Model Question Paper **CBCS Scheme**

USN | | | | | | | | | |

15ME82

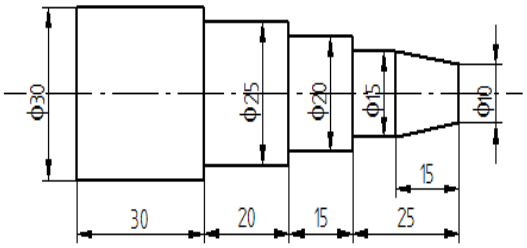
VIII Semester B.E. Degree Examination, May/June 2019

Additive Manufacturing

Time: 3 hrs Max marks: 80

Note: Answer any FIVE full questions, choosing one full question from each module

		Module-1
1	a.	Explain in detail post processing of additive manufacturing parts.**(10 Marks)**
	b.	Explain the applications of AM in various fields. **(6 Marks)**
		OR
2	a.	Explain with a neat sketch the working principle of Selective Laser Sintering process **(08 Marks)**
	b.	Explain with a neat sketch the working principle ofLOM process. **(08Marks)**
		Module-2
3	a.	Explain the working of Relays with a neat sketch.**(08Marks)**
	b.	Explain briefly the characteristics of Diodes and Thyristors with a neat sketch.**(08Marks)**
		OR
4	a.	Explain the Regenerative circuit with a neat sketch. **(10Marks)**
	b.	Enumerate the application of shape memory alloys as actuators in additive manufacturing process. **(06Marks)**
		Module-3
5	a	Explain with a neat sketch the working principle ofInjection Moulding,**(08 Marks)**
	b	Explain the following processes with a neat sketches i) Dry spinning ii) Wet spinning**(08Marks)**
		OR
6	a	Explain the different modern sintering techniques with respect to powder metallurgy. **(08Marks)**
	b	Explain briefly the defect analysis of sintered components **(08Marks)**
		Module-4
7	a	Explain briefly the Gas phase synthesis of nano materials **(08Marks)**
	b	With a neat sketch explain the Flame assisted ultrasonic spray pyrolysis**(08Marks)**
		OR
8	a	Explain briefly the working principle of X-Ray diffraction with a neat sketch.**(08Marks)**
	b	Explain briefly the working principle of Transmission electron microscope.**(08Marks)**

		Module-5
9	a	Classify the CNC machine tools based on control loops with a neat block diagram **(08 Marks)**
	b	Write the Manual part program for machining the profile as shown in fig 1  Fig:1 **(08 Marks)**
		OR
10	a	Explain the elements of automated system with a neat sketch **(08 marks)**
	b	Distinguish between Continuous vs discrete control system **(08 marks)**

1.a Explain in detail post processing of additive manufacturing parts. (10)

Post processing techniques used to enhance Components or overcome AM limitations.

1. Support material removal
2. Surface texture improvement
3. Accuracy improvement
4. Aesthetic improvement
5. Preparation for use as a Pattern
6. Property enhancements using non-thermal techniques
7. Property enhancement using thermal techniques

1. Support material removal

* Support materials are structures that are 3D printed along with the actual 3D model to provide support to fragile, thin or overhanging
* Support removal aka. the structural support is the process of removing parts after 3D printing. Traditional methods require technicians to manually spray off supports with high pressure hoses or chip away at the supports.

2. Surface texture improvements

* AM parts have common surface texture features that may need to be modified for aesthetic or performance reasons.
* The post-processing utilized for surface texture improvement is dependent upon the desired surface finish outcome.
* If a smooth or polished finished is desired, wet or dry sanding & hand-polishing are performed.

Accuracy improvement

* There is a wide range of accuracy capabilities in AM.
* Some processes are capable of sub-micron tolerances, whereas others have accuracies around 1mm.

Aesthetic improvement

* Aesthetics - the part is of critical importance for its end application.
* A difference in surface texture b/w one region & another may be desired.
* Finishing of selected surface only is required.

Property enhancement using Non-thermal techniques

* Powder-based & extrusion-based process often create porous structure.

* RP - impeller is a collection of material & treatment operations used to increase the strength, ductility, heat deflection or other properties of an. parts using nano-composite reinforcement.

Property Enhancement techniques using thermal

* many parts are thermally processed to enhance their properties
* Traditional heat-treatment developed for the specific metal alloy being employed are commonly used.

1.b Explain the application of Am. in various field. (6)

* Functional models

* There are a number of RP technologies that meet the need for building
* one of the RP process that are widely used for producing models for functional test is SLS.
* initially, four nylon-based materials were available commercially for this process.
* The production of nylon part is generally cost-effective when a small number of parts is required

Pattern for investment & vacuum casting

* RP technologies are widely used for building pattern for investment & Vacuum casting.
* Two SLS materials are currently available for producing casting pattern cast ferrous & non ferrous.
* It is processed at relatively low temperatures, good accuracy but moderate strength. The density of the ferrous parts can vary from 70 to 90% depending on build parameters & they can be polished to a mirror like finish.
* Durus parts are used as pattern for vacuum casting while nylon parts are better suited for investment casting.

Medical or Surgical model

* Nowdays medical devices, specific implants hearing aids, dental products & pills are being manufacture by RP.
* In august 2015, US FDA approved 3D printed pills which allows very porous pills to be produced, which enables high drug doses in a single

pill which dissolves quickly & can be ingested easily.

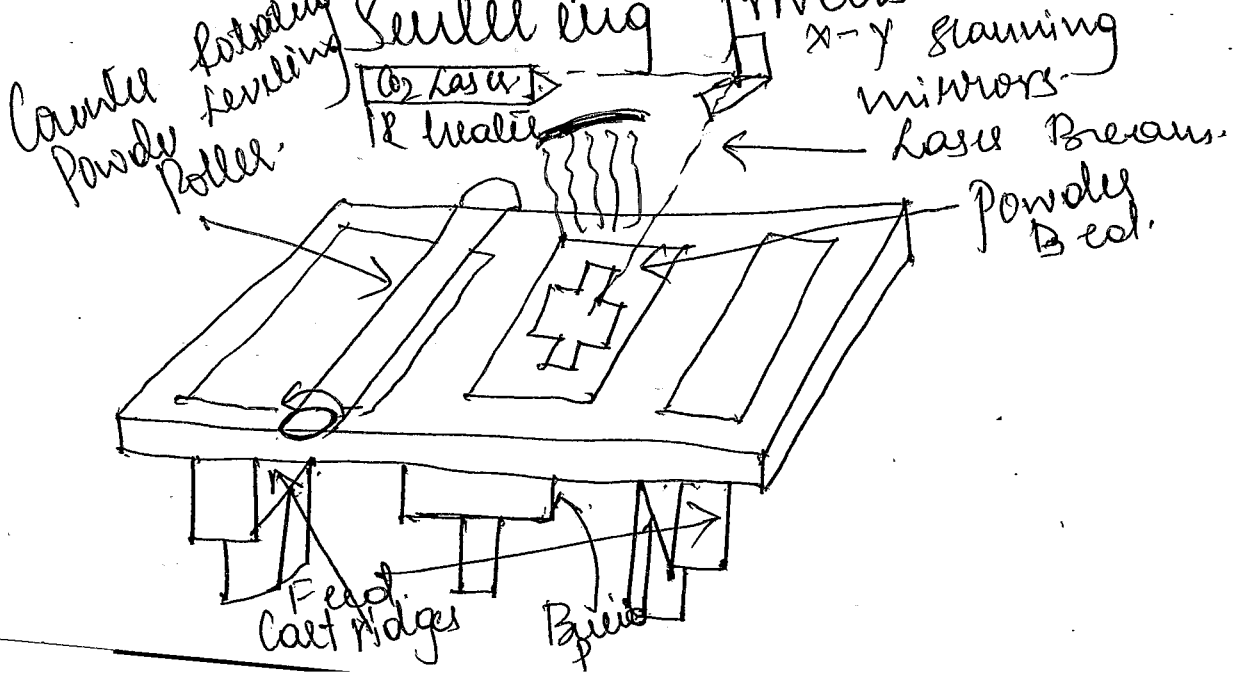
Bioprinting

* Bio printing refers to manufacturing artificial biological organs & body part capable of working like original or
* in this process, layers of living cells a deposited onto a gel medium or sugar matrix & slowly built up to form three dimensional structure including vascular system.

