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**Simulation, Analysis and Optimization of the Deisohexanizer (DIH)
Column in the Isomerization Unit (U.700/701) of RA1K**

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Abstract

The Deisohexanizer (DIH) column plays a critical role in separating light hydrocarbons to improve gasoline quality by increasing the Research Octane Number (RON). This study presents a comprehensive simulation, analysis, and optimization of the DIH column by examining the influence of key operational parameters. Using Aspen HYSYS and a Box-Behnken experimental design, optimal conditions were identified: $T = 128.18\text{ }^{\circ}\text{C}$, $R = 260\text{ m}^3/\text{hr}$, $D = 50.86\text{ m}^3/\text{hr}$, resulting in a maximum RON of 86.4661. This value was validated by simulation (RON = 86.4621) and accompanied by a significant reduction in 2-methylpentane content from 7.38% to 3.35%, confirming enhanced separation efficiency. These findings support more efficient and stable operation of the isomerization unit.

Keywords: Research Octane Number (RON), Deisohexanizer column, Aspen HYSYS, refining, isomerization, distillation, Box-Behnken design, process optimization.

Résumé

La colonne de déisohexanisation (DIH) joue un rôle essentiel dans la séparation des hydrocarbures légers, contribuant ainsi à l'amélioration de la qualité de l'essence par l'augmentation de l'indice d'octane moteur (RON). Cette étude présente une simulation, une analyse et une optimisation complètes de la colonne DIH en étudiant l'impact des principales variables opératoires. En combinant le logiciel Aspen HYSYS avec un plan d'expériences de type Box-Behnken, les conditions optimales ont été identifiées : $T = 128,18\text{ }^{\circ}\text{C}$, $R = 260\text{ m}^3/\text{h}$, $D = 50,86\text{ m}^3/\text{h}$, aboutissant à un RON maximal de 86,4661. Cette valeur a été confirmée par la simulation dans Aspen HYSYS, qui a prédit un RON de 86,4621 dans les mêmes conditions. Par ailleurs, la fraction massique du 2-méthylpentane (composant à faible indice d'octane) a été réduite de manière significative, passant de 7,38 % à 3,35 %, démontrant une amélioration notable de la performance de séparation. Ces résultats appuient une exploitation plus efficace, stable et qualitative de l'unité d'isomérisation.

Mots clés : indice d'octane moteur (RON), colonne de déisohexanisation, Aspen HYSYS, raffinage, isomérisation, distillation, plan de Box-Behnken, optimisation des procédés.

ملخص

يلعب عمود إزالة الإيزوهيكسان (DIH) دوراً محورياً في فصل الهيدروكربونات الخفيفة، مما يسهم في تحسين جودة البنزين من خلال رفع رقم الأوكتان البحثي (RON). تستعرض هذه الدراسة محاكاة شاملة وتحليلًا وتحسينًا لعمود DIH من خلال دراسة تأثير المتغيرات التشغيلية الأساسية. وباستخدام برنامج Aspen HYSYS مع تصميم تجريبي إحصائي من نوع Box-Behnken، تم تحديد الظروف التشغيلية المثلى عند درجة حرارة 128.18 درجة مئوية، معدل ارتداد 260 م³/ساعة، ومعدل تقطير 50.86 م³/ساعة، مما أدى إلى تحقيق أقصى قيمة لـ RON بلغت 86.4661. وقد تم التحقق من هذه القيمة من خلال المحاكاة، التي توقعت RON بقيمة 86.4621 لنفس الظروف. كما انخفضت نسبة 2-ميثيل بنتان، وهو مكون منخفض الأوكتان، من 7.38% إلى 3.35%، مما يدل على تحسين كفاءة الفصل. وتؤكد هذه النتائج فعالية واستقرار تشغيل وحدة الإيزومرة.

الكلمات المفتاحية: رقم الأوكتان البحثي (RON)، عمود إزالة الإيزوهيكسان، Aspen HYSYS، التكرير، الإيزومرة، التقطير، تصميم Box-Behnken، تحسين العمليات.

List of abbreviations

Symbol	Signification
RON	Research Octane Number
DIH	Deisohexanizer
DIP	Deisopentanizer
DP	Depentanizer
DMB	Dimethylbutane
MP	Methylpentane
BBD	Box–Behnken Design
RSM	Response Surface Methodology
ANOVA	Analysis of variance
LHSV	Liquid Hourly Space Velocity
wt%	Weight percent
Aspen EA	Aspen Energy Analyzer

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General Introduction

Crude oil is a complex mixture composed of hundreds of distinct hydrocarbon molecules, along with trace quantities of non-hydrocarbon elements such as oxygen, sulfur, nitrogen, vanadium, nickel, and chromium. The refining process is designed to separate and convert these components into valuable end-products through a series of sophisticated physical and chemical operations. An oil refinery is a network of interconnected processing units tasked with transforming raw petroleum into marketable fuels and petrochemical feedstocks. As one of the most technically demanding branches of the chemical industry, oil refining involves a wide array of intricate processes, often linked in highly integrated configurations. Atmospheric distillation, typically the first step, heats crude oil in a furnace to separate its constituents based on differences in boiling points. Crude blending further enhances economic efficiency, ensures compliance with quality standards, and facilitates smoother transportation and downstream processing. [1]

Among the various refined products, gasoline holds particular importance due to its widespread consumption and direct impact on vehicle performance. A key property of gasoline is its resistance to engine knocking, a phenomenon that limits the efficiency and output of spark-ignition engines. This characteristic is quantified by the Research Octane Number (RON), which serves as a benchmark for fuel quality. [2]

To meet increasingly stringent performance and environmental standards, refineries rely on advanced distillation and conversion technologies. One such process is isomerization, which improves gasoline octane by transforming straight-chain paraffins into branched isomers. This is achieved by rearranging linear hydrocarbons into branched alkanes or cyclic naphthenes, which can undergo partial dehydrogenation to form high-octane aromatic compounds. Since isomerization reactions are equilibrium-limited, the final RON depends largely on the effectiveness of downstream separation units.

In this context, the Deisohexanizer (DIH) column, located within the light naphtha isomerization unit, plays a pivotal role in product refinement. It fractionates the isomerized stream into three categories: a light isomerate enriched in high-octane components, a heavy isomerate, and a recycle stream containing unconverted, low-octane compounds. Under optimal conditions, the DIH can produce an isomerate with a RON of 87-88. However, operational challenges such as suboptimal column control or unplanned reactor shutdowns may compromise separation efficiency. This can result in the undesired recycling of high-octane dimethylbutanes (DMBs) and contamination of the light isomerate with low-octane methylpentanes (MPs). [3] Such outcomes negatively affect the final gasoline quality. For instance, a temporary reactor failure at the Skikda refinery exacerbated this issue, demonstrating the critical need for precise DIH operation.

The ongoing pursuit of higher RON values has direct implications for gasoline quality and refinery economics. [4] Achieving this goal requires sharper separation between high- and low-octane species, which in turn increases energy demands, particularly the reboiler duties of the DIH and other downstream columns. Alternatively, recycling low-RON components back to the reactor offers another path to enhanced octane but at the cost of greater process complexity and energy consumption.

The present study aims to model and simulate the behavior of the DIH column using Aspen HYSYS, with the objective of comparing simulation results to real plant data. Through this comparative analysis, the research seeks to identify actionable modifications to reduce MP

contamination in the light isomerate while maximizing DMB retention. Correlating simulated outputs with design parameters and chromatographic measurements allows for performance assessment under realistic operating scenarios. Ultimately, this work contributes to the broader objective of sustainable refining by minimizing additive dependency and ensuring compliance with evolving environmental regulations for cleaner fuel production.

Chapter 1: Presentation of the Isomerization Unit (U700/701) in the Skikda Refinery (RA1K)

1.1. Overview of the RA1K refinery

Located in the industrial zone of Skikda, the RA1K refinery is the largest petroleum refining facility in Algeria, with an annual crude oil processing capacity of 18 million tons and an additional 300,000 tons per year of imported reduced crude. The complex spans a surface area of approximately 190 hectares and is supplied by domestic crude oil from the Hassi Messaoud field via a 760-kilometer pipeline.

