Simulation of Steady State and Dynamic Response of Multi-effect Evaporators in Paper Industry

Deepak Kumar[1], Harendra Singhal[2], *Somesh Kumar[3]
1Department of Mathematics, GCET Greater Noida, U.P., India
2Department of Mathematics, NIET Greater Noida, U.P., India
3Department of Information Technology, NIET Greater Noida, U.P., India
dkriitr@gmail.com, singhalharendra@gmail.com , someshkumarrajput@rediff.com

Abstract: **In the present work, a dynamic model is developed for the Multi-effect evaporator (MEE) to study the transient behavior of the system. Each effect in the process is represented by some variables which are related to the energy and material balance equations for the feed, product and liquor flow. Backward feed is used for the development of the model for six effect evaporator system. For the steady state and dynamic simulation, the 'fsolve' and 'ODE45' solvers in MATLAB source code is used respectively.**

Keywords: **Multi-Effect Evaporator, backward feed, fsolve, ode45.**

I. INTRODUCTION

Some researchers have solved the mathematical models of MEE system of various process industries by using different solution techniques to obtain steady state simulation [3-20]. Some of them also have performed steady state simulation for MEE system of the paper industry [1], [2], [3], [9-11], [16-17], [20] & [29-34] by solving the models using numerical techniques. The dynamic behavior of two or three effect MEE systems in process industries like sugar, food, desalination and paper etc. is studied by few researchers [13] and [21-26]. Stefanov and Hoo [27] developed a distributed parameter model of black liquor falling film evaporator, based on first principles knowledge of fluid dynamics and heat transfer processes for evaporation side of the single plate (lamella) of a falling film evaporator. Stefanov and Hoo [28] further expanded a single plate model to develop a fundamental model of a falling film evaporator that accounted for the condensation side of the plate, the heating/flashing at the evaporator entrance, the evaporator inventory, mixing and recirculation flows but neglecting the effect of BPR.

In the present investigation, an attempt has been made for the study of dynamic responses for tubular type falling film MEE system. The lumped parameter model (System of ordinary differential equations) of sextuple effect falling film evaporator system of a paper industry is developed by using unsteady state energy and material balance equations and Physico-thermal properties of black liquor including the effect of boiling point rise for backward feed sequence. The transient behavior of the system is studied by disturbing the input parameters like feed flow rate, feed concentration, feed temperature and steam temperature. For the steady state and dynamic simulation 'fsolve' and 'ode45' solver in MATLAB source code is used respectively.

II. MATHEMATICAL MODELLING

The Mathematical modelling is carried out for sextuple effect falling film evaporator system with backward feed. In backward feed evaporator system, the steam input is given in the first effect and the feed liquor input is in the last effect as shown in the Fig. 1.

Model equations are developed for ith effect using material and energy balance equations as shown in [32]. The equations stating the physical properties of the black liquor are taken from [32]. It is assumed that the vapor generated by the process of concentration of black liquor is saturated. It is also assumed that the energy and mass accumulation in the vapor lump is very small as compared to the enthalpy of the steam and can be neglected.

Material balance for liquor in the i^{th} effect:

$$\frac{d}{dt} Ml_i(t) = Wl_{i+1} - Wl_i - Wv_i \tag{1}$$

Energy balance for liquor in the i^{th} effect: (2)

$$\frac{d}{dt}(Ml_i(t) * hl_i) = Wl_{i+1} hl_{i+1} - Wl_i hl_i - Wv_i hv_i + Wv_{i-1} hv_{i-1} - Wv_{i-1} hc_{i-1}$$

