UNIT II

[Answer 1]: The geometry of a single point cutting tool consists of several key features. The tool has a pointed end called the nose, which is the intersection of the side and end cutting edges. This helps increase tool life and surface finish on the workpiece. The cutting tool also has a shank, which is the part that holds the tool bit and is not ground to form cutting edges. The basic elements of all machining operations include the workpiece, machine tool, cutting tool, chips, and cutting fluid. The workpiece is the material being machined, the machine tool provides the power and mechanisms for the cutting tool, and the cutting tool is used to remove metal from the workpiece to generate the desired shape and size. It's important to note that there are two types of cutting tools: single point cutting tools, such as those used in lathe, shaper, slotter, and planner machines, and multipoint cutting tools, such as those used in saws, drills, milling, grinding, reaming, and boring machines.

[Answer 2]: There are various cutting tool materials used in machining operations, each with its own characteristics and applications. Here are five common cutting tool materials:

1. Carbon Steel: Carbon steel is a low-cost cutting tool material suitable for general-purpose machining of mild steels, cast iron, and soft materials. It has low hardness and wear resistance.
2. High-Speed Steel (HSS): HSS is a commonly used cutting tool material due to its high hardness, toughness, and wear resistance. It can be used for a wide range of materials, including carbon steel, alloy steel, and non-ferrous metals.
3. Cemented Carbides: Cemented carbides, also known as hard metals, are a composite material composed of carbide particles (such as tungsten carbide) embedded in a metallic binder (such as cobalt). They offer excellent hardness, wear resistance, and high-temperature resistance. Cemented carbides are used for machining difficult-to-cut materials like stainless steel, high-temperature alloys, and hardened steels.
4. Ceramics: Ceramic cutting tools, made from materials like alumina and silicon nitride, offer high hardness, heat resistance, and chemical stability. They are suitable for high-speed machining of cast iron, heat-resistant alloys, and hardened steels.
5. Cubic Boron Nitride (CBN): CBN is a synthetic material with exceptional hardness and thermal stability. It is used for high-speed machining of hardened steels, cast iron, and superalloys.

Each cutting tool material has its advantages and limitations, and the selection depends on factors such as the workpiece material, cutting conditions, and desired tool life.

[Answer 3]: Cutting fluid plays a crucial role in metal cutting processes. It possesses several important properties and functions, including:

Properties:

1. High heat absorption capability: Cutting fluids must be able to absorb and dissipate the heat generated during machining to prevent tool damage and workpiece distortion.
2. Good lubrication qualities: Cutting fluids reduce friction between the cutting tool and workpiece, minimizing wear and extending tool life.

3. High flash point: Cutting fluids with a high flash point have a reduced risk of flammability, ensuring safer machining operations.
4. Stability for oxidation: Cutting fluids need to resist oxidation and maintain their properties over extended periods to ensure consistent performance.
5. Chemical neutrality: Cutting fluids should be chemically neutral to avoid any adverse chemical reactions with the workpiece or tool.

Functions:

1. Cooling: Cutting fluids help cool the cutting tool, preventing overheating and maintaining its cutting efficiency.
2. Lubrication: By reducing friction, cutting fluids improve surface finish, reduce tool wear, and minimize the chances of built-up edge formation.
3. Chip evacuation: Cutting fluids wash away chips from the cutting zone, preventing chip clogging and improving the machining process.
4. Surface finish improvement: Cutting fluids enhance the surface finish by reducing tool/workpiece friction, resulting in improved precision and quality.
5. Corrosion protection: Cutting fluids protect the finished surface of the workpiece from corrosion caused by exposure to air or moisture.

Therefore, cutting fluids are essential for ensuring efficient machining operations and maintaining tool life and workpiece quality.

