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# Modeling the stabilization column in the petroleum refinery

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**Abstract**

The objective of this work was to model, the gasoline stabilization column to get a better use of energy, increased yield and reduced costs of operation. The calculation of the stabilization column was performed by using Soave-Redlich-Kong (SRK) thermodynamic model with pseudo-component approach. The results given by this model was compared with experimental data obtained from functioning stabilization column of petroleum refinery and conclusions about the accuracy of the models studied are drawn. Using SRK model, a technical feasibility study was followed to run the stabilization column at an optimum pressure. The results allowed us to highlight the effect of pressure on the separation of products, recommending the optimal pressure for optimizing the energy consumption of reboiler.



*Keywords:* Modeling; simulation; Soave-Redlich-Kong EOS; LPG; Essence; stabilization column; energy

## 1. Introduction

The crude oil refining produces different chemicals components. Particularly, we distinguish Liquefied Petroleum Gas (LPG) beside the gasoline. The separation of these products necessarily requires a distillation column. This manufacturing process is widely used to separate oil products, but its disadvantage is the high energy consumption [1]. Working between a heat source at the bottom (reboiler) and a cold source on the top (condenser), the distillation column of petroleum fractions can be considered as a heat engine which receives energy at the reboiler level and rejects a part in the condenser level, to separate a liquid mixture [2]. Despite efforts which were conducted by many researchers to minimize energy consumption, the problem is always posed, to achieve separation. So this research

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will firstly devote to model the distillation column of petroleum fractions especially the gasoline stabilization column. Secondly, use the accurate and reliable model to get a better use of energy, increased yield and reduced costs of operation.

**Nomenclature.**
$M_i$: molecular mass of the compound i
N: Feed flow rate (kmol/h)
$P_i^s$ Saturation pressure (bar)
Q: heat flow (G Cal/h)
SG : Specific gravity, at 15°C
R: ideal gas constant = 8314.5 J/kmol/K
$x_i$: liquid phase mole fraction of component i
$y_i$ : vapor phase mole fraction of component i
$z_i$ : mole fraction of component i

## 2. Industrial Process

The petroleum is a complex mixture of different hydrocarbons fractions, small amounts of sulfur and trace amounts of oxygen, nitrogen and metals. Separation is effected by heated the mixture to an elevated temperature of about 400°C, then injected into an atmospheric pressure distillation column. Distillation is the separation of completely miscible mixtures of liquids according to the difference of the boiling point and volatility of the components in the mixture. However, the lighter products, as butane, are obtained at the head of the column and the heavier components such as gasoline, kerosene and gas oil (diesel oil) remains successively lower [3]. As for the residue that cannot be distilled, even at very high temperatures remain at the bottom of the distillation column.

Of the tray 13 of distillation column is drawn off the naphtha which feeds stabilization column. The purpose of the latter is to achieve the separation of the total naphtha in its various constituents and prepare the load of catalytic reforming [4]. Stabilization column is equipped with a partial condenser, 30 bubble cap trays and a reboiler (Figure 1). Stabilization column operation is similar to that of the atmospheric distillation column, except that it does not have the side streams. The power supply is disposed at the sixteenth tray (the trays are numbered from top of the column to bottom of the column). The effluent recovered at the column head is the fuel gas. At the first tray level of this column, we obtain the LPG consisting, principally of propane and butane. At the bottom of this column, we get a cut of heavy gasoline containing hydrocarbon chains type $C_6$, $C_7$, $C_8$, $C_9$ and $C_{10}$ [4].

### *2.1. Modeling*

The set of equations that govern the operation of the column is obtained using the equations of balance material and energy and the equations relating to conditions of Vapor-Liquid Equilibrium (VLE). The figure 1 shows the diagram for principle of an equilibrium stage. Each stage, j receives a diet feed $F_j$, a fluid flow, $L_{j-1}$ from the upper stage and a steam flow, $V_{j+1}$ of the lower stage, a liquid extraction $U_j$, a steam extraction $W_j$ and a heat input $Q_j$ can be considered [5]. All these equations required for modeling are written, at each tray of the column and are given below:

- Material balance equation is given by:

$$L_{j-1}x_{ij-1} - \left(V_j + W_j\right)y_{ij} - \left(L_j + U_j\right)x_{ij} + V_{j+1}y_{ij+1}F_j z_{ij} = 0 \tag{1}$$

- Energy balance equation is given by:

$$L_{j-1}h_{j-1} - \left(V_j + W_j\right)H_{ij} - \left(L_j + U_j\right)h_j + V_{j+1}h_{ij+1}F_j h_{Fj} - Q_j = 0 \; \mathrm{L_{j-1}h_{j-1}\text{-}(V_j + W_j)H_{ij}\text{-}(L_j + U_j)h_j +}$$