EXAMINATION FOR THE ENGINEER’S CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINING (081905606)

12 June (X-Paper) 09h00-13h00

REQUIREMENTS: Graph paper
Pocket calculators may be used.

Candidates are allowed to use any notes, text or reference books during the examination.

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Total marks : 100
To pass : 50

INSTRUCTIONS:

All calculations are to be shown.
No credit will be given for calculations in which the steps cannot be clearly followed.

Candidates are expected to make reasonable assumptions where necessary and these, together with any formula used, must be clearly stated.

Answer QUESTION 1 and QUESTION 2 and any THREE other questions.

QUESTION 1 (Compulsory)

(a) With the aid of sketches, describe a system for a Koepk winders by which the end-of-wind protection is automatically adjusted after each trip.

(b) The following data refer to a multirope friction winder operating with two skips of equal mass:
Mass of each skip 10 t
Mass of attachments of each skip 2 t
Net payload 10 t
Mass per unit length of each head rope 3.6 kg/m
Number of head ropes 4
Mass per unit length of each tail rope 7.2 kg/m
Number of tail ropes 2
Depth of wind 550 m
Angle of contact of rope on driving sheave 200°
Coefficient of friction of rope on driving sheave 0.2
Frictional resistance on each side 3 kN
The effect of inertia of the deflecting sheaves may be neglected

(i) Determine the maximum acceleration of the loaded skip from the shaft bottom without the ropes slipping over the sheave.

(ii) Assuming that the maximum duty occurs when the load is raised and that the static factor of safety of the ropes is to be 8, determine the minimum rope diameter suitable for this installation. The maximum breaking strength of the rope is 0.75 \( d^2 \) kN (\( d = \) diameter in mm).

\( \text{(15) } \)

\( \text{QUESTION 2 (Compulsory)} \)

\( \text{(a) On a twin-motor alternating current winder of which the motors share a common liquid controller, it was found on the first attempt, that the nearest the rotors can be coupled to the gearbox to be in phase, is half a tooth pitch of the Bibby coupling. The Bibby coupling has 80 teeth. Satisfactory load sharing can only be attained if the rotors are not more than 0.5° out-of-phase. } \)

Describe THREE normal facilities available to achieve the desired phasing.

\( \text{(b) An electricity supply company installed a generating plant of capacity 10 MW to supply a remote mine with electricity. } \)
The following data relate to the installation:

Capital cost of the installation R600/kW.

Annual running costs (fuel, maintenance, et cetera) R4 800 000.

Annual interest and depreciation plus other fixed charges are 16% of the capital cost.

The mine's maximum demand is 7 MW with a load factor of 0.4 and a power factor of 0.85.

Derive the TWO-PART TARIFF necessary to cover the basic costs of the supply company. (10)

QUESTION 3

(a) During a test on a hydraulic pump-and-motor-type transmission for an underground scooptram, the motor developed a shaft power of 10.75 kW with a constant torque of 120 Nm. The transmission efficiency was 80% and the other details were as follows:

Pump:

Overall efficiency = overall efficiency of motor
Leakage coefficient = leakage coefficient of motor
Leakage rate = 22 ml/s

Motor:

Capacity 50 ml/r
Mechanical efficiency 80%

Calculate:

(i) the speed of the motor
(ii) the pressure rise across the pump
(iii) the leakage coefficient for the motor and pump (ml/s) kPa
(iv) the overall efficiency of the motor
(v) the shaft power of the pump

(12)

(b) Calculate to the nearest mm, the diameter of an orifice plate to measure the flow of water at a rate of 100 l/s in a pipe with an internal diameter of 314 mm and a differential pressure across the orifice plate of 2 540 mm water.

The coefficient of discharge for the orifice plate is 0.7. (8)

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QUESTION 4

(a) The lower limit switches of an elevator failed and the car was stopped on the two buffer springs. The mass of the loaded elevator car is 1,135 t and its full speed is 1 m/s. The stiffness of the springs is 31 kN/m.

Calculate the maximum compression of the springs in this case and the maximum deceleration of the car.

(b) The residue pumps of a gold plant must pump 160 000 tons of residue per milling month. The moisture content of the pulp is 47 % by mass and density of the solids 2,7 t/m³.

Calculate:

(i) The volume of pulp in l/s.

(ii) The volume of water in l/s returned from the slimesdam if 80 % of the water in the pulp evaporates.

QUESTION 5

(a) Explain with the aid of a schematic diagram the principles of dynamic braking with compounding of excitation as applied to a mine winder driven by a three-phase wound rotor induction motor.