where

$$Wv_{i-1} = \frac{Q}{hv_{i-1} - hc_{i-1}}$$

where Q is the rate of heat transfer and also

$$Q = U_i A_i (Tv_{i+1} - Tv_i - BPR_i)$$

shell area of the evaporator and Li is the liquor level for i^{th}

*Author for correspondence

shell area of the evaporator and L_i is the liquor level for i^{th}

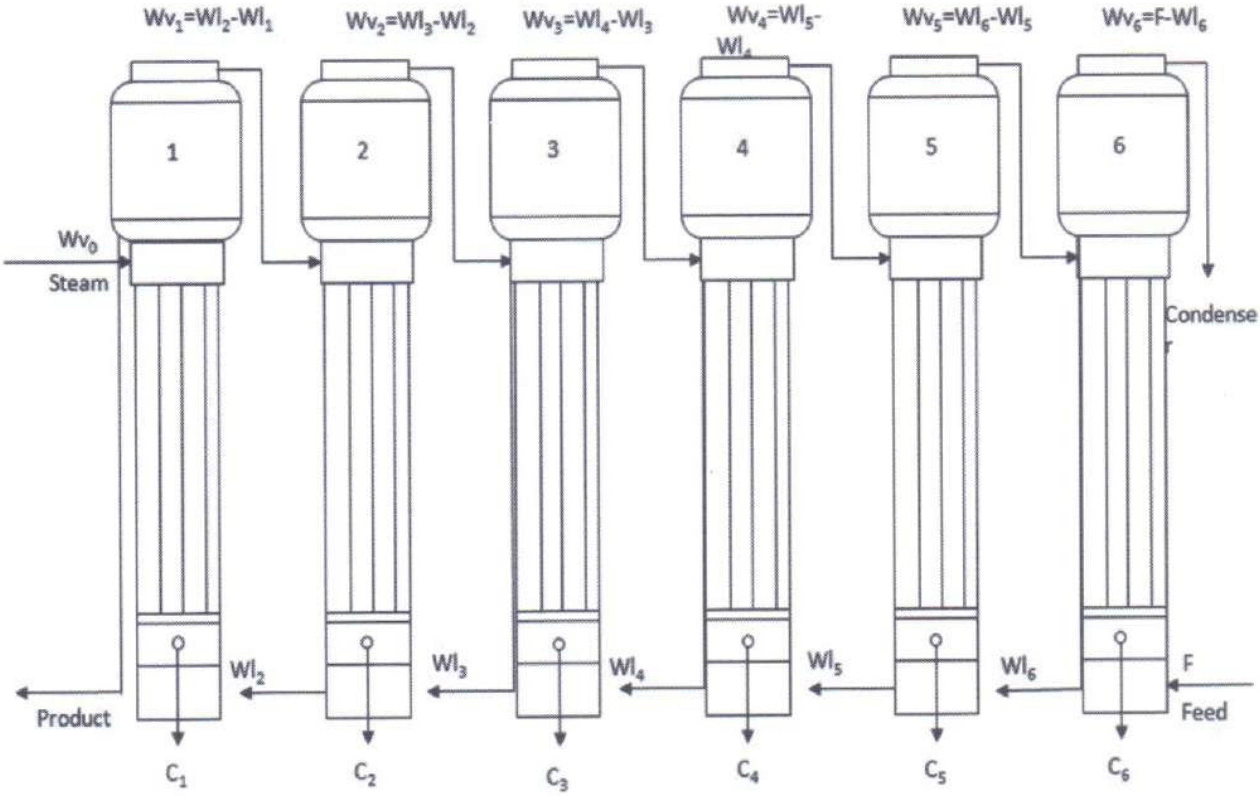


Fig. 1: Flow diagram of Sextuple Backward feed evaporator

Material balance for solids in ith effect:

$$\frac{d}{dt}(Ml_i(t) * X_i(t)) = Wl_{i+1}X_{i+1} - Wl_iX_i \tag{3}$$

The vapor and liquor in ith effect are in equilibrium and the relation for the liquor and vapor temperature is defined in terms of boiling point rise (BPR) is as follows:

$$Tl_i = Tv_i + BPR_i \tag{4}$$

where boiling point rise (BPR) is a function of temperature and solid concentration

Differentiating equation (4) with respect to time we get

$$\frac{d}{dt}Tl_i(t) = \left(\frac{d}{dt}Tv_i(t)\right)\left\{1 + \left(\frac{\partial}{\partial Tv}BPR_i\right)\right\} + \left(\frac{\partial}{\partial X}BPR_i\right)\left(\frac{\partial}{\partial t}X_i(t)\right) \tag{5}$$

Ml_i can be written as:

$$Ml_i = AL_i\rho_i \tag{6}$$

where ρi is the density of the liquor for ith effect, which is the function of temperature and solid concentration, A is the effect. Differentiating equation (6) with respect to time

$$\frac{d}{dt}Ml_i(t) = AL_i(t)\left(\frac{d}{dt}\rho_i\right) + A\rho_i\left(\frac{d}{dt}L_i(t)\right) \tag{7}$$

Since ρi is a function of temperature Tl and concentration X, this equation reduces to equation (8) by substituting of $\frac{d}{dt}Tl_i(t)$ from equation (5) and rearranging the terms.

$$\frac{d}{dt}Ml_i(t) = A\rho_i\left(\frac{d}{dt}L_i(t)\right) + AL_i(t)\left(\frac{d}{dTl}\rho_i\right)\left\{1 + \frac{\partial}{\partial Tv}BPR_i\right\}\left(\frac{d}{dt}Tv_i(t)\right) + AL_i(t)\left\{\left(\frac{\partial}{\partial t}\rho_i\right)\left(\frac{\partial}{\partial X}BPR_i\right) + \left(\frac{\partial}{\partial X}\rho_i\right)\right\}\left(\frac{d}{dt}X_i(t)\right) \tag{8}$$

Comparing the resultant differential equation (8) with equation (1) we get

$$C1 = C2\left(\frac{d}{dt}L_i(t)\right) + C3\left(\frac{d}{dt}Tv_i(t)\right) + C4\left(\frac{d}{dt}X_i(t)\right) \tag{9}$$

where

$$C1 = Wl_{i+1} - Wl_i - W_{vi}$$

$$C2 = A\rho_i$$

$$C3 = AL_i(t)\left(\frac{\partial}{\partial Tl}\rho_i\right)\left\{1 + \left(\frac{\partial}{\partial Tv}BPR_i\right)\right\}$$

$$C4 = AL_i(t)\left\{\left(\frac{\partial}{\partial Tl}\rho_i\right)\left(\frac{\partial}{\partial X}BPR_i\right) + \left(\frac{\partial}{\partial X}\rho_i\right)\right\}$$

Enthalpy is a function of temperature. Differentiating $Ml_i(t)*hl_i(t)$ with respect to time and substituting $\frac{d}{dt}Tl_i(t)$ from equation (5) and $\frac{d}{dt}Ml_i(t)$ from the equation (8)

$$\left(\frac{d}{dt}Ml_i(t)\right)hl_i + Ml_i(t)\left(\frac{d}{dt}hl_i\right) = A\rho_i hl_i\left(\frac{d}{dt}L_i(t)\right) + AL_i(t)\left(1+\frac{\partial}{\partial Tv}BPR_i\right)$$
$$\left\{\rho_i\left(\frac{\partial}{\partial Tl}hl_i\right)+\left(\frac{\partial}{\partial Tl}\rho_i\right)hl_i\right\}\left(\frac{d}{dt}Tv_i(t)\right) + AL_i(t)\left(\frac{d}{dt}Xi(t)\right)$$
$$\left\{\rho_i\left(\frac{\partial}{\partial Tl}hl_i\right)\left(\frac{\partial}{\partial X}BPR_i\right)+\rho_i\left(\frac{\partial}{\partial X}hl_i\right)+hl_i\left(\frac{\partial}{\partial Tl}\rho_i\right)\left(\frac{\partial}{\partial X}BPR_i\right)+\left(\frac{\partial}{\partial X}\rho_i\right)hl_i \tag{10}$$

