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: 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) (i) Define the term 'ferrous' metal and give one example.

Ferrous metals are those that primarily contain iron as their main constituent. They are usually magnetic and prone to rust when exposed to moisture, unless alloyed with elements like chromium or nickel. An example of a ferrous metal is mild steel, which is widely used in construction and fabrication.

(ii) Define the term 'non-ferrous' metal and give one example.

Non-ferrous metals are those that do not contain significant amounts of iron. They are generally resistant to rust and corrosion, have low density compared to ferrous metals, and are non-magnetic. An example of a non-ferrous metal is aluminum, which is commonly used in aircraft structures due to its light weight.

(iii) Describe the characteristic properties of a material with high 'ductility'.

A ductile material can undergo significant plastic deformation before fracture. Such a material can be stretched into wires or drawn into thin sheets without breaking. High ductility also means the material absorbs a considerable amount of energy before failure, making it suitable for applications requiring flexibility, such as in copper wires.

(iv) Explain the phenomenon of 'work hardening' and suggest a way to reverse its effects.

Work hardening occurs when a metal becomes stronger and harder after being plastically deformed, such as by hammering, rolling, or bending. This happens because the dislocation density within the metal increases, restricting further movement of atoms. To reverse the effects of work hardening, the material can be annealed by heating it to a suitable temperature and then cooling it slowly, which restores its ductility.

(b) State three common workshop applications for cast iron.

Cast iron is used in making machine tool beds because of its high compressive strength and excellent vibration-damping properties. It is also used in the manufacture of engine blocks due to its ability to withstand high temperatures. Additionally, cast iron is used in making pipes and fittings because of its durability and resistance to wear.

(c) Identify two common types of keys used in mechanical power transmission.

One common type is the square key, which has a square cross-section and is widely used for transmitting torque in shafts. Another type is the Woodruff key, which is semicircular and fits into a matching recess in the shaft, providing a secure fit and easy assembly.

2. (a) Briefly explain the purpose and steps of the heat treatment process known as 'normalizing'.
The purpose of normalizing is to refine the grain structure of steel, relieve internal stresses, and improve toughness and machinability.

The process involves heating the steel above its critical temperature to make the structure uniform. It is then cooled in still air, which gives a more refined structure than annealing while still maintaining good strength.

(b) Outline the steps involved in the process of 'tempering' a hardened steel tool.
First, the hardened steel tool is cleaned so that its surface is visible for color changes.

Next, it is reheated to a temperature below the critical point, typically between 150°C and 600°C depending on the desired properties.

The tool is then held at this temperature for a specified period to reduce brittleness.

Finally, it is cooled, usually in still air, to obtain a balance of hardness and toughness.

(c) (i) Explain the term 'quenching' in heat treatment.
Quenching is the rapid cooling of a heated metal by immersing it in a cooling medium such as water, oil, or brine. The sudden cooling transforms the metal's structure into a hard but brittle form.

(ii) Give two examples of common quenching media.
Two common quenching media are water, which cools very quickly and produces high hardness, and oil, which cools more slowly and reduces the risk of cracking.

3. (a) Differentiate between 'hot working' and 'cold working' of metals.
Hot working is the process of shaping metals above their recrystallization temperature, which allows large deformations without cracking and improves ductility.

Cold working, on the other hand, is performed below the recrystallization temperature, leading to increased strength and hardness but reduced ductility due to work hardening.

(b) (i) Explain the term 'case hardening' and give one application.
Case hardening is a heat treatment process where the surface of a low-carbon steel component is hardened

by adding carbon or nitrogen while the core remains tough and ductile. An application is in gears, where a hard surface resists wear while the tough core absorbs shocks.

(ii) Outline the main objective of the annealing heat treatment process.
The main objective of annealing is to soften the metal, relieve internal stresses, and restore ductility lost during cold working. This process also improves machinability and prepares the metal for further processing.

(c) State four desirable properties of a material used for making machine tool beds (e.g., lathe bed).
The material should have high compressive strength to withstand heavy loads. It should also possess good vibration-damping capacity to maintain accuracy during machining. Wear resistance is another important property to ensure long service life. Finally, it should have dimensional stability to avoid distortion under varying temperatures.

4. (a) (i) Give two examples of thermoplastic polymers.
Examples of thermoplastics include polyethylene and polyvinyl chloride (PVC), both of which can be softened and reshaped multiple times by heating.

(ii) Give two examples of thermosetting polymers.
Examples of thermosetting polymers are bakelite and epoxy resins, which permanently set into a rigid form after curing and cannot be remolded by reheating.

