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SYLLABUS

UNIT 1. Manufacturing process / Methods → Casting, forming, Machining, Joining, Advanced Manufacturing methods.

UNIT 2. CNC Machinery, Additive Manufacturing.

UNIT 3. Fitting operations and power tools.

UNIT 4. Carpentry

UNIT 5. Plastic moulding, glass cutting.

UNIT 6. Metal casting.

UNIT 7. Welding (arc and gas), Brazing, Soldering.

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MANUFACTURING

Manufacturing is the production of work pieces having defined geometric shapes.

CASTING

- Expendable Mould
  - Sand casting (Green dry)
  - Shell casting
  - Lost foam casting
  - Investment casting
- Permanent mould
  - Gravity die casting
  - Pressure die casting
  - Centrifugal casting
  - Continuous casting

FORMING

- Hot working
  - Forging
  - Rolling
  - Extrusion
- Cold working
  - Wire drawing
  - Bending
  - Shearing
  - Roll forming.

$$\text{Specific strength} = \frac{\text{Strength}}{\text{weight}}.$$

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MACHINING

- Conventional
  - Turning
  - Milling
  - Grinding
  - Drilling
- Non-conventional
  - Laser beam
  - Electropolishing
  - Ultrasonic
  - Electrodischarge
  - Electrochemical

JOINING

- Permanent joining process
  - Welding
  - Rivetting
- Temporary joining process
  - Bolts & Nuts
  - Soldering
  - Brazing
  - Adhesive bonding

CASTING – Casting is the process of producing metal parts by pouring molten metal into mold cavity of the required shape and allowing the metal to solidify.

The solidified metal piece is called as 'casting'.

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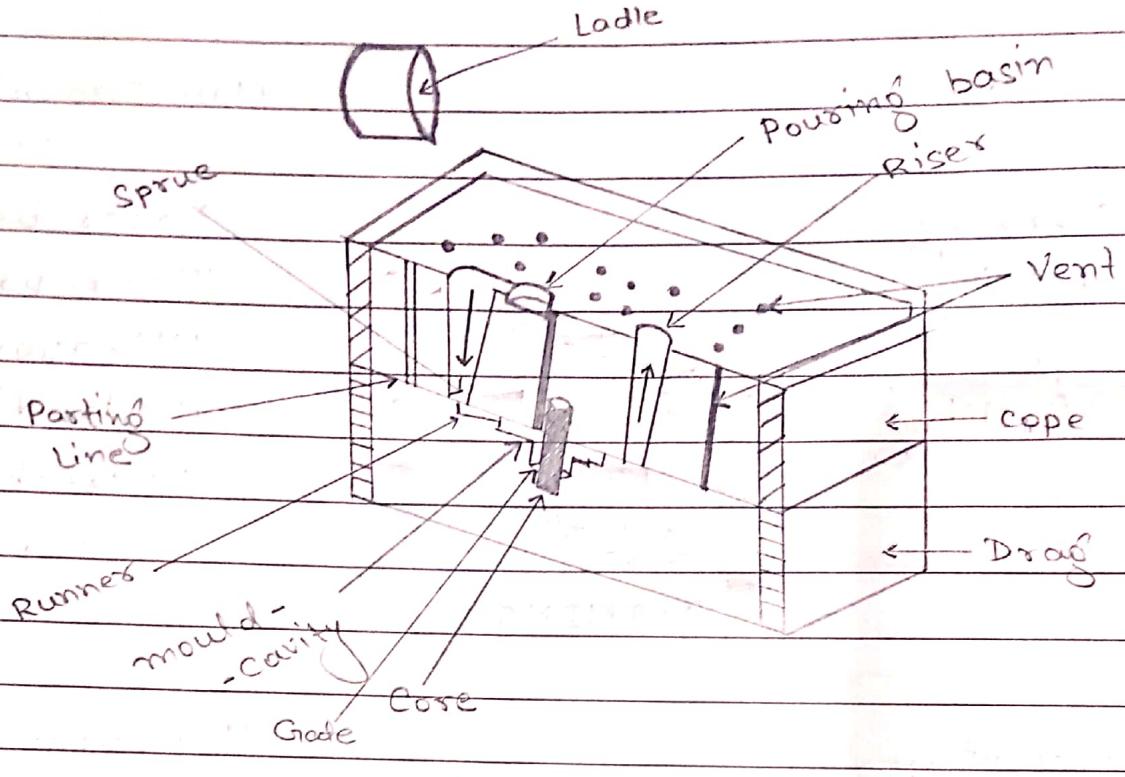

Cross section of a sand mould ready for pouring.

MOULD BOX – It is usually a metallic frame used for making and holding a sand mould. The mould box has two parts ; the upper part 'cope' and lower part called 'drag'.

PARTING LINE / PARTING SURFACE – It is the zone of separation between cope and drag portions of the mould in sand casting.

SPRUE – It is vertical passage through which the molten metal will enter the gate.

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POURING BASIN – The enlarged portion of the sprue at it's top into which the molten metal is poured.

GATE / INGATE - It is a short passage way which carries the molten metal from the runner/sprue into the mould cavity.

RISER – A riser or feed-head is a vertical passage that stores the molten metal and supplies the same to the casting as it solidifies.

MOULD CAVITY – The space in a mould that is filled with molten metal to form the casting upon solidification.

CORE – A core is a pre-formed (shaped) mass of sand placed in the mould cavity to form hollow cavities in castings.

The basic steps in making a casting are:

(i). Pattern making.
(ii). Mould preparation.
(iii). Core Making.
(iv). Melting and Pouring.
(v). Cleaning and Inspection.

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DIE CASTING:

Die casting is the process of rapid production of precise castings.

The molten metal under pressure is fored into split metal dies to fill the entire die.

