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Absorption refrigeration: An alternative for lubricant dewaxing – A case study

C.L. Heard [a,*], M.A. Rodríguez Toral [b]

[a] Departamento de Teoría y Procesos de Diseño, División de Ciencias de la Comunicación y Diseño, Unidad Cuajimalpa, Universidad Autónoma Metropolitana, Avenida Vasco de Quiroga 4871, Colonia Santa Fe Cuajimalpa, Delegación Cuajimalpa de Morelos, C.P. 05300 México D.F., Mexico

[b] Dirección Corporativa de Planeación, Coordinación y Desempeño, Subdirección de Planeación Estratégica, Gerencia de Portfolio de Inversion, Torre Ejecutiva – Piso 12, Petroleos Mexicanos, Avenida Marina Nacional 329, Colonia Petroleos Mexicanos, Delegación Miguel Hidalgo, C.P. 11311 México D.F., Mexico

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ABSTRACT

Three refrigeration systems applied to a lubricant dewaxing process were analysed and compared: existing mechanical vapour compression and proposed ammonia/water and ammonia/lithium nitrate absorption refrigeration. The absorption systems offer higher thermal efficiencies using cheaper, lower pressure steam. The ammonia/lithium nitrate system has the capacity to provide the highest efficiency option at the cost of a higher investment due to its adverse transport properties: high viscosities. The ammonia/water system is a tried and tested technology whereas the ammonia/lithium nitrate has been demonstrated, but to the authors' knowledge, not used in an industrial scale system.

Froid à absorption: Une alternative pour un déparaffinage de lubrifiant – Une étude de cas

Mots clés : Absorption ; Compression mécanique de vapeur ; Ammoniac ; Eau ; Nitrate de lithium

* *Corresponding author.* Departamento de Teoría y Procesos de Diseño, División de Ciencias de la Comunicación y Diseño, Unidad Cuajimalpa, Universidad Autónoma Metropolitana, Avenida Vasco de Quiroga 4871, Colonia Santa Fe Cuajimalpa, Delegación Cuajimalpa de Morelos, C.P. 05300 México D.F., Mexico. Tel.: +52 55 5814 6500 Ext 3535.
E-mail address: cheard@correo.cua.uam.mx (C.L. Heard).
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Nomenclature

Cp	specific heat capacity, [J kg^{-1} K^{-1}]
D_i	internal diameter, [m]
G	mass velocity, [kg s^{-1} m^2]
h_i	interior heat transfer coefficient, [W m^{-2} K^{-1}]
h_o	exterior heat transfer coefficient, [W m^{-2} K^{-1}]
k_b	thermal conductivity, [W m^{-1} K^{-1}]
N_{nu}	nusselt number
X	mass concentration of refrigerant

Greek symbols

μ_b	bulk dynamic viscosity, [N s m^{-2}]
μ_w	wall dynamic viscosity, [N s m^{-2}]

Subscripts

Weak solution	solution with a low refrigerant concentration
Strong solution	solution with a high refrigerant concentration
$NH_3/LiNO_3$	ammonia/lithium nitrate
NH_3/H_2O	ammonia/water

1. Introduction

The refining of lubricant oils is a significant consumer of refrigeration services in a refinery when dewaxing is achieved through thermally driven crystallization. These services are typically provided using an axial compressor with multiple inlet flows at a series of pressures corresponding to the various operating temperatures of the dewaxing process. Such a compressor has limited flexibility in the ratios of refrigerant flow at the differing inlet pressures. These systems must have a refrigerant recycle circuits to allow vapour flow to the compressor inlet to balance flow rates and ratios especially at startup. They are usually driven by a steam turbine using superheated medium pressure steam. An alternative would be the use of an absorption refrigeration unit which could offer lower energy and operating costs by using low pressure steam (frequently more readily available in a refinery and much cheaper than medium pressure superheated steam), using fewer large rotating machines, lowering maintenance requirements, providing higher availability and much greater operational flexibility.