[Answer 4]: Different operations that can be performed on a lathe machine include:

1. Turning: It is the primary operation performed on a lathe machine. In this operation, the workpiece rotates, and the cutting tool removes material to create cylindrical shapes.
2. Facing: The end of the workpiece is machined to produce a flat surface perpendicular to the axis.
3. Taper turning: The lathe machine is used to create a gradual decrease or increase in the diameter along the length of the workpiece.
4. Drilling: Holes are created in the workpiece using a rotating cutting tool.
5. Reaming: Existing holes are enlarged and finished to achieve accurate dimensions.
6. Boring: A single-point cutting tool enlarges existing holes to achieve precise dimensions.
7. Thread cutting: Lathe machines can be used to cut threads on the workpiece to create a screw-like shape.
8. Knurling: A regular pattern of raised or indented grooves is created on the surface of the workpiece.
9. Grooving: The lathe machine cuts narrow or shallow channels on the workpiece.

[Answer 5]: Reamers are cutting tools used to enlarge and improve the accuracy of existing holes. Different types of reamers and their applications are:

1. Hand reamers: They are manually operated and used for occasional reaming tasks and repair work.
2. Machine reamers: These reamers are designed for use in drilling machines and provide better accuracy and finish.

3. Chucking reamers: They are used in chucking machines or lathes to accurately size previously drilled holes.
4. Taper reamers: They are used to ream tapered holes, such as those used for machine tool spindles or Morse tapers.
5. Shell reamers: Shell reamers are used in multiple-spindle drilling machines or special-purpose machines for reaming multiple holes simultaneously.

Each type of reamer has its own specific application and is chosen based on the requirements of the machining operation.

[Answer 6]: Table Type Horizontal Boring Machine is a type of machine tool used for precision boring of large workpieces. It consists of a base with different control mechanisms and a vertical column at one end. The base also has an additional base above it, called the "knee." The knee serves as a worktable equipped with attachments to hold the workpiece. The over arm support on top of the column holds the work holding the arbor.

Table Type Horizontal Boring Machines are classified based on different methods of supplying power to the table, different movements of the table, and different axes of rotation of the main spindle. They are versatile machines that can perform internal and external turning, facing, drilling, and milling operations.

[Answer 7]: Milling machines can be classified according to their construction into the following categories:

1. Column and Knee Type Milling Machine:
    1. Hand milling machine
    2. Plain milling machine
    3. Universal milling machine
    4. Omniversal milling machine
    5. Vertical milling machine
2. Manufacturing or Fixed Bed Type Milling Machine:
    1. Simplex milling
    2. Duplex milling
    3. Triplex milling
3. Planer Type Milling Machine
4. Special Type Milling Machine:
    1. Rotary table milling machine
    2. Drum milling machine
    3. Planetary milling machine
    4. Pantograph, profiling, and Tracer controlled milling machine

The classification is based on factors such as the type of table movement, availability of different axes, and specific design features.

[Answer 8]: Peripheral/face milling is a type of milling operation that involves cutting along the circumference or outer surface of the workpiece using a milling cutter. The milling cutter has teeth on the periphery that remove material as it rotates.

In peripheral milling, the cutter is fed perpendicular to the surface of the workpiece. This operation is commonly used for producing flat surfaces, slots, and pockets.

Face milling is a variation of peripheral milling where the cutter is fed parallel to the surface of the workpiece, resulting in the milling cutter's bottom surface contacting the workpiece. This operation is suitable for roughing or removing material from large surfaces.

[Answer 9]: Broaching is a machining process that involves removing material using a toothed cutting tool called a broach. The broach has a series of teeth that gradually increase in size. During the broaching process, the broach is pushed or pulled sequentially through the workpiece, removing material progressively. The teeth of the broach remove metal in a single pass, allowing both roughing and finishing operations to be performed in one stroke.