Comparing the resultant differential equation (10) with equation (2) we get

$$C5 = C6\left(\frac{d}{dt}L_i(t)\right) + C7\left(\frac{d}{dt}Tv_i(t)\right) + C8\left(\frac{d}{dt}X_i(t)\right) \tag{11}$$

where

$$C5 = Wl_{i+1}hl_{i+1} - Wl_ihl_i - Wv_ihv_i + Wv_{i-1}hv_{i-1} - Wv_{i-1}hc_{i-}$$

$$C6 = A\rho_i hl_i$$

$$C7 = AL_i(t)\left(1+\frac{\partial}{\partial Tv}BPR_i\right)\left\{\rho_i\left(\frac{\partial}{\partial Tl}hl_i\right)+hl_i\left(\frac{\partial}{\partial Tl}\rho_i\right)\right\}$$

$$C8 = AL_i(t)\rho_i\left\{\left(\frac{\partial}{\partial Tl}hl_i\right)\left(\frac{\partial}{\partial X}BPE_i\right)+\left(\frac{\partial}{\partial X}hl_i\right)\right\} + AL_i(t)hl_i\left\{\left(\frac{\partial}{\partial Tl}\rho_i\right)\left(\frac{\partial}{\partial X}BPR_i\right)+\left(\frac{\partial}{\partial X}\rho_i\right)\right.$$

Finally differentiating $Ml_i(t)*X_i(t)$ with respect to time and substituting the value of $\frac{d}{dt}M_i(t)$ from equation (8) and rearranging the equation and representing it in the form of coefficients

where

$$C9 = C10\left(\frac{d}{dt}L_i(t)\right) + C11\left(\frac{d}{dt}Tv_i(t)\right) + C12\left(\frac{d}{dt}X_i(t)\right) \tag{12}$$

$$C9 = Wl_{i+1}X_{i-1} - Wl_iX_i$$

$$C10 = A\rho_iX_i$$

$$C11 = AL_iX_i\left(\frac{\partial}{\partial Tl}\rho_i\right)\left\{1+\left(\frac{\partial}{\partial Tv}BPR_i\right)\right\}$$

$$C12 = AL_i\left[\rho_i + X_i\left\{\left(\frac{\partial}{\partial Tl}\rho_i\right)\left(\frac{\partial}{\partial X}BPR_i\right)+\left(\frac{\partial}{\partial X}\rho_i\right)\right\}\right]$$

Thus the equations (9), (11) and (12) form a set of differential equations representing the liquor flow inside the evaporator and the solid content of the liquor for the ith effect. These final equations, represehts the dynamics of multi-effect evaporators, derived from basic energy and mass balance equations and using various terms related to physical properties of black liquor, water and steam like density and specific heat of the liquor, boiling point rise (BPR), enthalpy of water and saturated steam. Further equations are applied to all the six effects for i = 1, 2, 3, 4, 5 and 6.

III. STEADY STATE SIMULATION

For obtaining the steady state solution of the sextuple effect evaporator system there is a need to solve the system of nonlinear simultaneous equations given by (9), (11) and (12) under steady state conditions. The detailed study of steady-state simulation is given in our earlier work Kumar et al. [31].

33

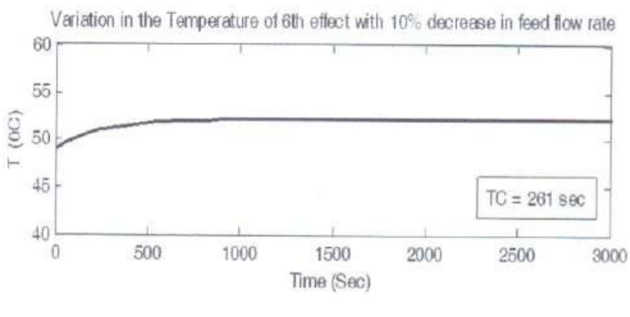
IV. DYNAMIC SIMULATION

For the dynamic simulation first order nonlinear differential equations (8), (9) and (10) are solved simultaneously in the same order for all the six effects of the backward feed sextuple effect evaporator system. Steady-state solution of the model provides the initial values of the system variables at time, t = 0. The Solution of such types of simultaneous nonlinear ordinary differential equations is extremely intricate in nature even by using sophisticated numerical techniques. In the present investigation, an attempt has been made for dynamic simulation for tubular type falling film MEE system with split feed sequence by using 'ode45' solver in MATLAB source code respectively.

V. RESULTS AND DISCUSSION

A. Effect of varying feed flow rate

Since MEE system is in backward feed, hence the input liquor enters the evaporator system from the last effect. Thus for the variation in the feed flow rate the disturbance is applied in the last effect. The effect of ±10% step input in feed flow rate on the temperature and concentration of last (6^{th}) and first (1^{st}) effects are shown in the Fig. 3 to Fig. 4 respectively. The temperature and concentration of both the effects show an increase or decrease with decrease or increase in the feed flow rate. It is obvious as fresh steam supply rate is constant and water to evaporate and decreases per unit time. The Time constant (TC) for each plot is obtained and shown in the plot. TC indicates that response time for temperature change is much less than that of concentration change. Also, the steady state in 6th effect is achieved at a faster rate than the 1st effect. This is noticeable as in backward feed sequence; feed enters first in the 6th effect, so the disturbance dampened out in the 6th effect at the faster rate.



