OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

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B.E. DEGREE (ELECTRICAL)

ME4002 - PRODUCTION ENGINEERING

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Answer **three** questions from **EACH** section

Approved calculators are permitted

TIME ALLOWED
3 hours

SECTION A: MATERIALS PROCESSING & DESIGN FOR MANUFACTURE

1. (a) A valve control wheel consists of a central cylindrical hub, four cylindrical spokes and an annular rim, as shown below in Figure 1. The wheel is to be cast from a eutectic alloy. Using Chvorinov's modulus technique, determine the solidification sequence of the wheel. All dimensions are in cm.

   (b) An engineer has suggested that by reducing the thickness of the annular rim from 5 cm to 3 cm will enable the wheel to be cast using a single feeder located at point *A* on the hub. Show that this is not possible, stating clearly the criteria for one primitive to feed another.

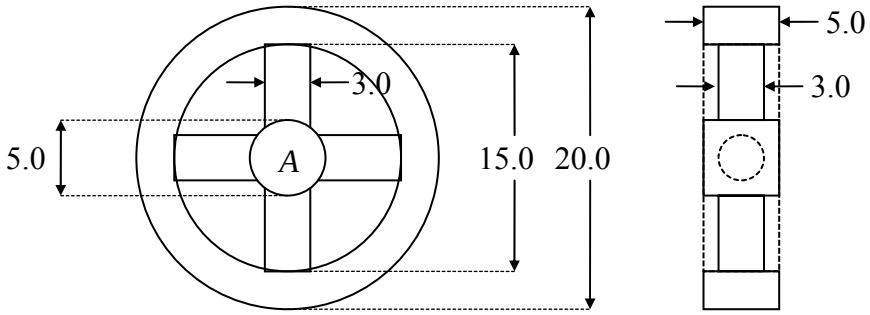

Figure 1: Valve control wheel for Question 1

2. The component shown below in Figure 2 is to be manufactured in a high shrinkage polymer by injection moulding. Criticise the design and suggest improvements. All dimensions are in mm. (Diagrams not to scale)

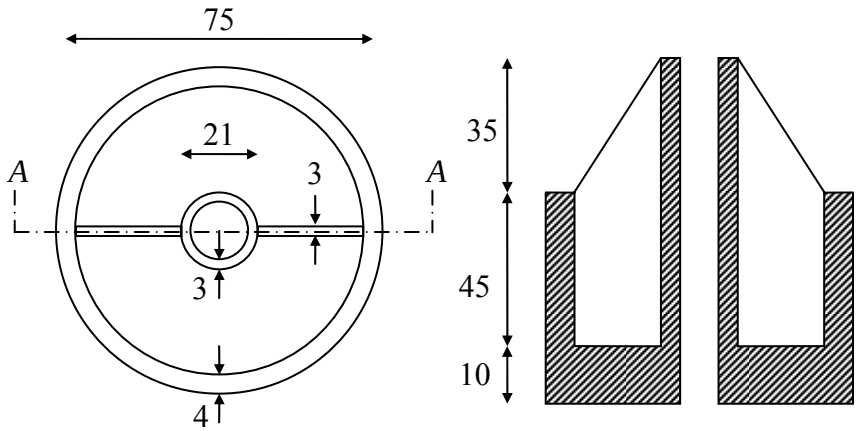

Figure 2: Component for Question 2

3. (a) Explain in detail what is meant by springback in sheet metal forming operations, and describe three ways in which it may be eliminated.

   (b) Describe in detail the deep drawing process, using diagrams where appropriate. Explain the causes of wrinkling, fracture and earing defects in deep drawing, and describe measures that can be taken to prevent them.

4. The component shown below in Figure 3 is to be constructed from 5 pieces of mild steel. The overall length of the component is 0·5 m, all other dimensions may be estimated. Discuss the suitability of the component for manufacture by (a) manual arc welding, and (b) adhesive bonding.