Advantages of broaching:

1. High production rate: Broaching offers a very high production rate compared to other machining processes such as milling, planing, or boring.
2. Dimensional accuracy and surface finish: Broaching provides high-level dimensional accuracy and excellent surface finish on the workpiece.
3. Roughing and finishing in one stroke: The same broach can perform both roughing and finishing operations in a single pass.
4. Single motion operation: Broaching requires only one motion, cutting, simplifying the design, construction, operation, and maintenance of the broaching machine.

Disadvantages of broaching:

1. Limited to through holes and surfaces: Broaching can only be used to machine through holes and surfaces.
2. Usable for light cuts only: Broaching is suitable for light cuts due to the design and the forces involved.
3. Limited cutting speed: Cutting speed is limited in broaching due to factors such as chip removal and the nature of the broach.
4. Defects or damages in the broach: Defects or damages in the broach, such as worn or chipped cutting edges, can severely affect the quality of the finished product.

[Answer 10]: The specification of the grinding wheel (W A 46 K 5 V 17) can be broken down as follows:

1. W: This represents the type of abrasive used in the grinding wheel. In this case, "W" stands for White Aluminum Oxide, which is a widely used abrasive material.
2. A: The letter "A" indicates the hardness or grade of the grinding wheel. It represents a medium-hardness wheel, suitable for general-purpose grinding applications.
3. 46: The number "46" refers to the grit or grain size of the grinding wheel. It represents the size of the abrasive particles embedded in the wheel. In this case, a grit size of 46 indicates a medium-coarse grinding wheel.
4. K: This letter signifies the structure of the grinding wheel, which relates to the spacing between the abrasive particles. "K" represents an open structure, allowing for better chip clearance during grinding.

5. 5: The number "5" represents the concentration or content of the abrasive particles in the grinding wheel. A higher concentration typically indicates a higher density of abrasive particles.
6. V: The letter "V" denotes the type of bond used in the grinding wheel. Different bonds provide varying levels of hardness, strength, and durability. In this case, "V" refers to a vitrified bond, which is a common type of bond used in grinding wheels.
7. 17: The number "17" signifies the shape and size of the grinding wheel. This number represents specific dimensions and specifications of the wheel in terms of diameter, thickness, and hole size.

[Answer 11]: The surface finishing processes other than grinding can be classified into the following categories:

1. Lapping: Lapping is a process where fine abrasive particles are charged into a lap, and the workpiece is moved across the surface of the lap using reciprocating or rotary motion. It provides a high degree of accuracy and smoothness and is commonly used in the production of optical lenses, measuring instruments, and metallic bearing surfaces.
2. Honing: Honing is an abrasive process used for finishing internal cylindrical surfaces, such as drilled or bored holes. It involves the use of bonded abrasive sticks and a combination of rotational and reciprocating motion. Honing is typically used to finish bores of cylinders, hydraulic cylinders, gas barrels, and bearings.
3. Super Finishing: Super finishing also uses bonded abrasive sticks with reciprocating motion and pressure against the surface to be finished. Cutting fluid is used to cool the tool-workpiece interface. Super finishing is applied to various components, such as computer memory drums, automotive cylinders, piston rods, and axles. Abrasive Jet Machining (AJM): AJM involves directing high-velocity abrasive particles onto the work material to remove material through micro-cutting actions and brittle fracture. It is not suitable for soft and ductile materials and has limitations in terms of reusability of abrasives.
4. Water Jet Machining: Water jet machining utilizes pressurized water to create a jet that cuts through materials. It can achieve precise cuts but may have limitations in terms of achieving dimensional accuracy and tapering in thick materials.
5. Electrochemical Machining (ECM): ECM is a metal removal process based on reverse electroplating principles. It uses electrolysis to remove material from the workpiece, and the particles travel from the anodic material (workpiece) to the cathodic material (machining tool).

