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: 2002**

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 'electric arc welding'.

Electric arc welding is a process in which heat is generated by an electric arc struck between a consumable or non-consumable electrode and the workpiece. The heat from the arc melts the base metal and the filler electrode, forming a molten pool that solidifies to create a welded joint. This method is widely used because it produces strong, durable joints and is suitable for a variety of metals.

(ii) To which flow of electric energy is arc welding primarily based?

Arc welding is primarily based on the flow of either alternating current (AC) or direct current (DC). Direct current is most commonly used because it provides stable arcs, easier striking, and better control of penetration. Alternating current is also applied in some cases, especially for welding ferrous metals, but DC tends to give more reliable results.

(iii) Explain the function of the coating (flux) on a shielded metal arc welding (SMAW) electrode.

The coating, or flux, on an SMAW electrode performs several functions. It provides a shielding gas when burned, which protects the molten weld pool from atmospheric contamination such as oxygen and nitrogen. It also produces a layer of slag that covers the cooling weld bead, further preventing oxidation. Additionally, the coating helps to stabilize the arc, improves penetration, and sometimes introduces alloying elements into the weld metal.

(iv) Define the term 'weldability' of a material.

Weldability is the ability of a material to be welded successfully under fabrication conditions into a specific, intended structure that performs adequately in service. A material with good weldability requires little preheating, produces minimal distortion, forms strong joints, and is resistant to cracking during or after welding. Different materials exhibit different levels of weldability depending on their chemical composition and mechanical properties.

(b) Explain the importance of maintaining a short arc length in Manual Metal Arc Welding (MMAW).

Maintaining a short arc length is important in MMAW because it ensures proper concentration of heat at the weld pool, leading to better fusion of the base and filler metals. A short arc also reduces spattering, produces a smoother bead, and minimizes the risk of porosity caused by excessive air exposure. If the arc is too long, the arc becomes unstable, penetration becomes shallow, and the weld quality deteriorates.

(c) Outline four specific criteria to be considered during an electrode selection process.

The first criterion is the type of metal being welded, as electrodes must match or be compatible with the

base metal's composition. The second is the thickness of the material, since thicker metals require electrodes with higher current-carrying capacity and deeper penetration. The third is the welding position, because some electrodes are designed for flat positions only, while others can be used in vertical or overhead positions. The fourth is the required mechanical properties of the finished weld, such as tensile strength, ductility, and impact resistance, which influence the choice of electrode grade.

2. (a) Describe the appearance and purpose of the three basic types of oxy-acetylene flame: (i) Carburizing flame (ii) Neutral flame (iii) Oxidizing flame.

The carburizing flame has a bright inner cone with a longer feather-like outer flame. It contains excess acetylene and is used when welding high-carbon steels or non-ferrous metals like aluminum, as it prevents oxidation.

The neutral flame has a well-defined inner cone and a short, clean outer envelope with balanced oxygen and acetylene. It is the most widely used flame because it produces neither oxidation nor carburization, making it suitable for most metals.

The oxidizing flame has a shorter, pointed inner cone and a noisy, sharp outer cone. It contains excess oxygen and is used for welding brass and for cutting operations where oxidation helps the process.

(iv) Give the two main gases and their functions in Oxy-Fuel Gas Welding (OFW).

The two main gases are oxygen and acetylene. Oxygen supports combustion and raises the flame temperature, while acetylene provides the fuel that burns with oxygen to produce a very hot flame capable of melting most metals.

(b) Describe the proper procedure for safely shutting down an oxy-acetylene welding set after use.

To safely shut down an oxy-acetylene welding set, first close the acetylene valve on the torch, followed by the oxygen valve to extinguish the flame. Next, close both cylinder valves tightly to stop the gas supply. After this, open the torch valves one at a time to release any residual gas in the hoses, then close them again. Finally, back off the regulators to release spring tension, ensuring the system is safely depressurized and ready for storage.

(c) State four specific hazards associated with the use of acetylene gas in the workshop.

The first hazard is its high flammability, as acetylene can ignite easily when exposed to sparks or flames. The second hazard is the risk of explosion if acetylene is stored at pressures above 15 psi. The third hazard is gas leaks, which can accumulate in confined spaces and create dangerous atmospheres. The fourth

hazard is chemical instability, since acetylene can decompose violently under certain conditions if not handled properly.

3. (a) Differentiate between brazing and soldering in terms of process temperature and strength of the joint.

Brazing is a process that uses filler metals with melting points above 450°C but below the melting point of the base metals, resulting in stronger joints suitable for structural applications. Soldering, on the other hand, uses filler metals with melting points below 450°C, producing weaker joints typically used for electrical connections and light mechanical assemblies.

(b) (i) Outline four advantages of braze welding over fusion welding.

One advantage is that braze welding requires lower temperatures, reducing distortion and residual stresses in the workpiece. Another advantage is its ability to join dissimilar metals, which is difficult with fusion welding. A third advantage is that it often requires less preparation, as close tolerances are not always critical. A fourth advantage is the cleaner appearance and smoother surface finish achieved in braze-welded joints.

(ii) Describe the role of 'capillary action' in the brazing process.

Capillary action is the tendency of molten filler metal to flow into narrow gaps between closely fitted surfaces due to surface tension forces. In brazing, this phenomenon ensures that the filler metal spreads evenly through the joint, providing full coverage and a strong bond between the workpieces. Without capillary action, the filler would not penetrate the joint effectively.

