

**APPLICATIONS OF PINCH TECHNOLOGY
(HEAT EXCHANGER NETWORK DESIGN AND
PROCESS HEAT INTEGRATION)**



Mr. Manoch Limsukhon

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By : Mr. Manoch Limsukhon
Program : Petrochemical Technology
Thesis Advisors : Dr. Vivan Thammomgkol
Dr. Kitipat Siemanond
Mr. Nipon Kanongchaiyot

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K. Bunyakiat
..... College Director
(Assoc. Prof. Kunchana Bunyakiat)

Thesis Committee:

Kitipat Siemanond
.....
(Dr. Kitipat Siemanond)
Vivan Thammomgkol
.....
(Dr. Vivan Thammomgkol)
Nipon Kanongchaiyot
.....
(Mr. Nipon Kanongchaiyot)
Thirasak Rirksomboon
.....
(Assoc. Prof. Thirasak Rirksomboon)
Pramoch Rangsunvigit
.....
(Asst. Prof. Pramoch Rangsunvigit)

บทคัดย่อ

มาโนช ลิ้มปัฐคนธ์ : การประยุกต์ใช้เทคโนโลยีพินช์ (การออกแบบเครือข่ายแลกเปลี่ยนความร้อน และ การบูรณาการกระบวนการทางความร้อน) (Applications of Pinch Technology (Heat Exchanger Network Design and Process Heat Integration) อาจารย์ที่ปรึกษา: ดร.วิวรรณ ธรรมมงคล, ดร. กิติพัฒน์ สีมานนท์ และ นาย นิพนธ์ คนองชัยยศ 125 หน้า ISBN 974-17-2287-7

กระบวนการแยกก๊าซธรรมชาติเป็นหนึ่งในกระบวนการเย็นยิ่งยวด ค่าใช้จ่ายในการปฏิบัติการของกระบวนการจะเป็นค่าใช้จ่ายเนื่องจากสารทำความเย็นเป็นส่วนใหญ่ การประหยัดพลังงานเป็นสิ่งที่จำเป็นในการที่จะลดค่าใช้จ่ายในการปฏิบัติการ เทคโนโลยีพินช์ เป็นหนึ่งในวิธีการประหยัดพลังงาน เทคนิคนี้จะแสดงให้เห็นถึงแนวโน้มในการประหยัดพลังงานโดยการปรับปรุงกระบวนการ ในงานวิจัยนี้ได้มีการประยุกต์ใช้เทคโนโลยีพินช์กับโรงแยกก๊าซที่ 1 ของบริษัท ปตท. จำกัด มหาชน ในสองส่วนอันได้แก่การประหยัดพลังงานในหอกถันและการปรับปรุงเครือข่ายแลกเปลี่ยนความร้อน โดยได้ใช้โปรแกรม Aspen Plus และ Aspen Pinch จำลองกระบวนการแบบ design case ในงานวิจัยผลการศึกษาในเรื่องการประหยัดพลังงานในหอกถันพบว่าหอกถันทั้งสามหอกอันได้แก่ หอแยกมีเทน หอแยกอีเทน และ หอแยกโพรเพน มีการใช้พลังงานอย่างคุ้มค่าในกรณีของ design condition นอกจากนี้การศึกษาดังกล่าวถึงบูรณาการทางความร้อนระหว่างหอกถันแสดงให้เห็นว่า การปรับความดันเป็นวิธีหนึ่งที่สามารถใช้เพื่อให้เกิดการบูรณาการทางความร้อนระหว่างหอกถันแต่เนื่องจากข้อจำกัดของอุปกรณ์ทำให้ไม่สามารถดำเนินการได้ สำหรับการศึกษารอบการปรับปรุงเครือข่ายแลกเปลี่ยนความร้อนนั้น ค่าผลต่างอุณหภูมิที่น้อยที่สุด (ΔT_{min}) ควรจะถูกเลือกอย่างเหมาะสม ค่าผลต่างอุณหภูมิ 2 องศาเซลเซียสได้ถูกเลือกมาใช้ในการศึกษานี้ ผลการศึกษาพบว่า การปรับปรุงกระบวนการสามารถลดการใช้พลังงานจาก 12.18 เหลือเพียง 7.80 เมกกะวัตต์สำหรับสารหล่อเย็น ซึ่งคิดเป็นปริมาณค่าใช้จ่ายที่ประหยัดไปได้คือ 71,018.60 เหรียญสหรัฐต่อปี และค่าประสิทธิภาพทางเทอร์โมไดนามิกส์มีค่าเพิ่มขึ้นจาก 14.01 เป็น 15.91 เปอร์เซนต์