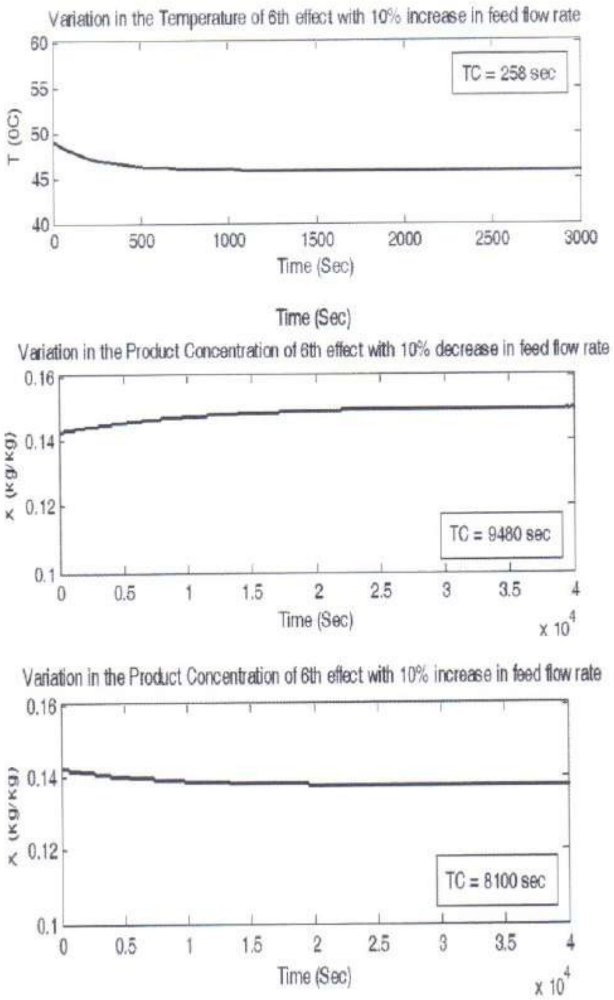
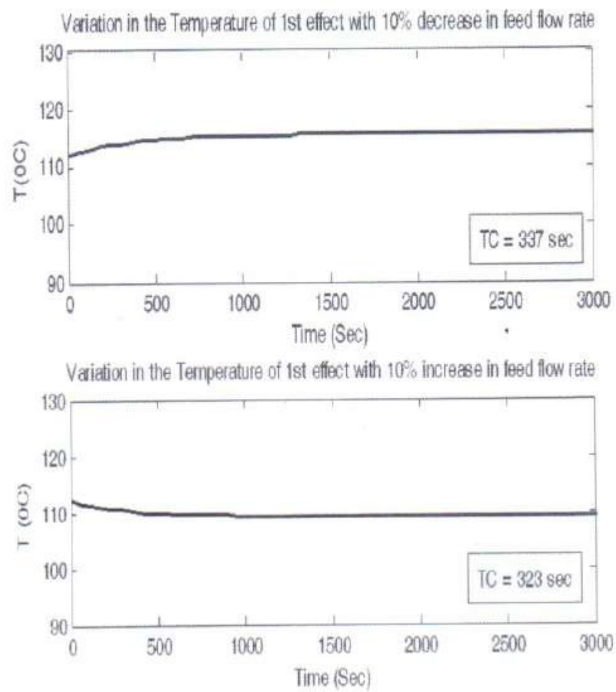


Figure 3 Response of 6th effect by disturbing ± 10% in the feed flow rate



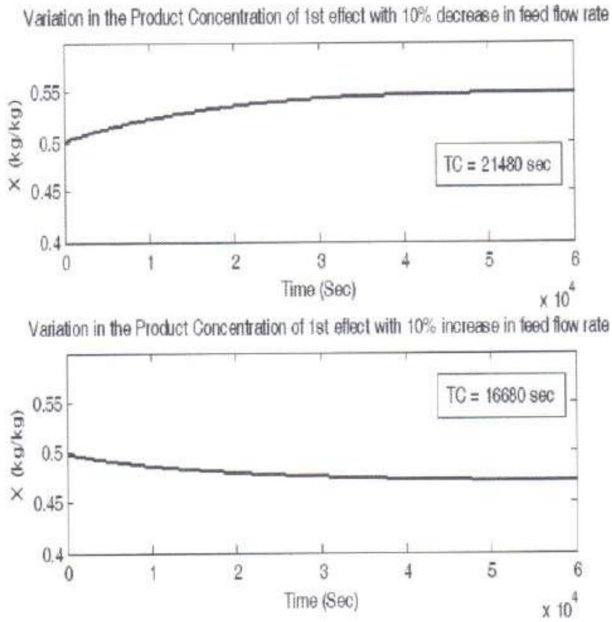
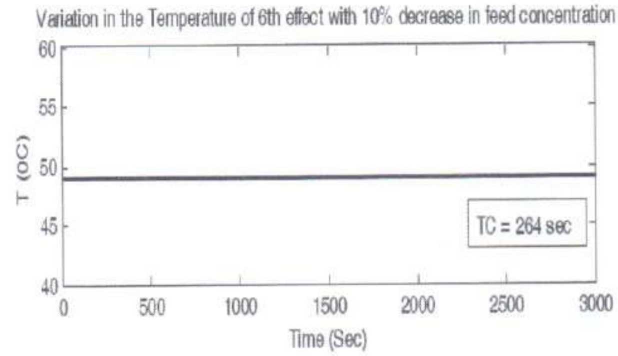


Figure 4. Response of 1st effect by disturbing ± 10% in the feed flow rate

B. Effect of varying feed concentration

For the variation in the feed concentration, the disturbance is applied in the last effect. The effect of ±10% step input in feed concentration on the temperature and concentration of last and the first effect are shown in the Fig. 5 to Fig. 6 respectively. The dynamic behavior of effect's temperature on disturbances in feed concentration shows a slight but insignificant change in temperature. However the change, it observed is unidirectional i.e. the temperature increases irrespective of increase or decrease in feed concentration. The changes in product concentration of both the effect show increase or decrease according to as the feed concentration is increase or decrease. This is because the fact that ΔT across the evaporator system remains constant and vapor-liquid equilibrium of each effect remains almost unchanged for the optimum performance. Time constant shown in the figures indicates that response time for temperature change is much less than that of concentration change. Since the feed is backward thus, the steady state in 6th effect is achieved at a faster rate than the 1st effect.