Construction of the refinery was initiated under a contract signed on April 30, 1974, between the Algerian government and Italian engineering firms SNAM PROGETTI and SAIPEM, with technical support provided by Algerian companies Sonatro, Sonatiba, and SN Metal. Groundbreaking began on January 2, 1976, and the refinery was commissioned in March 1980. [5]

In 1993, the refinery was expanded with the addition of two new units: a naphtha pretreatment and catalytic reforming unit, and a gas treatment and separation unit, both built by the Japanese firm JGC Corporation. [5]

In 2013, the RA1K complex underwent a major rehabilitation project led by Samsung Engineering and Construction (South Korea). This modernization initiative included the installation of the U700/701 isomerization unit, alongside the refurbishment and capacity enhancement of several existing units. [5]

1.2. Description of the isomerization unit (U700/701)

As part of the 2013 modernization project, the isomerization unit (U700/701) was commissioned to upgrade low-RON light naphtha (C5/C6) from the topping unit into high-octane gasoline components. The unit is divided into two primary sections: the pretreatment (hydrotreatment) section and the reaction (isomerization) section.

1.2.1. Hydrotreatment section

The primary objective of this section is to eliminate undesirable impurities such as sulfur (S), lead (Pb), nitrogen (N), oxygen (O), water (H₂O), and trace metals found in light naphtha (Naphta A). These contaminants adversely affect the catalyst's performance by causing deactivation (catalyst poisoning), promoting corrosion of equipment, and contributing to environmental pollution via gaseous emissions. The removal of such impurities is therefore essential to protect the integrity of the process and to maintain product quality. [2] [6]

1.2.2. Isomerization section

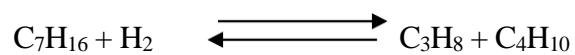
This section aims to convert the pretreated naphtha into high-octane components, primarily dimethylbutanes (DMBs), by eliminating chlorides and residual low-octane species. The isomerization reaction takes place in a fixed-bed reactor, employing a platinum-based catalyst characterized by high selectivity and activity toward branched isomer formation. The feed and make-up hydrogen must be devoid of water, carbon monoxide (CO), and carbon dioxide (CO₂) to ensure optimal catalytic performance. [7]

1.2.2.1. Process flow of the isomerization section

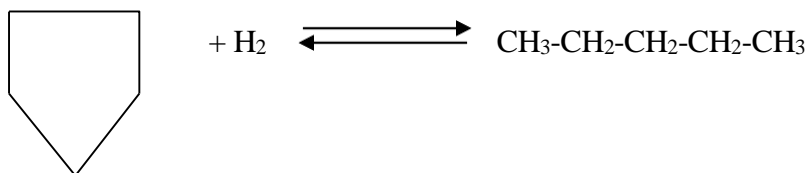
The hydrotreated naphtha, containing less than 0.1 ppm of nitrogen and 0.5 ppm of sulfur, is further dried before it reaches the isomerization reactor. This is achieved using adsorber vessels (701-V-2A/701-V-2B) to remove all traces of water. The dried feed is then pressurized to 39.91 kg/cm² and mixed with recycled hydrogen. A second drying step (701-V-4A/701-V-4B) ensures complete removal of residual moisture. The mixture is then preheated to 130 °C via a heat exchanger train before entering the reactor.

Two other possible reactions :

A- Hydrocracking reaction :



B- Opening of the naphthenic cycle :



Cyclopentane

n-pentane

✓ The same thing for Methylcyclopentane and cyclohexane.

Chapter 2: Literature Review

2.1. Introduction

The isomerization process plays a pivotal role in petroleum refining, particularly in upgrading the octane number of light naphtha fractions. In response to increasingly stringent environmental regulations and the growing demand for cleaner, high-performance fuels, improving the efficiency of isomerization units, especially the Deisohexanizer (DIH) column, has become a key area of research. This literature review explores advances in isomerization technology, with a particular focus on DIH column optimization. It examines catalyst development, process control strategies, and the influence of operational parameters on final product quality.

2.2. Overview of the isomerization process

Isomerization involves the transformation of low-octane linear paraffins (C_5/C_6) into high-octane branched isomers, thereby improving gasoline quality. Typically, the process includes multiple reactors followed by separation units such as distillation columns. Among these, the Deisohexanizer (DIH) column is a crucial component, as it separates high-octane compounds like dimethylbutanes (DMBs) from lower-octane methylpentanes and normal hexane. These lower-octane species are then recycled to the reactor for further conversion. The efficiency of the DIH column directly affects the Research Octane Number (RON) of the isomerate product. [6]

2.3. Simulation and optimization of the isomerization process

Chuzlov et al. [8] proposed a mathematical modeling framework for the isomerization of light naphtha, aiming to maximize the conversion of normal paraffins into isoparaffins. Their study emphasized the importance of catalyst activity and feed composition in determining optimal operating conditions. The Isomalk-2 process, which utilizes platinum oxide-based catalysts to enhance RON, was also examined. The study found that hydrogen-to-feed ratio, catalyst formulation, and reaction temperature significantly impact both conversion and selectivity. Furthermore, operating pressures below 450 psig promoted undesirable cyclohexane adsorption on the catalyst surface, while pressure variations of just 50 psig affected DMB purity by up to 2.3%.

2.4. Operating variables affecting octane number

Shehata et al. [9] conducted a comprehensive analysis of industrial-scale isomerization at the MIDOR refinery in Egypt. Their investigation focused on critical operational parameters, including Liquid Hourly Space Velocity (LHSV), temperature, benzene contamination, and hydrogen consumption. Using Response Surface Methodology (RSM), they identified that decreasing LHSV and operating at temperatures between 156 °C and 170 °C favored the formation of branched isomers, particularly when using chlorinated alumina catalysts. The study revealed that benzene concentrations exceeding 2% led to a decline in RON by approximately 2 units. Additionally, DIH column performance was shown to contribute up to a 12.7 point increase in RON through high purity recovery of normal hexane (>98%). Optimal hydrogen flow rates between 102.6 and 124 kmol/h were also crucial for maintaining catalyst stability and selectivity.

2.5. Unit modification and process reconfiguration

Osman et al. [10] explored improvements in separation efficiency and fuel quality by integrating a de-isopentanizer (DIP) column into the isomerization process, both upstream and downstream of the reactor. Through simulations in Aspen HYSYS, various configurations were

analyzed to determine the most effective setup. The inclusion of a second DIP column enhanced separation and enabled more efficient recycling of unconverted C₆ hydrocarbons. The optimal configuration, operating at 155 °C and 45.4 barg at the reactor inlet, achieved a 7% increase in RON and a 13% reduction in operating costs.

2.6. Simulation and equipment adjustments for isomerization improvement

To further improve RON, Hajghani et al. [4] evaluated different equipment arrangements, such as DIP-DIH, DIP-DP, and DIP-DH configurations. Using the Aspen Energy Analyzer, the study also assessed the energy implications of each setup. The simulation identified 80 trays as the optimal configuration for the DIH column. Among the alternatives, the DIP-DP (Deisopentanizer-Depentanizer) configuration provided the best trade-off between energy consumption and RON improvement, yielding a 6.6% increase in RON and a 7.9% reduction in energy usage.

2.7. Advanced modeling and benzene control

Awan et al. [11] investigated the impact of benzene content in the feed on isomerization performance and catalyst lifespan. Using Aspen HYSYS, they modeled the saturation of benzene and the role of stabilizer columns in controlling aromatic levels. Elevated benzene concentrations were shown to affect the process negatively, increasing reactor temperatures by up to 11 °C and intensifying reboiler duty. Their study also proposed advanced benzene removal techniques, including fractional distillation and catalytic hydrogenation, as means of preserving catalyst efficiency. Additionally, the implementation of ZnO guard beds was shown to mitigate sulfur poisoning, further enhancing catalyst longevity.

Chapter 3: Development of the simulation model

3.1. Introduction

To optimize the operational conditions and minimize the loss of dimethylbutanes (DMBs) in the recycle stream of the Deisohexanizer (DIH) column, this chapter focuses on the modeling and simulation of the DIH column in the isomerization section using Aspen HYSYS. The simulation was conducted in three main phases. First, the design case was simulated to validate the selection of the thermodynamic model and ensure the accuracy of the simulation. Second, a real operating case was simulated using actual refinery data to serve as a baseline for future optimization. Finally, operating parameters were fine-tuned in order to minimize DMB losses in the recycle stream and to enhance the overall performance of the column.

