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: 2001**

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 lathe operation called 'boring'.

Boring is the process of enlarging or finishing an existing hole in a workpiece using a single-point cutting tool on a lathe. Unlike drilling, which creates a new hole, boring improves the accuracy of diameter, alignment, and surface finish of an already drilled or cast hole.

1. (a) (ii) Explain the function of the Apron mechanism on a centre lathe.

The apron mechanism is mounted on the carriage and houses the gears and clutches that control the movement of the carriage along the bed. Its primary function is to enable both manual and automatic feed motions during turning operations. It also contains controls for threading by engaging with the lead screw, ensuring precise tool movement.

1. (a) (iii) Identify four essential functions of the carriage assembly on a centre lathe.

The carriage supports the cutting tool and moves it longitudinally or crosswise relative to the workpiece. This ensures proper guidance during cutting.

It provides stability and rigidity to the cutting tool to withstand cutting forces without deflection.

The carriage enables accurate feeding of the cutting tool, both manually and automatically, depending on the operation.

It also houses mechanisms such as the cross-slide and compound rest, which allow angular and transverse tool positioning for versatile machining.

1. (b) Differentiate between the 'lead screw' and the 'feed rod' on a lathe machine.

The lead screw is a precision threaded shaft used primarily for threading operations. It ensures accurate synchronization between the spindle and carriage, allowing threads to be cut precisely.

The feed rod, on the other hand, is a smooth shaft that transmits power from the headstock to the apron for automatic feed. It is used for general turning and facing operations but not threading.

1. (c) Outline the steps required to safely perform a knurling operation on a lathe.

First, the workpiece must be securely clamped in the chuck, and the tool post tightened to avoid vibrations.

Second, the knurling tool is mounted rigidly and aligned at the correct position on the workpiece surface.

Next, the tool is brought into firm contact with the rotating workpiece by applying steady pressure until the knurl pattern starts to form.

Finally, sufficient cutting fluid is applied to reduce friction, and the operation is performed at a low spindle speed to avoid overheating.

2. (a) State four specific requirements for securely mounting a workpiece in a four-jaw independent chuck.

Each jaw should grip the workpiece firmly to prevent slipping during machining.

The jaws must be adjusted independently to ensure that the workpiece is centered accurately.

A dial indicator should be used to check for runout and achieve proper alignment before machining begins.

The workpiece must be tightened gradually by alternating between jaws to maintain balance and stability.

2. (b) Explain the term 'centre drilling' and its importance before the main drilling operation on a lathe.

Centre drilling is the process of creating a small conical hole at the end of a workpiece using a combined drill and countersink tool. Its importance lies in guiding the main drill bit accurately, preventing it from wandering or deflecting. This ensures the main hole is properly aligned and reduces the risk of drill breakage.

2. (c) Outline the procedure for aligning the tailstock of a centre lathe to correct for a taper error.

First, a test bar is mounted between centers and machined lightly along its length. The diameter is then measured at both ends.

If a taper is detected, the tailstock is loosened and adjusted laterally using the set screws until both ends of the bar measure equal.

The adjustment is verified by repeating the test cut until no taper remains, after which the tailstock is firmly tightened in place.

3. (a) (i) Define the terms 'feed' and 'depth of cut' with reference to lathe operations.

Feed is the distance the cutting tool advances along the workpiece for each revolution of the spindle. It determines the surface finish and material removal rate.

Depth of cut is the thickness of material removed in one pass of the cutting tool, measured as the difference between the original and final diameters of the workpiece.

3. (a) (ii) Describe the phenomenon of tool chatter and state two ways to minimize its occurrence.

Tool chatter is a self-excited vibration that occurs when the cutting tool and workpiece oscillate during machining, producing poor surface finish and noise.

It can be minimized by ensuring the cutting tool is sharp and rigidly clamped to reduce deflection.

It can also be reduced by decreasing the feed rate or using cutting fluids to dampen vibrations.

3. (a) (iii) Differentiate between roughing cuts and finishing cuts.

Roughing cuts are deep and heavy cuts taken to remove large amounts of material quickly. They are used at higher feeds and depths of cut, with less concern for surface finish.

Finishing cuts are light cuts taken after roughing to produce the final dimensions and improve surface finish. They are done at slower feeds and smaller depths of cut.

3. (c) State three purposes of performing a facing operation on a lathe.

Facing is used to produce a flat surface at the end of a workpiece.

It is also performed to bring the workpiece to the required length accurately.

Additionally, facing provides a smooth surface for assembling components, such as seating a washer or bearing.

4. (a) Give the functions of the following lathe accessories: (i) The steady rest (ii) The follower rest (iii) The chasing dial (iv) The machine spindle.

The steady rest supports long workpieces during machining to prevent bending or vibration.

The follower rest moves with the carriage and provides continuous support close to the cutting tool, useful for slender workpieces.

The chasing dial assists in thread cutting by showing when the half-nuts can be engaged with the lead screw for proper thread alignment.