Space

* In September 2014, "Space x" delivered the first zero gravity 3D printer to the international space station.

Q.a. Explain with a neat sketch, the working principle of selective laser sintering process. (8)



Working Principle

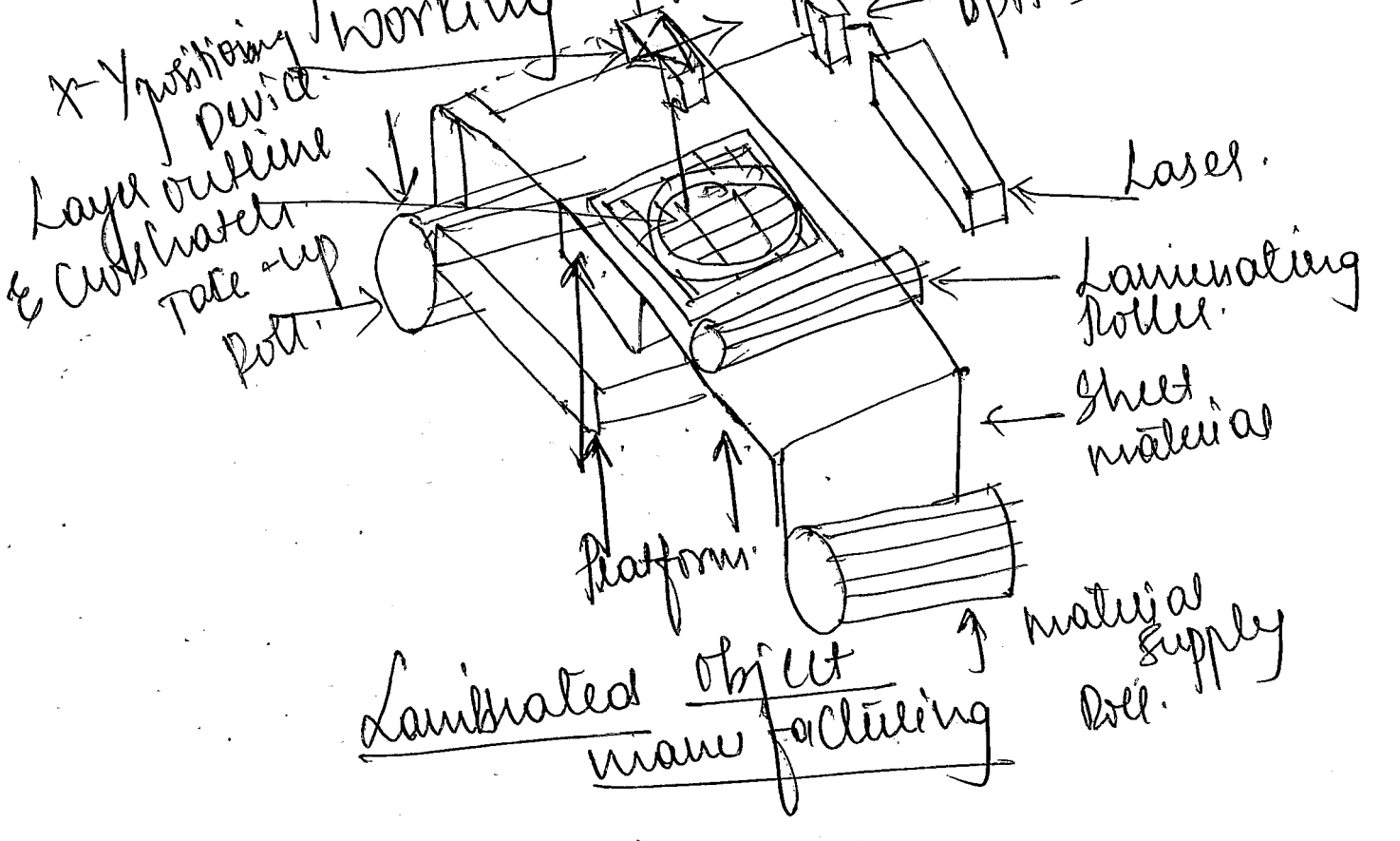
* CAD data files are converted to STL file format & transferred to the Rapid prototyping system where they are sliced.
* A thin layer of heat fusible powder is deposited on the part building chamber & layer thickness is of order of 0.1 mm thick.
* The part bed is heated just below the melting point & or glass transition temperature of the powdered material.
* The part building takes place inside an enclosed chamber filled with nitrogen gas to minimized oxidation & degradation of the powdered material.
* Infrared heaters are used to maintain an elevated temperature around the part being formed.
* A focused CO_2 laser beam is moved on the bed in such a way that it thermally fuses the material to form the slice cross section.
* Surrounding powder remains loose & serve as support for subsequent layers.
* When the cross section is completely drawn an additional layer.

A powder is deposited with a roller mechanism on the top of previously scanned layers. This prepare the next layer of scanning.

* This is repeated until each layer fuses to the layer below until the part is completed.

* SLS parts may then require some post processing or secondary finishing such as sanding, lacquering & painting, depending upon the applications.

Q.6. Explain with a neat sketch the working principle of Laminated Object manufacturing process. (8)