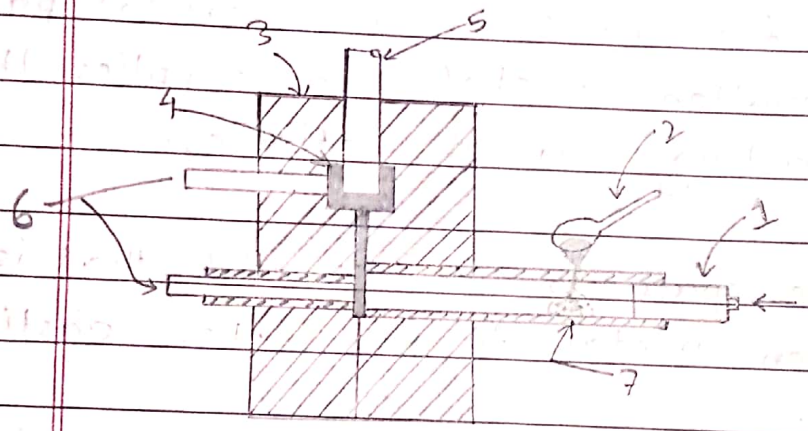

Fig. 1.

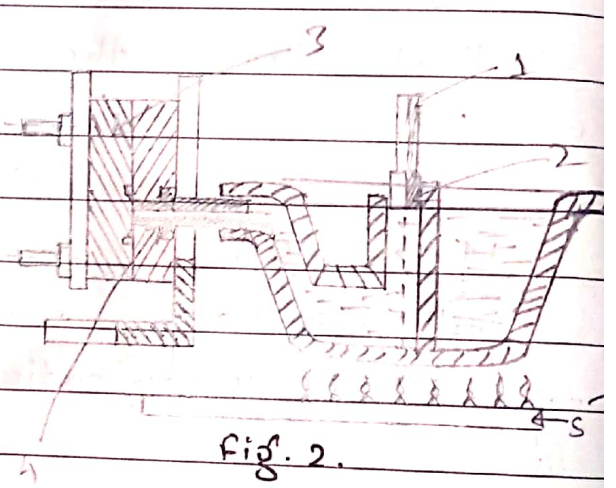

Fig. 2.

Figure 1.

1. Plunger
2. ladle
3. Die
4. Cavity
5. Core
6. Ejectors

Figure 2.

1. Plungers
2. Holes
3. Die
4. Gate
5. Heating.

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HOT CHAMBER DIE CASTING:

The molten metal fills the channel by gravity and the plunger forces the metal into the die.

COLD CHAMBER DIE CASTING:

It has a chamber operated pneumatically or hydraulically. Molten metal is poured into horizontal channel.

ADVANTAGE:

(a). Very high rate of production.
(b). Very precise dimension.
(c). Very thin casting can be produced.
(d). Die has long life.
(e). Cast of casting is low.

LIMITATIONS:

(a). Process is not economical for low match.
(b). Heavy castings cannot be produced.
(c). The cost of equipment and die is high.
(d). The castings have porosity.

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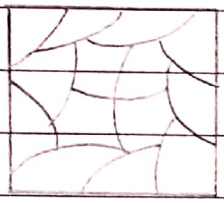
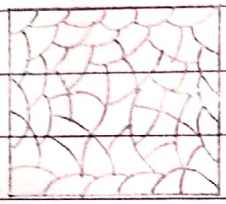
METAL FORMING PROCESS:

→ Metal forming process are involved in the mechanical working of metals by application of forces.

→ These processes may be carried out at room temperature, below recrystallization temperature or above recrystallization temp.





METHODS OF METAL FORMING ARE:

1. Rolling
2. Forging
3. Drawing
4. Spinning
5. Extrusion
6. Press work.

1. ROLLING:

The rolling process consists of passing the material between two rolls rotating in opposite direction to produce bars and other structural materials of different shapes.

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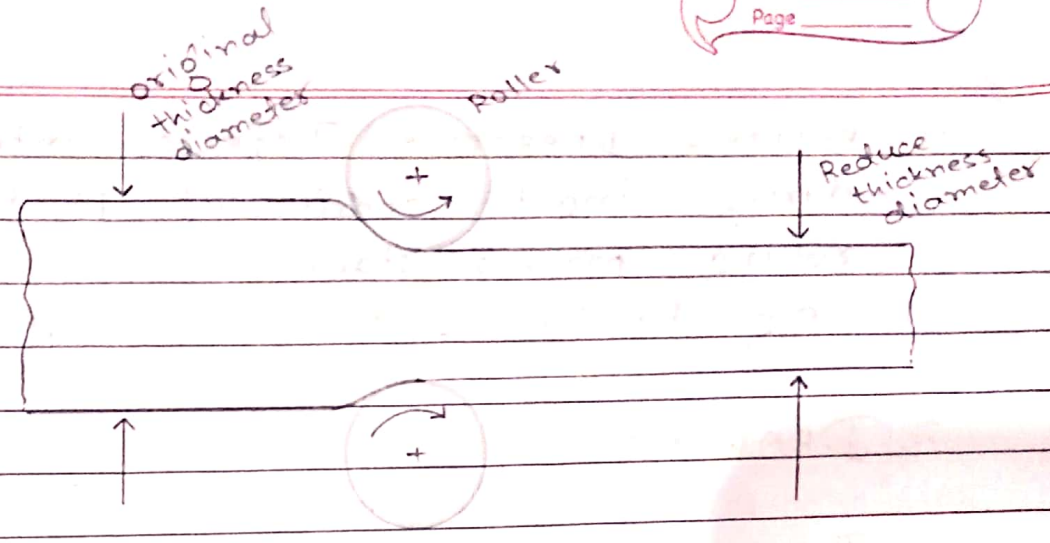

The stock is subjected to high compressive stresses and surface shear stresses due to squeezing actions of rolls.

Following factors control the rolling process

(a). Diameter of roller
(b). Material strength
(c). Friction between metal and roller.

