Fuel 90 (2011) 364–368

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

A coupled technology to produce high-purity normal and isomeric pentane with reforming topped oil

Benxian Shen, Jun Cao *, Jichang Liu, Xiaodong Wang

State Key Laboratory of Chemical Engineering, East China University of Science and Technology, Shanghai 200237, China

ARTICLE INFO

Article history:
Received 22 May 2009
Received in revised form 24 June 2010
Accepted 9 August 2010
Available online 21 August 2010

Keywords:
Reforming topped oil
Rectification
Adsorption
Pentane

ABSTRACT

This paper investigates a coupled technology to produce the high-purity normal and isomeric pentane from reforming topped oil. The coupled technology is adsorption after rectification technology, which is better than the traditional one in product purity and energy consumption. The purity of the *n*-pentane and the iso-pentane obtained from the coupled technology are both higher than 99%, and the quality of pentane foamer obtained from blending the *n*-pentane with the pentane oil meets the Q/SHZL 0005-1999 standard.

1. Introduction

Reforming topped oil is the topped oil from the catalytic reforming unit, whose boiling range is from the dropping point to 333 K. The topped oil belongs to the satisfied hydrocarbon category, which contains no mechanical impurities and has achromatic color. The composition of the topped oil is mainly *n*-pentane and iso-pentane.

The *n*-pentane and iso-pentane are basic chemical raw materials and have a wide range of applications in industry, especially in the foamer area [1]. At present, the way used mostly to obtain pentane from the topped oil is Four-Tower-Continuous-Rectification technology; however, the energy consumption of this technology is too high as it requires a high reflux ratio and a large number of trays in the tower for removing the iso-pentane.

To separate the normal paraffin from the branched one, one of the most efficient ways is by adsorption separation on 5A molecular sieves. 5A molecular sieves can adsorb the normal paraffin selectively and then achieve the aim of separating the *n*-paraffin from the reforming topped oil based on the molecular management of the petroleum resource. The early stages of industrialization of the 5A molecular sieve adsorption process were by Union Carbide for increasing the octane number of the petroleum [2]. Later, more technologies were developed and industrialized, like the Molex technology by Universal Oil Products Company (UOP) [3,4], the NS-2 pressure swing adsorption technology by Britain Petroleum Company (BP), the Isosiv technology by Union Carbide Corporation (UCC) [5,6], the Ensorb technology by Exxon [7], the Texaco Selective Finishing (TSF) technology by Texaco [8], and the Parex technology by Phillips Petroleum Company [9]. In the middle of 1980s, Shell [10] invented a coupled technology for the isomerization and adsorption separation of C5–C6. Mazzotti et al. [11] researched on the adsorption separation technology by simulated-moving-bed in gas phase. The typical technologies of 5A molecular sieve adsorption are the MaxEne technology by UOP and the Isosiv technology by UCC; the former one uses the simulated-moving-bed technology which is operated in liquid phase [12] while the later one is in the gas phase. In the recent years, the improvement of research applications on the 5A molecular sieve adsorption technology is mainly indicated by the different kinds of feed [13–17].

The C5 component, which takes about 50–60% of the total amount of the reforming topped oil, can be further processed into the oil with high-purity *n*-pentane and high-purity iso-pentane respectively. The high-purity pentane can be blended with the pentane oil according to the different requirement of the foamer, while the high-purity iso-pentane can be used as the harmonic component of the petroleum with high octane number.

This paper investigates a new coupled technology of adsorption separation and rectification to separate the *n*-pentane and the iso-pentane from the reforming topped oil. The technology is the adsorption separation of *n*-pentane and iso-pentane after the pentane oil is obtained by the rectification process. Then the coupled technology is compared with the traditional one in product purity and energy consumption.

* Corresponding author. Tel.: +86 21 64253346; fax: +86 21 64252160.
E-mail address: caojun25885@163.com (J. Cao).

0016-2361/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.fuel.2010.08.005

Table 1
The composition of the reforming topped oil.

Component	Content (%)
Iso-pentane	17.5
n-Pentane	30.5
2-Methylpentane	14.1
3-Methylpentane	4.7
n-Hexane	13.9
Methyl cyclopentane	4.8
Cyclohexane	0.9
2-Methylhexane	4.3
2,3-Dimethylpentane	1.4
1,1-Dimethylcyclopentane	0.6
3-Methylhexane	1.5
cis-1,3-Dimethylcyclopentane	0.5
trans-1,3-Dimethylcyclopentane	0.4
cis-1,2-Dimethylcyclopentane	0.7
n-Heptane	1.9
Methyl cyclohexane	1.1
3-Ethylpentane	1.3

2. Experimental

2.1. Materials and reagents

The reforming topped oil is from Urumchi Petrochemical Cooperation (PetroChina Company Ltd.). The composition of the reforming topped oil is mainly C_5–C_7, the density is 611.0 kg/m^3 (298 K), the boiling range is from 299 to 378 K, the mass fraction of *n*-paraffin is about 46.35 (wt.%), of which *n*-pentane takes about 30.54%, *n*-hexane takes about 13.88% and *n*-heptane takes about 1.93%. The composition of the reforming topped oil analyzed by gas phase chromatography is listed in Table 1.

