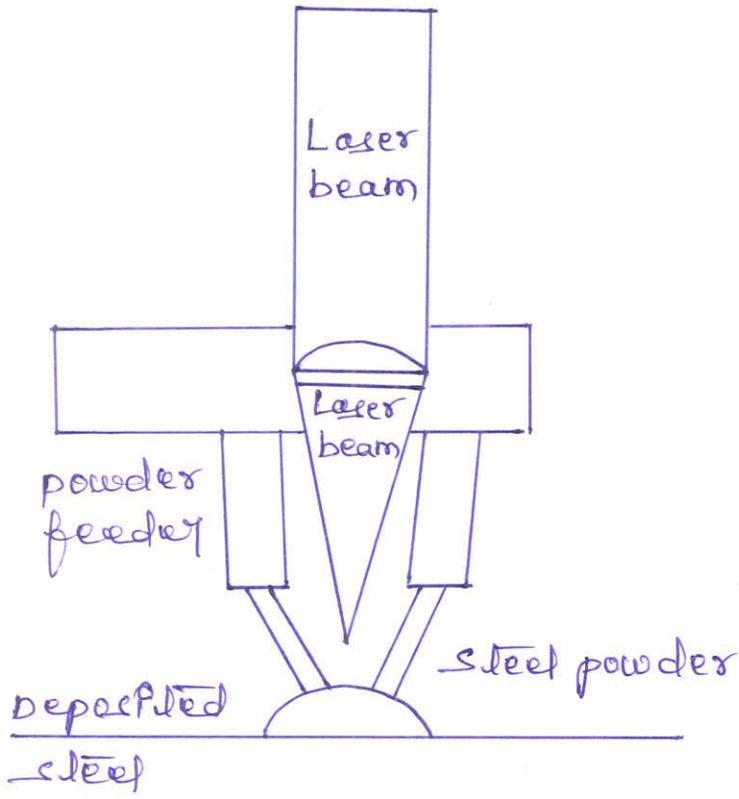
Traditional, complex parts require more manufacturing steps, along with more material and labor costs. The time to create and assemble them is longer, and it increases inventory. There is a better way. With additive manufacturing you can print the assembly as a single piece, saving money and time from start to finish.

Disadvantages:

It's almost always cost-prohibitive, just like metal injection molding (MIM), metal rapid prototyping is rarely the most cost-effective path to an end product. There are considerable capital costs to purchase the equipment necessary to support rapid prototyping.

* Applications RP:

- Aerospace industry & suppliers.
- Automotive industry & suppliers
- Machinery (eg. Turbines, special machinery)
- Medical implants (Dental, orthopedic)
- Handling and Robotics.



* Selective Laser Sintering (SLS):-

Selective Laser Sintering (SLS) is a prototype technique that uses a laser as the power source to sinter powdered material (typically nylon or polyamide) aiming the laser automatically at points in space defined by 3D model, binding the material together to create the solid structure. It is similar to selective laser melting. The two are instantiations of the same concept but differ in technical details.

Working:

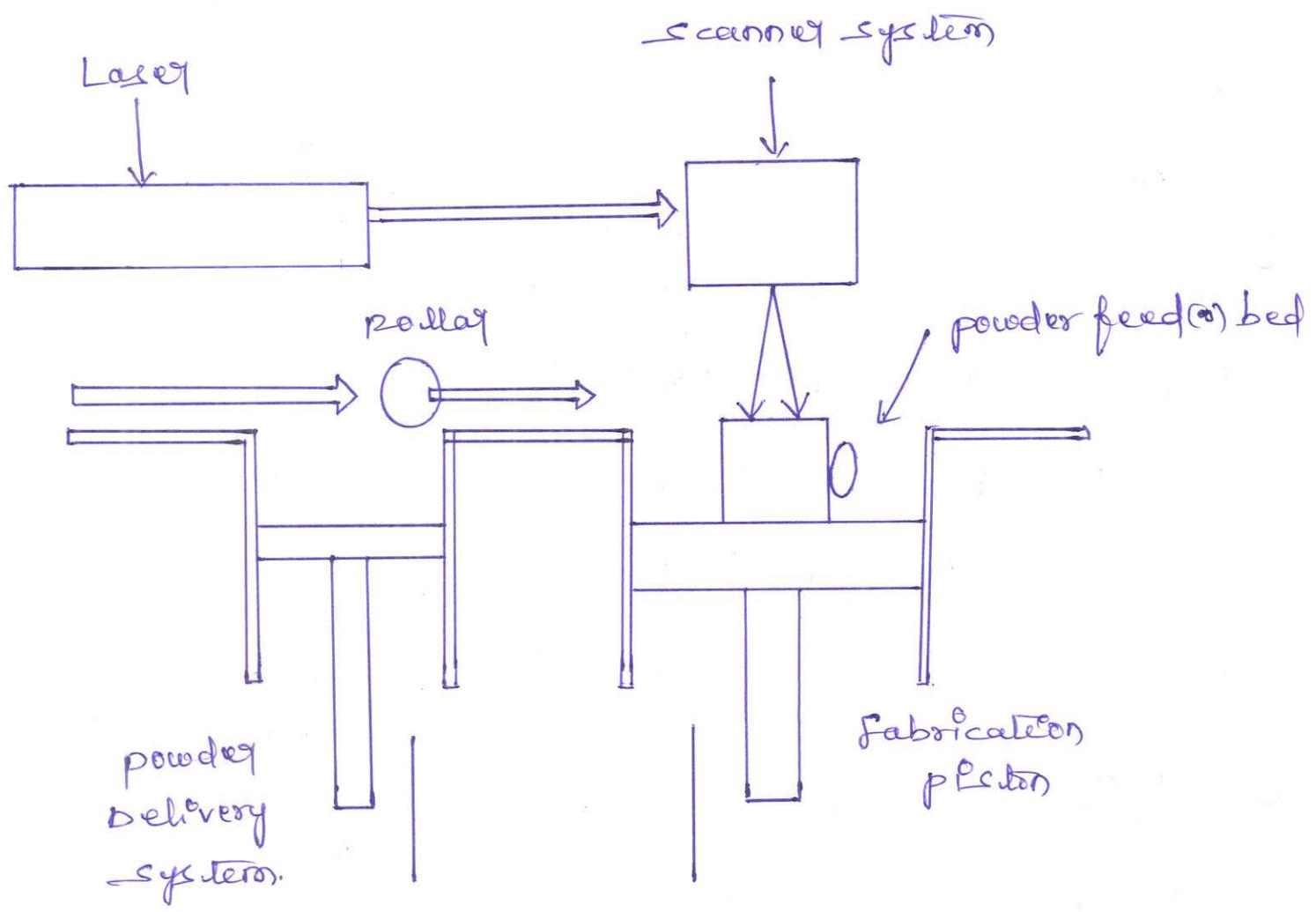
Selective Laser Sintering (SLS) is an RP technique that uses a laser as the power source to sinter powdered material.

The laser process uses a laser source to provide thermal energy and selectively fuse together particles of a powder material into complex three dimensional shapes in layer-by-layer strategy.

Advantages:

- Cheap and no harmful healthy material.
- Large selection of used materials
- Is not needed supported construction
- Decreasing of destruction possibility of inside stresses.

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* Disadvantages (SLs):

- Roughness surface after final modification it means "stairs" effect
- Porosity of Components.
- Different intensity in various parts of generated Components.
- Material transformations are needing cleaning of the production device.

• Materials:

- Aluminium-filled (PA12-AL)
- Carbon fiber filled Nylon (used form XT)
- Flame Retardant Nylon (Duraform FR100)
- Glass-filled Nylon (Duraform GF)
- Impact-resistant Nylon (Duraform EN)
- Nylon (Duraform PA)
- Rubber-like (Duraform Flex plastic).

-Applications:

- prototype
- Design cycle
- Investment Casting
- wind tunnel
- Limited-run manufacturing
- Jigs
- Fixtures.

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* Three dimensional Printing (3DP):-

3D printing, also known as additive manufacturing, is a method of creating a three dimensional object layer-by-layer using a computer created design. 3D printing is an additive process where by layers of materials are built on top to create a 3D part. As a result 3D printing creates less material wastage.