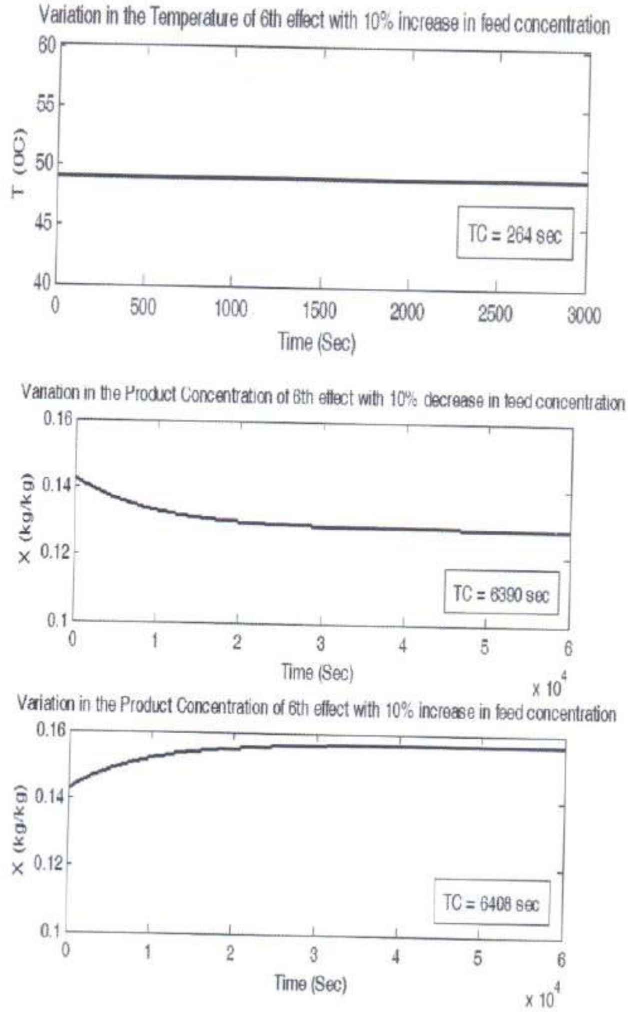
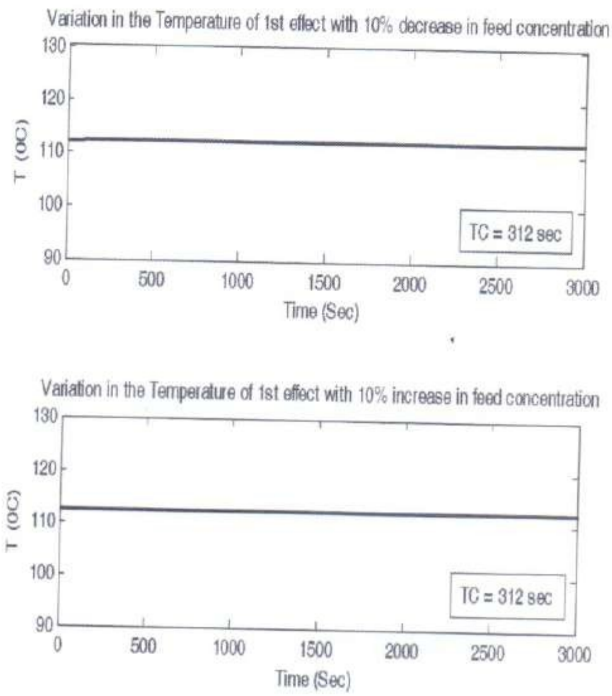


Figure 5. Response of 6th effect by disturbing ± 10% in the feed concentration



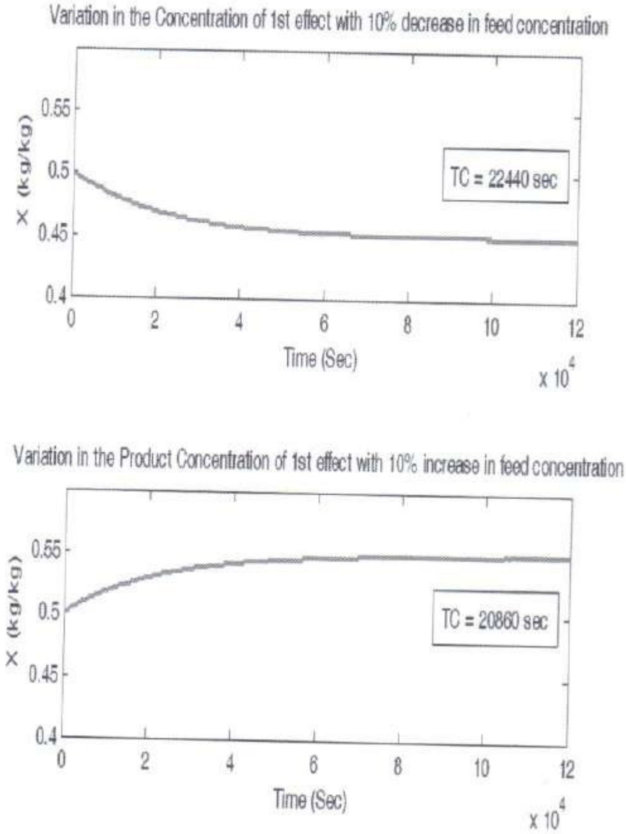
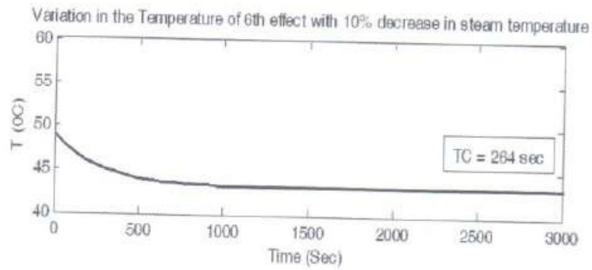


Figure 6. Response of 1st effect by disturbing ± 10% in the feed concentration

C. Effect of varying steam temperature

In backward feed MEE system, live steam enters in the first effect. Thus for the variation in the steam temperature, the disturbance is applied in the first effect. The effect of ±10% step input in steam temperature on the temperature and concentration of last and first effects are shown in the Fig. 7 to Fig. 8 respectively. The 10% change in steam temperature results in increase or decrease in the temperature of both the effects before obtaining the steady state for 10% increase or decrease respectively. 10% disturbance in steam temperature does not result in any noticeable change in the product concentration of both the effects. However after scaling down Y-axis value, it was observed that product concentration increase and then decrease or decrease and then increase for 10% increase or decrease in the steam temperature respectively.