The pentane oil is from Urumchi Petrochemical Cooperation (PetroChina Company Ltd.). *n*-Pentane takes up 38.55% of the pentane oil while iso-pentane takes up 61.42%. The density is 623.6 kg/m^3 (293 K).

5A molecular sieves (5AMS) are from UOP (Shanghai, China). The equilibrium adsorptive capacity of *n*-butane in the pressure of 0.033 MPa and 298 K is 9.3 (wt.%).

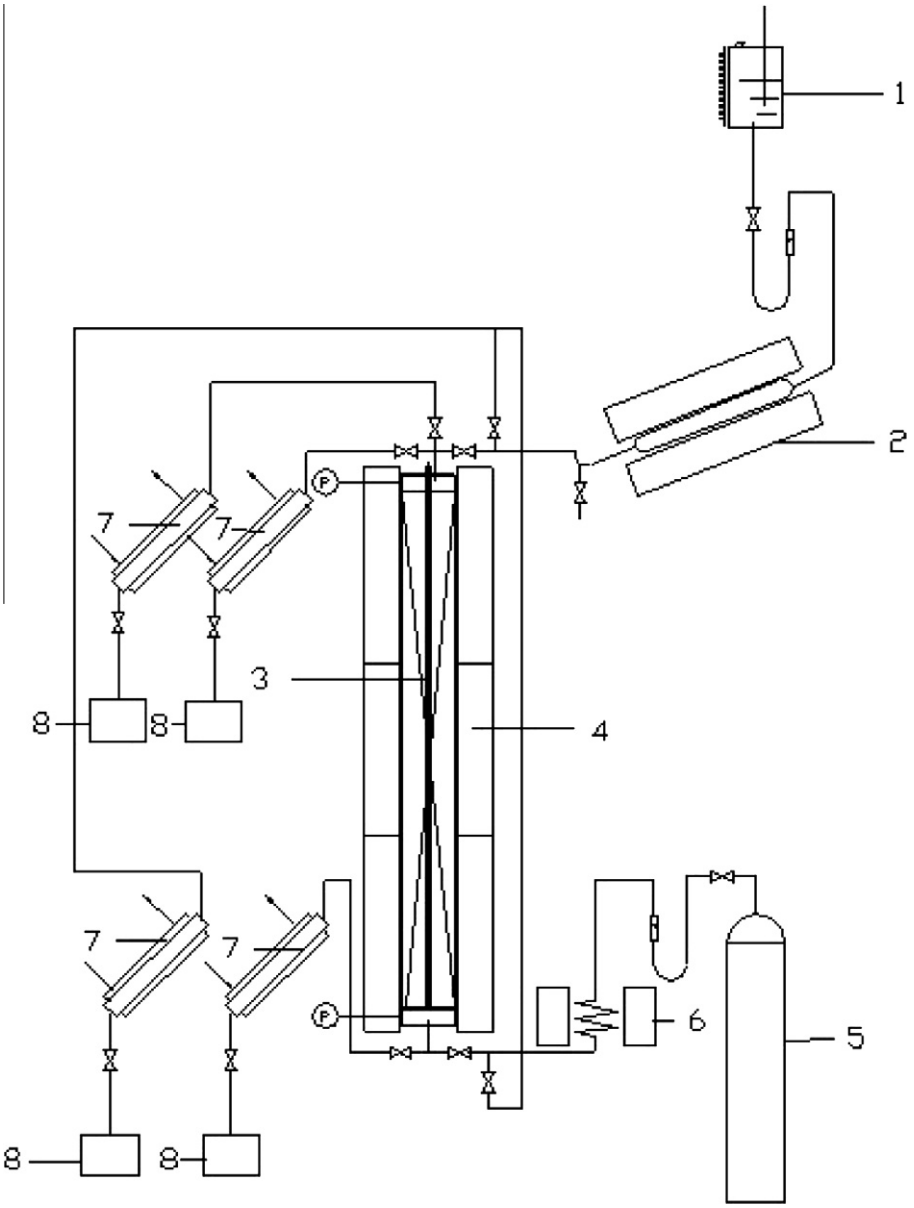

Fig. 1. The flow chart of the adsorption apparatus. (1) Naphtha tank; (2) naphtha vaporizer; (3) molecular sieve bed; (4) bed preservation heater; (5) N_2 cylinder; (6) gas preheater; (7) condenser; and (8) product vessel.