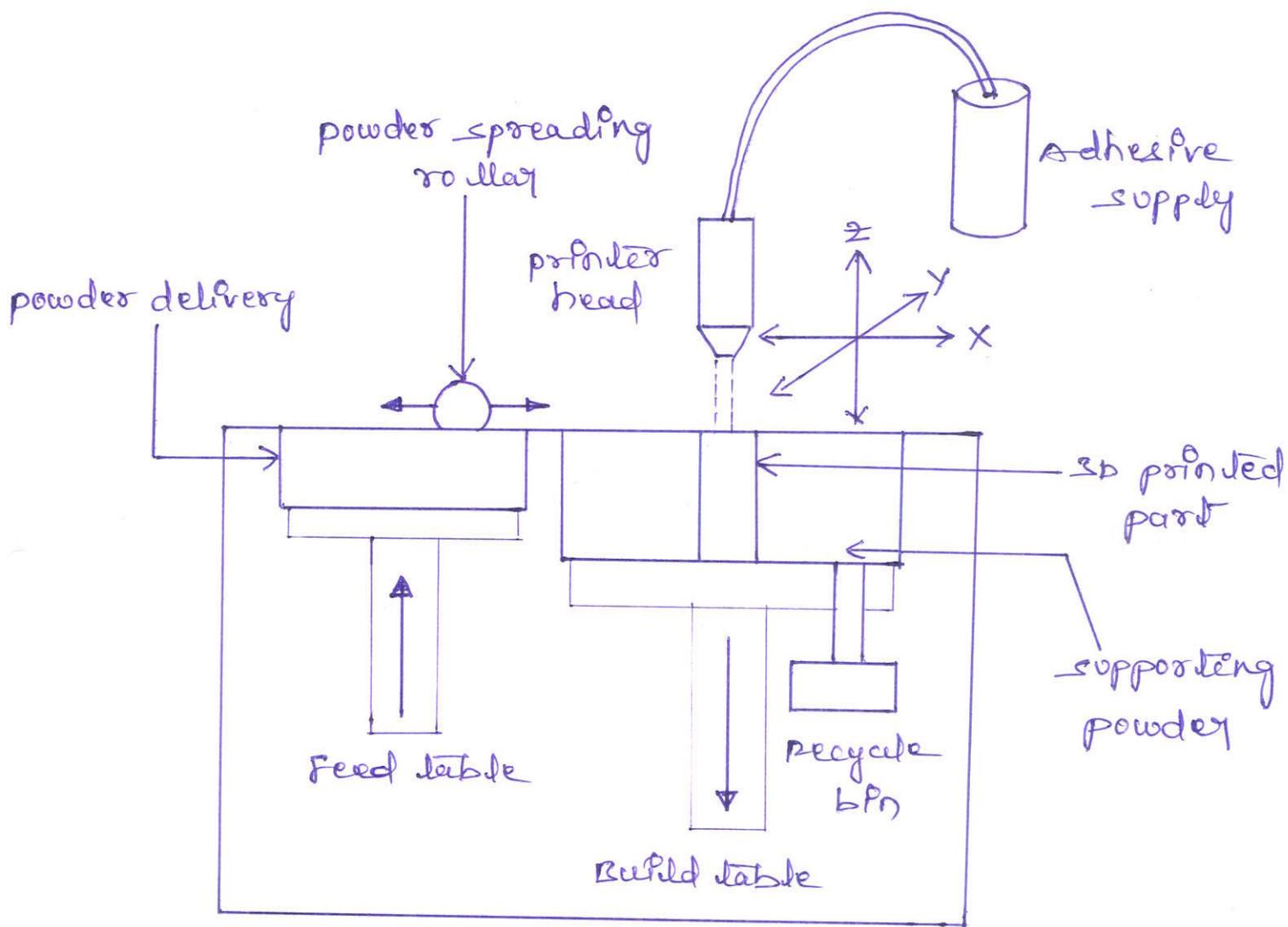
→ 3D printing, or 3P, is the construction of a three-dimensional object from a CAD model or a digital 3D model.

Working principle:

A 3D printer essentially works by extruding molten plastic through a tiny nozzle that it moves around precisely under computer control. It prints one layer, waits for it to dry, and then prints the next layer on top. The plastic from which models are printed is obviously hugely important.

* Working:

1. A Laser source sends a laser beam to solidify the material.
2. The Elevator raises and lowers the platform to help lay the layers.
3. The Vat contains the material used to create the 3D object.
4. The 3D object is created as parts are layered on top of each other.
5. Advanced 3D printers use one or more materials, including plastic, resin, titanium, polymers and even gold and silver.



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* The Top Five 3D printing Applications:-

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\* Education- Every day, more schools are incorporating 3D printing methods into their Curriculums.