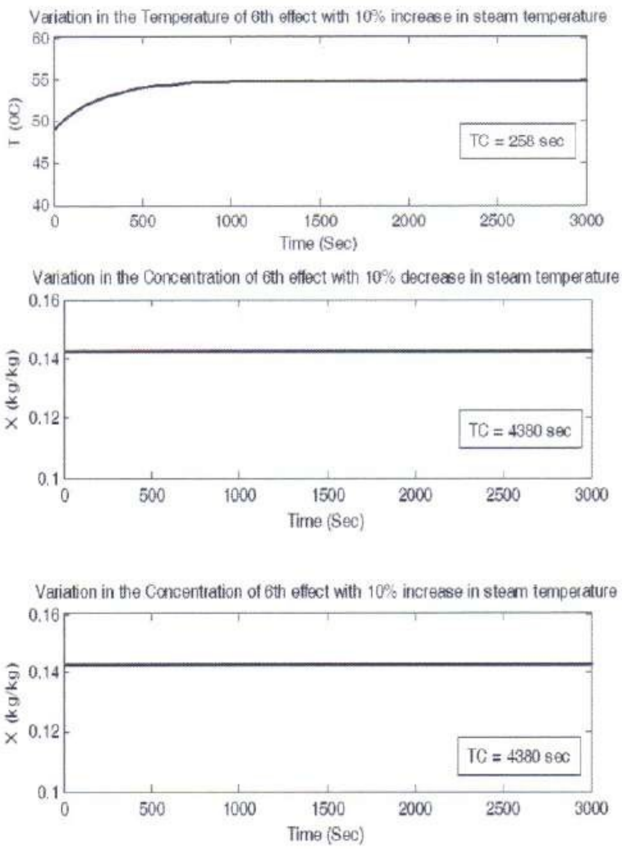


Figure7. Response of 6th effect by disturbing ± 10% in the steam temperature

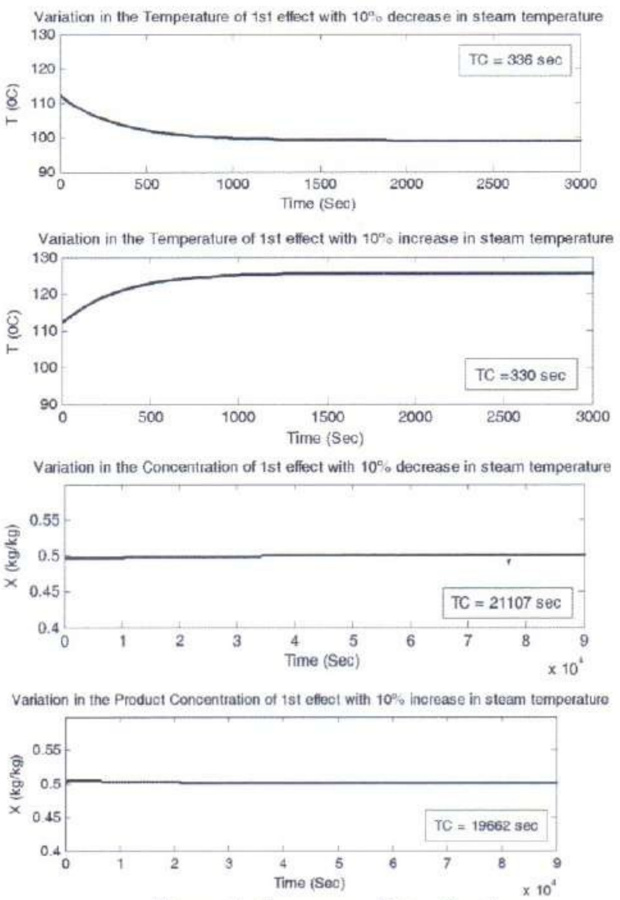


Figure 8. Response of 1st effect by disturbing ± 10% in the steam temperature

D. Effect of varying feed temperature

Since feed liquor enters in the last effect, thus for the dynamic response of the feed temperature the disturbance is applied in the last effect. The effect of ±10% step change in feed temperature on the temperature and concentration of last and the first effect are shown in the Fig. 9 to Fig. 10 respectively. It is evident from the figures that 10% disturbance in feed temperature does not bring noticeable change in the temperature and product concentration each effect. However after scale down Y-axis, it is observed that temperature of the both the effect increases and decreases to obtain the steady-state with an increase and decrease in feed temperature and the product concentration of each effect first decreases and then increases to obtain the steady state with a very small fluctuations about the steady-state up to four to five decimal places in the value of concentrations of both the effect and conversely for 10% increase in feed temperature.

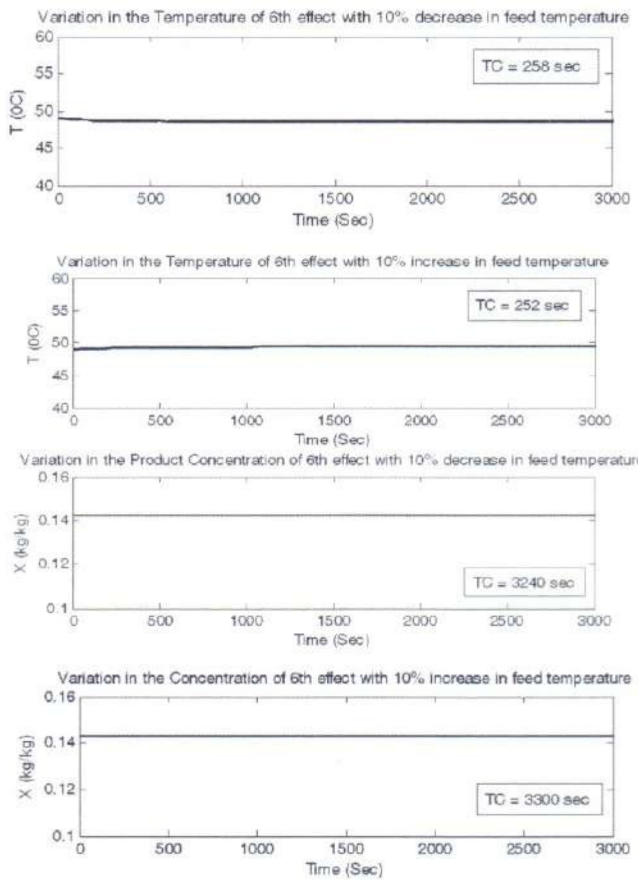
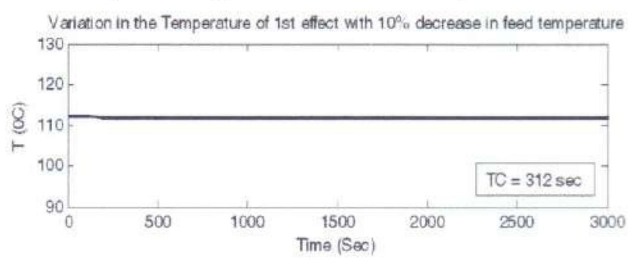


