THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

789 METAL WORKING AND MECHANICAL PRACTICE

Time: 3 Hour. **ANSWERS** **Year: 2003**

Instructions

1. This paper consists of **eight (8)** questions.
2. Answer any **five (5)** questions.
3. Each question carries **twenty (20)** marks.
4. Non-programmable calculators may be used.
5. Communication devices, programmable calculators and any unauthorized materials are **not** allowed in the examination room.
6. Write your **Examination Number** on every page of your answer booklet(s).

1. (a) Bench work refers to the set of manual operations carried out on a metal workpiece while it is placed on a workbench. It involves the use of hand tools such as hammers, files, and hacksaws for shaping, assembling, or finishing metal components, typically before or after machine processes.

   (b) One operation performed during bench work is filing, which is done to smoothen or fine-tune the dimensions of a workpiece after cutting. Sawing is another operation used to cut metal rods or sheets to required sizes using a hacksaw. Drilling is also performed to create holes in the workpiece, usually done with a hand or bench drill. Tapping is used to cut internal threads in a drilled hole, allowing bolts or screws to be fastened into the workpiece.

   (c) Accuracy is important in bench work to ensure that parts fit together properly during assembly. It helps maintain dimensional standards required for mechanical components. Accurate work prevents material wastage by avoiding rework or rejection. It also contributes to the reliability and performance of the final product.

   (d) Poor accuracy in fitting can result in loose or tight joints that affect mechanical operation. Misaligned holes or parts can lead to equipment malfunction or failure. It may cause excessive wear and tear due to uneven load distribution. Inaccurate components may also be rejected, increasing costs and project delays.

2. (a) Metal cutting is the process of removing unwanted material from a workpiece to achieve the desired shape or size. It is a fundamental operation in fabrication that prepares parts for assembly or finishing and can be done using tools like chisels, saws, or machines such as lathes and milling machines.

   (b) A cold chisel is used for cutting metal without heat. It is struck with a hammer to shear the metal along a scribed line. Precautions when using a chisel include wearing safety goggles to protect the eyes from flying metal chips, ensuring the chisel edge is sharp and free of damage, and striking the chisel accurately to maintain control and prevent slippage.

   (c) Chisel angles refer to the various cutting edge angles that determine the effectiveness of the chisel during cutting. The lip angle, usually about 60 degrees, controls how aggressively the chisel cuts. The clearance angle allows chip removal and prevents rubbing. The side relief angle facilitates smooth entry into the material.

   (d) Cold chisels allow quick and manual cutting of metal, which can be convenient and cost-effective for small jobs. They do not require electricity or machines. However, they are less accurate than saws and may produce rougher cuts. Chisels also require more physical effort and generate more noise and vibration.

3. (a) A die is a tool used in external threading to cut threads on the outside of a cylindrical workpiece, such as a rod or bolt. It ensures uniform thread formation and is used in both repair and manufacturing processes.

   (b) A split die has an adjustable design that allows for minor size changes and easier removal after threading. A solid die is a fixed unit with a rigid structure and is typically used for precision threading where adjustment is not needed.

   (c) To cut external threads with a die, the workpiece should be chamfered to start the threading easily. The die is then aligned squarely to the end of the rod and rotated clockwise to begin cutting. After a few turns, the die is reversed slightly to clear chips, then continued until the full thread length is achieved. Finally, the die is removed by unscrewing, and the threads are cleaned.

   (d) Poor-quality threads may result from using a worn or dull die, which tears the material rather than cutting cleanly. Misalignment of the die leads to crooked threads. Lack of lubrication increases friction and damages the thread surface. Applying excessive force during cutting can deform the threads or break the die.

4. (a) Oxy-acetylene welding is a gas welding method that uses a flame produced by mixing oxygen and acetylene gases. The high-temperature flame melts the base metals and a filler rod, which fuse together to form a strong joint upon cooling.

   (b) Neutral flame has a balanced oxygen-to-acetylene ratio and is used for general welding as it does not alter the metal's composition. Carburizing flame has excess acetylene and is used when welding high-carbon steels or for flame hardening. Oxidizing flame has excess oxygen and is suitable for welding copper or zinc-based alloys.