(b) Describe the main advantage of using 'composites' (like fiber-reinforced plastic) over pure metals in certain applications.
The main advantage of composites is their high strength-to-weight ratio. They provide excellent mechanical strength while being much lighter than metals, which makes them ideal for applications in aerospace, automotive, and sporting equipment where weight reduction is critical.

(c) State three different ways that chips (swarf) can be disposed of in a mechanical workshop.
One way is recycling, where metal chips are collected and sent for remelting to make new products. Another method is compaction, where chips are pressed into briquettes for easier handling and transport. A third way is safe disposal in designated waste bins to keep the workshop clean and prevent accidents.

5. (a) Explain the function and main operating principle of a shaper machine.
A shaper machine is used to produce flat surfaces, grooves, and slots on a workpiece. Its operating

principle is based on the reciprocating motion of a single-point cutting tool, which removes material during the forward stroke while the return stroke is idle.

(b) State three advantages of using a power hacksaw over a hand hacksaw, focusing on efficiency and quality.

The power hacksaw cuts metal faster than a hand hacksaw, improving efficiency in the workshop. It produces more uniform and accurate cuts because the feed and stroke are controlled mechanically. It also reduces operator fatigue since the cutting is automated.

(c) Identify the main components of a belt drive system and explain the function of the slack side.

The main components of a belt drive system include the driver pulley, the driven pulley, and the belt itself. The slack side of the belt is the portion that returns from the driven pulley to the driver pulley, carrying less tension. Its function is to accommodate belt elasticity and minimize vibration, ensuring smooth power transmission.

6. (a) Outline the general procedures for safely lifting and moving a heavy machine tool in the workshop.

First, inspect the lifting equipment such as cranes, slings, or forklifts to ensure they are in good condition. Next, secure the machine properly by attaching lifting points or using slings in recommended positions. Then, lift the machine slowly and steadily, avoiding sudden jerks. Finally, move the machine carefully to the new location and lower it onto a stable foundation.

(b) State four reasons why lubrication is crucial for the efficient and prolonged life of workshop machinery.

Lubrication reduces friction between moving parts, minimizing wear and extending their service life. It also helps in dissipating heat generated by friction, preventing overheating. Lubricants protect metal surfaces from rust and corrosion. Additionally, lubrication helps in keeping contaminants away by flushing out debris and dirt.

(c) Explain the function of the 'clearance hole' in a bolted joint.

A clearance hole is a hole drilled slightly larger than the bolt diameter, allowing the bolt to pass freely without threading into the material. Its function is to ensure easy assembly and alignment of bolted parts while the nut provides the clamping force.

7. (a) Explain the term 'draft' in metal casting and explain why it is necessary.

Draft is the slight taper provided on the vertical surfaces of a pattern used in casting. It is necessary because it allows the pattern to be withdrawn easily from the sand mold without damaging the mold cavity. Without draft, the mold could break or distort.

(b) How are anvils and swage blocks used in connection with metal forming?

Anvils provide a hard surface on which metals can be hammered, shaped, or forged during blacksmithing operations. Swage blocks, on the other hand, are used for forming specific shapes like curves, angles, and holes by hammering the metal into their grooves or depressions.

(c) Describe the process of using a bearing puller to safely dismantle a press-fit assembly.

To use a bearing puller, first position the puller's jaws securely behind the bearing. Then, align the center screw of the puller with the shaft end. As the screw is turned, it applies a pulling force that gradually extracts the bearing without causing damage to the shaft or bearing housing.

8. (a) A metal bar is subjected to a tensile force of 150 kN. If the cross-sectional area of the bar is 2500 mm², calculate the tensile stress in N/mm² (MPa).

Stress = Force / Area

Stress = 150,000 N ÷ 2500 mm² = 60 N/mm²

Thus, the tensile stress is 60 MPa.

(b) A 10 mm wide key is used in a shaft. If the shaft diameter is 40 mm and the allowable shear stress is 50 N/mm², calculate the minimum key length required to transmit a torque of 50 N·m.

Torque (T) = 50 N·m = 50,000 N·mm

Shear force (F) = T / (shaft radius) = 50,000 ÷ 20 = 2500 N

Shear stress = Force / (Area) = F ÷ (length × width)

50 = 2500 ÷ (L × 10)

L = 2500 ÷ (50 × 10) = 5 mm

Thus, the minimum key length required is 5 mm.

(c) A force of 10 kN is applied to a 2 m long bar causing it to extend by 0.5 mm. If the cross-sectional area is 100 mm², calculate the strain in the bar.

Strain = Change in length / Original length

Strain = 0.5 mm ÷ 2000 mm = 0.00025

Thus, the strain is 0.00025 (dimensionless).