TYPES OF ROLLING

(a). HOT ROLLING - The stock in hot plastic state is passed between rolls. The stock is reduced in cross-section or thickness and length is increased. The materials commonly hot rolled are aluminium, copper, magnesium, steel etc.

(b). COLD ROLLING - Cold rolling is used as finishing operations for bars, rods, sheets and stress. Foil is also made up of soft material by rolling.

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(c). ROLLING DEFECTS – Defects introduced during ingot stage of production and rolling process stage.
e.g. · blowholes, scratches scales etc.

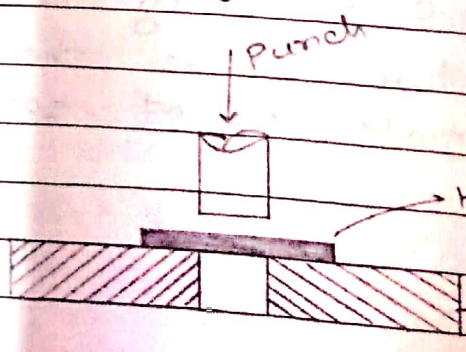
2. DRAWING:

Process of drawing is pulling the metal through a die to achieve a reduction in diameter.

The part to be drawn is inserted into orifice of die and pulled with great force by gripping in jaws.

The process is used to draw pipes, cylinders, wires, etc. by hold and cold working.

(a). HOT WORKING – Hot drawing is also called deep drawing or cupping. The plate is heated to ensure plasticity in working and placed over the cavity of die. The punch is pushed over heated plate cylinders and pipes are produced by this process.



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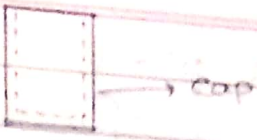

Deep Drawing

(b). COLD DRAWING - Rods and tubes are given a cold-finishing operation to reduce the size increase in strength and improve the accuracy of finished product.

3. EXTRUSION:

It is a hot metal working process to produce long length of uniform sectors from a metal billet. The billet is forced through an orifice or die.

The process is widely used for Steel, copper, aluminium, magnesium and Nickel in hot conditions.

Applications:
Rods, tubes, structural sections, aircrafts parts, door etc.

(a) HOT EXTRUSION - Most metals are extruded under hot conditions as very large forces are required.

(b). COLD EXTRUSION - This is also called impact extrusion. The small workpiece of ductile

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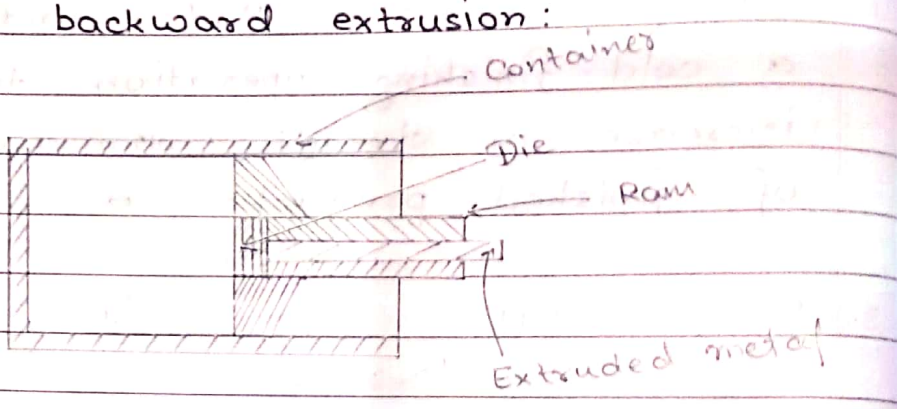
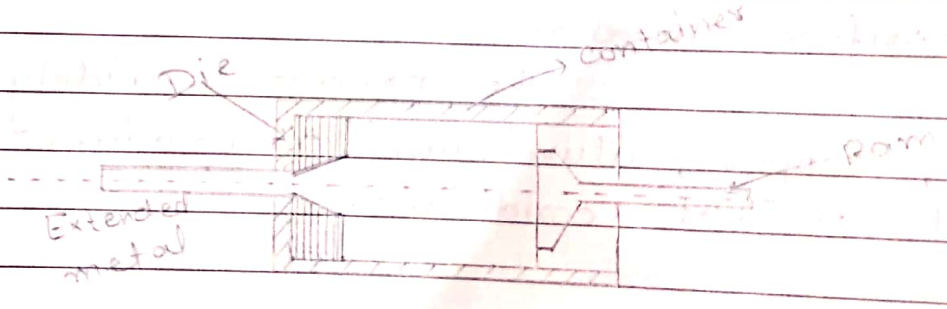
material is placed in a die and a ram punch is forced into the die causing the metal to flow plastically around the punch. (figure 1) (Next page).

HOT EXTRUSION

Indirect or backward extrusion:



Direct extrusion or forward extrusion:



INDIRECT EXTRUSION	DIRECT EXTRUSION
Metal in plastic state is filled in the container. The die is placed in the ram. The ram is force towards left and extruded	The apparatus consists of a metal container

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metal is forced through the die towards right

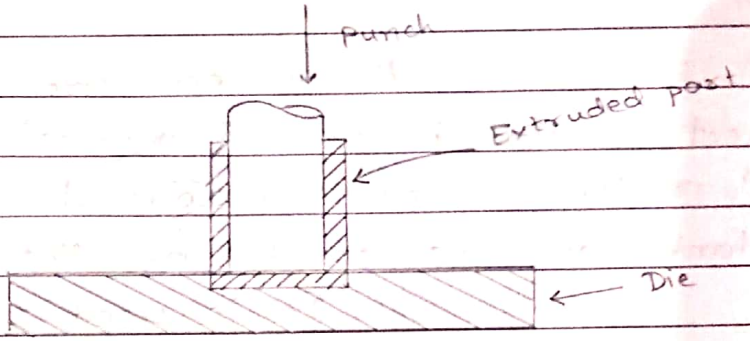

Figure 1. (cold extrusion).