\* Prototyping and manufacturing 3D printing was first developed as a means for faster prototyping.

\* Medicine

\* Construction

\* Art and Jewelry.

Advantages:

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- Flexible D/n
- Rapid prototyping
- Print on Demand
- Strong and Lightweight parts
- Fast D/n and production.
- Cost Effective
- Ease of Access

Disadvantages:

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- High energy Consumption
- 3D printing Technology is expensive
- Limited Materials.
- 3D printers Aren't that user-friendly
- Harmful Emissions
- Too much Reliance on plastic
- 3D printers are slow.

## \* Rapid tooling :

Rapid tooling (RT) denotes manufacturing on a slim time line. Some of the main advantages to rapid tooling trades is that it decreases the time and cost of the product. With rapid tools being fast and easily reproducible, it requires less stock for finished tools. These tools will be produced on demand and are available almost immediately. Special tools or tools where no supplier is existing on the market can more can be reproduced without bigger effort and production efforts.

However, the disadvantages are that it is not as accurate and also shortens the lifespan of the product.

Rapid tooling is mainly used for specific needs including prototype and trouble shooting existing problems. Rapid prototyping is not often used for large scale and long term operations for a part. Nevertheless, rapid tooling is starting to be used to create molds for commercial operations because the time lag is so short between start to finish and since a CAD file is the only thing needed for the design stage.

Since alternate methods require precious time and resources, rapid tooling provides a way to quickly provide molds for the required products. This allows companies to quickly make commercial products with the advances of rapid prototyping.

In addition, rapid tooling provides the customization necessary for personal applications. Instead of tedious trial and error measurements, rapid prototyping processes allow scientists and doctors the ability to scan and digitize the item or patient.

## \* Conventional Tooling Vs Rapid tooling:

The difference b/w Rapid tooling and Conventional tooling is: A time reduction of up to 1/5<sup>th</sup> is made when using Rapid tooling. Rapid Tooling Can Cost less than 5% of the Conventional tooling Cost. Conventional tools generally have a longer life Cycle.

### 1. Speed :

Rapid tooling is significantly faster than the Conventional process. This is particularly useful in instances where Small-run manufacturing is extremely time-sensitive. The Creation of a prototype and troubleshooting of the prototype are also ideal candidates for rapid prototyping due to the need to work expeditiously and create multiple iterations of the same concept.

### 2. Cost :

Rapid tooling is much more-effective because it's a simplified process that takes less time and requires less human labor. Also, as much of it is managed by machine and computer programs, the risk of human error, which can lead to wasted resources and labor, is reduced.

### 3. Quality :

Rapid tooling often results in parts that are less durable and have shorter life spans than those created via Conventional tooling. These types of tools will likely also impact the longevity of the products they create. That's not always a bad thing, as some products aren't meant to last for the long term. So spending money to ensure their durability is wasteful.

\* Need for rapid tooling :-  
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Rapid tooling is mainly used for specific needs including prototyping and troubleshooting existing problems. Rapid prototyping is not often used for large scale and long term operations for a part.

Rapid tooling is when rapid prototyping techniques and conventional tooling practices are used together to produce a mold quickly. This process is also used to prepare parts of a model from CAD data is less time and at a lower cost compared to traditional manufacturing methods.

* Classification of RT :-
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→ Two types.

- (1) Direct tooling
- (2) Indirect tooling.

(1) Direct tooling :-  
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The first type of rapid tooling is direct tooling. With direct tooling, you perform the following steps :-

Step-1: Create a model of the tool or mold using Computer-Aided Design (CAD) Software

Step-2: Send the file to a machine or printer to make the actual mold or tool that will be used for producing prototypes. This can either be a subtractive process where a CNC machine cuts raw material to form the shape or an additive process where a 3D printer build up the shape from scratch.

Step-3: The tool or mold produced can then be used directly to make prototypes - typically a very small number of them.

(2) Indirect Tooling :-

→ The second type of rapid tooling is indirect tooling. With indirect tooling, you perform the following steps.

Step-1: Create a model of the master tool or mold using CAD software

Step-2: Send the file to a machine or printer to create a master mold or tool, also known as a pattern. This master pattern is typically very durable.