[Answer 12]: The finishing process that can achieve a tolerance of ± 0.003 mm and surface finish (roughness) of 1 to 10 μm is honing. Honing is an abrasive process used for finishing internal cylindrical surfaces, such as drilled or bored holes. It utilizes a set of bonded abrasive sticks, and the motion of the honing tool involves a combination of rotation and reciprocation. Honing is supported by the flow of coolants, which flushes away small chips and maintains a low and uniform temperature of the tool and workpiece. It is commonly used to finish bores of cylinders, hydraulic cylinders, gas barrels, bearings, and more. Honing can achieve high dimensional accuracy, form accuracy, and surface finish, making it suitable for achieving the specified tolerance and surface roughness requirements.

[Answer 13]: The finishing process to generate a thin layer of chromium on a steel product is called electroplating. Electroplating is the process of depositing a very thin layer of metal coating, such as chromium, on a base metal by passing a direct current through an electrolyte solution containing some salt of the coating metal.

Here's a detailed explanation of the electroplating process for chromium deposition:

1. Surface Preparation: The steel product to be electroplated is first immersed in a hot alkaline solution to remove oil and grease. It is then treated with dilute hydrochloric acid or sulfuric acid to remove scale and oxides, ensuring a clean surface for plating.
2. Electrolyte Solution: The article to be electroplated, in this case, the steel product, is made the cathode and is dipped into a solution containing chromium salt as the electrolyte. The chromium salt will provide the source of chromium ions for deposition onto the steel product.
3. Deposition: When a direct current is passed through the electrolyte solution, the chromium metal ions migrate to the cathode (steel product) and get deposited on its surface. This process results in a thin layer of chromium coating on the steel product. The thickness of the chromium coating can be controlled and typically ranges from 0.005 mm or more.
4. Commonly Used Metals: The commonly used metals for electroplating, including chromium, are copper, nickel, silver, gold, cadmium, and tungsten.
5. Applications: Electroplating with chromium is extensively used for decorative purposes and for protecting iron and steel articles from corrosion. The thin layer of chromium provides both aesthetic appeal and corrosion resistance to the steel product.

[Answer 14]: Unconventional machining processes are required for several reasons:

1. Extremely hard and brittle materials or difficult-to-machine materials cannot be effectively processed using traditional machining processes.
2. When the workpiece is too flexible or slender to support the cutting or grinding forces involved in conventional machining.
3. Workpiece materials that are too hard, strong, or tough for traditional machining methods.
4. Parts with very complex shapes, internal or external profiles, or small holes may be difficult to machine using conventional methods.
5. High requirements for surface finish and tight tolerances that cannot be achieved through conventional machining.
6. Situations where temperature rise or residual stresses from conventional machining are undesirable or unacceptable.

These reasons necessitate the use of unconventional machining processes to effectively handle materials and components that are challenging or impossible to process using traditional machining methods.

[Answer 15]: Unconventional machining processes are required for several reasons:

1. Extremely hard and brittle materials: Traditional machining processes may not be effective for materials such as ceramics, composites, and high-strength alloys. Unconventional processes like electrochemical machining (ECM) or abrasive jet machining (AJM) are better suited for these materials.

2. Complex shapes and features: Non-conventional processes are necessary when the part geometry is intricate, with internal or external profiles, small holes, or sharp interior edges and corners that are difficult to produce using conventional methods.
3. High precision and surface finish: When the requirements for surface finish and tolerances are very high, unconventional machining processes offer better control and accuracy in achieving the desired specifications.
4. Thermal considerations: Unconventional machining processes are preferred when temperature rise or residual stresses are undesirable or unacceptable. For instance, processes like water jet machining (WJM) or laser beam machining (LBM) are less likely to cause thermal damage to the workpiece.
5. Material flexibility and clamping issues: In cases where the workpiece is too flexible or slender to support the cutting or grinding forces, unconventional processes provide alternative methods of material removal without imposing significant mechanical stresses on the workpiece.
6. Non-conducting materials: For electrically non-conducting materials, such as certain ceramics and polymers, traditional machining methods are not suitable, making unconventional processes the only viable option.
7. High material removal rate: Some unconventional processes offer higher material removal rates compared to conventional methods, making them advantageous for specific applications where productivity is a crucial factor.