4. SPINNING:

It is a process of shaping very thin sheet metal by pressing it against a form/pattern while it is rotating.

The sheet metal is rotated at high speed and blunt tool is used to ~~pr~~ocess the metal against a form or pattern. The metal will flow to take the shape. The equipment required is a lathe or other machine tool, burnt forming tool and a wooden or metallic former or pattern to suit the shape required.

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(a). COLD SPINNING - A round blank of sheet is cut and positioned against the former by a compression pad. A round nose blunt tool is forced while lathe rotates. It is used for making kitchen-ware, kettles of aluminium, etc.

(b). HOT SPINNING — A heated circular blank of sheet metal is pressed against a former. A roller is pressed against the rotating blank on the spindle of the lathe.

It is used for automobile head lamps, aeroplane parts, etc.

5. HOT FORGING - This process basically consists of heating the metal to plastic state and then applying pressure in this is not continuous. The pressure may be applied by hand Hammer called Hand or smith Forging, by power hammer called Hammer Forging, by press, called Press Forging.

6. PRESSWORK — Presses and dies are used to carryout different metal forming processes.

(a). SHEARING - The term shearing stands for cutting of sheet metal by two parallel cutting edges moving in opposite directions. This can be done either manually by using hand shears or by means of machine called 'shears'.

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PIERCING AND BLANKING:

Piercing is basically a hole punching operation while blanking is an operation of cutting out a blank. In both cases, Blanks will be produced, but in the former case obtaining a blank is not the objective. It is the hole of a desired size which is the objective and the blank produced may or may not be used further. In the later operation, the production of a blank of desired size is the main objective.

TRIMMING:

During shearing and punching operations, some excess material may be left around. Trimming is the process of removing the excess material.

PUNCHING:

Punching is the operation of cutting holes of various shapes and sizes in the blanks. Two or more holes may be cut at the same time by fixing different punches and dies.

NOTCHING:

It is a process of removing metal from the side or edge of a blank to a desired shape.

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MACHINING PROCESS

Machining process is the gradual removal of metal from a workpiece. It is also called Secondary process. The roughly finished products are provided machining operations to obtain desired shape and dimensional accuracy. The machining operations are mainly necessary when a very close dimensional accuracy and a very high degree of surface finish are required.

These operations require the use of one or more machine tools, cutting tools, job holding devices, marketing and measuring instructions, testing devices and gauges, etc.

Common machining operations are:

1. Turning
2. Threading
3. Knurling
4. Drilling
5. Bouring
6. Planing
7. Shaping
8. Milling
9. Grinding.

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JOINING PROCESS

These processes are used for joining metal parts and in general fabrication work. In order to fabricate a desired structure, several pieces are to be joined together. Temporary or permanent type of fastening is also enabled by these processes. Sintering enables bonding of metal particles by heat. Most of the other processes also require heat for joining metal pieces.

Common joining processes are:

1. Welding
2. Soldering
3. Brazing
4. Riveting
5. Screwing
6. Sintering
7. Adhesive bonding.

ADVANCED MACHINING PROCESSES

In recent years, hard, high-strength and temp. resistant materials have been developed for aerospace, nuclear engineering and other industries. These superalloys have high strength-to-weight ratio, hardness, and heat-resisting qualities. For e.g. nimonics, Carbides, Stainless steel, etc.

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Machining of these materials into complex shape is difficult, time-consuming and sometimes impossible.

Non-Conventional machining processes have emerged to overcome the above limitations of conventional machining processes. These processes do not employ a traditional tool for metal removal but utilize some form of energy for metal machining such as mechanical, electrical, chemical, electrochemical, thermoelectric etc.

The different non-conventional machining processes are broadly classified into following groups according to energy source.

(A). Mechanical Processes

- Ultrasonic machining (USM)
- Abrasive jet machining (AJM)
- Water-jet machining (WJM)

(B). Chemical Processes

(C). Electrochemical Processes

These processes include electrochemical machining (ECM) and Electrochemical grinding (ECG), deburring, etc.

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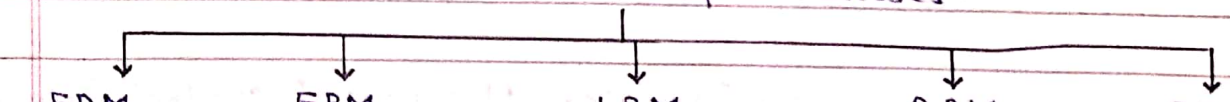
(D). Electrothermal Processes.



ADVANTAGES AND APPLICATION:

Non-conventional machinery processes have certain advantage over traditional processes and are used for the following reasons:

Machinability → Many materials having high hardness, thermal resistance and abrasive wear are difficult to machine by traditional processes.

Complex Shape → Many shapes such as a sharp cornered square hole cannot be produced by conventional machining methods.

Surface Defects → Conventional processes can cause surface cracks.

Precision → Many non-conventional processes can give high precision not available with conventional methods.

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2. CNC MACHINING

CNC System ≡ Computer Numerical control System.

Numerically controlled machine (NC machine) tools have been developed for high productivity, low production cost, and highly precise machining.

NC controllers we control systems with all the functions handled by hardware, logic circuits, switches etc.

With rapid development in computer, a computer numerical control System (CNC) has taken over the NC System and the function of NC systems. The various functions of the controller, interpolation, decoding etc. are carried by software rather than hardware.

★ Advantages of NC/CNC over conventional machine tools.

(a). Avoidance of human intervention.

(b). Omission of conventional tooling and fixturing

(c). Optimization of machining parameters.

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★ Main components of NC/CNC System:

(a). The program of instructions.

(b). The controller unit.

(c). The machine tool.

A. The program of instructions:

It is called part program. It is a mixture of alphabetical codes and numerical date, which is interpreted by the NC controller. The program were fed to the controller using a paper tape reader. Presently, the program is fed electronically from an on-line programming system remote from the machine.