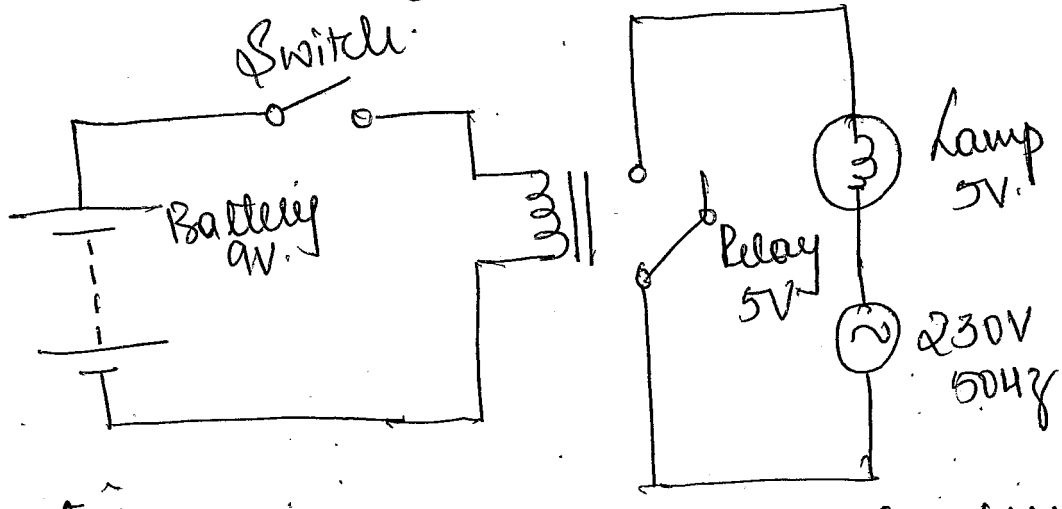


* In that models are built up with layers of cross section of the part. Hence as layers are being added, the excess material is not required for that cross section is being cut away.
* LOM is one of the fastest RP process for parts with longer cross-sectional area which make it ideal producing large parts.
* In LOM process the material consists of paper laminated which is coated with thermoplastic adhesive & rolled up on-spools as shown in figure.
* A feeder mechanism advance the sheet over the build platform, which a basis made up from paper & double-sided foam tape.
* A heated rolls applies pressure to bond the paper to the base.
* CO_2 laser traces the outline of the CAD-data fed in the computer.
* After the laser cutting is completed the platform move down & a fresh sheet of laminated paper is rolled on.

* The process is repeated as needed to build the part.
* Low process is used in pattern making & toy designing as this process is cheaper & high-volume production can be achieved.

3.a. Explain the working of relay with a neat sketch. (8)

Relays are switching that open & close circuits electromechanically or electronically. Relays control one electrical circuit by opening & closing contact in another circuit. Relay have two circuit: a control circuit & a load circuit.

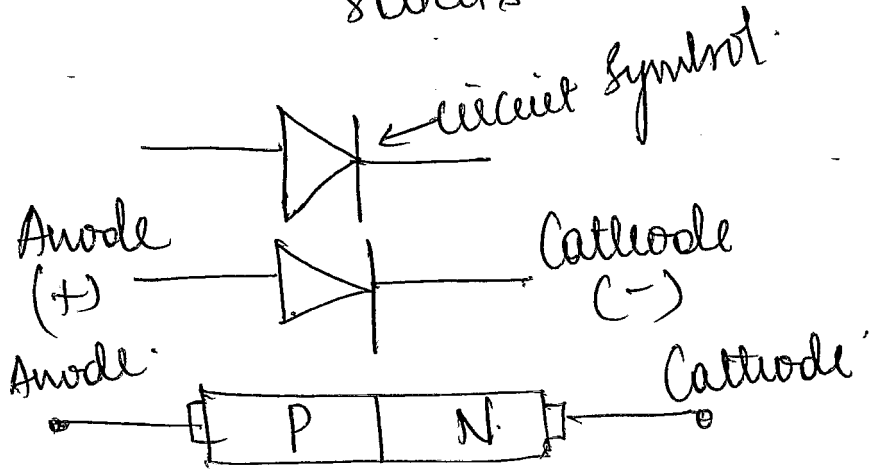


Operation

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, & one or more set of contacts.

The armature is hinged to the yoke & mechanically linked to one or more sets of moving contacts it is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay is closed, and the other set is open.

3.b Explain briefly the characteristics of diode & thyristors with a neat sketch. (8)



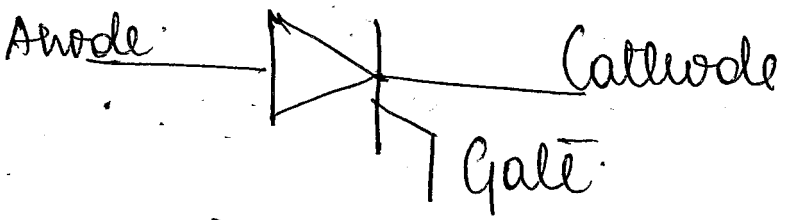
Diode

A diode is simply a PN junction, but its application are extensive in electronic circuit. There important characteristic of a diode. all; first of all, the forward voltage drop. under a forward bias condition, this should be about. The there is the reverse voltage drop in this reverse, when we reverse bias the dibe the depletion layer widens & usually the applied

Voltages are felt across the diode. That is the reverse breakdown voltage. Reverse voltage drop that will reverse current flow & in most cases destroy the diode.

Thyristors

Thyristors is a small device which can control large amount of voltage & power. Thyristors are used as current reversal to turn off the device.



Thyristor

There are three states in a thyristor

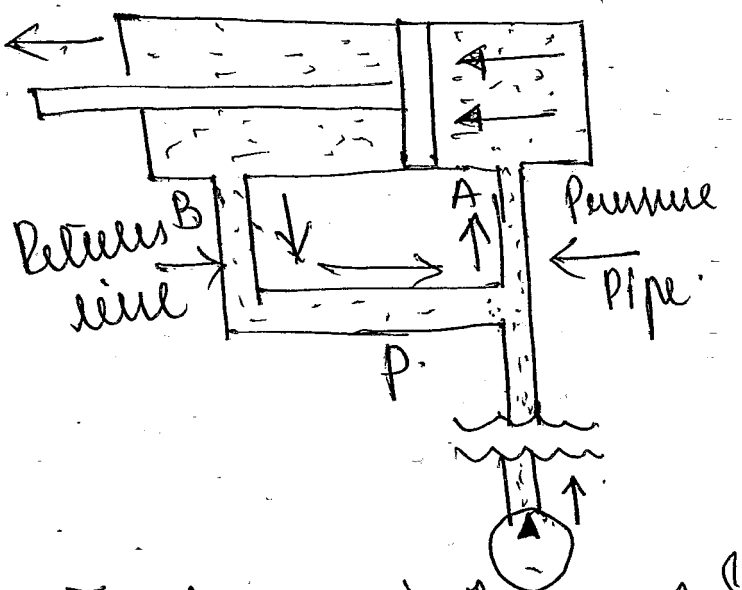
* Reverse blocking mode:- in this mode of operation, the diode will block the voltage which is applied.
* Forward blocking mode:- in this mode the voltage applied in a direction make a diode to conduct. But conduction will not happen here because the thyristor has not triggered.
* Forward conducting mode:- the thyristor has triggered & current will flow through the device until the forward current reaches below the threshold value.

which is known as "holding current".

4.a. Explain the regenerative circuit with a neat sketch. (10)

Principle of regenerative circuit is recovering the energy available with returning oil by using regenerative technique. The concept of regenerative circuit is explained from following figure. Consider the double acting cylinder. Pressurized oil from Pump is admitting in cylinder cavity through port (A). Due to Pressure force piston is moving from right to left. During this movement, the oil present on piston rode side of piston starts coming out through port (B). This oil will return to the oil reservoir via DC valve. It is clear from figure that returning oil now enter in pressure pipe through Pipe P' During exit of oil through port (B), some energy is still there with oil on piston rod side. This energy is otherwise wasted if the oil directly goes to oil reservoir.

To avoid wastage of this energy, Pipe 'P' is connected. So that, the pressurized oil gets more energy & it will create more pressure force while entering through port (A).



4.b Enumerate the application of Shape memory alloy as actuators in additive manufacturing process. (6)

Shape memory alloy (SMA) is an alloy & it is one type of smart material. There are the material that "remember" their original shape.

SMA are useful for such thing as actuators which are materials that "change" shape, stiffness, position, natural frequency & other mechanical characteristics in response to temperature.