In summary, unconventional machining processes are necessary for addressing the limitations of traditional machining methods when dealing with challenging materials, complex geometries, high precision requirements, thermal concerns, material flexibility, and specific productivity needs.

[Answer 16]: Abrasive Jet Machining (AJM) is a non-traditional machining process that uses high-speed abrasive particles mixed with a gas to remove material from the workpiece. Here's a detailed explanation along with a sketch, advantages, disadvantages, and applications of AJM:

Abrasive Jet Machining involves the following components:

1. Gas Supply: High-pressure gas (commonly air or nitrogen) is used to propel the abrasive particles towards the workpiece.
2. Abrasive Feeder: This component feeds the abrasive particles into the mixing chamber.
3. Mixing Chamber: It mixes the abrasive particles with the high-pressure gas to form a high-velocity abrasive jet.
4. Nozzle: The abrasive jet exits the nozzle and is directed towards the workpiece, removing material upon impact.

Neat Sketch: [Here, you would typically include a sketch illustrating the components and working principle of Abrasive Jet Machining.]

Advantages of Abrasive Jet Machining:

- Ability to machine fragile and heat-sensitive materials.
- Non-thermal process, avoiding heat-affected zones and thermal distortion.
- Capability to machine intricate shapes and small holes with high precision.

- Environmentally friendly, as it does not involve hazardous chemicals.

Disadvantages of Abrasive Jet Machining:

- Slow material removal rate compared to conventional machining processes.
- Abrasive wear on nozzles, requiring frequent replacement.
- Limited to relatively low material hardness and thickness.

Applications of Abrasive Jet Machining:

- Precision cutting of thin materials like composites, laminates, and circuit boards.
- Surface cleaning and preparation in industries such as aerospace and automotive.
- Etching and engraving on delicate surfaces.
- Machining of brittle materials like glass, ceramics, and semiconductors.

[Answer 17]: Water jet machining is a process that utilizes the principle of pressurizing water to extremely high levels and allowing it to escape through a small opening called an "orifice" or "jewel." This high-pressure water stream is used to cut various materials.

Neat Sketch: Unfortunately, I am unable to provide a sketch.

Advantages of Water Jet Machining:

- No heat is generated during the process, making it suitable for cutting tool steel and other metals where excessive heat may alter the material properties.
- Unlike machining or grinding, water jet cutting does not produce harmful dust or particles that can be inhaled.
- High accuracy parts can be machined with a narrow heat-affected zone.

Disadvantages of Water Jet Machining:

- Economically, only a limited number of materials can be cut using this process.
- Thick parts cannot be cut economically and accurately.
- Taper can be a problem in very thick materials, causing dimensional inaccuracy.

Applications of Water Jet Machining:

- It is mostly used to cut lower strength materials such as wood, plastics, and aluminum.
- When abrasives are added (abrasive water jet cutting), stronger materials such as steel and tool steel can be cut effectively.

[Answer 18]: Ultrasonic machining is a non-traditional mechanical machining process that uses ultrasonic vibrations to remove material from the workpiece. The process involves a tool vibrating at an ultrasonic frequency (usually 20-30 kHz) while being pressed onto the workpiece. The tool, typically a hard abrasive material such as diamond or boron carbide, is mixed with an abrasive slurry in the presence of an ultrasonic energy source. This mixture of abrasives and slurry removes material from the workpiece through the process of micro-chipping or erosion.

Advantages of ultrasonic machining:

- Ability to machine hard and brittle materials such as ceramics, glass, and semiconductors.
- High precision and intricate detailing can be achieved.
- Low tool wear due to the use of abrasives in a slurry.

Disadvantages of ultrasonic machining:

- Limited to small or intricate components due to the size limitations of the ultrasonic tool.
- Slow material removal rate compared to traditional machining processes.
- High initial equipment cost.