As an example, a refrigerant train in a central Mexican oil refinery was considered. An old lubricant dewaxing system based on mechanical vapour compression refrigeration was in operation at the time of writing. Historical design data were

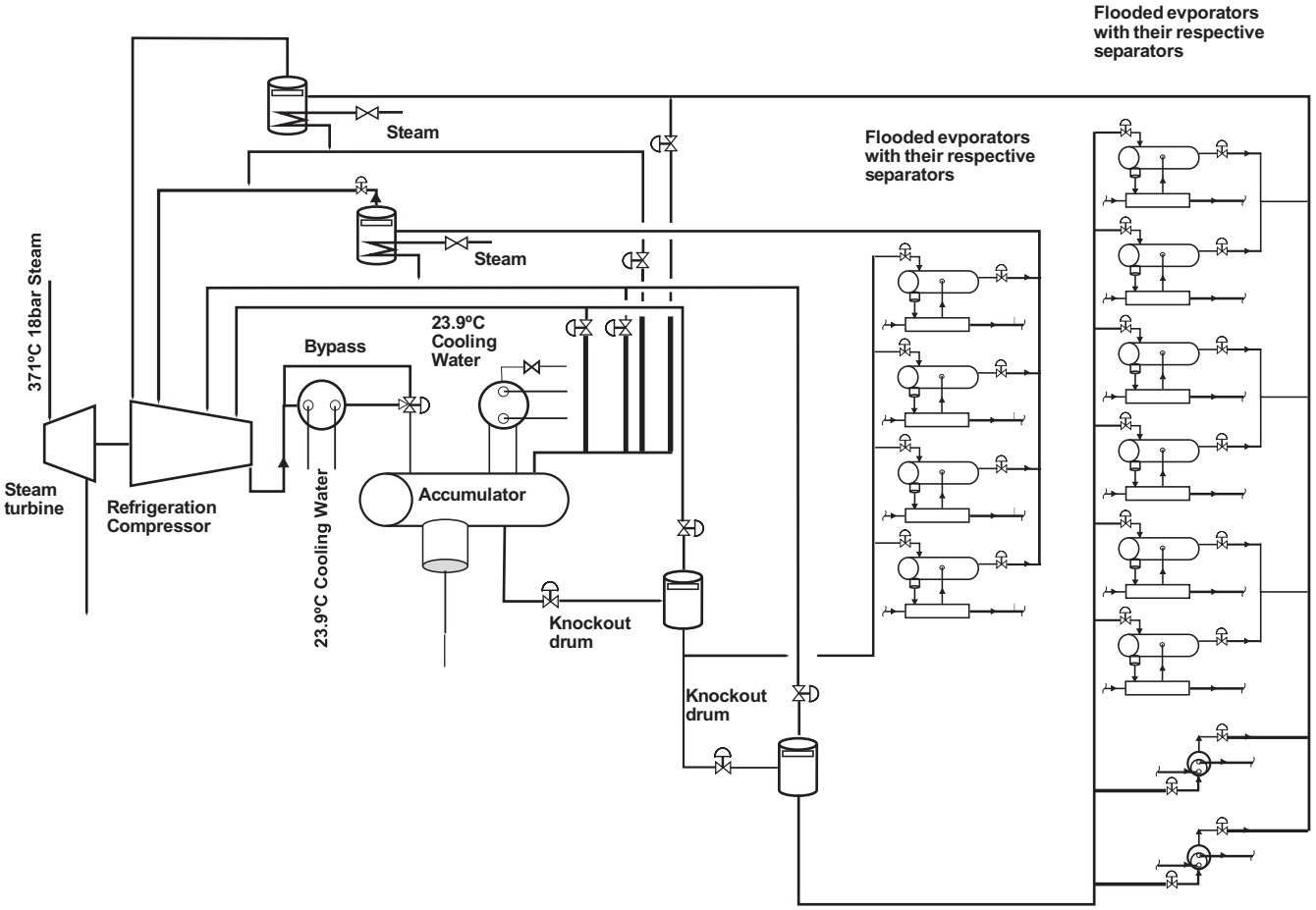

Fig. 1 – Mechanical vapour compression refrigeration system.