These instructions are fed to the controller to execute the following functions by the machine tools:

(a). Movement of machine slides to generate the required surface on the workpiece.

(b). Control of displacements, velocities and accelerations of various machine tool components.

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B. The controller unit :

The controller unit (the machine tool controller) accepts the part-program of instructions and converts them into electric signals. The controller forms a part of a feedback control system for the motion of the machine tool sideways.

The main functions of a controller are:

(a). Interpolation
(b). Feed rate generation.
(c). Auxiliary functions which are machine depedent.

The interpolator breaks down the complex curve into small individual increments for each controlled motion of machine tool.

C. The Machine Tool :

The machine tool responds to the electrical signals from the controller and executes various slide motion and spindle rotations to machine a component. CNC machine tool is a general purpose machine with table, spindle and computer.

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Types of NC/CNC Machines:

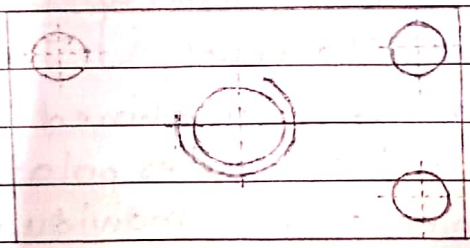
Based on NC motions, three types are followings:

(a). Positional (Point - to - point)
(b). Paraxial (Straight line)
(c). Continuous path (contouring)

POINT - TO - POINT (PTP) OR POSITIONAL CONTROL:

The machine tool elements (tools, table, etc) are moved to programmed location and the machining operations are performed after the motions are completed. The co-ordinates of the end points of the motions are accurately controlled.

This control is suitable for drill presses and boring machines where drilling, tapping or boring operations have to be performed at various locations on the workpiece.



Workpiece e.g. of positional control.

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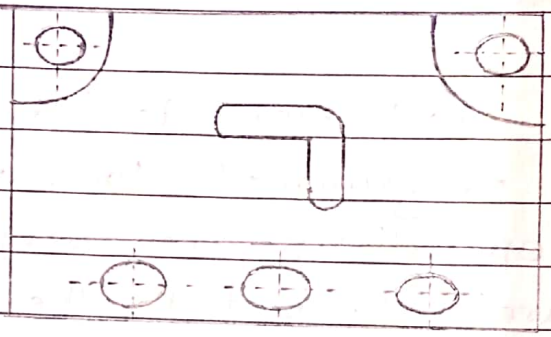
STRAIGHT LINE OR LINEAR CONTROL:

The cutting tool is moved parallel to major axis of machine tool at a controlled rate suitable for machining. The tool can be moved in one direction only. Angular cuts in a workpiece are not possible.



Workpiece e.g. of straight line control.

CONTINUOUS PATH OR CONTOURING CONTROL:

The motions of two or more machine axes are controlled simultaneously so that the position and velocity of the tool are changed simultaneously. The curves and surfaces can be machined at controlled feed rate. The interpolator determine the increments of individuals controlled axes of the machines to produce the desired motion.

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COMPUTER NUMERICAL CONTROL AND DIRECT NUMERICAL CONTROL:

CNC uses a dedicated microprocessor as an integral part of MCU (Machine control Unit) to execute the basic NC control function.

DNC makes use of a mainframe computer to manipulate operations of a member of NC machines.

DNC computer is located at a central place away from NC machines and manages information flow to a group of machines. (fig 1 and fig 2)

POSITION AND MOTION CONTROL IN NC MACHINES:

A group of devices are used to control the position of machines tool slides and spindle speed. These devices are electrical, hydraulic or pneumatic.

There are two control systems:

(a). Open loop system: This is a control system without feedback.

(b). Closed loop system: It is with feedback system.

Feed back system mainly to compare the actual table movement with the desired table movement.

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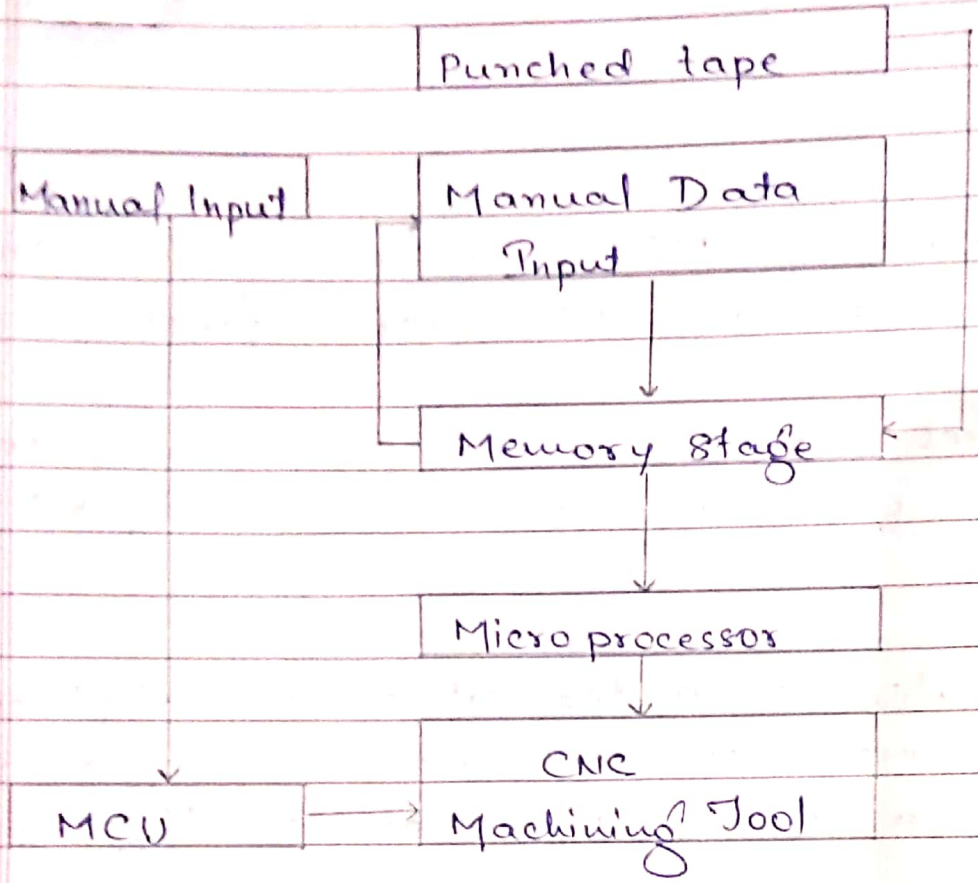

