UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE *EXTRACTION METALLURGY*
SUBJECT	:	**PROCESS CONTROL III**
CODE	:	**MPE 32-1**
DATE	:	SUMMER EXAMINATION 2015 7 NOVEMBER 2015
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	85

EXAMINER	:	MK KALENGA	082013003
MODERATOR	:	LM OMARI	5142
NUMBER OF PAGES	:	4 PAGES AND 3 ANNEXURES	

INSTRUCTIONS	:	CALCULATORS ARE PERMITTED.
REQUIREMENTS	:	

INSTRUCTIONS TO STUDENTS

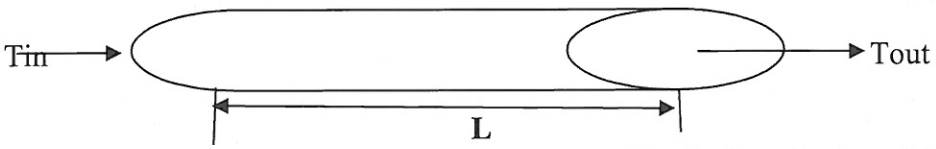
PLEASE ANSWER ALL THE QUESTIONS.
QUESTION PAPER TO BE HANDED IN WITH SCRIPT

QUESTION 1

Consider the flow of an incompressible, nonreacting gas through a pipe as per figure below, which is used to pre-heat a dolomite for calcination. If the pipe is completely thermally insulated and the heat generated by the friction of the flowing gas is negligible, it is said that it is to easy to see that at steady sate the temperature Tout of the outlet stream will be equal to that of the inlet, Tin. With the assumption that you have started at time t=0, the temperature of the inlet being shown in the graph below :

1.1 Discuss the change in the evolution between Tout and and the end of the pipe (10)

1.2 It is said that there might be a serious impact on the design of effective controllers due to time that it takes for the effect of the be sensed on the process. Discuss the statement based on a possible equation. (10)

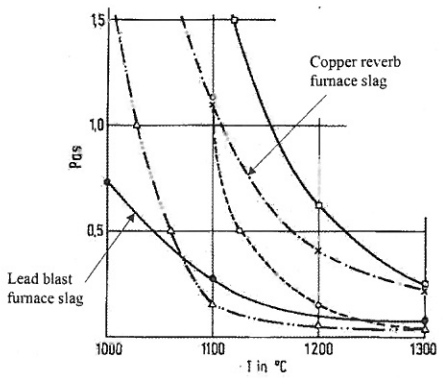


Assume that the cross-sectional area to be A and Uav is the velocity of the gas over the cross-sectional area of the pipe, assumed to be constant.

[20]

QUESTION 2

Measurements were taken to study the effect of temperature on the viscosity of slag. The strong effect of temperature on slag viscosity is illustrated in the following graphs:



Discuss extensively whether the above graphs would represent a mathematical model of copper reverberatory furnace slag and lead blast furnace slag. Please, be explicit.

[15]

QUESTION 3

Consider a binary mixture of components A and B, to be separated into two products streams using conventional distillation. The mixture is fed in the column as saturated liquid (meaning as its bubble point), onto the fray (see figure herewith annexed), with a molar flow rate (mol/ min) F_f and a molar fraction of component A, c_f. The overhead vapour stream is cooled and completely condensed, and then it flows into the reflux drum. The cooling of the overhead vapour is accomplished with cooling water. The liquid from the reflux drum partially pumped back in the column (top tray, N) with a molar flow rate F_R (reflux stream) and is partly removed as the distilled product with a molar flow rate F_D. If M_{RD} is the liquid holdup in the reflux drum and X_D the molar fraction component A in the liquid of the reflux drum. F_B and X_B are flow rate and molar fraction of A (of the product at the bottom).

Assumptions:

1. ***V is the volume and is constant for all trays***
2. ***Each tray is 100% efficient***
3. ***Neglect the vapour holdup for each tray***
4. ***The molar heats of vaporization of both components A and B are approximately equal meaning 1 mol of condensing vapour releases enough heat to vaporize 1 mol of liquid***
5. ***The heat loss from the column to the surroundings are assumed to be negligible and the relative volatility α of the two components remains constant throughout the column***