Figure 9. Response of 6th effect by disturbing ± 10% in the feed temperature



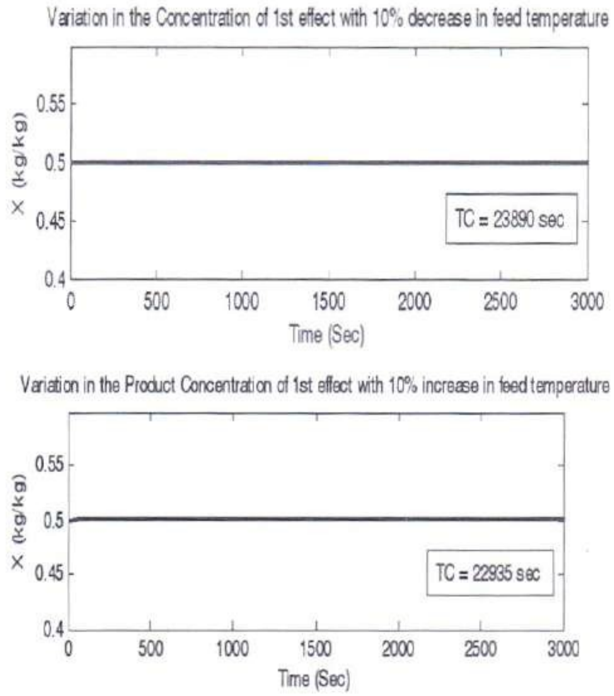


Figure 10. Response of 1st effect by disturbing ± 10% in the feed temperature

VI. CONCLUSION

Dynamic modeling is an useful tool in the determination of process variables in transient conditions. For designing an effective and efficient control system, it is always desirable to have a thorough knowledge of the system behavior in different conditions as well as detailed knowledge of variation in the process variables under transient condition. There is always a desire in the process industry for easier to use and more affordable advanced control technologies and products. Dynamic model helps us in better understanding of the process and behavior of its variables, thereby helps in determining a better control system. Thus in the present investigation, an unsteady-state lumped parameter models were developed for sextuple effect falling film evaporator for backward feed sequence for concentrating the black liquor by using material, energy balance equations and parametric correlations. For the steady state and dynamic simulation, the 'fsolve' and 'ode45' solvers.in MATLAB source code is used. The model is validated for the steady state solution using literature data. The dynamic behavior of each effect's temperature and product concentration was studied by disturbing the liquor flow rate, feed concentration, steam and feed temperatures by ±10%. The transient study shows that the steady state is reached more quickly for temperature in comparison of the solid concentration and all of the responses converge in a smooth fashion.

NOMENCLATURE

A	Shell area, m^2	U	Overall Heat Transfer Coefficient (OHTC), kJ/sec.m^2 °C
BPR	Boiling point rise, °C	W	Mass flow rate, kg/s
C	Constant	X	Solid content, %
Cp	Specific heat of water at constant pressure, kJ/kg	Λ	Latent heat of vaporization
h	Enthalpy, kJ/kg °C		**Subscripts**
L	Liquor level, m	C	Condensate
M	Mass, kg	L	Liquor
Pl	Liquor density	I	Effect number
t	Time, sec	V	Vapor
T	Temperature, °C		

REFERENCES

[1] Rao NJ, Kumar R (1985) Energy conservation approaches in a paper mill with special reference to the evaporator plant: Proceedings of the IPPTA international seminar conservation in pulp and paper industry, 58-70.

[2] Lambert RN, Joyo DD, Koko FW (1987) Design calculations for multiple-effect evaporators 1. Linear method. Industrial & Engineering Chemistry Research 26: 100-104.

[3] Ray AK, Rao NJ, Bansal MC, Mohanty B (1992) Design data and correlations of waste liquor/black liquor from pulp mills. IPPTA Journal 4:1-21.

[4] Hanbury WT (1995): Proceeding of IDA World Congress on Desalination and Water Sciences. Abu Dhabi, UAE, 4, 375.

[5] El-Dessouky HT, Alatiqi I, Bingulac S, Ettouney HM (1998) Steady-State Analysis of the Multiple Effect Evaporation Desalination Process. Chem. Eng. Technol. 21(5): 437-451.

[6] H.T.El-Dessouky, H.M.Ettouney, F.Mandani, Performance of parallel feed multiple effect evaporation system for seawater desalination, Applied Thermal Engineering, 20, (2000a), 1679-1706.

[7] El-Dessouky HT, Ettouney HM, Al-Juwayhel F (2000b) Multiple effect evaporation-vapor compression desalination processes. Transactions of IChemE, 78 (Part A): 662–676.

[8] Costa AOS, Enrique EL, (2002) Modeling of an industrial multiple effect evaporator system. In Proceedings of the 35th Congresso e Exposicao Anual de Celulose e Papel.

[9] Ray AK, Singh P (2000) Simulation of Multiple Effect Evaporator for black Liquor Concentration. IPPTA 12(3): 35-45.