The SMA actuators are made as wire, spring or ribbon shape

As an actuator, the one-way SMA element is one can only provide force/displacement in one direction.

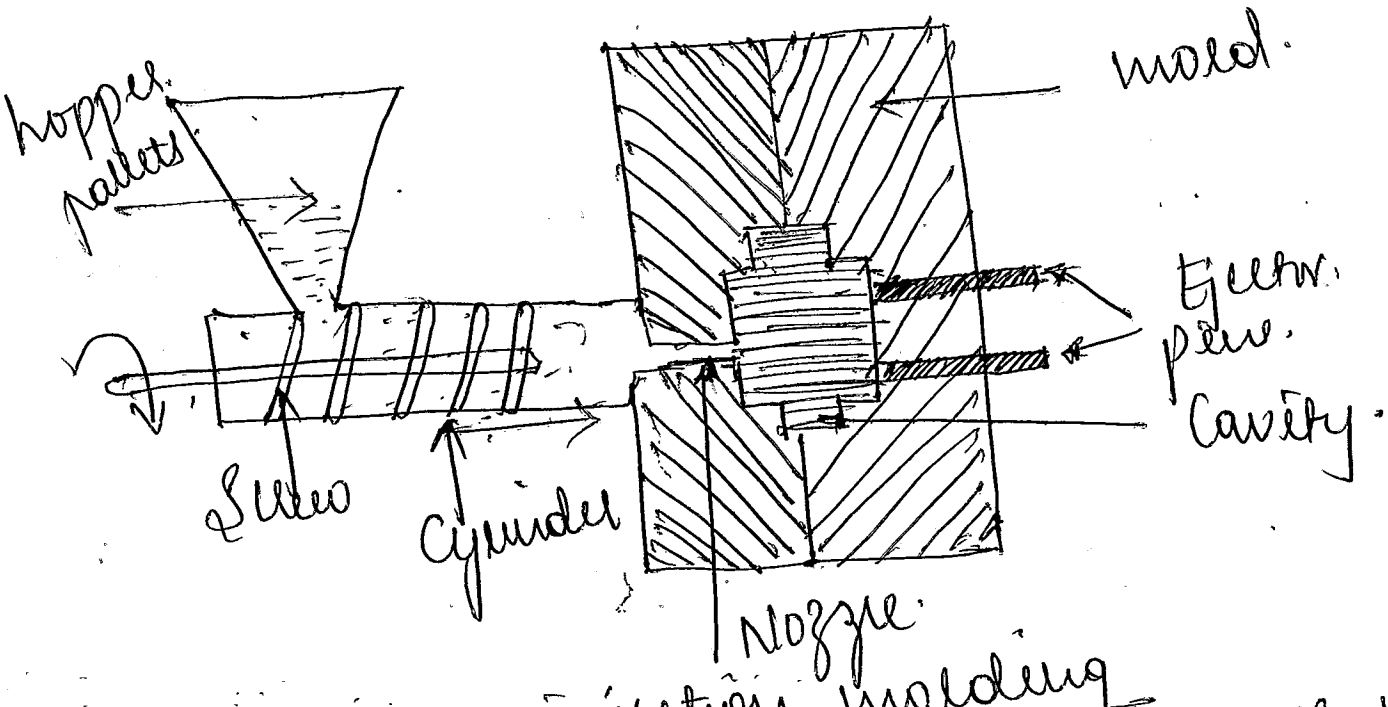
Examples:- A wire that compresses when heated does not expand without external force. When the alloy cool down. This is advantage of the one-way SMA actuators. A bias mechanism must be used if the actuator has to be returned to the original shape after the heating pulse.

SMA actuators are very popular because of their several advantages. Compact actuator with high value power/mass. easy activation with low voltage power supply; silent operation of a actuator; material of actuator is biocompatible

5a. Explain with neat sketch the working Principle of injection moulding (8)

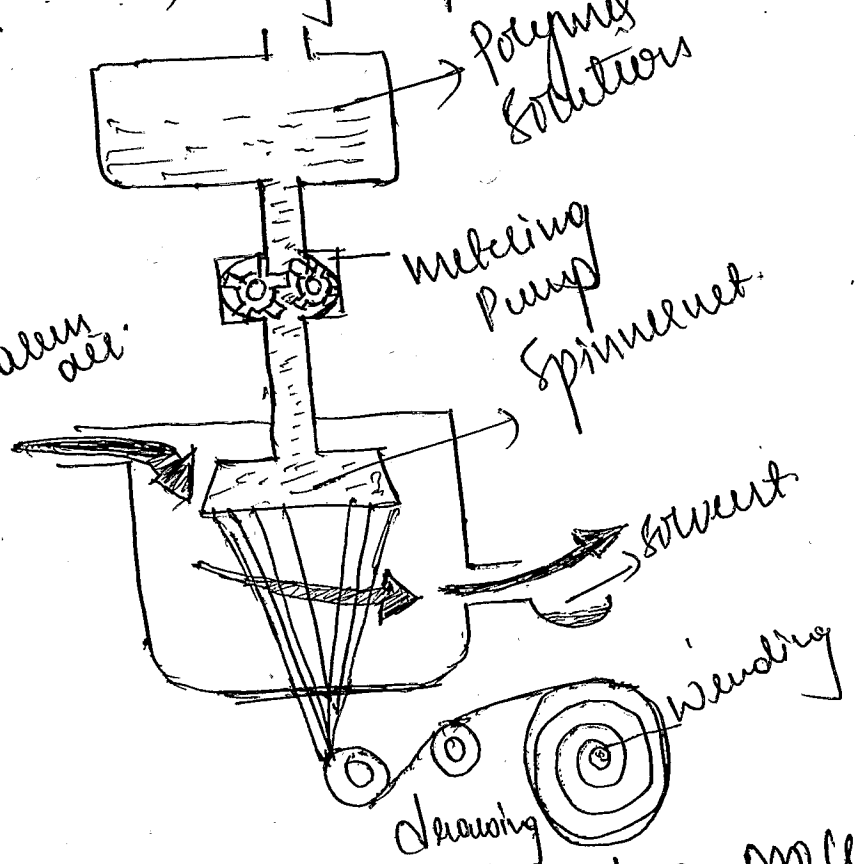
* Most widely used method for producing parts of both thermoplastic & thermo setting resins.

* Polymer is fed through a hopper to a injector screw.
* Die-end is surrounded with heater-bands brings the polymer to the required temp
* Process starts with feeding plastic pellets into hopper.
* Resins fall into the tube & pushed along the hot tube by reciprocating screw.
* Sufficient volume of molten plastic is available at the injection nozzle end.
* Entire screw is then plunged forward to force the material into the mould.
* Pair is held under pressure for a few seconds for the moulded part to solidify.
* It then retracts, slightly & the mould opens
* Knock-out pins get the moulded pile.
* Later the sprue & runner all trimmed off.
* 10 sec to 6 min. per run.
* Each run may produce one or several parts.