3.2. Overview of Aspen HYSYS

The HYSYS simulator software is a powerful tool for designing chemical engineering processes. It is widely used in the oil and gas, refining, and chemical industries. It provides robust simulation capabilities for designing, optimizing, and analyzing various processes, enabling engineers to improve efficiency, safety, and profitability. Aspen HYSYS allows for the detailed simulation of complex processes and equipment such as distillation, heat exchange, absorption, and chemical reactions. HYSYS includes a vast library of thermodynamic models and property packages that ensure accurate predictions of physical and chemical properties. In our study, the software was used to conduct a full analysis in order to understand the impact of variable changes on process performance, to finally make an optimization. [12]

3.3. Simulation of The deisohexanizer (DIH) column

3.3.1. Step 1: Introducing the feed compositions and characteristics

In the first step of the simulation setup, the generic hydrocarbon groups described in the material balance (e.g., aliphatic, naphthenic, aromatic) were translated into specific chemical components compatible with Aspen HYSYS. The component mapping used is shown below:

Table 1 List of components

	Components as described in the material balance	Component List in Aspen HYSYS Simulation
Aliphatic	iC₄	Isobutane
	nC₄	n-butane
	iC₅	Isopentane
	nC₅	n-pentane
	22DMB	2,2-dimethylbutane
	23DMB	2,3-dimethylbutane

	2MP	2-methylpentane
	3MP	3-methylpentane
	nC₆	n-hexane
	iC₇	Isoheptane or 2-Methylhexane
	nC₇⁺	n-heptane
	iC₈	iso-octane or 2-methylheptane
	nC₈	n-octane
Naphtene	C₅	cyclopentane
	CH	cyclohexane
	C₇	cycloheptane
	MCP	methylcyclopentane
	C₈	cyclooctane
Aromatic	Benzene	benzene

3.3.2. Step 2: Selection of the fluid package

The Peng-Robinson equation of state was selected for this simulation due to its robustness and accuracy in modeling vapor-liquid equilibria in hydrocarbon systems. It is suitable for handling systems involving single-phase, two-phase, or even three-phase behavior across a wide range of pressures and temperatures.

3.3.3. Step 3: Simulation setup and process definition

At this stage, the simulation environment was configured to reflect the real process parameters. The following process elements were defined based on equipment datasheets, process flow diagrams (PFD), material balances, and stream summaries:

- Feed stream compositions,
- Operating conditions (temperature, pressure, flow rate),
- Heat exchanger configuration,
- Distillation column specifications.

3.4. Simulation of the Deisohexanizer column (701-C-2)

3.4.1. Diagram of the Deisohexanizer column simulation by Aspen Hysys

The following figures represent the simulation of the Deisohexanizer column in RA1K.

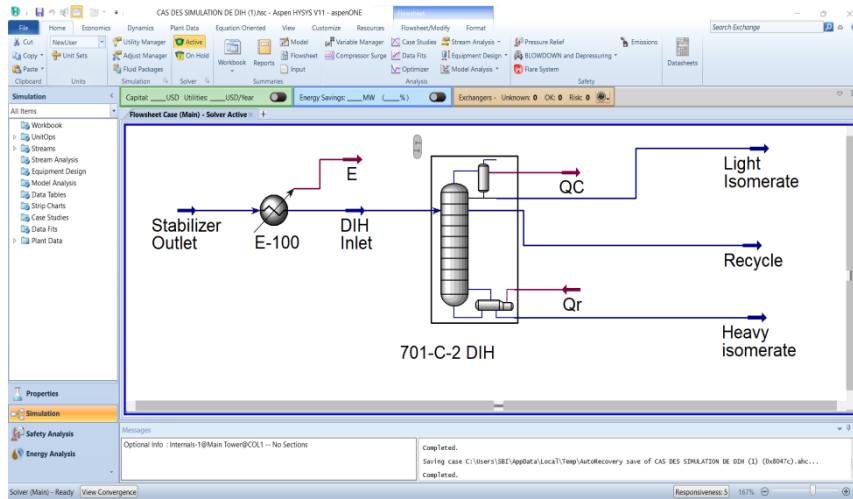


Figure 2 Deisohexanizer column simulation

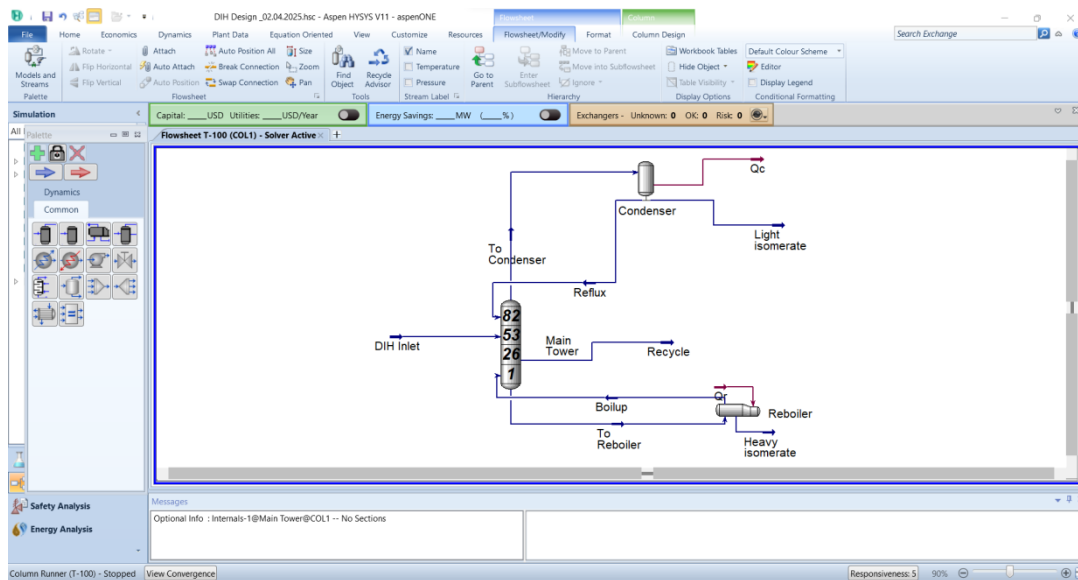


Figure 3 Column environment simulation

3.4.2. Design case simulation

To verify the validity of the selected thermodynamic model, a simulation was performed under design conditions. Key parameters: temperature, pressure, flow rate, and product composition, were compared with the actual design specifications. The comparison focused on critical points: the top product, the recycle stream, and the bottom product.

Table 2 Comparison of operating parameters (design vs simulation)

	Simulation			Design		
	Top	Recycle	Bottom	Top	Recycle	Bottom
T (°C)	71.62	113.4	144.7	60	112	144
P (kg/cm².g)	2.1	3.015	3.2	2.1	3.0	3.2
F (kg/h)	30410	23750	1983	30400	23758	1984

Table 3 Product Composition and RON Comparison

	Constituents in mass fractions (%)	RON	Light isomerate		Recycle	
			Design	Design simulation	Design	Design simulation
Aliphatic	iC ₄	100	0.35	0.35	0	0
	nC ₄	94	0.09	0.09	0	0
	iC ₅	92.3	51.30	51.29	0	0
	nC ₅	61.7	16.50	16.51	0	0
	22DMB	91.8	27.76	27.13	5.60	6.40
	23DMB	103.5	0.79	1.12	12.14	11.71
	2MP	73.4	0.82	1.12	36.32	35.97
	3MP	74.5	0.08	0.05	21.18	21.23
	nC ₆	24.8	0	0	14.38	14.43
	nC ₇ ⁺	0	0	0	0.07	0.07
Naphtene	C ₅	101.6	2.31	2.33	0.05	0.01
	CH	83	0	0	3.99	3.81
	MCP	91.3	0	0	5.61	5.71
	MCH	74	0	0	0.30	0.30
	11MCH	74	0	0	0.34	0.36
Aromatic	Benzene	108	0	0	0	0
Total			100	100	100	100
RON			87.27	87.25	72.19	72.18

Detailed mass fractions and calculated RON values confirmed a close match between design and simulation results, validating the modeling approach.

3.4.3. Real operating case simulation

The simulation was extended using real operating data from April 26, 2025. Adjustments were made to input compositions and conditions to align with actual refinery conditions. The objective was to validate the model under real constraints and to identify optimization opportunities.