fig 1. CNC System

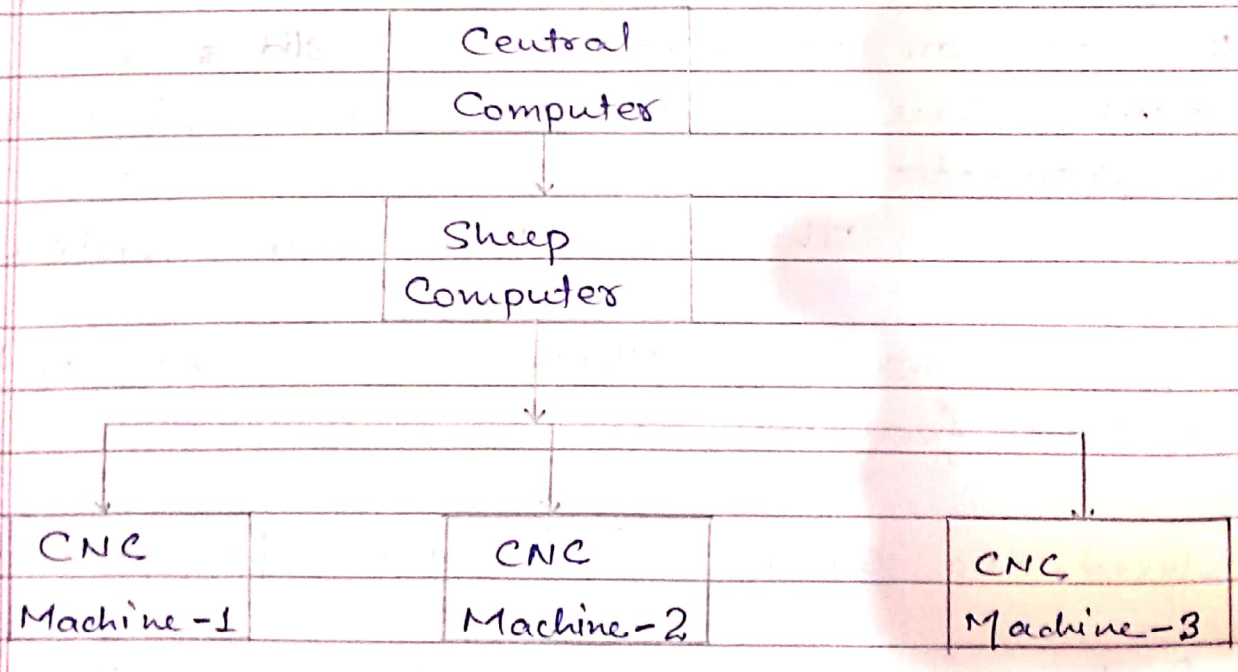

fig. 2. DNC System

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MEASURING SYSTEMS FOR NC MACHINES:

The position transducers are used as measuring system for NC machine tools. The transducers can be electric scales, electroptical scales, synchors, laser types, etc.

The transducer can be categorized as:

(a). Analogue control system.
(b). Digital control system.

ANALOGUE CONTROL SYSTEM:

The movement of machine table, rotation of spindle or movement of spindle are measured in terms of calibrated signals. These signals are continuous and proportional to continuous movement of machine parts. The accurate positioning is achieved by matching the continuous input voltage with the transducer output voltage.

DIGITAL CONTROL SYSTEM:

In digital control system, the movement of worktable is a discrete quantity and in the form of voltage pulse. Each pulse represents a basic length.