injection molding

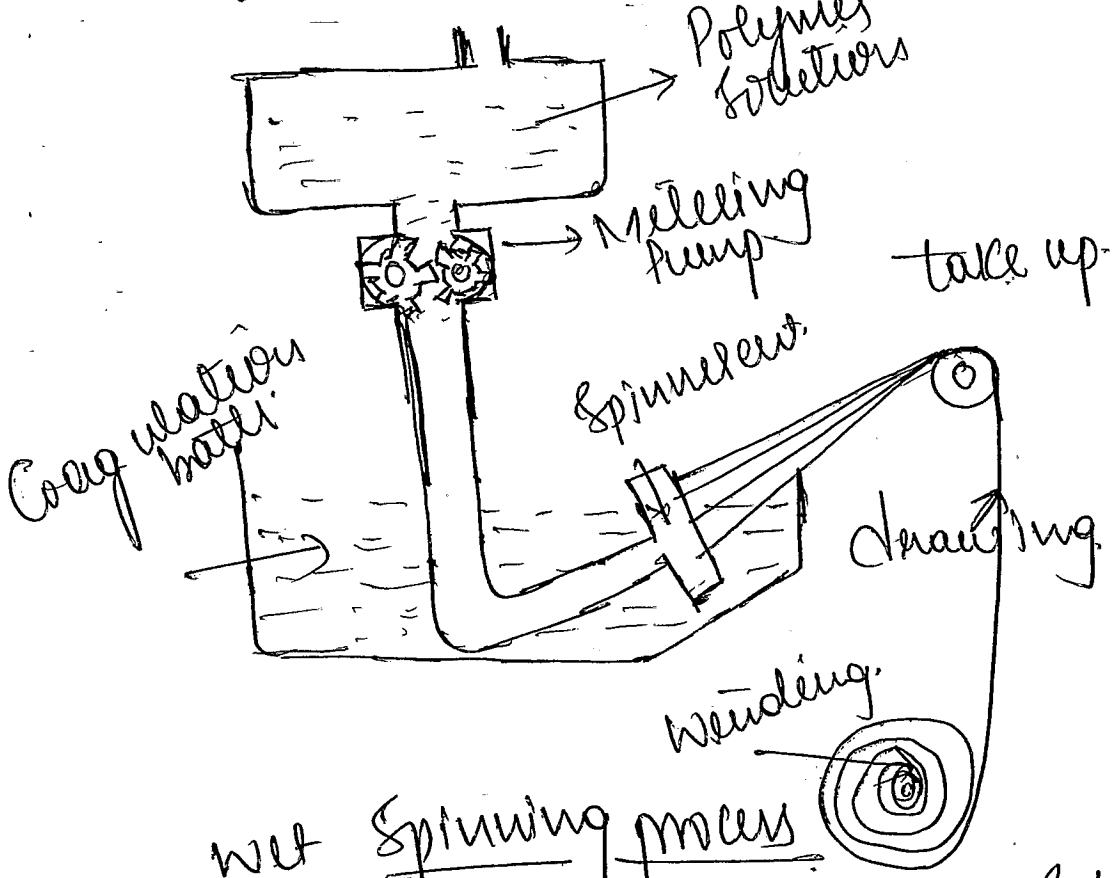
5b. Explain the following process with a neat sketch
i) Dry Spinning ii) Wet Spinning (8)



Dry Spinning process

* In dry spinning a volatile solvent is used to dissolve the raw material & form a solution.

* Then the solution is purified by filter.
* The solution is extruded through a spinneret into a warm air chamber where the solvent evaporates, solidifying the fine filaments.
* Finally the filament yarn either is immediately wound onto bobbins or is further treated for certain desired characteristics or end use.



wet Spinning process

* In wet spinning a non-volatile solvent is used to convert the raw material into a solution.
* The solvent is extruded through the spinneret into by simply washing it out.
* After extension, the solvent is removed in a liquid coagulation medium

* Finally the filament yarn either is immediately wound onto bobbins or is further treated for certain desired characteristics or end use.

6.a. Explain the different modern sintering techniques with respect to powder metallurgy. (8)

1. Microwave Sintering

Microwave energy is a form of electromagnetic energy with frequency range of 300MHz to 300 GHz. Microwave heating is a process in which the materials couple with micro wave absorb the electromagnetic energy volumetrically & transform into heat

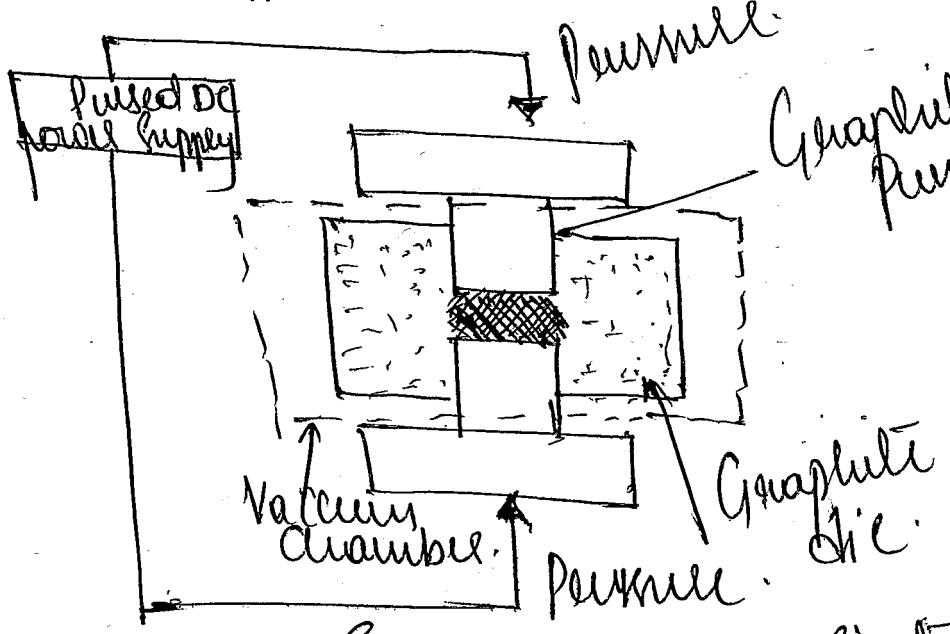
Advantages

a) Reduced energy Consumption
b) Very rapid heating rates.

2. Spark plasma Sintering

Instead of using an external heating source a Pulsed direct current is allowed to pass through the electrically conducting ground die & its appropriate cases, also through the sample. Die also, acts as a heating source. & that

the sample is heated from both outside & inside.



Spark plasma sintering

6.b. Explain briefly the defect analysis of Sintered Components. (8)

1) Testing & inspection procedures which do not statistically reflect actual use situations: Eg. particle size yield in floor screening by vibrating screens Vs the laboratory routine screening

2) Arbitrary material substitutions by the purchasing or manufacturing departments without adequate engineering evaluation, this is very important in case of hot material section for Compressor P/M parts.

3) Class design revisions to incorporate new features in existing design with minimum tooling changes

4) Failure to apply the same evaluation method to purchased components or powders as are applied to internally manufactured ones

5) Failure to anticipate misapplication of the product by the user for example in selecting the proper grade of cemented carbide for different cutting purposes

6) To little consideration given to the wide variation in the physical & intellectual abilities of customers

7) Interpretation of the statistical quality control function as absolute quality assurance rather than basis for action.