ABSTRACT

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Gas separation process is one of the cryogenic processes. The operating expenditures for this process are dominated by the refrigerant cost. To reduce the cost, the energy saving is needed. Pinch technology is one of the energy saving techniques. This technique provides the opportunities for energy saving by process modifications. In this research, two applications of pinch technology, distillation column targeting and heat exchanger network modifications, were applied to PTT gas separation plant unit I. The commercial simulation software; Aspen Plus and Aspen Pinch, were employed in this work. The result for distillation column targeting showed that all distillation columns; demethanizer, deethanizer, and depropanizer, were optimized at the design conditions. In the design case study of heat exchanger network modifications, the value of minimum temperature difference (ΔT_{\min}) should be selected appropriately. In this work, the value of 2 K was used. The results showed that the energy requirements were reduced from 12.18 to 7.80 MW for cold utilities, which corresponds to US\$ 71,018.60/yr of operating cost saving. Finally, thermodynamic efficiency of the process was improved from 14.01 to 15.91 %

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LIST OF SYMBOLS

CP	heat capacity flowrate
F	stream flowrate
C_p	stream specific heat capacity
ΔH	heat load of stream
T_t	stream target temperature
T_s	stream supply temperature
ΔT_{\min}	minimum temperature difference
$Q_{H\min}$	minimum hot utility requirement
$Q_{C\min}$	minimum cold utility requirement
GCC	Grand Composite Curve
N_{units}	minimum number of units in the network
N_h	number of hot streams
N_c	number of cold streams
N_u	number of utility streams
N_s	number of separate heat balanced systems
A_{network}	overall network area
ΔT_{LM}	log-mean temperature difference
h	film heat transfer coefficient
C_{network}	total cost of network
C_a	installation cost factors
C_b	pre-exponent cost factors
C_c	exponent cost factors
PDM	Pinch Design Method
$N_{\text{stream,in}}$	number of stream coming to pinch
$N_{\text{stream,out}}$	number of stream going out from pinch
CP_{in}	heat capacity flowrate of stream coming to pinch
CP_{out}	heat capacity flowrate of stream going out from pinch

CGCC	Column Grand Composite Curve
PNMTC	Practical Near Minimum Thermodynamics Condition
T-H diagram	Temperature-Enthalpy diagram
Stage-H diagram	Stage-Enthalpy diagram
GSP I	Gas Separation Plant I
Nu	Nusselt number
D_o	outside diameter of tube
D_i	inside diameter of tube
k	thermal conductivity of tube
ρ	fluid density
μ	fluid viscosity
CW	Cooling Water
MPS	Medium Pressure Steam
LPS	Low Pressure Steam
C	purchase cost
A	heat transfer area
ψ	stream thermal exergy
h	specific enthalpy at T, P
h_o	specific enthalpy at T_o, P_o
T_o	reference temperature (298.15 K)
s	specific entropy at T, P
s_o	specific entropy at T_o, P_o
η	second law efficiency
W_{useful}	useful work
W_{supply}	supply work
LW	loss work
Q	heat transfer from (to) heat reservoir (sink)
T	absolute temperature of heat reservoir (sink)
W_s	Shaft work

Q	Amount of heat exchanged
T_{hm}	Mean thermodynamic hot temperature
$h_{h,in}$	inlet specific enthalpy for hot stream
$h_{h,out}$	outlet specific enthalpy for hot stream
$s_{h,in}$	inlet specific entropy for hot stream
$s_{h,out}$	outlet specific entropy for hot stream
T_{cm}	Mean thermodynamic cold temperature
$h_{c,in}$	inlet enthalpy for cold stream
$h_{c,out}$	outlet enthalpy for cold stream
$s_{c,in}$	inlet specific entropy for cold stream
$s_{c,out}$	outlet specific entropy for cold stream
R	Gas constant
n_h	mole flowrate of hot stream
n_c	mole flowrate of cold stream
$p_{in, h}$	inlet pressure of hot side
Δp_h	pressure drop of hot side
$p_{in, c}$	inlet pressure of cold side
Δp_c	pressure drop of cold side