THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

789 METAL WORKING AND MECHANICAL PRACTICE

(SUPPLEMENTARY)

Time: 3 Hours. **ANSWER** **Year: 2010**

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) **Explain the purpose of metal forming.**

   The purpose of metal forming is to change the shape of a metal workpiece into a desired form by applying mechanical forces without removing material.

   It improves the strength of the material due to strain hardening, reduces waste compared to machining, and allows the production of complex shapes at a lower cost.

   (b) **Describe three types of metal forming operations:**

   i) **Forging**

   Forging is a process in which a metal is shaped by applying compressive forces using hammers or presses. It is often carried out when the metal is heated to increase its plasticity. Examples include making crankshafts, connecting rods, and wrenches.

   ii) **Rolling**

   Rolling is the process of reducing the thickness or changing the cross-section of metal by passing it between two rotating rolls. This method is commonly used for producing sheets, plates, and structural shapes such as I-beams.

   iii) **Extrusion**

   Extrusion is a process in which metal is forced through a die to produce long shapes of uniform cross-section. It can be used to produce rods, tubes, and aluminum window frames.

   (c) **State two advantages of metal forming.**

   Metal forming improves the mechanical properties of the material, such as strength and toughness.
   It also produces little waste, making it economical compared to machining.

2. (a) **Define drilling and countersinking.**

   Drilling is the process of producing a round hole in a workpiece using a rotating drill bit.
   Countersinking is the process of enlarging the top of a drilled hole in a conical shape to allow the head of a screw or rivet to sit flush with the surface.

   (b) **Explain the procedure for drilling a pilot hole.**

   To drill a pilot hole, the workpiece is first marked at the center of the hole using a center punch. A small-

diameter drill bit is then mounted in the drill, and drilling is performed at a suitable speed. The pilot hole acts as a guide for a larger drill bit, ensuring accuracy and reducing the cutting load.

(c) **Describe two safety measures when drilling.**

The workpiece should be securely clamped to prevent it from rotating with the drill bit.

The operator must wear safety goggles to protect the eyes from flying chips.

3. (a) **Define filing and its purpose in mechanical work.**

Filing is the process of removing small amounts of material from a workpiece surface using a hand file. Its purpose is to smooth, shape, and finish surfaces, edges, and slots after machining operations.

(b) **Describe three types of file cuts:**

i) **Single cut**

A single-cut file has rows of parallel teeth cut at an angle across the file face. It is used for smooth finishing and sharpening edges.

ii) **Double cut**

A double-cut file has two sets of intersecting teeth, producing a diamond-shaped pattern. It removes material quickly and is suitable for rough work.

iii) **Curved cut**

A curved-cut file has curved rows of teeth and is mainly used for filing soft metals like aluminum and lead.

(c) **List two ways to maintain a file.**

A file should be cleaned regularly using a file card to remove clogged material.

It should be stored properly to prevent damage to the teeth, such as keeping it away from contact with other tools.

4. (a) **Explain the importance of lubrication in machining operations.**

Lubrication reduces friction between the cutting tool and workpiece, thereby lowering heat generation. It prolongs tool life, improves surface finish, and helps in the removal of chips.

(b) **List four types of lubricants.**

Cutting oils

Emulsions (soluble oils)

Solid lubricants such as graphite

Synthetic fluids

(c) **Explain two methods of applying lubrication effectively.**

Flood lubrication involves continuously supplying a large amount of fluid to the cutting zone to cool and lubricate.

Mist lubrication uses compressed air mixed with fine oil droplets, which is efficient for high-speed machining.

5. (a) **Define welding and its importance.**

Welding is a process of permanently joining two or more metal parts by applying heat, pressure, or both, often with or without filler material. Its importance lies in producing strong, permanent joints that can withstand high loads and stresses.

(b) **Describe two types of electric arc welding:**

i) **Shielded arc welding**

In shielded arc welding, a flux-coated electrode is used. The flux melts and produces a shielding gas that protects the molten weld pool from atmospheric contamination. It is widely used in structural fabrication.

ii) **Submerged arc welding**

In submerged arc welding, a continuous electrode wire is used, and the arc is shielded by a blanket of granular flux. This method provides deep penetration and is used for heavy sections such as pressure vessels and pipelines.

(c) **Outline three electrode selection criteria.**

Electrodes should be selected based on the type of base metal being welded.

The required strength of the weld joint should determine the electrode grade.

The welding position (flat, vertical, or overhead) should be considered when choosing electrodes.

6. (a) **Explain the use of a surface grinder in finishing operations.**

A surface grinder is used to produce very smooth and accurate flat surfaces by removing small amounts

of material with a rotating abrasive wheel. It is commonly used for finishing machine parts requiring high precision.

(b) **Outline four maintenance procedures for grinders.**

Regularly dress the grinding wheel to maintain its cutting ability.

Lubricate the machine's moving parts to reduce wear.

Keep the machine clean and free from dust accumulation.

Check and replace worn-out parts such as bearings or belts.

(c) **Draw and label a grinding wheel with four key parts.**

A grinding wheel consists of the following key parts:

- Abrasive grains (responsible for cutting)
- Bond (material holding the grains together)
- Pores (spaces between grains for chip removal and cooling)
- Wheel structure (overall arrangement of grains, bond, and pores)

7. (a) A cylindrical workpiece of diameter 60 mm is to be turned.

i) **Material removal rate (MRR)**

MRR = $\pi \times D \times$ depth of cut $\times$ feed $\times N$

$= 3.142 \times 60 \times 2 \times 0.25 \times 180$

$= 16{,}964\ mm^3/min = 16.96\ cm^3/min$

ii) **Power required**

Cutting speed $V = (\pi \times D \times N) / 1000$

$= (3.142 \times 60 \times 180) / 1000$

$= 33.9$ m/min

Power = (Cutting force $\times$ Cutting speed) / 60

$= (800 \times 33.9) / 60$

$= 452\ W = 0.45\ kW$

(b) **Time to reduce length of 100 mm by 5 mm diameter**

Volume removed = $\pi \times (Do^2 - Df^2)/4 \times$ length

$= 3.142 \times (60^2 - 55^2)/4 \times 100$

$= 3.142 \times (3600 - 3025)/4 \times 100$

$= 3.142 \times 575/4 \times 100$

$= 45{,}097\ mm^3 = 45.1\ cm^3$

Time = Volume / MRR

= 45.1 / 16.96 = 2.66 min

(c) **Cutting speed**

Cutting speed $V = (\pi \times D \times N)/1000$

$= (3.142 \times 60 \times 180)/1000$

= 33.9 m/min

8. (a) A lathe is used to produce internal threads in a 40 mm bore.

i) **Spindle speed**

$N = (1000 \times V) / (\pi \times D)$

$= (1000 \times 30) / (3.142 \times 40)$

= 238 rev/min

ii) **Leadscrew rotation per spindle turn to cut M16 × 2 thread**

Pitch of thread = 2 mm

Therefore, leadscrew must rotate once for every 2 mm of carriage movement. Thus, 1 spindle revolution corresponds to 1 leadscrew revolution in this case.

(b) **Torque if cutting force is 450 N at radius 20 mm**

Torque = Force × Radius

$= 450 \times 0.02$

$= 9\ N \cdot m$

(c) **Reaming allowance**

Reaming allowance = Final hole diameter − Drilled hole diameter

$= 40 - 39.8$

$= 0.2$ mm