7a. Explain briefly the gas phase synthesis of nano materials (8)

Synthesis methods of nanoparticles in the gas phase are based on homogeneous nucleation in the gas phase & subsequent condensation & coagulation

Furnace

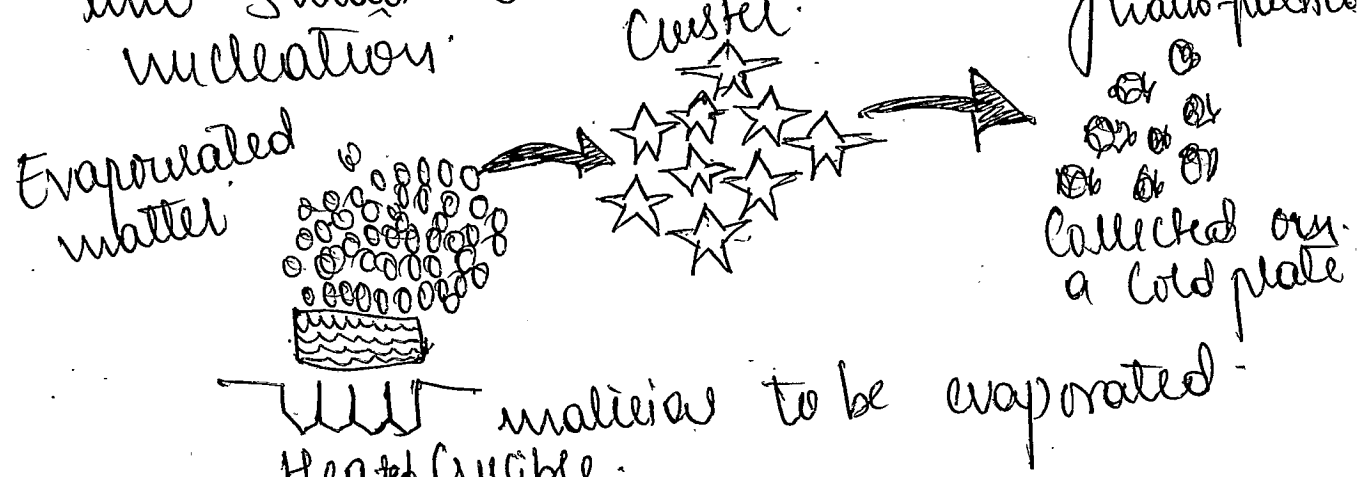
The simplest fashion to produce nanoparticles is by heating the desired material in a heat resistant crucible containing the desired material.

This method is appropriate only for materials that have a high vapour pressure at the heated temperature that can be as high as 2000°C.

Energy is normally introduced into the precursor by an heating, electronbeam heating or joule heating.

The atoms are evaporated into an atmosphere, which is either inert or reactive. To carry out reactive synthesis, materials with very low vapour pressure have to be fed into the furnace in the form of a suitable precursor such as organometallic, which decompose in the furnace in the form of gas to

produce a condensable material.
The hot atoms of the evaporated matter lose energy by collisions with the atoms of the cold gas & undergo condensation into small clusters via homogeneous nucleation.

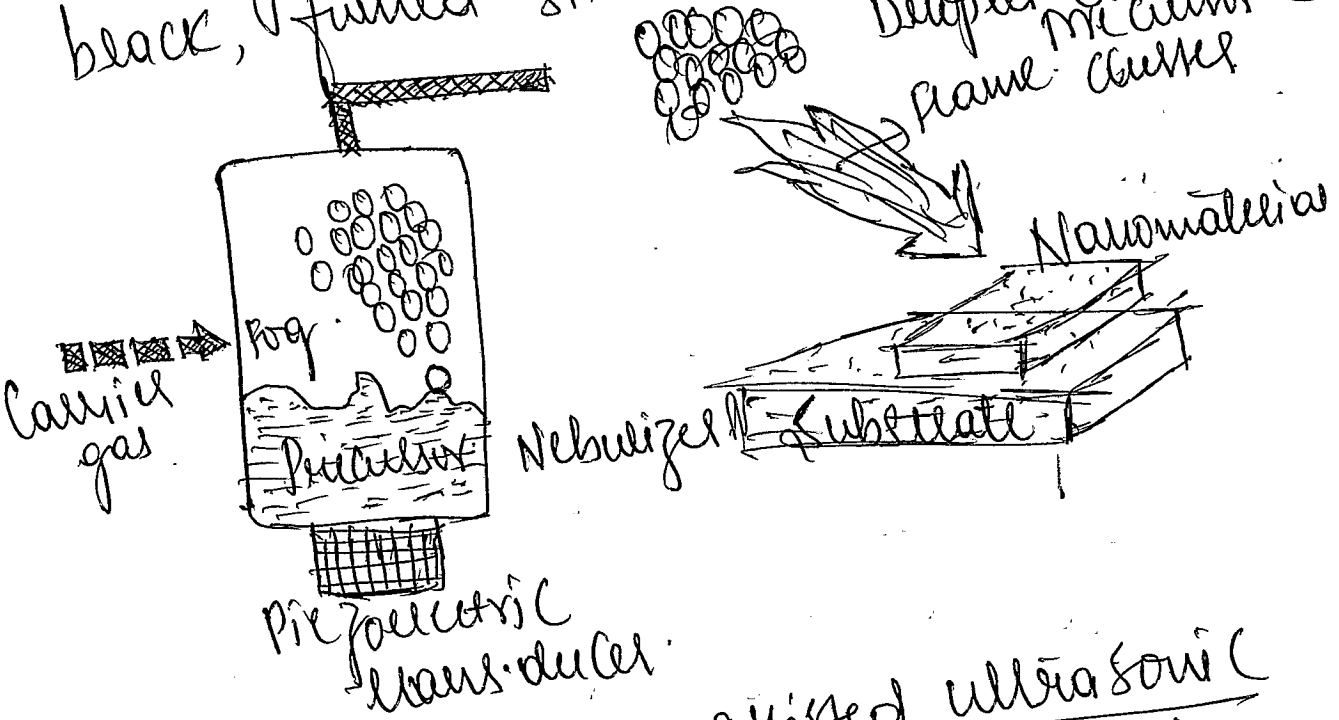


7.b. With a neat sketch explain the flame assisted ultrasonic spray pyrolysis (8).

In this process, precursors are nebulized & then unwanted components are burnt in a flame to get the required material. Eg: ZrO_2 has been obtained by this method from a precursor of $Zr(CH_3CH_2CH_2O)_4$

Flame hydrolysis that is a variant of this process is used for the manufacture of fused silica. In this process, silicon tetra chloride is heated in an oxy-hydrogen flame to give a finely dispersed silica. The resulting white amorphous powder consists of spherical particles with size in the range 7-40nm.