Table 4 Comparison between real case operating parameters and simulation results

	Simulation Results			Real Case		
	Top	Recycle	Bottom	Top	Recycle	Bottom
T (°C)	75.22	115.4	148.9	65	114	147
P (kg/cm².g)	2.1	3.015	3.2	2.1	3.0	3.2
F (m³/h)	54.99	49.01	3.002	55	55	3

Table 5 DIH Inlet composition

	Constituents in mass fractions (%)	DIH Inlet	
		Design	Real
Aliphatic	iC₄	0.19	0.09
	nC₄	0.05	0.09
	iC₅	27.78	19.49
	nC₅	8.94	7.95
	22DMB	17.4	16.85
	23DMB	5.56	5.17
	2MP	15.82	20.47
	3MP	9.01	12.1
	nC₆	6.12	8.39
	iC₇	0	1.17
	nC₇⁺	0	0.11
	iC₈	0	0.01
Naphtene	nC₈	0	0
	C₅	1.27	0.1
	CH	2.51	6.7
	C₇	3.71	1.31
	MCP	0.13	0
Aromatic	C₈	1.5	0
	Benzene	0	0
Total		100	100

Table 6 Comparison between real case composition and simulation results

	Constituents in mass fractions (%)	RON	Light isomerate			Recycle		
			Design	Real of 26/04/2025	Simulation results	Design	Real of 26/04/2025	Simulation results
Aliphatic	iC₄	100	0	0.26	0.18	0	0	0
	nC₄	94	0	0.23	0.18	0	0	0
	iC₅	92.3	42.4	40.12	39.12	0.37	0	0
	nC₅	61.7	13.73	16.16	15.96	0	0	0
	22DMB	91.8	41.31	31.71	32.45	1.41	0.35	1.46
	23DMB	103.5	0	3.27	3.70	14.49	7.89	7.09
	2MP	73.4	0.25	7.38	7.54	44.07	36.87	35.61
	3MP	74.5	0	0.48	0.65	23.33	26.29	25.08
	nC₆	24.8	0	0	0.01	13.5	19.64	17.86
	iC₇	65	0	0	0	0	0.64	0.77
	nC₇⁺	0	0	0	0	0	0.05	0.05
	iC₈	100	0	0	0	0	0	0
	nC₈	25	0	0	0	0	0	0
Naphtene	C₅	101.6	2.31	0.39	0.2	0	0	0
	CH	83	0	0	0	2.03	7.77	11.58
	C₇	85	0	0	0	0.8	0.5	0.50
	MCP	91.3	0	0	0	0	0	0
	C₈	90	0	0	0	0	0	0
Aromatic	Benzene	108	0	0	0	0	0	0
Total			100	100	100	100	100	100
RON			88.06	86.14	86.15	72.07	67.30	68.47

Chapter 4: Experimental planning and results discussion

4.1. Introduction

In this study, the optimization of the Deisohexanizer (DIH) column was carried out using a statistical experimental design approach based on the Box-Behnken methodology, implemented with Minitab software. The primary objective was to determine the optimal operating conditions of the column and to assess the individual and interactive effects of key operational parameters on its performance. Among the studied variables were the reflux rate (R), the column temperature (T), and the distillate flow rate (D), with the Research Octane Number (RON) serving as the main performance indicator.

4.2. Box-Behnken design

The experimental approach was developed within the framework of Response Surface Methodology (RSM), with the Box-Behnken Design (BBD) selected for its efficiency and suitability in quadratic modeling without requiring extreme values. The aim was to improve RON by investigating both the main and interaction effects of the operational variables. The range of studied parameters is shown in Table 7.

Table 7 Range of studied parameters

	Minimum (-1)	Middle (0)	Maximum (0)
R (m ³ /hr)	240	250	260
T(°C)	120	127.5	135
D (m ³ /hr)	45	50	55

The experimental matrix is summarized in Table 8.

Table 8 Experimental matrix of factors and responses according to the Box-Behnken design

OrdEssai	TypePt	Blocs	R	T	D	RON _{exp}	RON _{theo}
1	0	1	250	127.5	50	86.37	86.3733
2	2	1	250	135.0	55	86.10	86.1225
3	2	1	240	120.0	50	86.33	86.3187
4	2	1	250	120.0	45	86.09	86.0675
5	0	1	250	127.5	50	86.37	86.3733
6	2	1	240	127.5	45	86.08	86.1137
7	2	1	250	120.0	55	86.10	86.1200
8	2	1	260	127.5	45	86.11	86.1188
9	2	1	240	127.5	55	86.06	86.0512
10	2	1	250	135.0	45	86.09	86.0700
11	2	1	260	120.0	50	86.42	86.4338
12	2	1	260	135.0	50	86.43	86.4412
13	0	1	250	127.5	50	86.38	86.3733
14	2	1	240	135.0	50	86.33	86.3162
15	2	1	260	127.5	55	86.32	86.2862

4.2.1. Mathematical model

A second-order regression model was developed from the Box-Behnken desing to predict RON as a function of R, T, and D in their uncoded units (eq 4.1) and coded units (eq 4.2). The model includes linear, quadratic, and interaction terms:

$$RON = 84.2 - 0.1849 R + 0.0901 T + 0.744 D + 0.000258 R^2 - 0.000385 T^2 - 0.010267 D^2 + 0.000033 R \times T + 0.001150 R \times D \quad (eq 4.1)$$

$$RON = 86.3733 - 0.06 R + 0.0013 T + 0.0262 D + 0.0258 R^2 - 0.0217 T^2 - 0.2567 D^2 + 0.0025 R \times T + 0.0575 R \times D \quad (eq 4.2)$$

4.2.2. Main effects

Analysis of the main effects plot reveals that an increase in reflux rate (R) positively influences RON, confirming that enhanced internal reflux improves separation and enhances high-octane component recovery. Conversely, both column temperature (T) and distillate flow rate (D) exhibited nonlinear effects: RON peaked at intermediate values of T and D, indicating the presence of an optimal operating window.

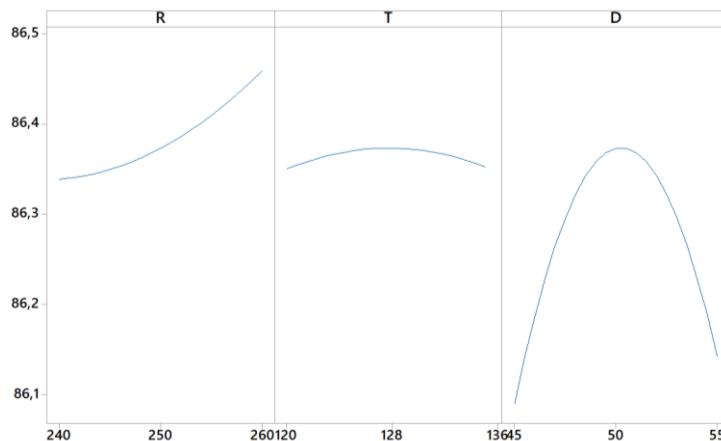


Figure 4 Main effects plot for RON

4.2.3. Normal probability plot of residuals

The residuals lie close to the straight red line, indicating that they are approximately normally distributed. This suggests that the model's errors are random and unbiased, satisfying one of the key assumptions of regression analysis. Therefore, the model used to predict RON is statistically valid and reliable. As a result, the RON prediction model is both statistically valid and credible.

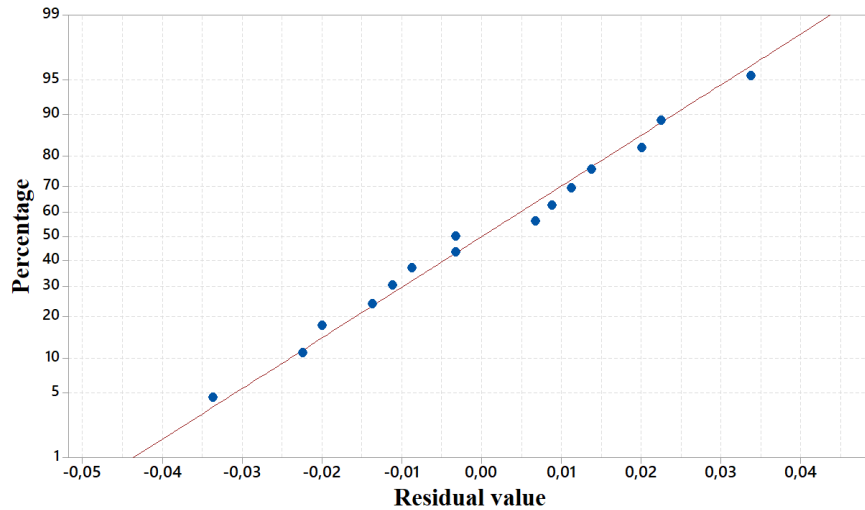


Figure 5 Henry's line

4.2.4. Analysis of variance

The p-value is used to determine the significance of factor effects. If the p-value is less than or equal to 0.05 (5% error threshold), we can conclude that the effect is significant. If the p-value is less than or equal to 0.01, the effect is highly significant. If the p-value is less than or equal to 0.001, we say that the effect is very strongly significant. [13]

Table 9 Results of the analysis of variance according to the Box-Behnken design.