Step-3: Make more molds or tools based on the master pattern. The new molds or tools can be made from different types of materials with different properties. You can use the master pattern for either hard tooling (tools made from durable or robust materials) or soft tooling (tools that are less robust). A single master pattern can produce many different tools or molds in large or small quantities, which in turn can produce many more prototypes.

* Indirect Methods of Rapid Tooling:

- RTV Silicone Rubber Molds. One of the most popular tooling applications for RP is the production of room temperature Vulcanizing (RTV) silicone rubber molds.
- Vacuum Casting
- RIM
- Wax Injection Molding
- Spin - Casting

- Cast Resin Tooling
- Spray Metal Tooling
- Sprayed Steel.

* Arc spray metal deposition:-
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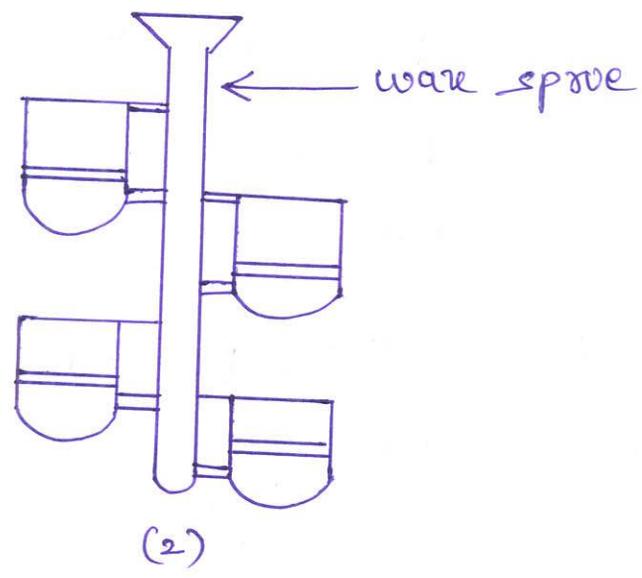
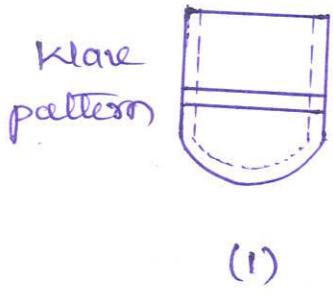
Arc spray (Sometimes referred to as twin wire arc spray or thermal arc spray) is a process that uses an electric arc to melt wires. The wires are forced together and form an electric arc, melting the wire. Compressed air passes through a nozzle which atomises the molten metal and sprays it onto the work piece.

\* Investment Casting:  
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The Investment Casting process - using the lost wax technique - is one of the oldest casting methods known and examples of its uses in producing jewellery and statues can be traced back several thousand years. While its roots in ancient Mesopotamia and Egypt, its commercial life only really began during World War II when military demands were creating the machine tool industry.

→ Advantages of Investment Casting:

- Smooth Finish
- Faster Production
- Tight Tolerances
- Affordable Tooling
- Vast Size Range
- Material Variety



INVESTMENT CASTING

* Disadvantages:

High Cost in large production runs parts are less complex.

Lower dimensional accuracy.

Surface finish requires additional work.

Applications of Investment Casting:

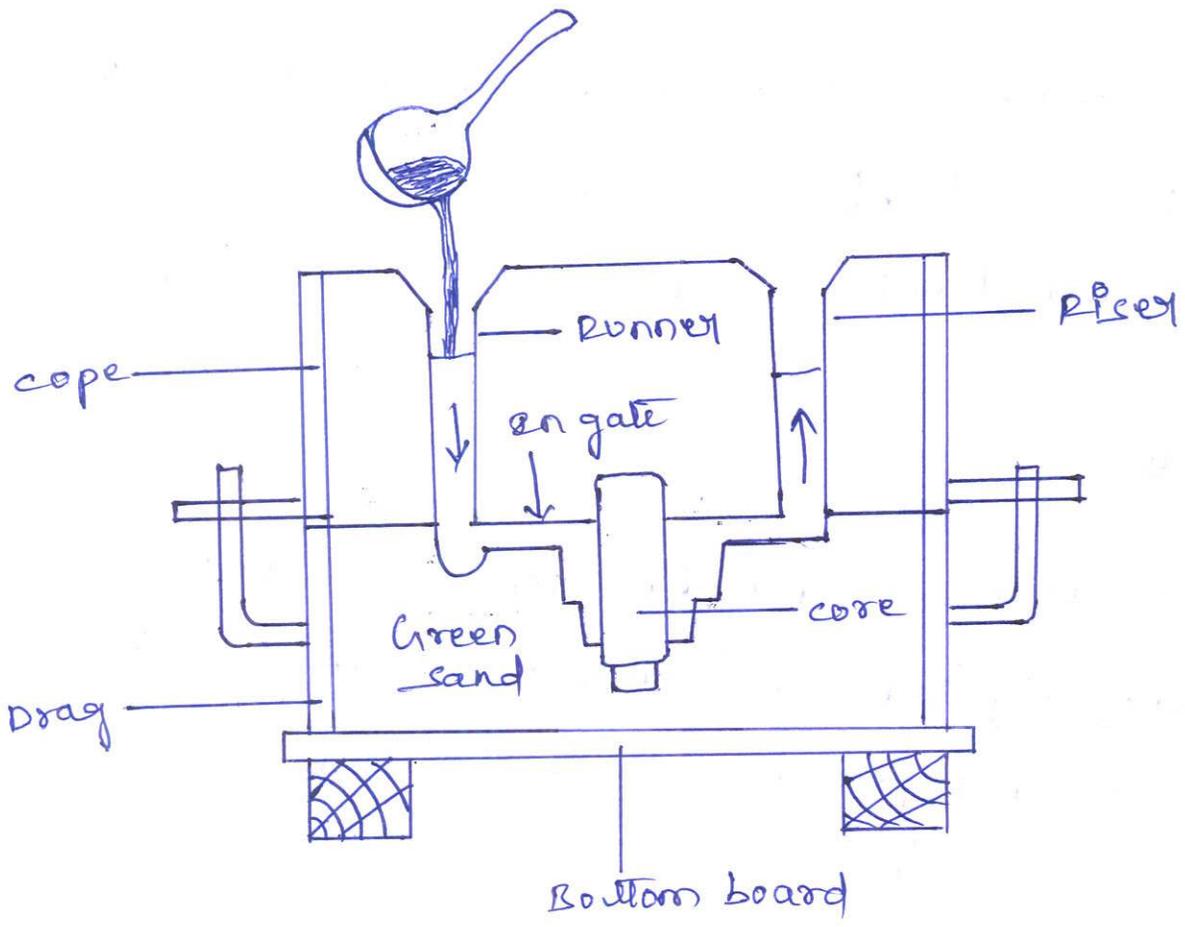
The application of investment castings are limitless. However, the aerospace power generation, firearms, automotive, military, Commercial, food service, gas and oil, and energy industries use these metal components the most.

* Sand Casting:

It also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. over 60% of all metal castings are produced via sand casting process.

1. Place a pattern in sand to create a mold.
2. Incorporate the pattern and sand in a setting system.
3. Remove the pattern
4. Fill the mold cavity with molten metal
5. Allow the metal to cool.
6. Break away the sand mold and remove the casting.

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SAND CASTING

The basic steps involved in making sand castings are:

1. **Patternmaking.** Patterns are required to make molds. The mold is made by packing molding sand around them. The mold is usually made in two parts so that the pattern can be withdrawn. In horizontal molding, the top half is called the cope, and the bottom half called the drag. The vertical molding the leading half of the mold is called the swing, and the back half is called the ram. The mold cavity, together with any internal cores as required, is ultimately filled with molten metal to form the casting.
2. If the casting is to be hollow, additional patterns, referred to as core boxes, are needed to shape the sand forms, or cores, that are placed in the mold cavity to form the interior surfaces and sometimes the external surfaces as well of the casting. Thus the void between the mold and core eventually becomes the casting.
3. **Molding** is the operation necessary to prepare a mold for receiving the metal. It consists of ramming sand around the pattern placed in support, or flask, removing the pattern, setting cores in place, and creating the gating/feeding system to direct the metal into the mold cavity created by the pattern, either by cutting it into the mold by hand or by including it on the pattern, which is most commonly used.
4. **Melting and pouring** are the processes of preparing molten metal of the proper composition and temperature and pouring this into the mold from transfer ladles.
5. **Cleaning** includes all the operations required to remove the gates and risers that constitute

Advantages of using Sand Casting:

- Nearly any alloy: Sand Castings can be readily produced in nearly any ferrous or non ferrous alloy.
- Low tooling cost: The relatively low cost of tooling makes Sand Casting a process of choice for lower volume needs.
- Versatile - Size, weight, shape
- Any quantity
- Timing

Disadvantages of Sand Casting:

- Low strength - low material strength due to high porosity compared to a machined part
- Low dimensional accuracy - Because of shrinking and the surface finish dimensional accuracy is very poor.
- Poor surface finish - Due to internal sand mould wall surface texture.