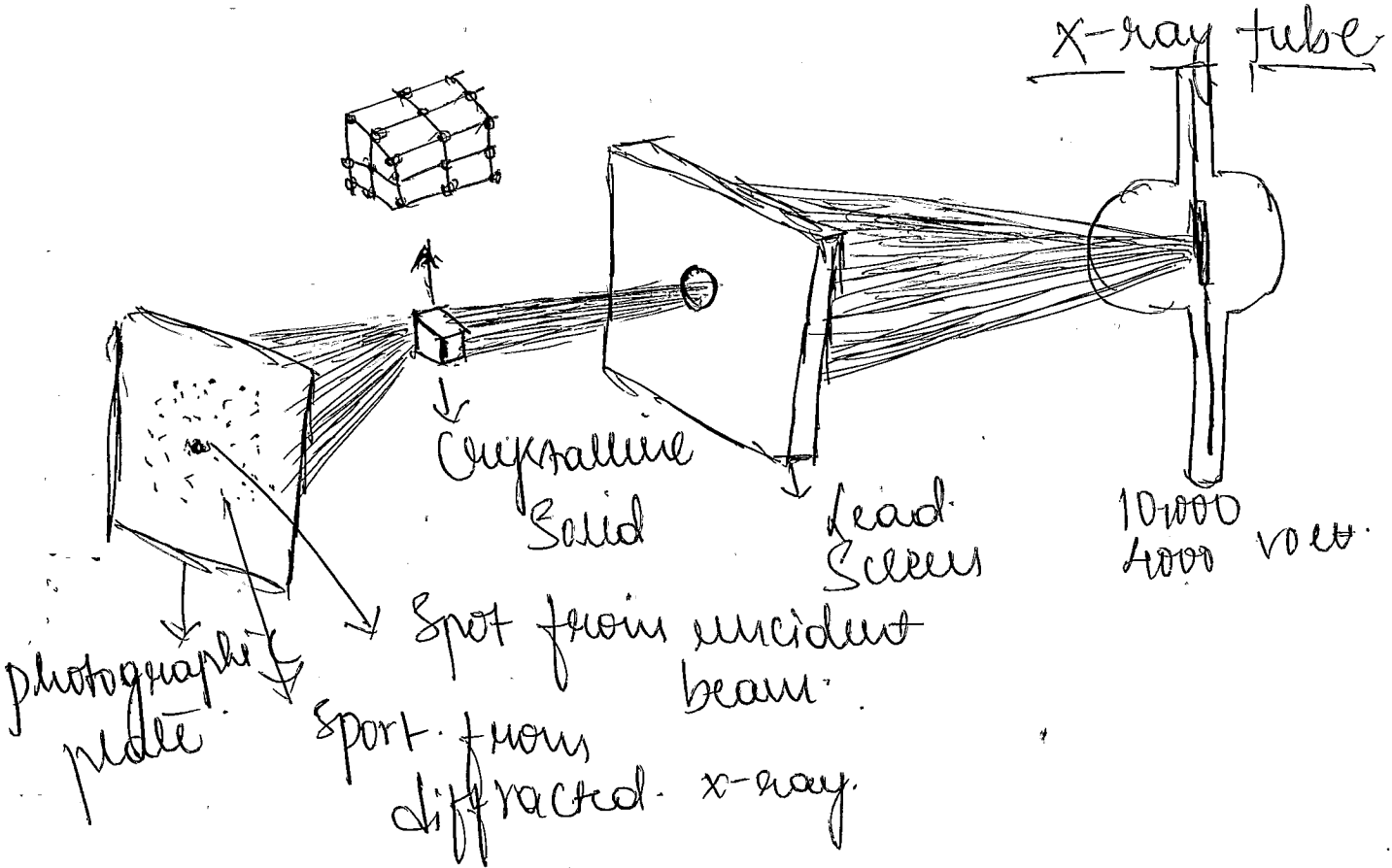
The Combustion flame synthesis, in which the burning of a gas mixture, e.g. acetylene & oxygen or hydrogen & oxygen, supplies the energy to initiate the pyrolysis of precursor compounds, is widely used for the industrial production of powders in large quantities, such as carbon black, fumed silica & titanium di-oxide.



Flame assisted ultrasonic spray pyrolysis

8.a. Explain briefly the working principle of x-ray diffraction with neat sketch. (8)

x-ray diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material & can provide information on unit cell dimensions.



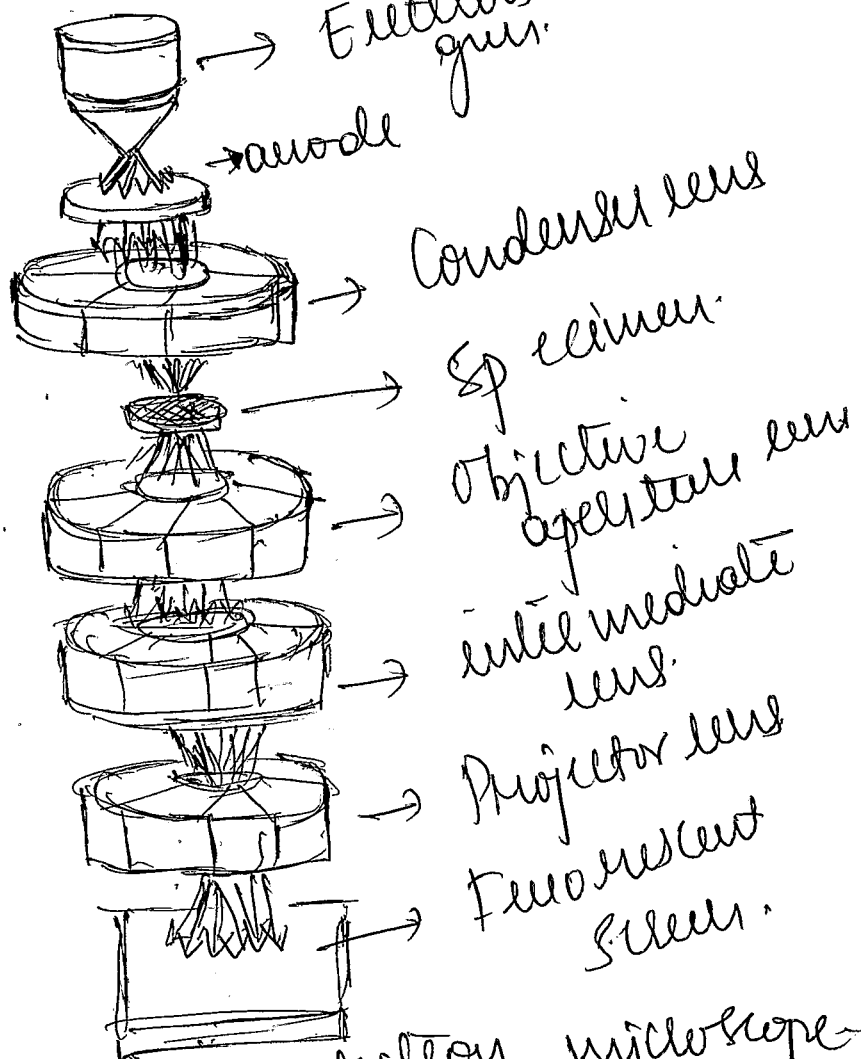
Working principle

* X-ray diffraction is based on Constructive interference of monochromatic x-rays & crystalline sample.
* These x-rays are generated by a cathode ray tube, filtered to produce monochromatic radiation, collimated to concentrate & directed toward the sample. The interaction of the incident ray with sample produces constructive interference when conditions satisfy Bragg's law ($n\lambda = 2d \sin\theta$).
* This x-ray are then detected, processed & counted.

* By scanning the sample through a range of 2θ angles, all possible diffraction directions of the lattice should be attained due to the random orientation of the powdered material.

* Conversion of the diffraction peaks to d-spacing allows identification of the mineral because each mineral has a set of unique d-spacings.

8.b. Explain briefly the working principle of transmission electron microscope (8)



Transmission electron microscope

1. A high-voltage electricity supply powers the cathode.
2. The cathode is a heated filament, a bit like the electron gun in an old-fashioned cathode-ray tube (CRT) TV. It generate a beam of electrons that works in an analogous way to the beam of light in an optical microscope.
3. An electromagnetic coil concentrates the electrons into a more powerful beam.
4. Another electromagnetic coil focuses the beam onto a certain part of the specimen.
5. The specimen sits on a copper grid in the middle of the main microscope tube. The beam passes through the specimen & "picks-up" an image of it.
6. The projector lens magnifies the images.
7. The image become visible when the electron beam hits a fluorescent screen at the base of the machine.
8. The image can be viewed directly through binocular at the side or on a TV monitor attached to an image intensifier.