Source	DL	Value of F	Value of p
Model	9	33.57	0.001
Linear	3	11.58	0.011
R	1	29.14	0.003
T	1	0.01	0.915
D	1	5.58	0.065
Square	3	84.67	0.000
R*R	1	2.49	0.175
T*T	1	1.75	0.243
D*D	1	246.11	0.000
2 factor Interactions	3	4.47	0.070
R*T	1	0.03	0.880
R*D	1	13.38	0.015
T*D	1	0.00	1.000
Error	5		
Inadéquation of ajustement	3	48.75	0.020
Pure Error	2		
Total	14		

ANOVA results presented in Table 9 show that the model is statistically significant ($p = 0.001$, $F = 33.57$). The most significant term was the quadratic effect of the distillate flow rate (D^2), with $p = 0.000$, highlighting its dominant influence. Other statistically significant terms included the linear effect of the reflux rate (R , $p = 0.003$) and its interaction with D ($R \times D$, $p = 0.015$).

4.2.5. Contour and response surfaces

Three-dimensional (3D) response surface plots and two-dimensional (2D) contour plots were employed to analyze the influence of the independent variables on the performance of the Deisohexanizer (DIH) column. These graphical tools provide a simplified yet informative representation of the interaction effects between the process parameters.

At a fixed distillate flow rate of $D = 50 \text{ m}^3/\text{hr}$, the contour plot (Figure 6) reveals a gradual increase in the Research Octane Number (RON) with rising values of both the reflux rate (R) and the column temperature (T). Optimal RON values, approaching 86.42, are observed in the upper-right region of the graph, where R exceeds $258 \text{ m}^3/\text{hr}$ and T approaches 128°C . This trend is further confirmed by the corresponding 3D surface plot, which illustrates a smooth upward curvature along both the R and T axes. The concurrent increase in RON concerning both variables indicates a synergistic interaction between reflux rate and temperature in enhancing the octane number.

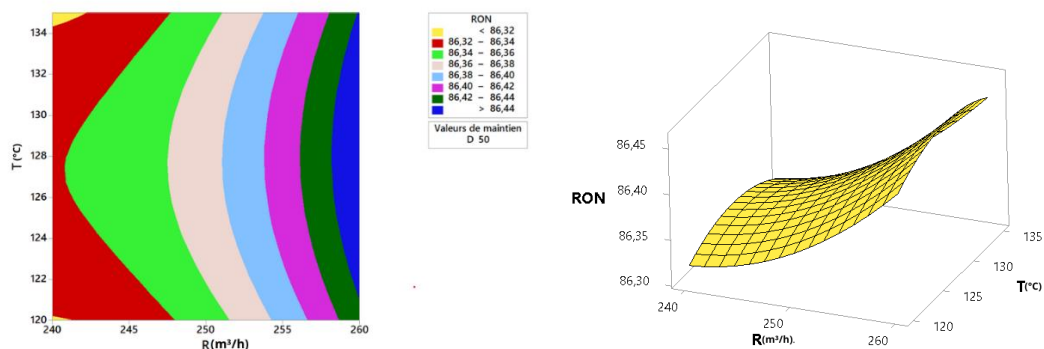


Figure 6 Contour and Surface Plots of RON vs T; R at $D = 50 \text{ m}^3/\text{h}$.

At a fixed column temperature of $T = 127.5^\circ\text{C}$, the contour plot (Figure 7) demonstrates a progressive increase in the Research Octane Number (RON) as both the reflux rate (R) and distillate flow rate (D) increase. The highest RON values, approaching 86.4, are concentrated in the central-to-right region of the graph, particularly where D is close to $50 \text{ m}^3/\text{hr}$ and R ranges between 254 and $260 \text{ m}^3/\text{hr}$. This observation suggests that elevated reflux rates, combined with moderate-to-high distillate flow rates, positively influence the enhancement of RON.

The corresponding 3D surface plot further supports this interpretation, displaying a continuous upward trend in RON with increasing R and D . The surface exhibits an incline along both parameter axes, indicating a synergistic interaction between these two variables.

This interaction implies that simultaneous increases in R and D yield improved RON values, thereby confirming their combined positive impact on column performance.

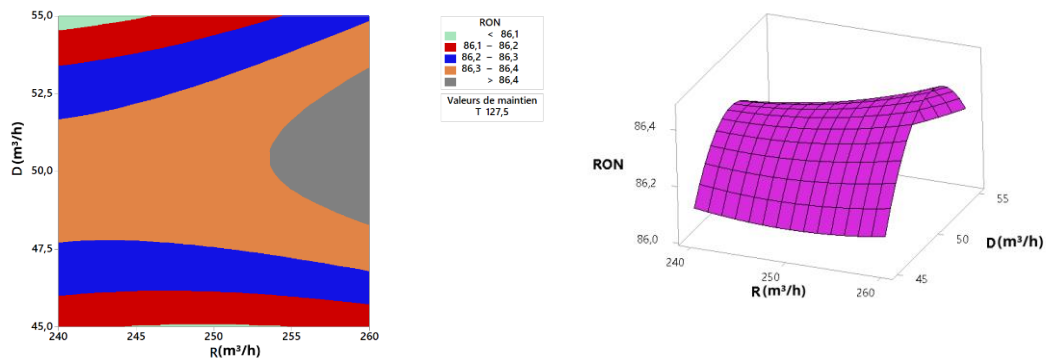


Figure 7 Contour and Surface Plots of RON vs R;D at T = 127,5°C.

At a fixed reflux rate of R = 250 m³/hr, the contour plot (Figure 8) illustrates notable variation in the Research Octane Number (RON) in response to changes in both column temperature (T) and distillate flow rate (D). The highest RON values, approaching 86.35, are concentrated within a central elliptical region of the plot, particularly where D is approximately 50 m³/hr and T ranges from 126 °C to 130 °C. These results indicate that optimal RON values are achieved under intermediate temperature and moderate distillate conditions.

The corresponding 3D surface plot confirms this trend, showing a centrally peaked surface where RON plateaus, especially when D remains near 50 m³/hr and T increases gradually. This visual evidence reinforces the conclusion that a significant interaction exists between T and D, and that their combined effect contributes to maximizing RON. The optimal response is thus attained within a specific mid-range window of both variables, highlighting the importance of balanced operating conditions for efficient column performance.

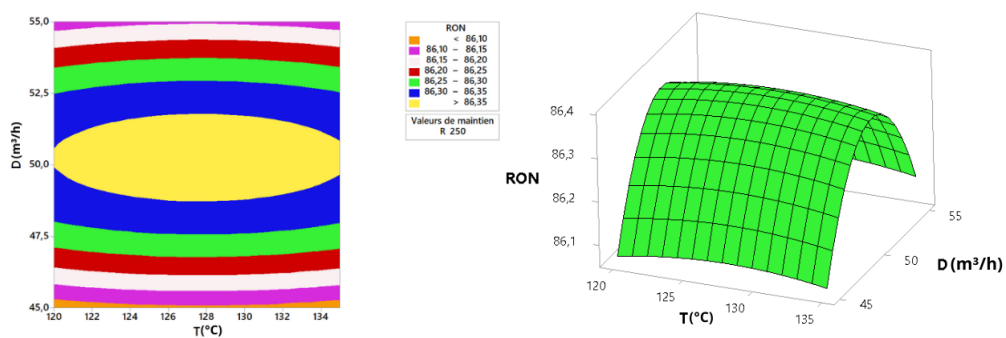


Figure 8 Contour and Surface Plots of RON vs D;T at R= 250 m³/h.

4.2.6. Optimization

Given that the experimental design method can be used to optimize the parameters influencing

the deisohexanizer column performance, a constrained optimization was carried out. The conditions applied in this optimization are presented in Table 10.

Table 10 Optimization settings

Response	Goal	Lower	Target	Higher	Weight	Importance
RON	Maximum	86.06	86.43	/	1	1

After several optimizations, it was found that the optimization process yielded the following optimal conditions: a reflux rate (R) of 260 m³/h, a column temperature (T) of 128.18 °C, and a distillate flowrate (D) of 50.86 m³/h. Under these conditions, the predicted RON reached 86.4661, with a composite desirability value of 1.000, indicating an ideal solution within the design space.