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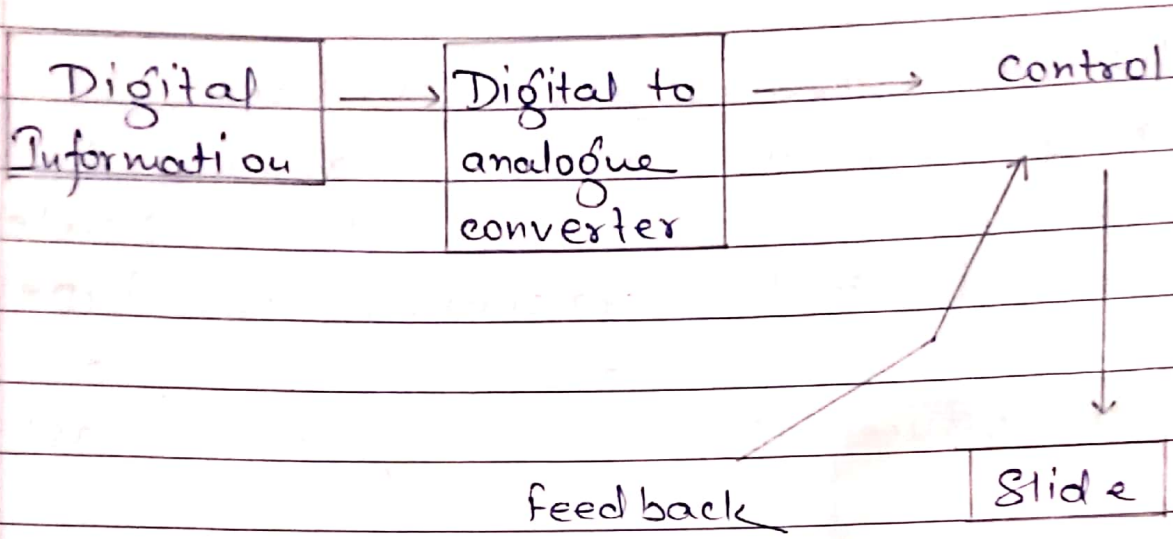
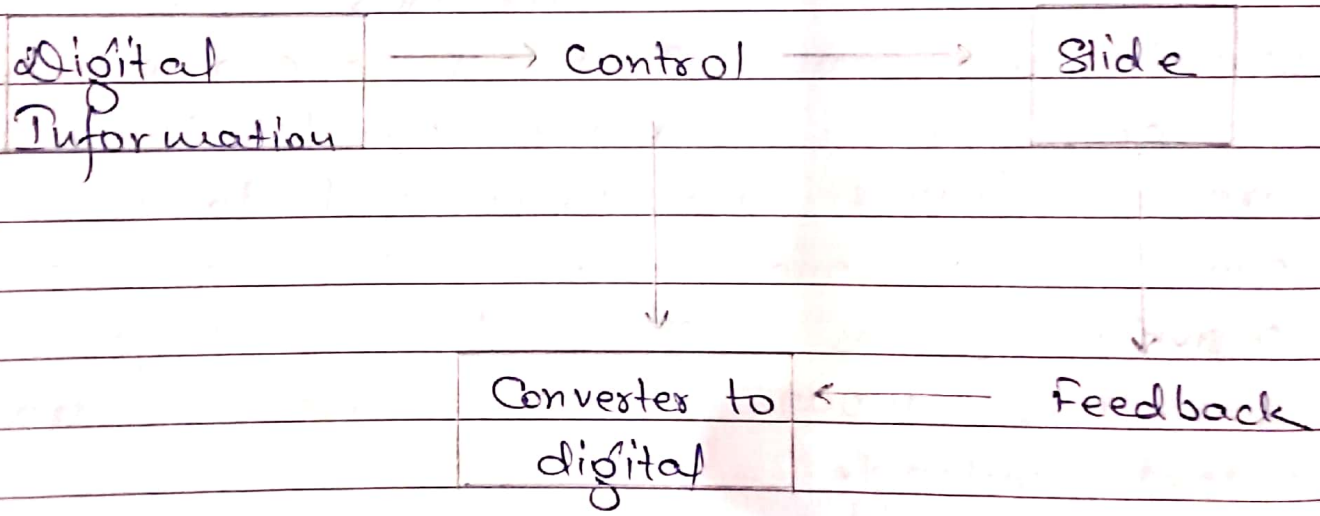


Analog control System



Digital Control System.

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ADDITIVE MANUFACTURING:

The traditional manufacturing methods involve the use of forming processes or primary shaping processes followed by machining processes by cutting or removing the undesirable material to achieve a product of desired shape, size and design. Additive manufacturing (AM) is a new and recent concept where a product or structure is created by adding thin layers of materials rather than removing the unwanted materials. The AM process involves the use of a computer and special Computer-Aided Design (CAD) software to relay message to the printer to print the desired shape. The print head or nozzle of the printer sprays and deposite the construction material rather than ink. The construction material may be a metal, plastic, concrete or other engineering material. Therefore, this technology is also called "3D-Printing".

Scope - AM includes various technologies such as 3D-printing, Rapid Prototyping (RP), Direct digital manufacturing (DDM), layered manufacturing and additive fabrication. starting from RP to preproduction visualization models. It is being used more recently to fabricate end-use products for aircraft, dental, medicine, automobile, fashion, etc. The potential is so high that it is predicted its applications for production of human ~~beings~~ organs.

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TYPES OF ADDITIVE MANUFACTURING (AM):

1. Single layer Adjustment (SLA)

It is suitable for photopolymer resin, which changes its properties when exposed to light. The build is prepared in a pool of resin. A laser beam is directed into pool of resin. The platform on which the build is repositioned is lowered by a single layer thickness. The process is repeated until the modal is completed.

2. Fluid Directed Modeling (FDM):

This technology is suitable for thermoplastic resin, which changes to liquid when heated and again solidifies when cooled. The materials are injected through nozzles into a platform. The nozzle traces the cross-section pattern for each layer. The thermoplastic material hardens before the next layer is applied. The process repeats to complete the modals.

3. Multi-Jet Modeling (MJM):

It is similar to an inkjet printer. A head can shuttle back and forth in 3D. The nozzle can produce hundreds of small jets to apply a layer of thermopolymer material layer-by-layer.

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4. Selective layer sintering (SLS):

It is similar to SLA. The material used can be metal, plastic, ceramics or glass. A powdered laser beam is used to fuse small particles of the material. The platform on which model is prepared is repositioned by lowering a single layer thickness. The process is repeated until model is completed.

APPLICATIONS:

Initially, the process was used for concept modeling and rapid prototyping. For last 5-7 years, it is used for direct component manufacturing in industrial sectors such as architecture, medical, dental, aerospace, automotive, furniture and jewellery etc.

Typical applications are as follows:

(a). Production of models and prototypes for R&D projects.

(b). Components for pilot series production in medical, aerospace, and automotive industries.

(c). For high cost tooling system, AM can be used

(d). Components of high geometrical complexity which cannot be produced by conventional manufacturing such as moulding, grinding, milling, etc.

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ADVANTAGES AND LIMITATION:

(a). The component can be produced directly from a CAD model without the need of tooling.

(b). Components of any shape can be produced.

(c). The technology is not suitable for mass production of large quantity of similar simple parts.

(d). Dental application

(e). Fuel nozzle (25% light and 5 times more durable than the existing part).

(f). Functional prototypes.

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FITTING OPERATION

Fitting work is a very important work in engineering. In fitting shop, unwanted material is removed with the help of hand tools.

It is done for manufacturing and repair purposes.

Commonly used tools are hacksaw, files, chiesels, etc.