   (c) Flux during oxy-acetylene welding prevents oxidation by forming a protective layer on the molten metal. It helps in cleaning the metal surface by removing impurities. Flux also facilitates better flow of the molten filler metal, ensuring strong joint formation.

   (d) When handling acetylene gas cylinders, keep them upright to prevent acetone leakage. Never expose them to open flames or heat sources as they are highly flammable. Ensure that regulators and valves are fitted properly and never use oil-based substances near the fittings as they may ignite.

5. (a) Soldering is the process of joining two or more metal components using a filler material called solder, which has a lower melting point than the base metals. It is used in electronics, plumbing, and sheet metal works to form reliable joints with minimal heating.

   (b) Soft soldering uses lead-tin alloys that melt below 400°C and form relatively weak joints. It is suitable for electronics and light sheet metal. Hard soldering, such as silver soldering, involves higher melting alloys and forms stronger joints suitable for mechanical assemblies and load-bearing applications.

(c) To solder copper wires, first strip the insulation to expose clean metal ends. Next, apply flux to prevent oxidation and improve solder flow. Heat the joint with a soldering iron until the solder melts and flows into the joint. Finally, allow the joint to cool naturally without movement for a strong bond.

(d) Defects in soldered joints include cold joints, which result from insufficient heating, leaving the solder dull and weak. Dry joints occur when the solder fails to bond properly due to contamination or movement during cooling. Overheating can cause burnt flux and brittle joints that crack easily.

6. (a) A surface plate is a flat, solid base made of granite or cast iron, used as a reference plane for marking and inspection. It provides a stable surface to lay out workpieces and perform precision measurements or flatness checks.

(b) One method of checking flatness is by placing the workpiece on the surface plate and sliding a feeler gauge under it to detect gaps. A dial indicator can be swept across the surface to measure variations. Using a straight edge and light source also reveals uneven areas by the passage of light beneath the edge.

(c) Surface plates offer high accuracy for layout and inspection tasks. Their flatness ensures consistent reference for measurements. They are non-magnetic and stable under temperature changes, making them reliable in various conditions.

(d) Limitations include their weight, which makes them difficult to move. They require a clean, vibration-free environment to maintain accuracy. Their size also limits the dimensions of workpieces that can be handled, and they are prone to damage from impact or misuse.

7. (a) Cutting fluids are applied during machining to cool the cutting area, reduce tool wear, and improve surface finish. They also help in flushing away chips and preventing the workpiece from thermal distortion.

(b) Soluble oils are used in general machining operations and provide good cooling and lubrication. Straight oils are used in slow-speed operations like tapping or threading, offering strong lubricating properties. Synthetic fluids are used in high-speed operations where cooling is the main concern, such as grinding.

(c) Without cutting fluid, heat builds up rapidly, leading to thermal expansion and poor dimensional accuracy. Tool life is reduced due to overheating and increased friction. Surface finish becomes rough as chips may weld to the tool or damage the workpiece.

(d) To protect health and the environment, used fluids must be disposed of properly according to regulations. Operators should wear gloves and avoid prolonged skin contact. Good ventilation is needed to prevent inhalation of mists or fumes, especially from synthetic or oil-based fluids.

8. (a) Countersinking is the process of enlarging the top of a drilled hole with a conical shape to allow a flat-head screw or rivet to sit flush with the surface. It improves both the aesthetic and functional quality of assemblies.

(b) The operation is performed by securing the workpiece and aligning a countersink tool with the hole. The tool is rotated at a moderate speed while applying light pressure until the desired conical seat is achieved. Care is taken to avoid removing too much material.

(c) Three types of countersinks include single-flute countersinks used for general purposes, multi-flute countersinks which offer smoother finishes, and zero-flute countersinks suitable for soft metals and plastics. Each is selected based on material type and hole size.

(d) Countersinks are used to ensure that fasteners sit flush with the material, preventing obstruction or snagging. They also help distribute load evenly across the surface, reducing the risk of material damage around the hole.