Accepted Manuscript

Title: A novel approach for operational optimization of multi-stage refrigeration cycles in gas refineries

Author: Hossein Kalantar-Neyestanaki, Mostafa Mafi, Ali Ashrafizadeh

PII: S0140-7007(17)30185-8
DOI: http://dx.doi.org/doi: 10.1016/j.ijrefrig.2017.05.001
Reference: JIJR 3629

To appear in: *International Journal of Refrigeration*

Received date: 16-2-2017
Revised date: 26-4-2017
Accepted date: 1-5-2017

A Novel Approach for Operational Optimization of Multi-Stage Refrigeration Cycles in Gas Refineries

Hossein Kalantar-Neyestanaki[1], Mostafa Mafi[2*], Ali Ashrafizadeh[3]

[1]MSc Graduate, Faculty of Mechanical Engineering, K. N. Toosi University of Technology, Tehran, Iran; hossein.kalantar@mail.kntu.ac.ir

[2*]Assistant Professor, Department of Mechanical Engineering, Imam Khomeini International University, Qazvin, Iran; m.mafi@eng.ikiu.ac.ir; Tel: (+98)2833901122; Fax: (+98)2833780073

[3]Associate Professor, Faculty of Mechanical Engineering, K. N. Toosi University of Technology, Tehran, Iran; ashrafizadeh@kntu.ac.ir

Highlights

- A novel approach for optimization of in-use refrigeration cycles is proposed.
- The performance limitations of components are considered in this approach.
- The independent variables of multi-stage refrigeration cycles are introduced.

Abstract

The efficient use of energy in refrigeration cycles of gas liquefaction plants is a contemporary topic of interest. The previous optimization studies on refrigeration cycles have not considered the components' operational limitations. By considering the fact that in operating plants, all constraints must be thoroughly taken into account, this paper presents a novel approach for operational optimization of in-use refrigeration cycles which takes into account the operational limitations of the components as well as the interaction between the refrigeration cycle and the core process. This novel approach exploits a combination of thermodynamic principles and pinch technology to express the multi-stage refrigeration cycles' power consumption as a function of several independent variables. To examine the applicability of the proposed approach, it is used to optimize a three-stage refrigeration cycle in a propane liquefaction plant. About 15.4% reduction in the specific power consumption is achieved.

Keywords:

Multi-stage refrigeration cycle, gas liquefaction plants, operational limitations of components, optimization, independent variables.

Nomenclature

η_{ex}	exergetic efficiency
η_C	Carnot factor
η_s	isentropic efficiency
$A_{ECC\ or\ EGCC}$	enclosed area in the ECC or EGCC (kW)
T_0	ambient temperature (K)
T	temperature (K)
H	enthalpy (kJ)
h	specific enthalpy (kJ.kg^{-1})
ΔT	temperature difference (K)
ΔT_{min}	minimum temperature difference approach (K)
$\dot{m}$	mass flow rate (kg.h^{-1})
$\eta_{s,comp}$	isentropic efficiency of compressor
$\dot{W}$	power consumption (kW)
X	vapor quality
$\dot{Q}_{evp}$	cooling rate of evaporator (kW)
h_{fg}	enthalpy of vaporization (kJ.kg^{-1})
CRS	compressor rotational speed (rpm)
PR	pressure ratio
$\dot{w}$	specific power consumption (kJ.kg^{-1})
MIX	mixer
AC	air condenser
D	drum
EV	expansion valve
E	evaporator
Base case	denote the refrigeration cycle before optimization
Case A	denote the refrigeration cycle after optimization by the CPEA
Case B	denote the refrigeration cycle after optimization by the presented approach

Subscripts

evp	evaporator
s	isentropic
$cond$	condenser
$comp$	compressor
U	upper stage
L	lower stage
max	maximum