## INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

## CANDIDATE'S DECLARATION

I hereby assure that the work presented in this report entitled "**Simulation of Extractive Divided Wall Distillation Column"** in partial fulfillment of the requirement for the award of the Degree of **Master of Technology**, submitted in the Department of Chemical Engineering of the Indian Institute of Technology Roorkee, Roorkee is an authentic record of my own work carried out during a period from June 2013 to June 2014 under the supervision of **Dr. Vineet Kumar**, Associate Professor, Department of Chemical Engineering, Indian Institute of Technology Roorkee, Roorkee, India.

I have not submitted the matter, embodied in this report for the award of any other degree.

**Date**

Place: IIT Roorkee **(RAMJI PATEL)**

## CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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# ABSTRACT

Distillation is widely used as a separation technique but it consumes more energy. Therefore it's necessary to find efficient design which will reduce energy consumption maintaining same desired purity. Many attempts have been made in this direction, Petlyuk proposed a promising, thermally integrated design which is highly energy efficient. Further, divided wall column (DWC) was introduced in which fully thermally coupled Petlyuk column configuration was implemented in one single column by providing single vertical wall dividing column into two parts. Out of these two parts, one works as pre or post fractionator, and other as main column. Thermodynamically both Petlyuk column and DWC are equivalent.

Divided wall column (DWC) finds many applications in the field of separation of liquid mixture, viz., separation of three or more component mixture, separation of azeotropic mixtures, extractive distillation, reactive distillation, etc. Examples of extractive distillation include separation of aromatic compounds, aqueous alcohol solutions, mixture of hydrocarbons, etc.

Amount of energy consumed is the major operating cost factor; therefore optimal design is obtained in terms of minimum energy consumption without compromising with the product quality. Design variables such as reflux ratio operating parameter such as feed temperature extracting agent flow rate and its temperature have significant effect on optimal design.

In the present study we designed and optimized extractive dividing wall distillation column for dehydration of bio-ethanol. We used RADFRAC model of ASPEN PLUS simulator and NRTL as property method.

In the study we found that for economical and efficient operation proper design of column is important, proper operating parameters like reflux ratio, total number of stages, operating pressure, are important similarly feed condition such as temperature and flow rate also important for economic and efficient operation. By selecting proper feed temperature of mixture to be separated, we can get desired purity with minimum or optimum expenses in terms of reboiler duty and condenser duty. As we have seen with increment in feed temperature recovery of pure ethanol increases but beyond certain value recovery continues to increase but quality decreases

continuously along with continuous increase in reboiler duty. Therefore we have to select optimum point at which we recover maximum ethanol with maximum purity.

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# NOMENCLATURE

$A_h$ = Total cross sectional area of all the holes on a tray, $m^2$

B= Bottom Product

DWC= Divided wall column.

$D_1$ = Distillate of prefractionator

$D_2$ = Distillate of main column.

F= feed flow rate.

H = Enthalpy of vapour KJ/mol.

h = Enthalpy of liquid KJ/mol.

$H_f$ = feed enthalpy.

HK= heavy key.

LK=light key.

$L_{1p}$= liquid flow rate leaving from 1st stage of prefractionator.

$L_{1m}$= liquid flow rate leaving from 1st stage of main column.

$L_{2p}$= liquid flow rate leaving from second stage of prefractionator.

$L_{2m}$= liquid flow rate leaving from second stage of main column.

$L_{Nm-1}$ = liquid flow rate from $N_{m-1}$ stage of main column.

$L_{Nm}$= liquid flow rate from the last divided stage of main column.

$L_{Np}$= liquid flow rate from the last divided stage of prefractionator.

$L_{Np-1}$ = liquid flow rate from stage $N_{p-1}$.

$l_{Np}$= liquid flow rate from the stage $N_p$.

MK = Middle boiling key component.

$N_t$ = first undivided stage of main column.

$N_m$ = last divided stage of main column.

$N_p$ = last divided stage of prefractionator.

$N_{m-1}$ = stage before last divided stage of main column ($N_m$).

$N_{p-1}$ = stage before last divided stage of prefractionator ($N_p$).

R1 = vapour split ratio.

$V_{2p}$ = vapour stream flow rate from second stage of prefractionator.

$V_{3p}$ = vapour stream flow rate from third stage of prefractionator.

$V_{2m}$ = vapour stream flow rate from second stage of main column.

$V_{3m}$ = vapour stream flow rate from third stage of main column.

$V_{Nm}$ = vapour stream flow rate from ($N_m$) stage (last divided) of main column.

$V_{Nt}$ = Vapour flow rate coming from $N_t$ stage.

$V_{Np}$ = Vapour flow rate coming from $N_p$ stage.

$V'_t$ = vapour flow rate from stage $N_t$ to prefractionator.

$V''_t$ = vapour flow rate from stage $N_t$ to main column