The machine spindle holds and rotates the chuck or faceplate, transmitting power from the motor to the workpiece.

4. (b) Briefly describe how to determine the correct clearance angle for a cutting tool based on the material being machined.

The clearance angle is selected according to the hardness of the work material. Softer materials require larger clearance angles to prevent rubbing, while harder materials need smaller angles to maintain tool strength. Manufacturers provide recommended angle charts that machinists follow when grinding cutting tools.

4. (c) Outline four safety precautions specific to working around a rotating lathe chuck.

Loose clothing and jewelry must not be worn to avoid entanglement with the rotating chuck.

The chuck key should never be left in the chuck after tightening to prevent accidents when the machine starts.

Hands should not be placed near the rotating workpiece; instead, tools should be used to remove chips.

The operator should always stand clear of the rotating chuck to avoid being struck by protruding jaws.

5. (a) (i) Define the operation of ‘reaming’.

Reaming is the process of finishing a drilled hole to a precise size and smooth surface using a multi-edged tool called a reamer.

5. (a) (ii) Explain the difference between a parallel shank reamer and a taper shank reamer.

A parallel shank reamer has a straight cylindrical shank and is held in a drill chuck or collet.

A taper shank reamer has a conical shank that fits directly into the machine spindle’s taper socket for rigid support.

5. (a) (iii) Outline the four main steps for the correct procedure of sharpening a twist drill.

First, the drill is secured at the correct angle against the grinding wheel.

Second, each cutting edge is ground evenly to maintain symmetry.

Third, the chisel edge at the center is shortened to reduce thrust during drilling.

Finally, the lip clearance is checked to ensure proper cutting performance.

5. (b) Give three reasons why excessive drill speed can be detrimental to the drill bit and the workpiece.

High speed generates excessive heat, which can soften and damage the cutting edges of the drill.

It may cause the drill to lose accuracy by wandering off the intended centerline.

It can also damage the workpiece surface, producing rough holes and poor finish.

5. (c) What is the function of the pilot on a counterbore tool?

The pilot guides the counterbore tool into the drilled hole, ensuring concentricity and preventing the tool from wandering.

6. (a) Explain the concept of 'runout' in a rotating machine spindle.

Runout refers to the deviation of the spindle or tool from its true rotational axis, causing eccentric rotation. Excessive runout leads to poor accuracy, uneven wear, and vibration during machining.

6. (b) (i) Define the terms 'limit' and 'tolerance' in engineering design.

A limit is the maximum or minimum allowable size of a manufactured part.

Tolerance is the permissible variation between the maximum and minimum limits.

6. (b) (ii) Explain the importance of keyways and state two common types of keys used in power transmission.

Keyways are slots cut in shafts and hubs to fit keys, which lock rotating elements such as gears or pulleys to the shaft. This prevents slipping and ensures torque transmission.

Two common types of keys are the square key and the woodruff key.

6. (c) State three different types of fit (clearance, transition, and interference) that can exist between two mating parts.

A clearance fit provides space between the parts, allowing easy assembly and movement.

A transition fit may result in either slight clearance or slight interference, giving accurate alignment with moderate assembly force.

An interference fit requires force or heating/cooling methods for assembly since the parts are tightly pressed together.

7. (a) Outline three basic types of chip produced when cutting metals.

Continuous chips are produced when machining ductile materials at high speed, giving smooth surfaces.

Discontinuous chips occur when machining brittle materials, resulting in a rough finish.

Built-up edge chips form when material sticks to the cutting edge, causing poor surface quality.

7. (b) Explain the primary function of a cutting fluid (coolant) in machining.

The main function is to reduce heat generated by cutting, preventing tool wear. It also lubricates the cutting zone, flushes away chips, and improves surface finish.

7. (c) State four criteria for selecting the correct cutting fluid for a turning operation.

The material of the workpiece must be considered, as different materials require specific fluids.

The cutting speed and type of operation determine whether coolant, lubricant, or both are needed.

The compatibility of the fluid with the machine and environment is important to prevent corrosion or hazards.

The cost and ease of disposal should also be considered to ensure economical use.

8. (a) A 30 mm diameter bar is being turned at 400 r.p.m. with a feed of 0.15 mm/rev. Calculate the metal removal rate (MRR) in mm^3/min, assuming a depth of cut of 2 mm.

$MRR = \pi \times D \times d \times f \times N$

= 3.14 × 30 × 2 × 0.15 × 400

= 11,304 mm^3/min

8. (b) Calculate the feed per tooth in mm/tooth if a 12 tooth milling cutter is running at 100 r.p.m. and the table feed rate is set to 180 mm/min.

Feed per tooth = Feed rate / (N × Z)

= 180 / (100 × 12)

= 0.15 mm/tooth

8. (c) Calculate the rotational speed (N) in r.p.m. required to machine a 50 mm diameter bar with a cutting speed of 150 m/min. (Take π = 3.14).

N = (1000 × V) / (π × D)

= (1000 × 150) / (3.14 × 50)

= 954 r.p.m.