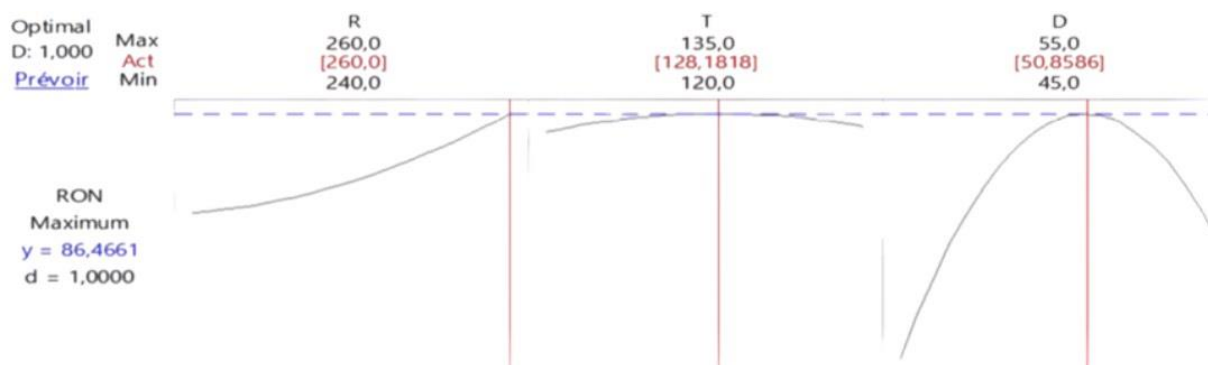


Figure 9 Optimization diagram

To verify the reliability of these results, the optimized parameters were applied in Aspen HYSYS for dynamic simulation of the DIH column. The simulation converged successfully, confirming stable operation and consistent behavior across the column. The top, recycle, and bottom sections exhibited temperatures of 73.86 °C, 114.00 °C, and 141.50 °C, respectively, with corresponding pressures of 2.10, 3.015, and 3.20 kg/cm².g, and flow rates of 50.86, 50.15, and 5.996 m³/hr.

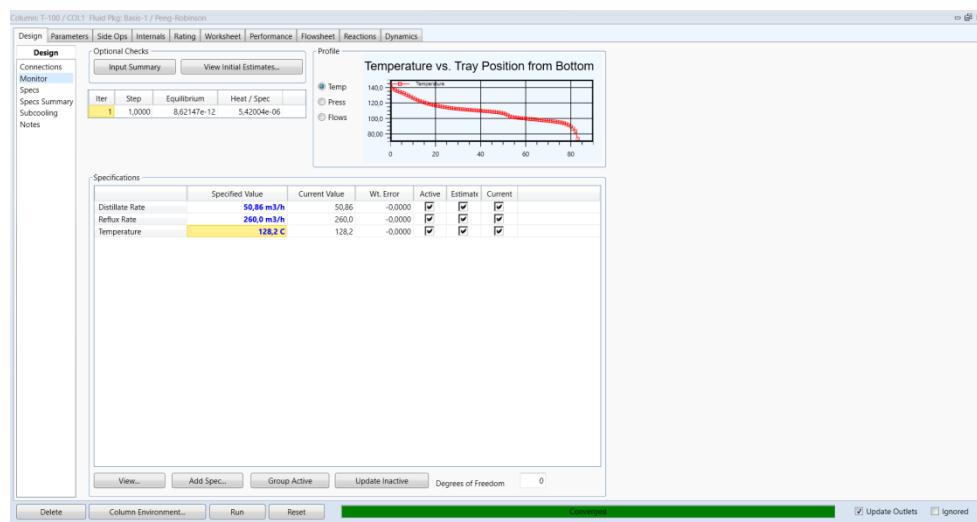


Figure 10 Monitor of DIH column

The DIH column simulation successfully converged with stable and consistent parameter values throughout the column, indicating reliable operation under the specified conditions.

Table 11 Optimized operating parameter values for the column

	Optimization Results		
	Top	Recycle	Bottom
T (°C)	73.86	114	141.5
P (kg/cm².g)	2.1	3.015	3.2
F (m³/h)	50.86	50.15	5.996

	DIH Inlet	Light isomerate	Recycle	Heavy isomerate
i-Butane	0.0013	0.0036	0.0000	0.0000
n-Butane	0.0013	0.0036	0.0000	0.0000
i-Pentane	0.2212	0.4529	0.0000	0.0000
n-Pentane	0.0902	0.1847	0.0000	0.0000
2,2-Dimethylbutane	0.1601	0.3036	0.0262	0.0000
2,3-Dimethylbutane	0.0491	0.0195	0.0878	0.0001
n-Hexane	0.0797	0.0000	0.1728	0.0278
2-Methylpentane	0.1945	0.0300	0.3984	0.0034
3-Methylpentane	0.1150	0.0017	0.2326	0.0020
n-Heptane	0.0009	0.0000	0.0004	0.0118
2-Methylhexane	0.0096	0.0000	0.0050	0.1207
n-Octane	0.0000	0.0000	0.0000	0.0000
2-Methylheptane	0.0001	0.0000	0.0000	0.0010
Cyclopentane	0.0012	0.0024	0.0000	0.0000
Cyclohexane	0.0023	0.0000	0.0206	0.0066
Cycloheptane	0.0109	0.0000	0.0042	0.1496
Cyclooctane	0.0000	0.0000	0.0000	0.0000
Methylcyclopentane	0.0000	0.0000	0.0000	0.0000
Benzene	0.0000	0.0000	0.0000	0.0000

Figure 11 Molar composition of column streams after optimization

The simulated RON under these conditions was 86.4621, closely matching the predicted value from the optimization model. Furthermore, the mass fraction of 2-methylpentane (2MP), a low-octane component, was significantly reduced from 7.38% to 3.35%, confirming improved separation efficiency and enhanced product quality. These findings validate both the statistical model and the effectiveness of the applied optimization strategy in improving DIH column performance.

4.3. Discussion

This study confirms the effectiveness of using the Box-Behnken design combined with Aspen HYSYS simulation to optimize the Deisohexanizer (DIH) column. The reflux rate (R) had the strongest positive effect on RON, consistent with Shehata et al. [9], who showed that higher reflux enhances the recovery of high-octane isomers. Temperature (T) and distillate flow rate (D) showed nonlinear effects, with optimal RON observed at intermediate values. These findings align with Chuzlov et al [8]., who noted that exceeding 135 °C leads to reduced selectivity due to hydrocracking.

ANOVA confirmed the high significance of the D² term (p = 0.000), highlighting distillate rate as a critical factor, in agreement with Hajghani et al. [4] A meaningful R×D interaction (p = 0.015) also confirmed the need to adjust variables in combination, as discussed by Awan et al.

[11] The simulation results validated the model, with a predicted RON of 86.4661 closely matching the simulated 86.4621. The reduced 2MP content (from 7.38% to 3.35%) confirmed improved separation. These results support the conclusions of Ivanchina et al. [14], emphasizing the importance of coupling separation modeling with experimental design for accurate octane optimization.

General Conclusion

The primary objective of this study was to assess and optimize the performance of the Deisohexanizer (DIH) column in order to enhance gasoline quality, specifically by improving the Research Octane Number (RON), while maintaining operational stability and minimizing unnecessary energy consumption. By employing a statistical experimental design based on the Box-Behnken methodology and simulating the process using Aspen HYSYS, the influence of three key operating parameters: reflux rate (R), column temperature (T), and distillate flow rate (D), was systematically evaluated.

The methodology proved effective in identifying the optimal operating conditions that maximize RON. A maximum RON of 86.4661 was achieved at a column temperature of 128.18 °C, a reflux rate of 260 m³/hr, and a distillate flow rate of 50.86 m³/hr. These experimental results were validated through dynamic simulation in Aspen HYSYS, which confirmed the RON value with a high degree of accuracy (86.4621), thereby reinforcing the reliability of the model.

In addition to RON enhancement, the optimization significantly reduced the concentration of 2-methylpentane, a low-octane isomer, from 7.38% to approximately 3.35%, thereby improving the purity and overall quality of the isomerate product. This outcome highlights the dual benefit of the optimization process : enhancing performance and refining product selectivity.

From an industrial standpoint, the optimized conditions offer both economic and operational advantages. Improved product selectivity, reduced internal hydrocarbon circulation, and lower reprocessing needs contribute to decreased energy losses and less strain on separation units. These factors collectively enhance operational efficiency and process sustainability.

Moreover, the study underscores the critical importance of precise control and real-time optimization in distillation processes, particularly in isomerization units where even slight fluctuations in process variables can significantly affect product quality. The use of response surface methodology enabled a better understanding of the nonlinear and interactive effects between variables, revealing insights that would be difficult to obtain through conventional trial-and-error approaches.