VICES:

Vices are the most suitable and widely used tools for gripping different jobs in position during the various operations carried out in a fitting shop.

COMMON TYPES OF VICES:

BENCH VICE: It is a common tool used for holding jobs. It consists of cast iron body and cast iron jaws. One jaw is fixed to the body and second slides on a square threaded screw with the help of a handle. The jaws are opened upto required length, job is placed in the two jaws and fully tightened with handle.

HAND VICE: Hand vice is used to grip very small objects. These are made in different shapes and sizes. It consists of two steel legs hinged together at the bottom and carrying the

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hardened steel jaws at the other end. A spring attachment is provided between the two legs, which always tends to keep the jaws separate. A screw is fastened to one leg and passes through the other. At the free end of screw, a wing nut is provided. The piece to be held is gripped between the serrated jaws by tightening the wing nut.

PIN VICE: A pin vice is used for holding very small pieces like wire nails and pins, etc. It is nothing but a small form of collect chuck. It consists of a handle and a tapared nose carrying a small collect chuck at it's end.

PIPE VICE: It is used to hold pipes. It consists of a vertical screw with square threads. A handle is attached on the top of the screw. A movable jaw is fixed on the lower end of the screw. It grips the pipe at four points.

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FITTING TOOLS

Fitting shop tools are classified as under:

(a). Clamping tools.
(b). Measuring & Marking tools.
(c). Cutting tools.
(d). Striking tools.
(e). Drilling tools.
(f). Threading tools.

CUTTING TOOLS:

The Tools which are used to remove the materials are known as cutting tools. These tools are:

(a). Hacksaw – Hacksaw is used for cutting of rods, flats, etc. The blade of Hacksaw is made up of high carbon steel. Frame is made from mild steel. Frame is made from mild steel. The length of blades varies from 8" to 14" but generally 12" blade is used in fixed frame hacksaw. The thickness and width of the blade are 1mm and $\frac{1}{2}$" respectively. Blades are classified as under:

(i). Depending upon the direction of cut
(a). Forward cut
(b). Backward cut

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(b). Depending on the pitch of the teeth.

(i). Coarse (8-14 Teeth per inch)
(ii). Medium (16-20 " " ")
(iii). Fine (24-32 " " ")

Types of hacksaw frames

(a). Fixed Frame
(b). Adjustable Frame

In fixed frame only one type of blade is used where as in adjusted frame, the length of the frame can be increased or decreased as per requirement.

Pitch of hacksaw: It is the number of teeth on blade in one centimeter. Hacksaw blades with small pitch are used for thin sections and the large pitch are used for thick sections.

FILE: File is also a mouth tooth tool. It is used to remove the material by rubbing it on the metal. Classification of files on the basis of grade.

Rough (20 teeth per inch)
Second cut (40 " " ")
Smooth file (50-60 teeth per inch)
Dead smooth (100 " " ")

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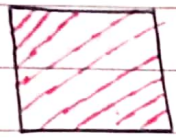
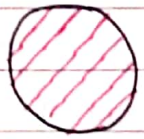
Classification on the basis of shape and size.

- The lengths of files very from 4" to 14".
- The shapes available are flat, square, round, triangular, half round, etc.



Square

Triangular



Round

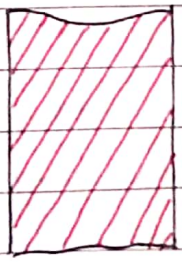
Half round

Flat

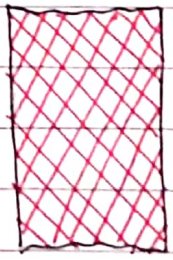
Classification on the basis of Number of cuts:

(i). Single cut - The teeth are cut in parallel rows at an angle 60° to the face.

(ii). Double cut - In addition, to single cut, another row of teeth is added in opposite direction.



Single cut file



Double cut file.

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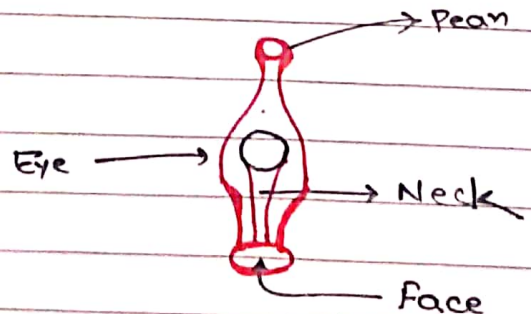
CHISELS : These are used for chipping away the material from the workpiece. These are made up of high carbon steel generally 6" to 8" long. The top is flattened and a sharp cutting edge is made on the bottom side.

Chisels are classified on their shape and width of the cutting edge. Commonly used forms of chisels are flat, cross-cut, half round and diamond point chisels.
Cutting angle of chisels is kept as under:

(a). For hard material (70°-75°)
(b). For medium hard material (60°)
(c). For soft material (90°)

STRIKING TOOL : Hammers are the only tools generally used for striking in fitting shop. These are used for chipping, fitting, punching etc. A hammer consists of a heavy iron body with a wooden handle. The weight ranges from 0.25 kg to 2 kg.

Types of hammer : Ball Pean, Straight Pean & Cross pean hammer



parts of hammer.

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FITTING PROCESS

(a). Marking
(b). Scrapping
(c). Chipping
(d). Grinding
(e). Drilling
(f). Measuring
(g). Reaming

POWER TOOLS: A large number of power tools are also used to carry out these operations. The use of power tool results in

(a). More production
(b). less fatigue to workers
(c). Save time
(d). More accuracy

Power tools can be grouped as

(a). Stationary power Tools
(b). Portable power Tools.

Stationary Power Tools is called machine tool. The source of energy is electric power. e.g. Bench drilling machine, bench grinder, Power hacksaw, etc.

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Portable Power Tools

The source of energy is battery, electricity or compressed air. e.g. Portable drill machine, portable grinder, portable metal cutting machines.

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