Cairo University

A NEW PROCESS TECHNOLOGY FOR CAPTURING/CONVERTING CO_2 INTO LIQUID FUEL MEOH

By

Wafaa Mohamed Gomaa Mohamed

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

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Under the Supervision of

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Title of Thesis:

A New Process Technology for Capturing/Converting CO_2 into Liquid Fuel MEOH

Key Words:
Carbon Dioxide; Methanol; Simulation; Global Warming; Energy Integration.
Abstract:

This work throws the light on the environmental problems caused by carbon dioxide accumulation in the atmosphere, together with the energy crisis and the rapid depletion of the fossil fuels. Also, this effort proposes the solution for both problems by presenting new approach for capturing/converting CO_2 into liquid fuel methanol.

The new approach seeks to reduce both, the fossil consumption and atmospheric CO_2 by recycling secondary CO_2 as a carbon source instead of using natural gas. Three models are suggested for converting carbon dioxide present in the large- scale flue gases streams emitted from electric power plants into liquid fuel methanol. Our work considers the CO_2 balance for the new technologies proposed taking into account all CO_2 flows from/to the environment.

Three new process technologies are developed and modeled for converting CO_2 streams into methanol. The total cost of equipment and utility for all processes are compared. The energy targets as well as the CO_2 emissions (balance) are determined. Heat integration is performed on the best selected process technology.

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In the Name of Allah, the most merciful, the most compassionate all praise be to Allah, the Lord of the worlds; and prayers and peace be upon Mohamed His servant and messenger.

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Dedication

It is my genuine gratefulness and warmest regard that I dedicate this work to the soul of my lovely father, Hosny Gomaa. No words can ever express your kind heart, fatherly approach and support you provided me during my life. I was privileged and honored to be your daughter. I will never forget the support and encouragement you provided me with to go ahead with my studies; I promise I will always be at your expectations.

You showed me how a real leader can perform, no matter what, no matter how!! You educated me a lot, because of you I know a lot about the commitment, ethics, patient, struggle …etc. I can NOT even list all what you taught me my lovely papa. You inspired me to work no matter the challenges were, in spite of all stresses and endeavors. I am very lucky to be your daughter. Thanks for being a great leader, advisor and above all kindest, lovely father. I wish you would always be available when I try to call you. I do wish you all the happiness in paradise.

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Nomenclature

A_i: Kinetic model constant
ATR: Auto-Thermal Reformer
B_i: Kinetic model constant
CCS: CO_2 Capture & Storage
DEA: Di Ethanol Amine
GDP: Gross Domestic Product
GHG: Green House Gases
GTCC: Gas Turbine Combined Cycle
HEN: Heat Exchanger Networks
ICI: Imperial Chemical Industries
IEA: International Energy Agency
IGCC: Integrated Gasification Combined Cycle
IPCC: The Intergovernmental Panel on Climate Change
K_{eqi}: Thermodynamic equilibrium constant
k_i: Kinetic model constant
LTMS: Low Temperature Methanol Synthesis
MDEA: Methyl Di-Ethanol Amine
MEA: Mono Ethanol Amine
NG: Natural Gas
NHV: Net Heating Value, (kJ/kg)
P_i: Partial pressure of component i
PRSV EOS: Peng-Robinson-Stryjek-Vera Equation of State
PSA: Pressure-Swing Adsorption
r_i: Rate of reaction in relation to component i
T: Temperature
TSA: Temperature-Swing Adsorption
α: The ratio of the molar masses of carbon dioxide and carbon