National Exams May 2009
04-Chem-B5
Pulp and Paper Technology

3 hour duration

Notes

1 If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made

2 Candidates may use one of two calculators, the Casio or Sharp approved models This is a CLOSED BOOK exam

3 Any 3 questions constitute a complete paper Only the first three questions as they appear in your answer book will be marked

4 All questions are of equal value Marks for question parts are indicated under each question

5 Most questions require an answer in essay format Clarity and organization of the answer are important

Question 1

Parts (a) – (e) are worth 5 marks each Part (f) is worth 10 marks

(a) Why is jack pine not a suitable species for making mechanical pulp for newsprint? Why is aspen not a suitable species for newsprint? Name a boreal forest species which is suited for newsprint

(b) Describe the construction of a pulp stone for the manufacture of groundwood pulp Give your understanding of the mechanism by which fibres are separated from the wood bole in a grinder

(c) Describe and distinguish among single-disk, double-disk, and twin-disk TMP refiners With simple sketches, indicate the locations of the refiner drives, the chip feeds to the refining zone and the pulp discharge

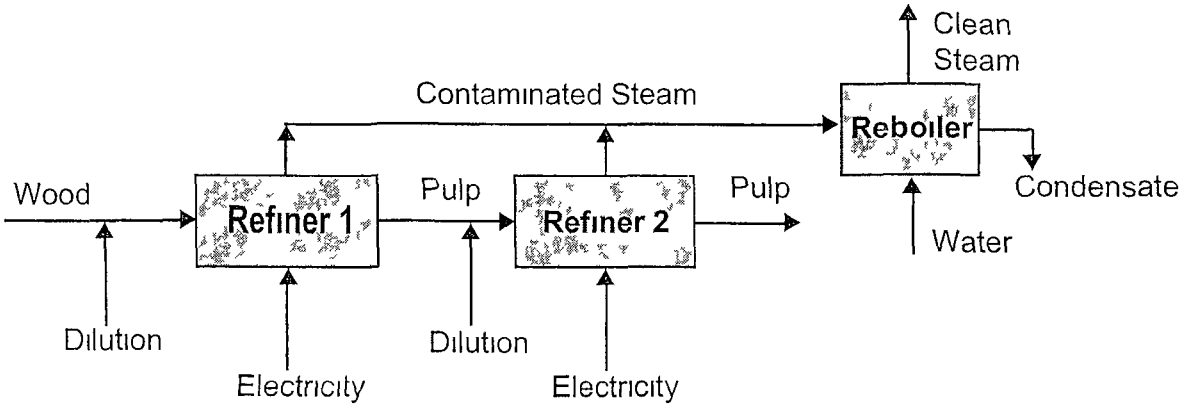
(d) What is fibre curl? Why is it important to decrease curl? Where in a TMP mill is this done?

(e) With the aid of a sketch show a typical configuration of primary and secondary screening in a TMP mill Also sketch a diagram depicting a typical pressure screen

(f) Below is a block diagram of TMP refining and heat recovery The refiners produce 300 oven dry (OD) metric tons per day of pulp at close to 100% yield The electrical energy used is 8 2 GJ/OD metric ton, distributed equally between the two refiners The wood enters the first refiner at 10°C and 40% moisture (on total wood) Dilution water at 70°C is added at each refiner to keep the discharge consistency at 45% The pressurized steam and pulp streams leaving each refiner are at 124°C Assume the enthalpy of steam is 2720 kJ/kg (0°C datum), and the heat capacity of water, wood and pulp are 4 18 kJ/kg/°C

i) Overall, how much contaminated steam is generated by the two refiners?

ii) How much clean steam at 115°C (enthalpy of 2680 kJ/kg) can be generated in the reboiler from 70°C water, from the contaminated steam condensing at 124°C?



Question 2

Parts (a) – (e) are worth 5 marks each Part (f) is worth 10 marks

(a) Give a broad classification for the chemical constituents of wood, giving approximate proportions for each component in a typical softwood How are these chemical constituents different in hardwood species?