This work also reflects the evolving nature of modern refining strategies, where the integration of process simulation and statistical optimization becomes essential for informed decision-making. The methodology presented here can be successfully extended to other distillation columns to improve operational performance, product quality, and energy efficiency.

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Apendix
of the final year project

**Simulation, Analysis and Optimization of the
Deisohexanizer (DIH) Column in the Isomerization
Unit (U.700/701) of RA1K**

Component properties



Process licensing

COMPONENT PROPERTIES

Job Number	Unit	Type	Page
06-2798	701	ICP	1/1

Client :	NAFTEC, Spa	Date	By	Check by	Iss.
	Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit :	Light Naphtha Isomerization Unit - I				
Run case :	FEED RA1K - CASE SOR				

Component	Molecular Weight kg/kmol	Density * kg/m3	Normal Boiling Point °C
H2	2.02	69.93	-253
C1	16.04	299.7	-161
C2	30.07	356.0	-89
C3	44.10	507.2	-42
IC4	58.12	562.4	-12
NC4	58.12	584.4	-1
IC5	72.15	624.4	28
NC5	72.15	630.4	36
22MB	86.18	653.4	50
23MB	86.18	665.3	58
2MP	86.18	657.4	60
3MP	86.18	668.3	63
NC6	86.18	663.3	69
CP	70.14	749.3	49
MCP	84.16	752.3	72
BENZENE	78.12	883.9	80
CH	84.16	782.2	81
NC7	100.21	687.3	98
MCH	98.19	773.2	101
11MCH	112.22	784.5	120
H2O	18.01	998.6	100

* Liquid density at 15°C or 60°F
REF: MOUTOU 4 11:01:24 AIO_1.46 P7.1

Weight composition of different streams



Process licensing

MATERIAL BALANCE (WEIGHT PERCENT)

Job Number	Unit	Type	Page
06-2798	701	1WP	6/11

Client :	NAFTEC, Spa	Date	By	Check by	Iss.
	Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit :	Light Naphtha Isomerization Unit - I				
Run case :	FEED RA1K - CASE SOR				

Flow rate unit : wt %	Stabilizer off gases to scrubber	Stabilizer reboiler inlet	Stabilizer reboiler outlet	Stabilizer bottom
	21	22	23	24
H2	11.02	0.00	0.00	0.00
C1	0.22	0.00	0.00	0.00
C2	0.00	0.00	0.00	0.00
C3	3.46	0.00	0.00	0.00
IC4	58.51	0.23	0.23	0.19
NC4	4.45	0.06	0.06	0.05
IC5	20.09	29.52	29.52	27.78
NC5	1.91	9.30	9.30	8.94
22MB	0.22	17.22	17.22	17.40
23MB	0.02	5.40	5.40	5.56
2MP	0.04	15.31	15.31	15.82
3MP	0.01	8.66	8.66	9.01
NC6	0.00	5.81	5.81	6.12
CP	0.05	1.28	1.28	1.27
MCP	0.00	2.37	2.37	2.51
BENZENE	0.00	0.00	0.00	0.00
CH	0.00	3.44	3.44	3.71
NC7	0.00	0.12	0.12	0.13
MCH	0.00	0.54	0.54	0.61
11MCH	0.00	0.76	0.76	0.89
H2O	0.00	0.00	0.00	0.00

Total	kg/h	779	324 393	324 393	56 142
Total	kmol/h	54.17	4 060.02	4 060.02	699.61

MATERIAL BALANCE (WEIGHT PERCENT)

Job Number	Unit	Type	Page
06-2798	701	IWP	7/11

Client :	NAFTEC, Spa	Date	By	Check by	Iss.
	Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit :	Light Naphtha Isomerization Unit - I				
Run case :	FEED RAIK - CASE SOR				

Flow rate unit : wt %	DIH pumparound HX tube side outlet	DIH inlet	DIH overhead	DIH air condenser outlet	
	25	26	27	28	
H2	0.00	0.00	0.00	0.00	
C1	0.00	0.00	0.00	0.00	
C2	0.00	0.00	0.00	0.00	
C3	0.00	0.00	0.00	0.00	
IC4	0.19	0.19	0.35	0.35	
NC4	0.05	0.05	0.09	0.09	
IC5	27.78	27.78	51.30	51.30	
NC5	8.94	8.94	16.50	16.50	
22MB	17.40	17.40	27.76	27.76	
23MB	5.56	5.56	0.79	0.79	
2MP	15.82	15.82	0.82	0.82	
3MP	9.01	9.01	0.08	0.08	
NC6	6.12	6.12	0.00	0.00	
CP	1.27	1.27	2.31	2.31	
MCP	2.51	2.51	0.00	0.00	
BENZENE	0.00	0.00	0.00	0.00	
CH	3.71	3.71	0.00	0.00	
NC7	0.13	0.13	0.00	0.00	
MCH	0.61	0.61	0.00	0.00	
11MCH	0.89	0.89	0.00	0.00	
H2O	0.00	0.00	0.00	0.00	
Total	kg/h	56 142	56 142	152 000	152 000
Total	kmol/h	699.61	699.61	2 009.31	2 009.31



MATERIAL BALANCE (WEIGHT PERCENT)

Job Number 06-2798	Unit 701	Type 1WP	Page 8/11
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Client : NAFTEC, Spa	Date	By	Check by	Iss.
Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit : Light Naphtha Isomerization Unit - I				
Run case : FEED RA1K - CASE SOR				

Flow rate unit : wt %	DIH reflux	DIH draw-off	DIH pumparound HX shell side inlet	DIH pumparound HX shell side outlet
	29	30	31	32
H2	0.00	0.00	0.00	0.00
C1	0.00	0.00	0.00	0.00
C2	0.00	0.00	0.00	0.00
C3	0.00	0.00	0.00	0.00
IC4	0.35	0.00	0.00	0.00
NC4	0.09	0.00	0.00	0.00
IC5	51.30	0.00	0.00	0.00
NC5	16.50	0.00	0.00	0.00
22MB	27.76	5.60	5.60	5.60
23MB	0.79	12.14	12.14	12.14
2MP	0.82	36.32	36.32	36.32
3MP	0.08	21.18	21.18	21.18
NC6	0.00	14.38	14.38	14.38
CP	2.31	0.05	0.05	0.05
MCP	0.00	5.61	5.61	5.61
BENZENE	0.00	0.00	0.00	0.00
CH	0.00	3.99	3.99	3.99
NC7	0.00	0.07	0.07	0.07
MCH	0.00	0.30	0.30	0.30
11MCH	0.00	0.34	0.34	0.34
H2O	0.00	0.00	0.00	0.00
Total	kg/h	121 600	53 700	29 942
Total	kmol/h	1 607.45	623.86	347.85



MATERIAL BALANCE (WEIGHT PERCENT)

Job Number 06-2798	Unit 701	Type 1WP	Page 9/11
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Client : NAFTEC, Spa	Date	By	Check by	Iss.
Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit : Light Naphtha Isomerization Unit - I				
Run case : FEED RA1K - CASE SOR				

Flow rate unit : wt %	DIH reboiler inlet	DIH reboiler outlet	DIH bottom	DIH distillate
	33	34	35	36
H2	0.00	0.00	0.00	0.00
C1	0.00	0.00	0.00	0.00
C2	0.00	0.00	0.00	0.00
C3	0.00	0.00	0.00	0.00
IC4	0.00	0.00	0.00	0.35
NC4	0.00	0.00	0.00	0.09
IC5	0.00	0.00	0.00	51.30
NC5	0.00	0.00	0.00	16.50
22MB	0.00	0.00	0.00	27.76
23MB	0.01	0.01	0.01	0.79
2MP	0.04	0.04	0.03	0.82
3MP	0.14	0.14	0.12	0.08
NC6	1.12	1.12	0.96	0.00
CP	0.00	0.00	0.00	2.31
MCP	4.22	4.22	3.79	0.00
BENZENE	0.00	0.00	0.00	0.00
CH	60.12	60.12	57.17	0.00
NC7	2.91	2.91	2.98	0.00
MCH	12.99	12.99	13.80	0.00
11MCH	18.45	18.45	21.15	0.00
H2O	0.00	0.00	0.00	0.00
Total	kg/h	489 744	489 744	1 984
Total	kmol/h	5 413.72	5 413.72	21.74



Operating settings



Process licensing

HEAT BALANCE

Job Number 06-2798	Unit 701	Type 1HB	Page 6/11
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Client :	NAFTEC, Spa	Date	By	Check by	Iss.
	Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit :	Light Naphtha Isomerization Unit - I				
Run case :	FEED RAIK - CASE SOR				