[10]Ray AK, Sharma NK, Singh P (2004) Estimation of Energy Gains through Modelling and Simulation of Multiple Effect Evaporator System in a Paper Mill. IPPTA 16(2): 35-45.

[11]Ray AK, Sharma NK (2004) Simulation of Multi-Effect Evaporator for Paper Mill-Effect of Flash and Product Utilization for Mixed Feeds Sequences. IPPTA 16(4): 55-64.

[12]Agarwal VK, Alam MS, Gupta SC (2004) Mathematical model for existing multiple effect evaporator systems. Chemical Engineering World 39: 76-78.

[13]Miranda V, Simpson R (2005) Modelling and simulation of an industrial multiple effect evaporator: tomato concentrate. Journal of Food Engineering 66: 203–210.

[14]Karimi M, Jahanmiri A, Azarmi M (2007) Inferential cascade control of multi-effect falling-film evaporator. Food Control 18: 1036-1042.

[15]Kaya D, Sarac IH (2007) Mathematical modeling of multiple-effect evaporators and energy economy, Energy 32: 1536–1542.

[16]Bhargava R, Khanam S, Mohanty B, Ray AK (2008 a) Selection of optimal feed flow sequence for a multiple effect evaporator system. Computers and Chemical Engineering, 32: 2203-2216.

[17]Bhargava R, Khanam S, Mohanty B, Ray AK (2008 b) Simulation of flat falling film evaporator system for concentration of black liquor. Computers and Chemical Engineering, 32: 3213-3223.

[18]Khademi MH, Rahimpour MR, Jahanmiri Á (2009) Simulation and optimization of a six-effect evaporator in a desalination process. Chemical Engineering and Processing 48: 339–347.

[19]Johansson M, Vamling L, Olausson L (2009) Heat transfer in evaporating black liquor falling film. International Journal of Heat and Mass Transfer 52: 2759–2768.

[20]Khanam S, Mohanty B (2010) Energy reduction schemes for multiple effect evaporator systems. Applied Energy 87: 1102–1111.

[21]Andre H, Ritter RA (1968) Dynamic Response of a Double Effect Evaporator, Canadian Journal of Chemical Engineering 46: 259-264.

[22]Bolmstedt U (1977) Simulation of the steady-state and dynamic behavior of multiple effect evaporator plants, Part: 2 Dynamic Behavior, Computer-aided Design 9(1): 29-40.

[23]El-Nashar AM, Qamhiyeh A (1990) Simulation of the Performance of MES Evaporators under unsteady state operating conditions, Desalination 79: 65-83.

[24]Tonelli S, Romagnoli JA, Porras JA (1990) Computer package for transient analysis of industrial multiple effect evaporators. Journal of Food Engineering 12: 267-281.

[25]Narmine HA, Marwan MA (1997) Dynamic response of Multi-effect evaporators. Desalination 114: 189-196.

[26]Svandova Z, Kotora M, Markos J, Jelemensky L (2006) Dynamic behavior of a CSTR with reactive distillation. Chemical Engineering Journal 119: 113-120.

[27]Stefanov ZI, Hoo KA (2003) Distributed Parameter Model of black liquor falling-film evaporators. Part 1. Modeling of a single plate. Ind. Eng. Chem. Res.42: 1925-1937.

[28]Stefanov ZI, Hoo KA (2004) Distributed Parameter Model of Black Liquor Falling-Film Evaporators. 2. Modeling of a Multiple-Effect Evaporator Plant. Ind. Eng. Chem. Res. 43: 8117-8132.

[29]Gullichsen J, Fogelholm CJ (2000) Chemical Pulping, Paper Making Science and Technology a series of 19 books, 6B, B18-20.

[30]Dutta BK (2005) Heat Transfer Principles and Applications. Prentice Hall of India Pvt.Ltd, New Delhi.

[31]Kumar Deepak, Kumar Vivek, Singh, V. P.,(2010) "To study the parametric effect on optimality of various feeding sequences of a multi-effect evaporators in Paper industry using Mathematical modeling and simulation with MATLAB". World Academy of Science, Engineering and Technology, International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering 4(12): 743-749.

[32]Kumar Deepak, Kumar Vivek, Singh, V. P.,

"Modelling and dynamic simulation of mixed feed multi-effect evaporators in paper industry". Applied Mathematical Modelling, (Elsevier Publications), ISSN: 0307-904X, Vol. 37, 2013, pp. 384–397.

[33]Kumar Deepak, Kumar Vivek, Singh, V. P., (2012) "Dynamic response of split feed Multi-Effect Evaporators using Mathematical Modelling and Simulation". International Conference on Fluid Dynamics and Thermodynamics Technologies (FDTT 2012), IPCSIT vol. 33, IACSIT Press, Singapore, pp. 183-189.

[34]Kumar Deepak, Gupta Anjana Rani, Kumar Somesh,(2014) "Dynamic Simulation of Multiple effect evaporators in Paper Industry using MATLAB". NIET Journal of Engineering and Technology, 5: 8-14.

Deepak Kumar received his Doctorate degree in Applied Mathematics from Indian Institute of Technology, Roorkee in 2012. During 2006-2012, he stayed in Research during Ph.D. program and received Junior and senior research fellowships from Ministry of Human Resource Development, Govt. of India. Author published many research papers in International Journal of repute. He has 14 years of teaching experience. Currently, He is associated with GCET as an Associate Professor in Mathematics Department.

Harendra Singhal received his M.Phil degree in Mathematics from Aligarh Muslim University in 2001. He has around 15 years of teaching experience. Currently, He is associated with NIET as an Assistant Professor in Mathematics Department.

Somesh Kumar received his M.C.A degree from MJP Rohilkhand University, Bareilly in 2000, and his M.E. and Ph.D. degrees from Dr. B. R. Ambedkar University, Agra in 2006 and 2011 receptively. Between 2000 and 2011, he served with the SGI and Apeejay Groups. Currently he is associated with NIET as professor & Head of IT department. He has published various research papers in Elsevier, Springer, Inderscience, etc.