9.a- Classify the CNC machine tools based on Control loops with a neat block diagrams. (8).

There are two loops (control) of CNC machine tools.

1) open loop systems
2) Closed loop system.

open loop system-

* Programmed instructions are fed into the Controller through an input device.
* These instructions are then converted to electrical pulses by the Controller & sent to the Servo amplifier to energize the Servo motors.
* The primary drawback of the open loop system is that it no feedback system to check whether the Program position & velocity has been achieved.
* The open-loop system is generally used in point-to-point systems where the accuracy requirement are not critical.

Closed loop system

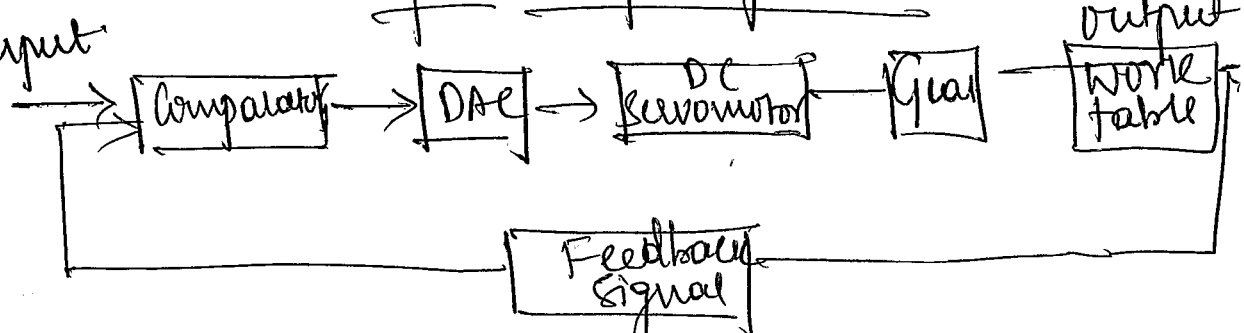
* The closed loop system has a feedback subsystem to monitor the actual output

& correct any discrepancy from the Programmed input.

* These systems use positions & velocity feed back.
* The feed back system could be either analog or digital.
* The analog system measure the variation by physical variable such as position & velocity in term of voltage levels.
* Digital systems monitor output variations by means of electrical pulses.

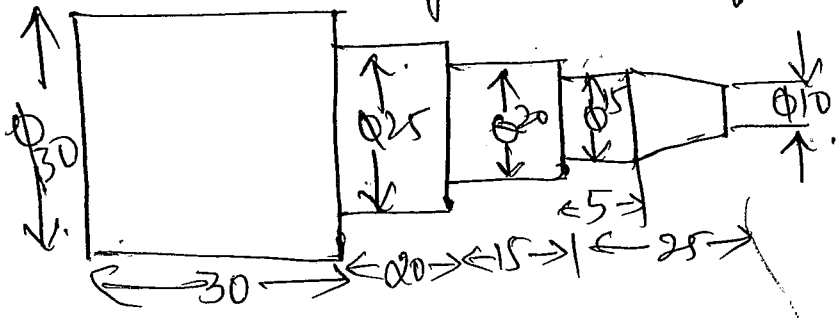
a) 

Open loop system.

b) 

Closed loop System

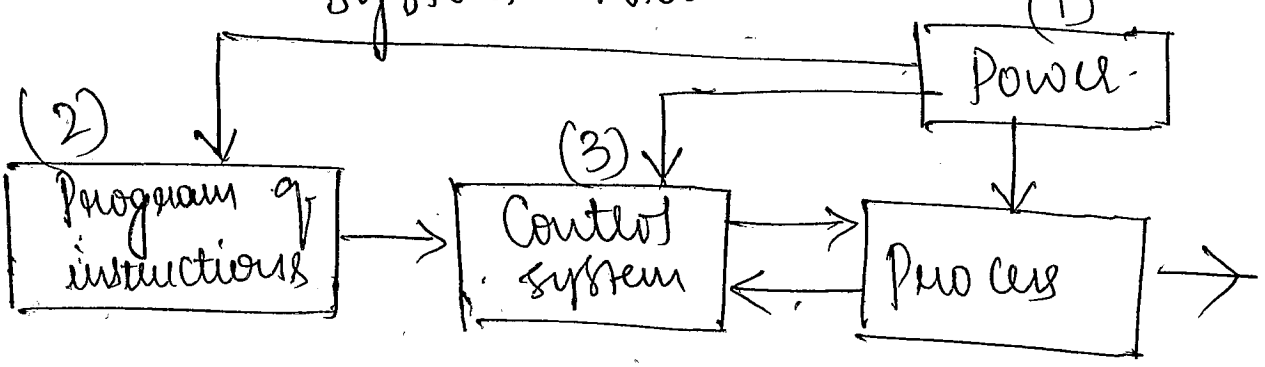
9.b. Write the manual part Program for machining the Profile. (8)



T0101
M03 S1000,
M08
G00 X11. Z00.
G00 Z02
G01 X10 F01.
G71 U1.0 R2.0
G71 P10 Q90 U0 W0 F0.2.
N10 G01 X10 Z0.
N20 G01 X15 Z-15.
N30 G01 X15 Z-25
N40 G01 X20 Z-25
N50 G01 X20 Z-40.
N60 G01 X25 Z-40
N70 G01 X25 Z-60
N80 G01 X30 Z-60
N90 G01 X30 Z-90.
N100 G00 X40 Z2.
M05 M09.
M30.

Using Longitudinal Cutting Cycle (G71) WRT CADM software.

10.a Explain the elements of automated system with a neat sketch. (8)



1. Power to accomplish the automated proces
* An automated System is used to operate Some proces, & power is required to drive the proces as well as the Control.
* The Principal Source of power in automated System is Electricity
* Widely available at moderate cost.
* Can be stored in long-life batteries.

2. Program of instructions

Set of Commands that Specify the Sequence of Steps in the work Cycle & the detail of each Step.

Ex:- CNC part program

During each Step, there are one or more activities involving Changes in one or more proces parameters.

Ex:- * Temperature Setting of a furnace.
* Axis position in a positioning System.
* Motor on or off.

3. Control System - two types

1. Closed-loop Control System:- a System in which the output variable is Compared with an input parameter

& any difference between the two is used to drive the output into agreement with the input.

2. Open-loop Control System:- operate without the feedback loop.
* Simple & less expensive

10.b. Distinguish between Continuous Vs. Discrete Control System (8).

Factor	Continuous Control	Discrete Control
Product output measures	weight, liquid volume, solid volumes.	Number of parts & products
Quality measure	Consistency, Solution Concentrations, absence of Contaminants Specification Conformance.	Dimensions, surface, finish appearance, absence of defects. Product reliability
Variables & parameter	Temperature, volume flow, rate, pressure	Position, velocity, force.
Sensor.	Flow meters, thermocouples pressure sensors.	Limit switches Sensor: Strain gauges
Actuators.	valves, heaters Pump.	Switches, motor.
Process time Constants.	Seconds, minutes, hour.	Less than a second.