UNIVERSITI SAINS MALAYSIA

First Semester Examination
2010/2011 Academic Session

November 2010

IEK 308 – INDUSTRIAL WASTEWATER TREATMENT PLANT DESIGN
[REKABENTUK LOJI PENGOLAHAN AIR SISA INDUSTRI]

Duration: 2 hours
Masa: [2 jam]

Please check that this examination paper consists of NINE pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer FOUR questions. You may answer the questions either in Bahasa Malaysia or in English.

[Arahan: *Jawab EMPAT soalan. Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

PART A (ANSWER ALL QUESTIONS)

1. (a) An influent from a primary settling tank containing 225 mg/L of BOD_5 is to be treated aerobically in a complete mixed reactor without recycle. The essential bio-kinetic coefficients are as follows:

K_s = 60 mg/L
K = 5.0 d^{-1}
K_d = 0.05 d^{-1}
Y = 0.5

Given: $$\frac{1}{\theta_c} = \frac{YKS_0}{(K_s + S_0)} - K_d$$

(i) Calculate the minimum mean cell residence time (MCRT) of biomass in the reactor
(ii) Calculate the design MCRT of the primary settling tank (assuming the designed MCRT is three times of minimum MCRT)

(11 marks)

(b) Give brief explanations on:

(i) Suspended growth processes
(ii) Attached growth processes

(14 marks)

2. A conventional activated sludge process (ASP) is to be used for treatment of 10,000 m^3/d of municipal wastewater. The influent BOD_5 to the ASP is 160 mg/L. As per requirements, the effluent from the ASP should have soluble BOD_5 of not more than 10 mg/L.

Assumptions:

MLSS = 2,500 mg/l
Mean cell residence time = 10 d
Return sludge from SST = 8,000 mg/l
Yield coefficient = 0.8 kg/kg
Endogenous decay rate constant = 0.06 d^{-1}
Neglecting effluent biomass concentration

Given:

$$X\theta\left(1+k_d\theta_c\right)=\theta_c Y\left(S_0-S\right)$$

$$\theta_c Q_w X_r = VX$$

$$RQ_0\left(X_r - X\right)=Q_0\left(X - X_e\right)-Q_w\left(X_r - X_e\right)$$

$$Y_{obs}\left(1+K_d\theta_c\right)=Y$$

$$P_{x(VSS)}=Y_{obs}Q_0\left(S_0-S\right)$$

Calculate:

(i) the volume of aeration tank

(ii) the mass (in kg) and volume (in m^3) of sludge to be wasted per day

(iii) the recycle ratio

(iv) food-to-microorganism ratio

(25 marks)

3. (a) Give brief explanation on physical and chemical treatment of industrial wastewater.

(9 marks)

(b) An industrial wastewater treatment plant has a flow of 30,000 m^3/d. The detention times in rapid-mix and flocculation tanks are 40 s^{-1} and 30 min, respectively. The water temperature is 20^{o}C. Assume that the optimal velocity gradient for rapid mixing is 800 s^{-1} and for slow mixing is 40 s^{-1}.

Determine:

(i) Size of rapid-mix tank.
(ii) Power requirement for rapid mixing.
(iii) Size of flocculation tank.
(iv) Power requirement for slow mixing.

Given μ of water at 20^{o}C is 1.002 ×10^{-3} kg/m.s

and $G = \sqrt{\frac{P}{\mu V}}$

(16 marks)

PART B (ANSWER ONE QUESTION ONLY)

4. A rectangular settling tank needs to be designed to remove suspended flocculant particles from the average wastewater having a flow of 15000 m^3/day. A column test indicates that an overflow rate of 40 m/day will produce satisfactory removal of suspended floc at 3.5 m depth. Calculate the dimensions of this rectangular settling tank.

   Design criteria:
   L : W = 2.5 : 1
   10% added for the length of inlet and outlet zone
   Two channels, each of 6.25 m
   Thickness of dividing walls of 0.5 m provided in the tank
   0.3 m free board and 0.2 m for sludge zone
   Peak factor is 2.5

   (i) Calculate the total surface area of the tank
   (ii) Calculate the dimension of the tank
   (iii) Calculate the volume of the tank
   (iv) Calculate the HRT at average and peak flows

   (25 marks)

5. A hydraulically mixed flocculation basin is to be designed for a wastewater treatment plant that has a capacity of 26 MGD. The flocculator is to be of an around-the-bend baffled basin.

   Assume a water temperature of 50°F and the value of $\mu = 2.735\times10^{-5}$ lb.s/ft^2, $\gamma = 62.41$ lb/ft^3, a detention time is 30 min, wastewater velocity is 1.5 ft/s and velocity gradient is 40 s^{-1}.

   Determine:

   (i) The required head loss in the channeled basin.
   (ii) The required number of channels.
   (iii) The basin dimensions with the depth of 12 ft.

