Cairo University

PREDICTIVE MODELING AND OPTIMIZATION FOR AN INDUSTRIAL COKER COMPLEX HYDROTREATING UNIT

By

Eslam Samir Elsbaaei Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Chemical Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

PREDICTIVE MODELING AND OPTIMIZATION FOR AN INDUSTRIAL COKER COMPLEX HYDROTREATING UNIT

By
Eslam Samir Elsbaaei Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Chemical Engineering

Under the Supervision of

Dr. Tamer Samir Mohamed Ahmed

Associate Professor of Chemical Engineering
Faculty of Engineering, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

PREDICTIVE MODELING AND OPTIMIZATION FOR AN INDUSTRIAL COKER COMPLEX HYDROTREATING UNIT

By
Eslam Samir Elsbaaei Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Chemical Engineering

Approved by the
Examining Committee

____
Assoc. Prof. Dr. Tamer Samir Mohamed Ahmed, Thesis Main Advisor

____
Prof. Dr. Mai Mohamed Kamal Eldeen Elsayed, Internal Examiner

____
Eng. Ashraf Hassan Kamal Eldeen, External Examiner
(Department Manger Technical Study at Suez Oil Processing Company)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

Engineer's Name: Eslam Samir Elsbaaei Ali
Date of Birth: 13/ 7/ 1990
Nationality: Egyptian
E-mail: eslam.sbaaei@yahoo.com
Phone: 01004673871
Address: Suez, Faisal, Najd quarter, structure:84
Registration Date: 1/10/2014
Awarding Date: …./…./……..
Degree: Master of Science
Department: Chemical Engineering

Insert photo here

Supervisors:

Dr. Tamer Samir Mohamed Ahmed

Examiners:

Prof. Mai Mohamed Kamal Eldeen Elsayed (Internal examiner)
Eng. Ashraf Hassan Kamal Eldeen (External examiner)
(Department Manger Technical Study at Suez Oil Processing Company)
Dr. Tamer Samir Mohamed Ahmed (Thesis main advisor)

Title of Thesis:

Predictive Modeling and Optimization for an Industrial Coker Complex Hydrotreating Unit

Key Words:
Coker Complex; TBR Model; Hydrotreating Unit; Model Calibration; Process Optimization

Summary:

A process model for an industrial Coker Complex Hydrotreating process was developed using Aspen HYSYS Petroleum Refining Hydroprocessor Bed module. The model could track the plant performance competently. In addition, the model was utilized for investigating the effect of each process variable on the process performance. Among all process variables, feed boiling range and inlet temperature of the trickle bed reactor (TBR) were the most dominant factors to influence the process performance. Finally, the model was used for optimizing the process at steady state conditions. Results acquired from the model showed that a considerable increase in product yield with improved specifications could be achieved by adjusting the TBR feed boiling range to reach the IBP and FBP which the TBR is designed to treat, while lowering the hydrogen partial pressure inside the TBR to the lowest possible practical value and increasing the TBR inlet temperature to the equilibrium limit. The surplus in make-up gas may be diverted to fuel gas system, resulting in significant fuel savings. Applying the optimization scheme saves the plant consumption of energy as well as enhances the plant productivity of diesel fuel with better specifications. The model may also be integrated into a real time optimization scheme. In this situation, the model should be finely tuned to match the plant performance strictly.

Acknowledgments

Thanksgiving and praise to Allàh alone on the bounty and grace He helped me to finish this work.

And I acknowledge with appreciation the support, encouragement, suggestions and advices of Dr. Tamer Samir Ahmed.

Dedication

For my father and my mother

Table of Contents

List of Tables

List of Figures

Nomenclature

Θ	Number of active sites on catalyst surface
b_i	Adsorption coefficient of compound i
U_o	Overall heat transfer coefficient
Δt_{LMTD}	Log mean temperature difference (LMTD)
F_t	LMTD correction factor
y_n	Average composition of vapor leaving plate n
y_{n-1}	Average composition of vapor arriving from plate n
y^*_n	Theoretical composition of vapor that would be in equilibrium with liquid leaving plate n
ψ_i	Property of a petroleum fraction
θ_i	Known property of a petroleum fraction
w_i	Weighting factor of process variable i
X_i	Process variable i
μ_L	Viscosity of feed at average tower temperature in Centipoises
α	Relative volatility of key components at average tower temperature
H^o_{700}	Standard heat of reaction at 700 K in cal/mol
S^o_{700}	Standard entropy at 700 K in cal/mol.grd

Abbreviations

A	Surface area available for heat transfer
CCR	Conradson carbon residue
DEA	Diethanolamine
DMDS	Dimethyl disulfide
E	Efficiency
EOR	End of Run
FBP	Final boiling point
HA	Heavy aromatic compounds
HDA	Hydrodeasphaltenization
HDM	Hydrodemetallization
HDN	Hydrodenitrogenation
HDO	Hydrodeoxygenation
HDS	Hydrodesulfurization
HN	Heavy naphthenic compounds
HNA	Heavy naphthenic aromatic compounds
HNi	Heavy nitrogen compounds
HP	Heavy paraffinic compounds