(c) In four points, give the importance of borax flux for the braze welding process.

Borax flux cleans the metal surfaces by dissolving oxides, ensuring good adhesion of the filler.

It also prevents further oxidation during heating by forming a protective barrier.

The flux improves wetting action, helping the molten filler metal spread evenly over the surfaces.

Finally, it lowers the surface tension of the filler metal, enhancing penetration and joint strength.

4. (a) Explain the term 'heat-affected zone' (HAZ) and why it is a critical area in a welded joint.

The heat-affected zone is the portion of the base metal adjacent to the weld that does not melt but undergoes structural and property changes due to high heat. It is critical because it can become the weakest

area in the joint if not properly controlled, often leading to brittleness, reduced toughness, or cracking. Controlling cooling rates and preheating can minimize adverse effects in the HAZ.

(b) (i) List four types of common welding joints.

The four common types are butt joints, lap joints, corner joints, and T-joints. Each is used depending on the design requirements and load conditions of the structure.

(ii) State two advantages of using 'inert gas' in TIG and MIG welding.

Inert gases such as argon or helium provide excellent shielding of the molten weld pool from atmospheric gases, preventing oxidation and contamination. They also stabilize the arc, resulting in smoother, cleaner weld beads with better mechanical properties.

(c) Describe the process of 'preheating' a workpiece before welding and list two materials for which it is commonly recommended.

Preheating is the process of heating the workpiece to a specified temperature before welding begins. This reduces the cooling rate, minimizes residual stresses, and lowers the risk of cracking in the weld and HAZ. Preheating is commonly recommended for materials such as high-carbon steels and cast iron, which are more susceptible to cracking.

5. (a) (i) Write the hazards of ultraviolet rays produced during arc welding.

Ultraviolet rays can cause severe eye damage such as welder’s flash, skin burns, and increase the risk of skin cancer with prolonged exposure.

(ii) Suggest three ways to prevent exposure to ultraviolet rays.

First, welders should wear appropriate PPE such as helmets with filter lenses to protect their eyes. Second, protective clothing and gloves should be used to cover the skin. Third, welding curtains or screens should be set up around the work area to shield other people nearby.

(b) (i) Differentiate between straight polarity (DCSP) and reverse polarity (DCRP) in DC arc welding.

In straight polarity (DCSP), the electrode is connected to the negative terminal and the workpiece to the positive, producing deeper penetration because electrons flow into the work. In reverse polarity (DCRP), the electrode is connected to the positive terminal, which produces more heat at the electrode, giving better cleaning action but shallower penetration.

(ii) Explain the term 'weld puddle'.

A weld puddle is the small pool of molten metal formed at the point where the arc strikes the workpiece. It is manipulated by the welder to ensure proper fusion and bead formation before it solidifies.

(c) State three common causes of 'porosity' (small gas pockets) in a completed weld.

Porosity can be caused by contamination of the base metal with oil, rust, or dirt.

It can also occur due to excessive arc length, which allows atmospheric gases to mix with the weld pool.

Another cause is inadequate shielding from the flux or shielding gas, which lets air enter the molten metal.

6. (a) List four types of welding defects that can be found in a completed weld.

Common welding defects include cracks, lack of fusion, undercut, and slag inclusion. Each reduces the strength and integrity of the weld.

(b) Describe the importance of 'venting' in resistance welding applications.

Venting is important because it allows gases produced during the welding process to escape. If gases are trapped, they can create voids or weaken the joint. Proper venting ensures the weld is sound and free from defects.

(c) State three characteristics of a good filler rod for gas welding.

A good filler rod should have chemical composition compatible with the base metal. It should melt easily and flow smoothly to produce clean joints. It should also provide mechanical properties such as strength and toughness comparable to the parent metal.

7. (a) Explain how the classification of brazing alloys is generally done in welding.

Brazing alloys are generally classified according to their base composition, such as copper-based, silver-based, or aluminum-based alloys. They may also be classified by melting range and application suitability.

(b) State three factors that influence the effectiveness of brazing operations.

The first factor is proper surface preparation, since dirt and oxides prevent bonding.

The second is correct joint clearance, as too wide or too narrow a gap reduces capillary action. The third is temperature control, as overheating or underheating affects filler flow and joint strength.

(c) Write the chemical name for the flux used in the welding of aluminium and state its purpose.
The flux commonly used is sodium chloride combined with potassium chloride, generally referred to as chloride-based flux.

Its purpose is to dissolve the stubborn oxide layer on aluminum, allowing the filler metal to wet the surface properly.

8. (a) Calculate the total amount of filler metal required (in kg) to complete a butt weld joint on a 10 mm thick plate, given that the required filler metal volume is 45 cm^3 and the density of the filler metal is 7.85 g/cm^3.
Mass = Density × Volume
Mass = 7.85 g/cm^3 × 45 cm^3 = 353.25 g
Convert to kg: 353.25 ÷ 1000 = 0.353 kg

(b) The formula for calculating arc time factor (ATF) is: ATF = (Arc Time / Total Time) × 100. Calculate the ATF if the total working time is 8 hours and the actual time the arc is running is 1.5 hours.
ATF = (1.5 ÷ 8) × 100 = 18.75%

(c) Calculate the time (in minutes) required to deposit a 1 m length of weld bead if the travel speed of the electrode is 15 cm/min.
Length = 100 cm
Time = 100 ÷ 15 = 6.67 minutes