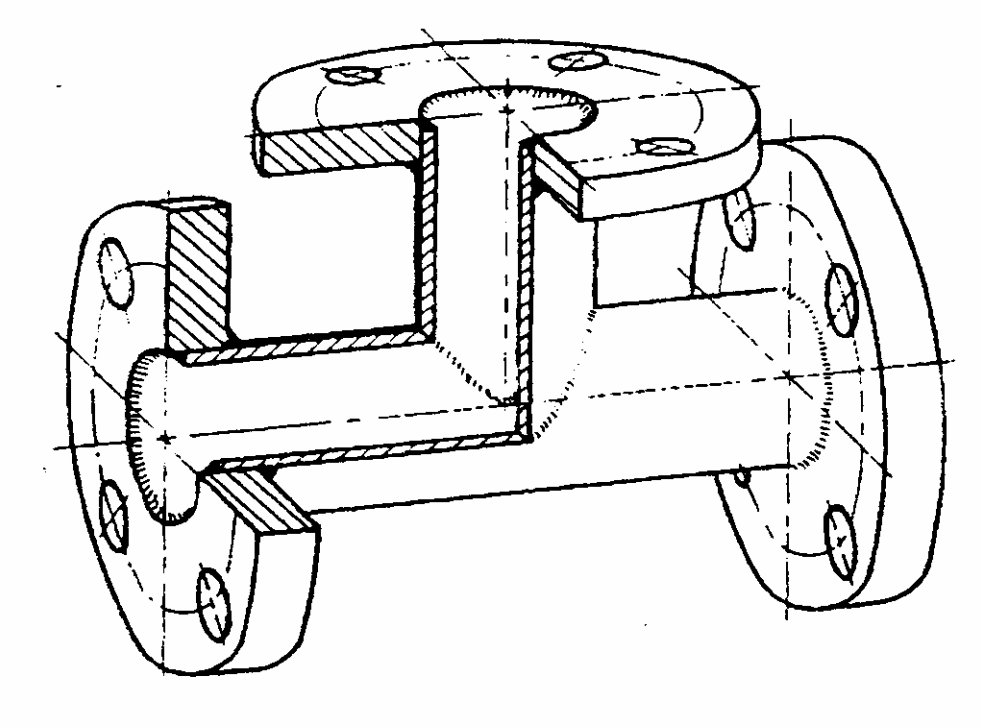

Figure 3: Component assembly for Question 4

SECTION B: NON-DESTRUCTIVE TESTING

5. (a) Describe the four main scattering mechanisms which may occur as X-rays or γ-rays pass through a material. Explain how the scattered radiation may degrade the quality of a radiographic image, and hence define the term "build up factor".

   (b) Describe in detail the principles of operation of TWO of the following, using diagrams where appropriate:

   (i) X-ray tube

   (ii) Image intensifier tube

   (iii) Microchannel plate

6. Outline the basic principles and methods involved in non-destructive testing (NDT) of engineering materials by magnetisation. Describe an application in which such magnetic methods of NDT could be used, with reference to the following considerations:

   - the advantages and disadvantages of using magnetic methods as compared with other NDT techniques;
   - the nature and type of defects that the test could be expected to reveal;
   - ways of improving the sensitivity of the technique.

7. A chemical engineering company proposes to use large cylindrical aluminium reaction vessels for a mildly corrosive, high temperature, high pressure process. Safety considerations will force the company to inspect the vessels periodically using non-destructive testing procedures to monitor the presence of any flaws. Inspection can be carried out while the vessels are not in service, but no direct access to the inner walls will be possible. Potentially hazardous types of flaw that could be generated are thought to include surface breaking cracks (on both exterior and interior surfaces), internal cracks with orientations ranging from radial to transverse (i.e. perpendicular and parallel to the surface respectively), extended regions of micro-porosity, and localised thinning of the vessel walls over areas greater than a few cm^2. Defects with sizes down to 1 mm should be detectable, as should any reduction in wall thickness of more than 5 mm. The nominal wall thickness of the reaction vessel is 30 mm.

   Outline suitable methodology based on ultrasonic NDT techniques for carrying out the required inspection. By using appropriate numerical data as the basis for quantitative reasoning, specify the type of probe(s), the operating frequency or frequencies, the mode(s) of wave propagation and the wave incidence angle(s) to be used. Sketch diagrams showing possible probe geometries for each of the flaws mentioned, and give diagrams showing the expected idealised received signals that would characterise the flaw in each case.

8. For each NDT requirement given below, describe a suitable method of achieving the stated objective. Give a brief outline of the underlying theory and outline any precautions to be taken to ensure consistent, reproducible results. State any advantages or limitations of the particular methods chosen, supporting your answers with quantitative arguments wherever possible.

    (a) detecting surface cracks down to 1μm in length in silicon nitride ceramic discs.

    (b) monitoring delamination of composite panels, consisting of five layers of 1 mm thick polymer sheet, bonded together with adhesive.

    (c) measuring the variations in electrical conductivity of copper rod, produced in long lengths 1 cm in diameter, intended for carrying very high electrical currents.

(End)