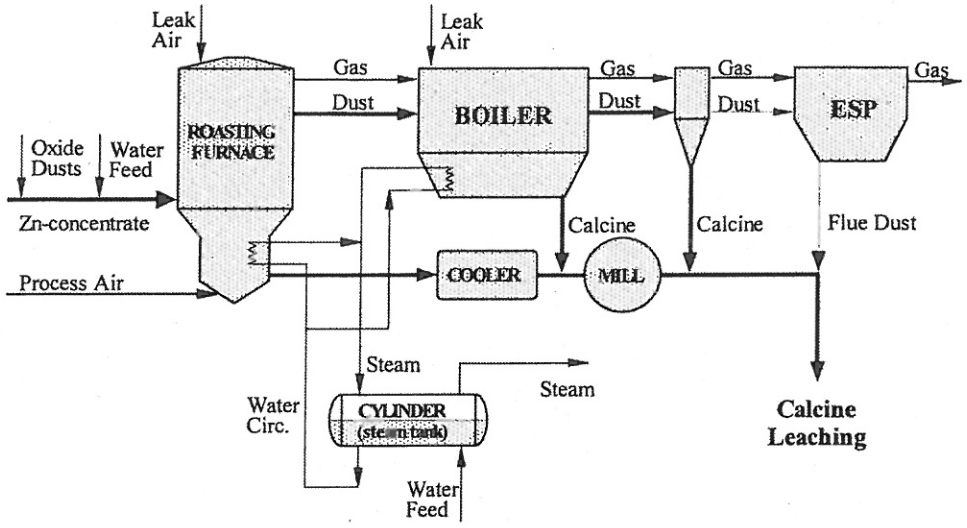
Develop (design) the mathematical model for the following:

3.1	free tray, component A	(6)
3.2	Top tray, component A	(6)
3.3	Bottom tray, component A	(6)
3.4	Reflux drum, component A	(6)
3.5	Column base, component A	(6)

[30]

QUESTION 4

The following sketch (taken from Lead-Zinc 2000) depicts gas cleaning equipment typically installed after sphalerite roasters in the zinc industry, where the SO_2-bearing gas is used for the production of sulphuric acid:



Design a specific configuration for each unit process and how efficient you think it is. Be specific by indicating what instrument reads what and at what level of the process

[20]

TOTAL MARKS 85

Laplace Transform Pairs

$f(t)$	$\bar{f}(s)$
$\sin(at)$	$\frac{a}{s^2+a^2}$
$\cos(at)$	$\frac{s}{s^2+a^2}$
$\frac{1-\cos(at)}{a^2}$	$\frac{1}{s(s^2+a^2)}$
$\frac{at-\sin(at)}{a^3}$	$\frac{1}{s^2(s^2+a^2)}$
$\frac{\sin(at)-at\cos(at)}{2a^3}$	$\frac{1}{(s^2+a^2)^2}$
$\frac{t\sin(at)}{2a}$	$\frac{s}{(s^2+a^2)^2}$
$\frac{\sin(at)+at\cos(at)}{2a}$	$\frac{s^2}{(s^2+a^2)^2}$
$\frac{\cos(at)-\cos(bt)}{b^2-a^2}$	$\frac{s}{(s^2+a^2)(s^2+b^2)}$
$\frac{1-\cos(at)-\frac{1}{2}at\sin(at)}{a^4}$	$\frac{1}{s(s^2+a^2)^2}$
$\frac{\frac{1}{a}\sin(at)-\frac{1}{b}\sin(bt)}{b^2-a^2}$	$\frac{1}{(s^2+a^2)(s^2+b^2)}$
$\sin(a+bt)$	$\frac{s\sin(a)+b\cos(a)}{s^2+b^2}$
$\cos(a+bt)$	$\frac{s\cos(a)-b\sin(a)}{s^2+b^2}$
$\sin(at)\sin(bt)$	$\frac{2abs}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$
$\cos(at)\cos(bt)$	$\frac{s\left(s^2+a^2+b^2\right)}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$
$\sin(at)\cos(bt)$	$\frac{a\left(s^2+a^2-b^2\right)}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$

Laplace Transform Pairs

$f(t)$	$\bar{f}(s)$
1	$\frac{1}{s}$
$t^n,\ n=0,1,2,\ldots$	$\frac{n!}{s^{n+1}}$
$t^v,\ v>1$	$\frac{\Gamma(v+1)}{s^{v+1}}$
$t^{n+1/2}$	$\left(\frac{\sqrt{\pi}}{2}\right)\left(\frac{3}{2}\right)\left(\frac{5}{2}\right)\cdots\left(\frac{n-1}{2}\right)\frac{1}{s^{n+1/2}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\frac{e^{-at}-e^{-bt}}{b-a}$	$\frac{1}{(s+a)(s+b)}$
$\frac{ae^{-at}-be^{-bt}}{b-a}$	$\frac{s}{(s+a)(s+b)}$
$\frac{e^{at}-1}{a}$	$\frac{1}{s(s-a)}$
$\frac{e^{at}-at-1}{a^2}$	$\frac{1}{s^2(s-a)}$
$\frac{e^{at}-\frac{1}{2}a^2t^2-at-1}{a^3}$	$\frac{1}{s^3(s-a)}$
$(1+at)e^{at}$	$\frac{s}{(s-a)^2}$
$\frac{1+(at-1)e^{at}}{a^2}$	$\frac{1}{s(s-a)^2}$
$\frac{2+at+(at-2)e^{at}}{a^3}$	$\frac{1}{s^2(s-a)^2}$
$t^ne^{at},\ n=0,1,2,\ldots$	$\frac{n!}{(s-a)^{n+1}}$
$\frac{\frac{1}{a}e^{at}-\frac{1}{b}e^{bt}+\frac{1}{b}-\frac{1}{a}}{a-b}$	$\frac{1}{s(s-a)(s-b)}$