Applications:

- Air Compressor piston
- Bearings
- Blowers & Impellers
- Bushings
- Cams
- Electronic equipment
- Engine Crank Cases

* 3D Kelttool processes:

- Fabricating the master patterns of Core and Cavity
- Producing RTV Silicon rubber mould from the pattern.
- Filling the Silicon rubber mould with metal mixtures to produce green parts duplicating the masters.
- Firing the green parts in a furnace to remove the plastic binder and sintering the metal particles together.
- Infiltrating the sintered parts (70% dense inserts) with Copper in the second furnace cycle to fill the 30% void space
- Finishing the Core and Cavity.

Advantages:

3D Kelttool is an unparalleled tooling solution, perfect for casting complex part geometries, which can be more time-consuming for a CNC and/or EDM machine. 3D Kelttool is the only proven technology capable of creating production steel tool inserts quickly and economically.

Disadvantages:

3D Kelttool also have a limitation of their standing geometry. Since the material is very weak in its green state, these types of geometries are often broken when demolding from the RTV rubber.

Direct rapid tooling:

It is actually more commonly used during manufacturing than for prototyping. In a short-run production, this type of rapid tooling enables you to create a mold or tool very quickly and begin producing products from it almost immediately.

Working:

Direct approaches to rapid tooling do not require the production of a pattern. Instead, additive processes are used to produce tooling inserts directly. These approaches can potentially reduce the no. of steps in the process and potentially impact overall part accuracy.

Direct AIM:

Rather than making a master Stereolithography pattern around which a material is cast, it also is possible to build the cavity on the stereo lithography machine.

3D Systems (Valencia, CA) has named this process Direct AIM.

Although not nearly as strong or hard as conventional tooling, it is possible to inject a range of thermoplastics into these cavities and produce useable parts. At present, only less abrasive and lower melting point polymers are being molded. Although research is underway to improve this application.

Direct Metal Tools:

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Metal parts for injection molding tooling inserts and for direct use have been built using the SDP™ process and placed into use.

Extrude-Hone Corporation has licensed the SDP™ technology for fabrication of metal parts and tools.

Parts have been created in a range of materials including stainless steel, tungsten and tungsten Carbide. Printed parts were sintered for strength, then they may be infiltrated with low melting point alloys to produce

dense parts. The ZDP™ process is easily adaptable to a variety ⁴⁵
of materials systems, allowing the production

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* Spin Casting:

Spin Casting, also known as Centrifugal rubber mold Casting, is a method of utilizing inertial produce Castings from a rubber mold. Typically, a disc-shaped mold is spun along its central axis at a set speed.

→ The Casting material, usually molten metal or liquid thermoset plastic, is then poured in through an opening at the top-center of the mold.

→ The filled mold then continues to spin as the metal (or thermoset plastic) solidifies.

* Die Casting: is a metal

Die Casting is a metal Casting process that is characterized by forcing molten under high pressure into a mould cavity. The mould cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mould during the process.