(b) Describe how chips are moved from the chip bin to the top of a conventional Kamyr digester How are the chips and liquor brought to operating temperature in a Kamyr digester?

(c) What is tall oil? Where is it recovered in a kraft mill, and how is it produced?

(d) Provide a clearly labeled block diagram of the process of recausticizing, writing any chemical reactions that take place

(e) What are direct contact evaporators? What environmental problem do they pose? How can the liquor be treated to lessen the environmental impact? In modern mills, what alternatives are available to replace direct contact evaporation?

(f) A Kamyr digester produces 600 metric tons per day of kraft pulp The wood moisture is 40% on total wood mass The pulp yield on oven dry (O D) wood is 46% Calculate the required application of white liquor on wood in L/min for an application rate of 17 5% active alkali on O D wood The white liquor has an active alkali concentration of 98 g/L and its density is 1 1 g/mL Also calculate the individual chemical application rates, in kg/min of Na_2O, of NaOH, Na_2S, Na_2CO_3 and Na_2SO_4, given a white liquor sulphidity of 28%, a causticizing efficiency of 75%, and reduction of 93% (Na = 23 0, S = 32 0, O = 16 0, H = 1 01

Question 3

Parts (a) – (e) are worth 5 marks each Part (f) is worth 10 marks

(a) A bleach plant uses the sequence ODEopD for kraft pulp bleaching What do each of the letters refer to, in this sequence? What are typical conditions for the Eop stage in an ODEopD sequence, including temperature, consistency, pH and chemical application?

(b) What chemical tests are performed on bleached pulp to determine how well bleached it is, and how degraded it is? Give typical values for these measures that you would expect for unbleached and fully-bleached pulp

(c) Describe the drum washers used to wash pulp in a DEDED kraft bleach plant? By means of a sketch, show the wash water and filtrate flow configuration for jump stage washing

(d) Describe one technology in use today for oxygen delignification, giving typical conditions How much delignification can be reasonably accomplished in oxygen bleaching, and what limits delignification?

(e) Describe the processes of primary and secondary effluent treatment Describe generally how BOD, TSS, and toxicity testing is done How are these measures improved by primary and secondary treatment?

(f) A bankrupt pulp mill leaves an inventory of 170,000 L of 8 9 gpL chlorine dioxide solution

(i) How much kraft pulp could have been bleached with this solution in the mill DEDED sequence? To answer this question you must clearly state the total percentage of ClO_2 on pulp is typically needed in a D stages of an DEDED sequence, and estimate the metric tons of pulp accordingly

(ii) Now that the mill is bankrupt, the ClO_2 will have to be stabilized by converting it to sodium chlorite by the unbalanced reaction

$$ClO_2 + NaOH - \rightarrow NaClO_2 + NaClO_3 + H_2O$$

How much 50% sodium hydroxide (metric tons) must be used for this reaction?

(iii) What is the concentration (g/L) of $NaClO_2$ in the resulting solution?

(Na = 23 0, Cl = 35 5, O = 16 0, H = 1 01),

Question 4

Parts (a) – (e) are worth 5 marks each Part (f) is worth 10 marks

(a) Describe a twin wire former, and in particular the elements that promote dewatering What advantages do twin-wire formers offer over the traditional fourdrinier?

(b) What is a deaerator and where is it found in a papermill? What is its purpose and why is it needed?

(c) Describe a double-felted nip press Describe an extended-nip press How is dewatering promoted in each?

(d) Describe the dryer section of a paper machine What are the typical moisture contents of the paper entering and leaving the dryer section?

(e) Describe the paper strength tests of tearing resistance, tensile index and burst Give and explain factors relating to pulp quality that influence paper strength Give and explain factors relating to paper machine operation that influence paper strength

(f) A 5 5 m wide paper machine is running at 720 m/min making 80 g/m^2 paper at a jet-to-wire ratio of 1 03 using an air-padded headbox

(i) Estimate the total pressure required in the headbox in both meters of head and kPa

(ii) Estimate the slice flowrate in m^3/s for a slice thickness of 2 2 cm

(iii) If the fibre one-pass retention is 55%, what is the consistency in the headbox?