Applications of ultrasonic machining:

- Machining of brittle materials like ceramics for electronic components.
- Fabrication of intricate shapes in semiconductors and optical components.
- Production of micro-sized components for medical and aerospace industries.

Neat Sketch: Unfortunately, as the sketch is not available in the provided sources, a neat sketch cannot be provided.

[Answer 19]: The unconventional machining process that gives the highest material removal rate is Electrochemical Machining (ECM). ECM is a non-traditional machining process that uses electrochemical phenomena to remove metal by anodic dissolution. It is suitable for complex three-dimensional surfaces, low machinability materials, and complicated shapes. The process involves the use of electrolytes to dissolve the workpiece material. Here is a detailed explanation of ECM:

Principle of ECM:

- ECM involves the use of electrolytes and electrical energy to remove metal from the workpiece.
- An anodic tool (cathode) and the workpiece (anode) are placed in close proximity in an electrolyte solution. When a potential difference is applied, metal ions are removed from the workpiece surface through electrochemical reactions, leading to material removal.

Advantages of ECM:

1. Accuracy: Complex three-dimensional surfaces can be machined accurately.
2. Surface Finish: ECM results in an excellent surface finish (Ra 0.2 to 0.6 μm) with almost stress-free machined surfaces and without any thermal damage.
3. Tool Wear: The tool wear is practically nil, resulting in a large number of components produced per tool.
4. Material Removal Rate (MRR): ECM offers a high material removal rate, which is comparable with conventional machining processes.

Disadvantages of ECM:

1. Corrosive Media: The use of corrosive media as electrolytes makes it difficult to handle.
2. Limitations in Shape: Sharp interior edges and corners (< 0.2 mm radius) are difficult to produce.
3. Cost: ECM machines are very expensive.
4. Forces and Energy Consumption: Forces are large due to fluid pumping forces, and the process has a very high specific energy consumption.

Applications: ECM is used for machining materials that are electrically conductive. It is suitable for aerospace components, automotive parts, medical devices, and intricate components with high precision requirements.

In summary, Electrochemical Machining (ECM) is an unconventional machining process that offers high material removal rates, excellent surface finish, and accuracy, making it suitable for machining complex shapes and difficult-to-machine materials.

[Answer 20]: Electron Beam Machining (EBM) is a thermal material removal process that utilizes a focused beam of high-velocity electrons to perform high-speed drilling and cutting. The process involves a stream of high-speed electrons impinging on the work surface, transferring kinetic energy to the work material and producing intense heating. Depending on the intensity of the heat generated, the material can melt or vaporize. EBM is capable of producing almost any programmable hole shape and is often applied for high-speed drilling of round holes in metals, ceramics, and plastics of any hardness.

Advantages of Electron Beam Machining:

- Able to drill materials up to 10mm thick at perforation rates that far exceed all other manufacturing processes.
- Capable of machining complex three-dimensional surfaces accurately, making it suitable for low machinability or complicated shapes.
- Provides an excellent surface finish (Ra 0.2 to 0.6 μm) with almost stress-free machined surfaces and without any thermal damage.
- Tool wear is practically nil, resulting in a large number of components produced per tool.

Disadvantages of Electron Beam Machining:

- High capital equipment cost.
- Holes produced in materials of thickness >0.13mm are tapered, limiting the process to thinner parts only.
- Requires a vacuum for operation.
- Availability is limited, and a high level of operator skill is required.
- Use of corrosive media as electrolytes makes it difficult to handle.

Applications of Electron Beam Machining:

- High-speed perforations in any kind of material, used in fluid and chemical industries to produce a multitude of holes for filters and screens.
- Drilling of tapered holes and non-circular hole drilling.
- Engraving of metals, ceramics, and vaporized layers.

- Machining of thin films to produce resistor networks in IC chip manufacturing.