(b) (i) The following information refers to a multistage compressor with intercooling when installed new:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature of intake air</td>
<td>21 °C</td>
</tr>
<tr>
<td>Pressure at intake</td>
<td>85,5 kPa</td>
</tr>
<tr>
<td>Volume at intake</td>
<td>8,97 m³/s</td>
</tr>
<tr>
<td>Discharge pressure</td>
<td>690 kPa</td>
</tr>
<tr>
<td>Electric power at terminals</td>
<td>2,745 MW</td>
</tr>
<tr>
<td>Isothermal efficiency</td>
<td>0,662</td>
</tr>
</tbody>
</table>

Calculate the design efficiency of the combined motor and drive gearbox.

(ii) After some years of use it is suspected that the compressor efficiency has dropped and a performance test yields the following data:
Temperature of air at intake 13 °C
Pressure of air at intake 87.5 kPa
Discharge pressure of air 460 kPa
Discharge temperature of air 45 °C
Differential water gauge at orifice plate 1073 mm water
Orifice constant: 2540 mm water = flow rate of 14.9 kg/s
Electric power absorbed at terminals 2360 kW

Calculate the actual intake volume.

(iii) Calculate the saving in the costs per annum if the compressor is overhauled and restored to the original condition and isothermal efficiency. A reduction in the maximum demand of 1 kW results in an overall saving of the mine of R47,50/month. The intake pressure and intake temperature remain 87.5 kPa and 13 °C respectively.

QUESTION 6

(a) A multistage turbine pump is required to deliver clean water at a rate of 480 m³/h 600 m above sump water through a vertical pipe 150 mm in diameter. The friction factor for the pipe is 0.01.

Determine the actual head to be developed by the pump.

(b) The run-off water from a slimesdam is pumped from a large shallow pan to the evaporation ponds through a straight pipeline 2 km long and 225 mm inside diameter, followed by a 1 km and 175 mm inside diameter pipe. The Hazen-Williams friction coefficients are 140 and 120 respectively. The height of the ponds above the pan is 6 m. The pump runs at 900 r/min and has a performance curve as given below:

| Head (m) | 22 22 22 21.9 21.4 20.7 20 18.7 |
| Flow (L/s) | 0 10 20 30 40 50 60 70 |
| Efficiency (%) | 30 47 60 64 66 64 63 |

(i) Estimate the power consumption of the pump.

(ii) A second similar pump is connected in series with this pump to pump away the additional water during periods of high rainfall. Estimate the maximum speed of this pump given that it is limited by the 600 kPa rating of the pipeline.
(iii) Estimate the power drawn by each pump when operating together.

(iv) Estimate and comment on the increase in energy used per litre of water pumped when the second pump is used.

QUESTION 7

(a) Discuss the reasons for a low lagging power factor in a colliery electrical plant.

(b) A dangerous condition was identified on an overhead crane in a workshop. If the power supply is unexpectedly interrupted, the direct-current motor can under certain conditions run away. Under these circumstances it was decided to connect a resistance across the motor terminals to limit the speed of the motor to 600 r/min when the descending load exerts a torque of 274 Nm on the drum shaft.

Calculate the resistance required to achieve this speed control. The resistance of the motor is 1.2 ohms. Take the efficiency of the transmission to be 86%.

Points on the magnetisation curve at 600 r/min are as follows:

<table>
<thead>
<tr>
<th>Current (A)</th>
<th>42</th>
<th>43</th>
<th>44</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMF (V)</td>
<td>383</td>
<td>390</td>
<td>397</td>
<td>403</td>
</tr>
</tbody>
</table>

QUESTION 8

(a) Describe how you will implement a system of loss control on the mine shaft where you are responsible to reduce property damage and practise waste control.

(b) Describe in detail how you, as the responsible engineer and part of the management team, will deal with an emergency, in the event of a total power failure (national grid failure) which may last for an indefinite period on a deep mine in which 4 000 people work underground simultaneously. The shaft is equipped with a double-drum 1.3 MW Ward-Leonard man winder having a cyclic time of 9 min (that is at full speed and including loading time) and a single-drum 230 kW service winder having a cyclic time of 17 min (up and down trip including loading time). The double-drum winder and the single-drum winder are capable of conveying 70 and 14 persons per cage respectively. A mobile 700 kW diesel-driven generator set is available on the mine. The emergency ventilation fan, pumps and lighting require approximately 250 kW.
NOTE: An emergency second outlet is provided with a ring main feed supply as legally required but it suffered the same loss of power since it is also dependent on the national grid.

(c) You are requested to re-apply electric power to a coal face after a long workers' strike. During the strike water had built up in one section of the face and this has stopped the ventilation. Methane gas had accumulated but after the water had been pumped out and normal ventilation restored, most of the methane gas had been removed.

If you were the responsible engineer, having regard for the relevant statutory requirements and for the compliance with the accepted practice, explain the procedure you would follow to restore electric power to the machinery without placing complete reliance on the mobile-switch-unit/gate-end-box. Give details of the problems you would expect to find and explain how you would overcome these problems.