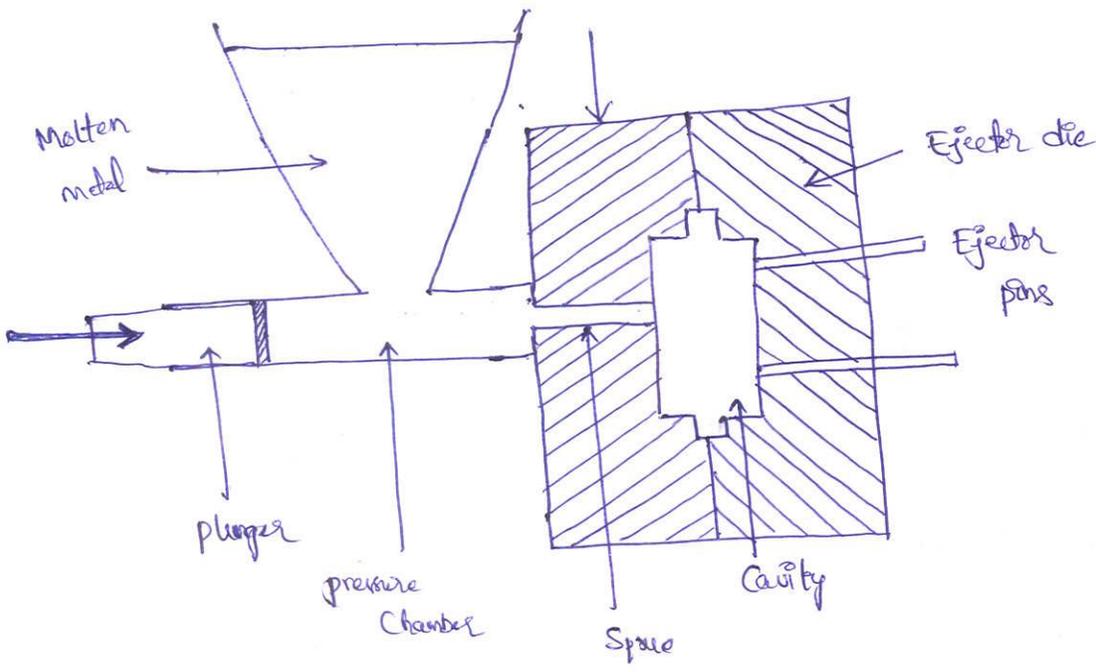
→ Most die Castings are made from non-ferrous metals, specifically Zn, Cu, Al, magnesium, lead, pewter, and tin-based alloys.

→ Depending on the type of metal being cast, a hot- or cold-chamber machine is used.

→ The Casting equipment and the metal dies represent large Capital Costs and this tends to limit the process to high-volume production.

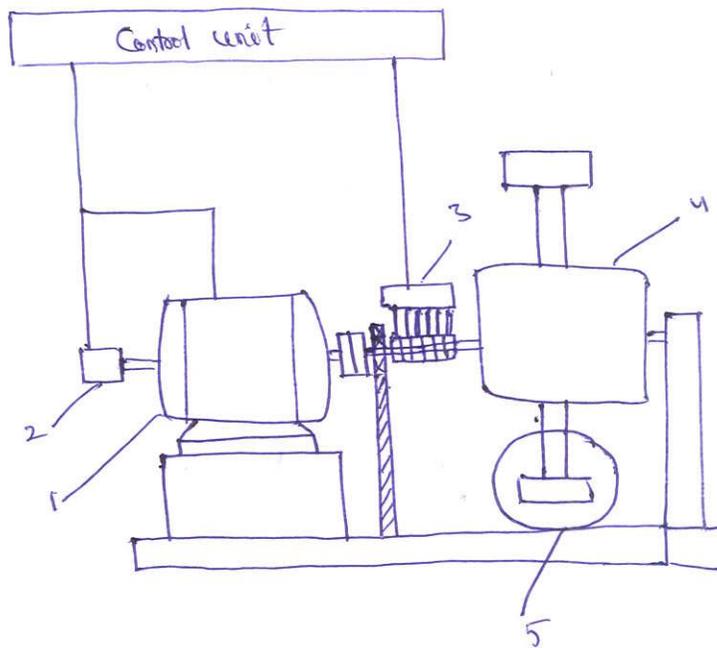
→ Die Castings are characterized by a very good surface finish (by Casting standards) and dimensional consistency.

* Die Casting:



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* Spin Casting:



- (1) Electric motor
- (2) tachometer
- (3) Collector
- (4) rotor
- (5) photodiodes

* RIV Epoxy Tools:

- Epoxy-based Composite tooling
- Like silicone rubber tooling, epoxy-based Composite tooling requires a master pattern.
- Typically, this pattern is finished and then embedded in a casting bone block to create the parting line of the mold.
- This process is similar to that of vacuum casting. The only difference being that instead of silicone rubber, the material used is aluminium.
- Once the mould is made from this material, it can be put on a moulding machine and components can be moulded in actual material of choice.
- The mould life normally is upto 200 pieces.

* Ceramic tools:

Ceramic tools are far superior to sintered carbides in respect of hot hardness, chemical stability and resistance to heat and wear, but are lacking in fracture toughness and strength. They are well suited to machining cast iron, hard steels and super alloys.