



Cairo University

PROCESS DYNAMIC SIMULATION OF AN EXISTING
NATURAL GAS LIQUIDS AND LIQUEFIED PETROLEUM
GAS PRODUCTION PLANT

By

Mohamed Mohamed Azab 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

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

Process Dynamic Simulation of an Existing Natural Gas Liquids and Liquefied
Petroleum Gas Production Plant.

Key Words:

Process Engineering; Steady State Simulation; Dynamic Simulation; Process Transient
Response; Process Optimization

Summary:

The objective of this work is to demonstrate the importance of process simulation in the design and operation of the plants through assessing a case study based on an actual problem from an existing NGL plant. The problem is that the plant is shut down whenever it is necessary to switch the gas flow from the turbo expander unit to the bypass JT valve due to the absence of any information about the process transient response during this switch. This shutdown and restart up last for three days with an estimated cost of MM\$ 5.91 due to production loss. The steady state and dynamic simulation tools will be used to study the process transient behavior during the switch and check if the switch can be done while the plant is running without shutting it down. A comprehensive detailed steady state model for the whole plant was built using PRO/II[®] and a rigorous dynamic simulation model was built for the De-Ethanizer Unit using DYNASIM[™] simulation software. The results from the two process simulation models were analysed and it was found that the switch could be done without shutting down the plant.

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DEDICATION

I dedicate my thesis work to the brave heart of Mohamed Mohamed Azab, a strong mind and a fighting soul. I could not have accomplished this work without having you by my side. It was not an easy task but I only managed to finish it through your endless support. Sacrifices were made and prices were paid but we eventually made it.

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NOMENCLATURE

°C	Degree Celsius
°F	Degree Fahrenheit
ACFM	Actual Cubic Feet per Minute
ASTM	American Society For Testing and Materials
BCPD	Barrel Condensate Per Day
BPD	Barrel Per Day
BTU	British Thermal Unit
BWPD	Barrel Water Per Day
CPF	Central Processing Facility
CS	Chao Seader
CSU	Condensate Stabilization Unit
EPC	Engineering, Procurement and Construction
EW	El Wastani
EWP	El Wastani Plant
FCV	Flow Control Valve
IN	Input
JT	Joule Thomson
LCV	Level Control Valve
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
Ltd.	Limited
LTS	Low Temperature Separator
LV	Level Valve
MEG	Mono Ethylene Glycol
MMSCFD	Million Standard Cubic Feet per Day
MRU	Mechanical Refrigeration Unit
MV	Measured Variable
NGL	Natural Gas Liquids
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
O&G	Oil & Gas
OUT	Output
OVHD	Overhead
PCV	Pressure Control Valve
PFD	Process Flow Diagram
P&ID	Process & Instrumentation Diagram
PR	Peng Robinson

ppmv	Parts Per Million Volume
psia	Pounds Per Square Inch Absolute
psig	Pounds Per Square Inch Gauge
PSV	Pressure Safety Valve
PV	Process Variable
RVP	Reid Vapor Pressure
SCF	Standard Cubic Feet
Std	Standard
T66	Therminol 66
UOM	Units Of Measure
UOP	Universal Oil Products
USGPM	United States Gallon Per Minute
WASCO	El Wastani Petroleum Company
WWT	Waste Water Treatment

ABSTRACT

The objective of this research work is to demonstrate the power and importance of the process simulation in the design and operation of process plants. The research will show how the process steady state and dynamic simulation models can be used to design and optimize a case study from an existing NGL & LPG production plant. The case study is based on an actual problem in which the plant was designed and built based on process steady state simulation model only. The problem appeared when the operation team wanted to switch the gas flow from the turbo expander unit to the bypass JT valve. The operation team did not have any information about the dynamic response of the process in case this switch was done while the plant was operating. Accordingly it was decided to shut down the whole plant then start it up again using the bypass JT valve. This shutdown lasted for three days corresponding to a loss of production amounting to MMS\$ 5.91.

This work will utilize steady state and dynamic simulation software to study if the required switch could be done while the plant is running without the need to shut down the plant and hence saving the cost of the shutdown. A comprehensive detailed steady state model will be built using PRO/II[®] simulation software covering all the plant process units. The PRO/II[®] model shall be used to predict the operating steady state conditions of the plant under the turbo expander and JT valve modes of operation and ensure that these conditions would give the required product market specifications. The process units were analyzed to define the most critical unit under the JT mode of operation and it was found to be the De-Ethanizer Unit. Accordingly a rigorous process dynamic simulation model will be built for the De-Ethanizer Unit using DYNsIM[™] to study the performance of the unit under the new mode of operation.

The results from the PRO/II[®] steady state and DYNsIM[™] dynamic process simulation models were analyzed and the following main findings were obtained:

1. The operation switch from the turbo expander unit to the bypass JT valve can be done smoothly and safely without the need to shut down the plant. Accordingly the shutdown cost of MMS\$ 5.91 could have been saved.
2. The operation switch cannot be done while the unit control system is on Automatic mode. Specific switching procedures have to be followed to allow the process to reach the new steady state conditions safely and rapidly.
3. The gas production increased from 152 MMSCFD under the expander operation to 154 MMSCFD under the JT valve operation. This 1.3% increase in production flow rate is a result of the lower liquids recovery achieved in the JT valve mode of operation.
4. The LPG production decreased greatly from 2,832 Std BPD under the expander operation to 1,414 std BPD under the JT valve operation. This 50% reduction in production flow rate is a result of the changes in operating conditions in the Turbo Expander Unit (Area-17) as a result of switching the flow from the expander to the bypass JT valve.
5. The stabilized condensate production did not show any changes under the JT valve operation. This is because the main source of the stabilized condensate production is the raw condensate separated in the Three Phase

Production Separators Group which is then sent to the Condensate Stabilizer Unit directly.

6. The shift in the production slate during the JT valve operation resulted in reducing the products revenue from MM\$ 1.97/day under the turbo expander operation to MM\$ 1.83/day under the JT valve operation.

The models can be used to study and analyze other different operation and upset scenarios as desired to predict the process response towards these scenarios and hence enable proper decisions regarding process design and operation.