   Given G = $\sqrt{\gamma h_f /(\mu t)}$, $h_f = nKv^2/2g$, g = 32.2 ft/s^2
   Assume K = 2 and baffle thickness = 4 in
   1 gal = 7.48 ft^3

   (25 marks)

BAHAGIAN A (JAWAB SEMUA SOALAN)

1. (a) *Influen daripada tangki pemendakan primer yang mengandungi BOD_5 berkepekatan 225 mg/L akan diolah secara aerobik dalam reaktor campuran sempurna tanpa edar ulang. Pekali asas biokinetik diberikan seperti berikut:*

K_s = 60 mg/L
K = 5.0 hari^{-1}
K_d = 0.05 hari^{-1}
Y = 0.5

Diberi: $$\frac{1}{\theta_c} = \frac{YKS_0}{(K_s + S_0)} - K_d$$

(i) *Hitung masa tahanan sel purata minimum (MCRT) bagi biojisim dalam reaktor*
(ii) *Hitung MCRT yang direkabentuk untuk tangki pemendakan primer (anggapkan MCRT yang direkabentuk adalah tiga kali MCRT minimum)*

(11 markah)

(b) *Beri penerangan ringkas berkenaan*

(i) *proses pertumbuhan terampai*
(ii) *proses pertumbuhan lekatan*

(14 markah)

2. *Proses enapcemar teraktif konvensional (ASP) digunakan untuk mengolah airsisa perbandaran berkadar aliran 10, 000 m^3/hari. Influen yang mengalir masuk ke ASP mengandungi BOD_5 berkepekatan 160 mg/L. Effluen daripada ASP disyaratkan mengandungi BOD_5 terlarut tidak melebihi 10 mg/L.*

Anggapan:

MLSS = 2, 500 mg/L
Masa tahnan sel purata =10 hari
Pengembalian enapcemar daripada tangi pemendakan sekunder = 8, 000 mg/L
Pekali hasil = 0.8 kg/kg
Pemalar kadar pereputan endogenus = 0.06 hari^{-1}
Abaikan kepekatan biojisim effluen

Diberi:

$$X\theta\left(1+k_d\theta_c\right)=\theta_c Y\left(S_0-S\right)$$

$$\theta_c Q_w X_r = VX$$

$$RQ_0\left(X_r-X\right)=Q_0\left(X-X_e\right)-Q_w\left(X_r-X_e\right)$$

$$Y_{obs}\left(1+K_d\theta_c\right)=Y$$

$$P_x\left(VSS\right)=Y_{obs}Q_0\left(S_0-S\right)$$

Hitung:

(i) isipadu tangki pengudaraan
(ii) jisim (dalam kg) dan isipadu (dalam m^3) enapcemar yang perlu dilupuskan setiap hari
(iii) nisbah edar ulang
(iv) nisbah makanan kepada mikroorganisma

(25 markah)

3. (a) *Beri penerangan ringkas mengenai rawatan fizikal dan rawatan kimia bagi air sisa industri.*

(9 markah)

(b) *Satu loji rawatan air sisa industri mempunyai kadar aliran 30, 000 m^3/hari. Masa tahanan bagi tangki pengadukan cepat dan tangki pembukuan ialah $40s^{-1}$ dan 30 min masing-masing. Suhu air berada pada 20^oC. Anggapkan kecerunan halaju optimum bagiv tangki pengadukan cepat ialah $800s^{-1}$ dan tangki pengadukan perlahan ialah $40s^{-1}$.*

Tentukan

(i) *Saiz tangki pengadukan cepat*
(ii) *Keperluan kuasa bagi tangki pengadukan segera*
(iii) *Saiz tangki pembukuan*
(iv) *Keperluan kuasa bagi tangki pengadukan perlahan*

Diberi μ bagi air pada suhu 20^oC ialah 1.002×10^{-3} kg/m.s

dan $G = \sqrt{\frac{P}{\mu V}}$

(16 markah)

BAHAGIAN B (JAWAB SATU SOALAN SAHAJA)

4. *Sebuah tangki pemendakan bersegi empat tepat perlu direkabentuk bagi menyingkirkan partikel-partikel flok terampai daripada airsisa yang mempunyai aliran purata 15000 m^3/hari. Ujikaji turus menunjukkan bahawa kadar limpahan air sebanyak 40 m/hari akan menghasilkan penyingkiran flok terampai dengan sempurna pada kedalaman 3.5 m. Hitung dimensi tangki pemendakan tersebut.*

Kriteria rekabentuk:
L:W = 2.5 : 1
10% tambahan untuk panjang bagi zon kemasukan dan pengeluaran.
Tangki tersebut mempunyai dua saluran paip yang setiap satunya mempunyai lebar 6.25 m.
Dinding pemisah yang disediakan berketebalan 0.5 m.
0.3 m ruang bebas dan 0.2 m disediakan untuk zon enapcemar
Faktor puncak ialah 2.5.

(i) Hitung jumlah keluasan permukaan tangki
(ii) Hitung dimensi tangki
(iii) Hitung isipadu tangki
(iv) Hitung HRT ketika aliran purata dan aliran pucak

(25 markah)

5. *Satu besen pencampuran pembukuan hidraulik perlu direka bagi loji rawatan air sisa yang berkapasiti 26 MGD. Pembuku adalah daripada jenis besen berpenghadang bengkok.*

Anggapkan suhu air 50^oF dan nilai $\mu = 2.735\times10^{-5}$ lb.s/ft^2, $\gamma = 62.41$ lb/ft^3, masa tahanan 30 min, halaju air sisa 1.5 ft/s dan kecerunan halaju 40s^{-1}.

Tentukan:

(i) Kehilangan turus di dalam saluran besen .
(ii) Bilangan saluran yang diperlukan.
(iii) Dimensi besen jika kedalaman ditetapkan pada 12 ft.

Diberi $G=\sqrt{\gamma h_f /(\mu t)}$, $h_f = nKv^2/2g$, *g = 32.2 ft/s^2*

Anggapkan K = 2 dan ketebalan penghadang = 4 in
1 gal = 7.48 ft^3

(25 markah)

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