EXAMINATION FOR THE ENGINEER'S CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINING
(081905606)

10 June (X-Paper)
09:00 - 13:00

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 formulae used, must be clearly stated.

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

QUESTION 1 (COMPULSORY)

(a) An air receiver, in fair condition, 6 m long and 1,5 m in diameter is salvaged from a scrap yard. Make a preliminary calculation whether the vessel is suitable for a pressure of 1,8 MPa.

The material is 16 mm thick and has an ultimate tensile strength of 400 MPa converted from a Brinell hardness test number of 520 Bhn.

Motivate your choice of safety factor.
(b) A 50 kg/min reciprocating air compressor has four stages with a claimed isothermal efficiency of 0.85.

The pressures at each stage are in geometric progression, and there is perfect intercooling to the initial temperature of 40 °C.

The initial pressure is 100 kPa and its final pressure 8.11 MPa. (absolute)

Verify the claimed isothermal efficiency by calculation.

Take n = 1.35 : Cp = 1.005 kJ/kg.K

Mechanical efficiency = 96 %

QUESTION 2 (COMPULSORY)

(a) (i) What are the main factors which influence the rating of an electric motor?

(ii) The temperature rise of a continuously rated motor operating on full load is 49.72 °C after 1 hour and 60.81 °C after 2 hours.

Assuming an exponential law, calculate:

(aa) the time constant

(bb) the final steady full-load temperature rise

(b) A three-phase induction motor takes a constant input of 1,25 MVA at a power factor of 0.8 lag.

In order to reduce the kVA demand, it is proposed to install correction equipment to improve the power factor.

The annual cost per kVA demand is R110 and the capital cost of the correction equipment is R300 per kVVAR with an interest and depreciation of 12 % per annum.

Calculate -

(i) the most economical power factor and

(ii) the annual saving when correction is made to the economic limit
Answer any THREE questions from the following questions.

QUESTION 3

(a) Briefly discuss the influence of flue gas temperature and excess air on boiler efficiency. (3)

(b) (i) Sketch a boiler plant comprising an economiser, evaporator, superheater and air heater.

(ii) During the commissioning of a plant it was found that the plant efficiency is only 71% compared with the manufacturer's claimed efficiency of 80%.

The manufacturer also claimed the following designed heat transfer per kilogram coal:

Economiser 4,994 MJ/kg
Evaporator 1,837 MJ/kg
Super heater 830 kJ/kg
Air heater 2,715 MJ/kg

The following observations were recorded during operation:

Feedwater temperature entering the economiser = 44 °C
Feedwater temperature leaving the economiser = 175 °C

The air for combustion is heated from 15 °C to 150 °C

Steam pressure = 3 MPa

Dryness fraction of steam entering superheater = 0.98

Temperature of steam leaving superheater = 250 °C

Calorific value of coal = 31.8 MJ/kg

Steam produced per kg of coal = 8.6 kg

Air-fuel ratio 20:1.

Determine the cause of the low efficiency compared with the manufacturer's efficiency and explain possible remedial steps to be taken.
Specific heats at constant pressure are:

Air = 1,005 kJ/kg.K
Flue gas = 1,045 kJ/kg.K
Superheated steam = 2,157 kJ/kg.K

**QUESTION 4**

(a) Describe the process used to anneal rope attachments for winders or elevators.

Explain, in detail, how the process changes the structure and mechanical properties of the steel.

(b) Explain why a manganese-steel alloy is especially suitable for rope attachments and why heat treatment is not necessary.

(c) Describe the non-destructive tests to be performed on attachments exempted from heat treatment.

**QUESTION 5**

(i) For the purpose of a test, a 100 m length of conveyor structure is laid horizontally and equipped with belting having a mass of 15 kg/m. When this empty belting is driven at a speed of 2 m/s the power required at the driving drum is 5 kW.

Calculate the coefficient of idler friction.

(ii) The same type of structure is installed in a roadway and operates over a distance of 800 m on an adverse gradient of 1 in 7. The conveyor is required to carry 260 t/h when driven at the test speed.

Assuming a drivehead efficiency of 78 % calculate the capacity of the motor required to drive the installation.
QUESTION 6

A mono-rope conveyor system has a total length of 400 m between the tensioning pulley and the return pulley and is used to transport material to the working place.

The bundles of material have a mass of 100 kg and is transported to the top of a 5 in 1 incline, 410 m from the loading station. The bundles are conveyed at 20 m intervals at a velocity of 0.8 m/s.

The rolling resistance coefficient is 0.15 and the coefficient of friction between the driving wheel and rope is 0.065. The driving rope passes two turns round the driving wheel.

(a) Determine the:

(i) tight side tension of the rope
(ii) minimum slack side tension of the rope
(iii) minimum initial tension in the rope
(iv) power to drive the loaded rope

(b) Select a suitable rope for the installation stating the factor of safety.

(c) Sketch a typical tensioning arrangement for the system.

QUESTION 7

(a) A machine is driven by a DC motor:

(i) Explain, with the aid of suitable diagrams, how thyristors may be used to control the speed and direction change of rotation of the machine.

(ii) Explain how electrical braking is achieved with a thyristor type of control.

(b) The load cycle of a hoist motor is as follows:

An acceleration period of 15 s during which the power output is constant at 5 MW.

A constant speed period of 25 s during which the power output falls uniformly from 3 MW to 2 MW.

A braking period of 10 s during which the regenerated power falls uniformly from an initial value of 5 MW to zero.
An interval of 10 s before the commencement of the next cycle.

Determine the rating of the motor required. (State any assumptions made.)

**QUESTION 8**

(a) A clutch on a heavy machine must be converted from manual operation to an intrinsically safe hydraulic operation.

Sketch the hydraulic circuit using a double-acting cylinder and a four ports-two position solenoid control valve.

(b) The following observations were made during a test of a multi-stage centrifugal pump:

<table>
<thead>
<tr>
<th>Delivery rate (l/s)</th>
<th>40</th>
<th>80</th>
<th>120</th>
<th>160</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head (m)</td>
<td>615</td>
<td>590</td>
<td>550</td>
<td>490</td>
<td>415</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>60</td>
<td>81</td>
<td>84</td>
<td>73</td>
<td>50</td>
</tr>
</tbody>
</table>

The pump is connected to a vertical pipe 500 m long and 200 mm diameter which discharges to atmosphere. The pipe friction factor is 0.009.

(a) Determine the pump delivery rate, total head and pump shaft power required for this duty.

(b) Due to an increase in the make up of water two proposals are to be considered in an attempt to upgrade the system.

**Proposal 1**

Installing a second pipeline similar to the first and parallel to it, in such a way that the flow from the pump is equally divided between the two pipelines.

**Proposal 2**

Installing a second pump similar to the first such that it delivers into the original pipeline at a point close to the existing pump.

For proposal (1) and (2) determine the new flow rate, total head and pump shaft power required.
Neglect velocity head and take the density of water as 1 000 kg/m³.

QUESTION 9

(a) Give a workable definition of the term 'hazard' in a work-place environment.

(b) Write notes on the following:

(i) The effect of hazards on the work process
(ii) The control of hazards
(iii) The main causes of accidents

(c) Name FOUR fundamental activities required for successful accident prevention.