	Stabilizer off gases to scrubber 21	Stabilizer reboiler inlet 22	Stabilizer reboiler outlet 23	Stabilizer bottom 24
Temperature °C	39	177	178	178
Pressure kg/cm ² g	11.1	19.3	19.3	19.3
TOTAL STREAM				
Weight rate kg/h	779	324 393	324 393	56 142
Molar rate kmol/h	54.17	4 060.02	4 060.02	699.61
Enthalpy Mkcal/h	0.10	35.09	38.87	6.11
Density kg/m ³	6.631	450.1	180.6	450.5
Mol. Weight kg/kmol	14.39	79.90	79.90	80.25
Wt pc vapor %	100.00		25.00	
Wt pc free water %	0.00	0.00	0.00	0.00
Vapor Pressure kg/cm ² a		20.3		20.3
TOTAL VAPOR				
Weight rate kg/h	779		81 098	
Molar rate kmol/h	54.17		1 028.19	
Volumetric rate m ³ /h	117.5		1 256.5	
Normal vapor rate Nm ³ /h	1 214.1		23 045.9	
Enthalpy Mkcal/h	0.10		12.39	
Spec. Enthalpy kcal/kg	133.1		152.8	
Density kg/m ³	6.631		64.54	
Mol. Weight kg/kmol	14.39		78.87	
Viscosity cP	0.012		0.012	
Thermal Cond. kcal/h.m.°C	0.046		0.029	
Specific Heat kcal/kg.°C	0.756		0.752	
Cp/Cv	1.237		1.308	
Comp. factor	0.991		0.648	
TOTAL LIQUID				
Weight rate kg/h		324 393	243 295	56 142
Molar rate kmol/h		4 060.02	3 031.82	699.61
Volumetric rate m ³ /h		720.8	540.1	124.6
Std liquid rate m ³ /h		496.6	371.7	85.8
Enthalpy Mkcal/h		35.09	26.48	6.11
Spec. Enthalpy kcal/kg		108.2	108.8	108.8
Spec. Gravity		0.6539	0.6553	0.6553
Density kg/m ³		450.1	450.5	450.5
Mol. Weight kg/kmol		79.90	80.25	80.25
Viscosity cP		0.064	0.064	0.064
Thermal Cond. kcal/h.m.°C		0.064	0.063	0.063
Specific Heat kcal/kg.°C		0.799	0.799	0.799
Surf. Tension dyn/cm		2.3	2.3	2.3
DRY LIQUID				
Weight rate kg/h		324 393	243 295	56 142
Spec. Gravity		0.6538	0.6553	0.6553
Density kg/m ³		450.1	450.5	450.5
Crit. Pressure kg/cm ² a		33.3	33.3	33.3

Job Number	Unit	Type	Page
06-2798	701	1HB	7/11

Client :	NAFTEC, Spa	Date	By	Check by	Iss.
	Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit :	Light Naphtha Isomerization Unit - I				
Run case :	FEED RAIK - CASE SOR				

	DIH pumparound HX tube side outlet	DIH inlet	DIH overhead	DIH air condenser outlet
	25	26	27	28
Temperature °C	125	93	80	60
Pressure kg/cm ² g	17.4	2.8	2.6	2.1
TOTAL STREAM				
Weight rate kg/h	56 142	56 142	152 000	152 000
Molar rate kmol/h	699.61	699.61	2 009.31	2 009.31
Enthalpy Mkcal/h	4.02	4.02	17.41	4.82
Density kg/m ³	533.7	34.13	10.07	589.2
Mol. Weight kg/kmol	80.25	80.25	75.65	75.65
Wt pc vapor %		29.91	100.00	
Wt pc free water %	0.00	0.00	0.00	0.00
Vapor Pressure kg/cm ² a	8.2			2.3
TOTAL VAPOR				
Weight rate kg/h		16 794	152 000	
Molar rate kmol/h		214.46	2 009.31	
Volumetric rate m ³ /h		1 576.9	15 096.1	
Normal vapor rate Nm ³ /h		4 806.8	45 036.7	
Enthalpy Mkcal/h		2.03	17.41	
Spec. Enthalpy kcal/kg		121.0	114.6	
Density kg/m ³		10.65	10.07	
Mol. Weight kg/kmol		78.31	75.65	
Viscosity cP		0.0087	0.0085	
Thermal Cond. kcal/h.m.°C		0.018	0.017	
Specific Heat kcal/kg.°C		0.494	0.482	
Cp/Cv		1.088	1.092	
Comp. factor		0.901	0.904	
TOTAL LIQUID				
Weight rate kg/h	56 142	39 348		152 000
Molar rate kmol/h	699.61	485.16		2 009.31
Volumetric rate m ³ /h	105.2	68.2		258.0
Std liquid rate m ³ /h	85.8	59.8		239.0
Enthalpy Mkcal/h	4.02	1.99		4.82
Spec. Enthalpy kcal/kg	71.6	50.5		31.7
Spec. Gravity	0.6553	0.6588		0.6366
Density kg/m ³	533.7	577.1		589.2
Mol. Weight kg/kmol	80.25	81.10		75.65
Viscosity cP	0.11	0.15		0.17
Thermal Cond. kcal/h.m.°C	0.079	0.089		0.098
Specific Heat kcal/kg.°C	0.655	0.612		0.586
Surf. Tension dyn/cm	6.8	10.2		11.8
DRY LIQUID				
Weight rate kg/h	56 142	39 348		152 000
Spec. Gravity	0.6553	0.6588		0.6366
Density kg/m ³	533.7	577.1		589.2
Crit. Pressure kg/cm ² a	33.3	33.2		34.0

Job Number 06-2798	Unit 701	Type 1HB	Page 8/11
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Client : NAFTEC, Spa Adaptation Project, SKIKDA Refinery, ALGERIA	Date	By	Check by	Iss.
	June 07	LMO	GCI	0
Unit : Light Naphtha Isomerization Unit - I				
Run case : FEED RA1K - CASE SOR				

	DIH reflux 29	DIH draw-off 30	DIH pumparound HX shell side inlet 31	DIH pumparound HX shell side outlet 32
Temperature °C	60	112	112	116
Pressure kg/cm ² g	2.6	3.0	3.5	3.0
TOTAL STREAM				
Weight rate kg/h	121 600	53 700	29 942	29 942
Molar rate kmol/h	1 607.45	623.86	347.85	347.85
Enthalpy Mkcal/h	3.86	3.35	1.87	3.96
Density kg/m ³	589.3	571.4	571.6	11.66
Mol. Weight kg/kmol	75.65	86.08	86.08	86.08
Wt pc vapor %				100.00
Wt pc free water %	0.00	0.00	0.00	0.00
Vapor Pressure kg/cm ² a	2.3	4.0	4.0	
TOTAL VAPOR				
Weight rate kg/h				29 942
Molar rate kmol/h				347.85
Volumetric rate m ³ /h				2 567.7
Normal vapor rate Nm ³ /h				7 796.7
Enthalpy Mkcal/h				3.96
Spec. Enthalpy kcal/kg				132.2
Density kg/m ³				11.66
Mol. Weight kg/kmol				86.08
Viscosity cP				0.0089
Thermal Cond. kcal/h.m.°C				0.019
Specific Heat kcal/kg.°C				0.517
Cp/Cv				1.079
Comp. factor				0.894
TOTAL LIQUID				
Weight rate kg/h	121 600	53 700	29 942	
Molar rate kmol/h	1 607.45	623.86	347.85	
Volumetric rate m ³ /h	206.4	94.0	52.4	
Std liquid rate m ³ /h	191.2	80.0	44.6	
Enthalpy Mkcal/h	3.86	3.35	1.87	
Spec. Enthalpy kcal/kg	31.7	62.4	62.4	
Spec. Gravity	0.6366	0.6717	0.6717	
Density kg/m ³	589.3	571.4	571.6	
Mol. Weight kg/kmol	75.65	86.08	86.08	
Viscosity cP	0.17	0.14	0.14	
Thermal Cond. kcal/h.m.°C	0.098	0.084	0.084	
Specific Heat kcal/kg.°C	0.586	0.632	0.632	
Surf. Tension dyn/cm	11.8	9.4	9.4	
DRY LIQUID				
Weight rate kg/h	121 600	53 700	29 942	
Spec. Gravity	0.6366	0.6717	0.6717	
Density kg/m ³	589.3	571.4	571.6	
Crit. Pressure kg/cm ² a	34.0	32.0	32.0	

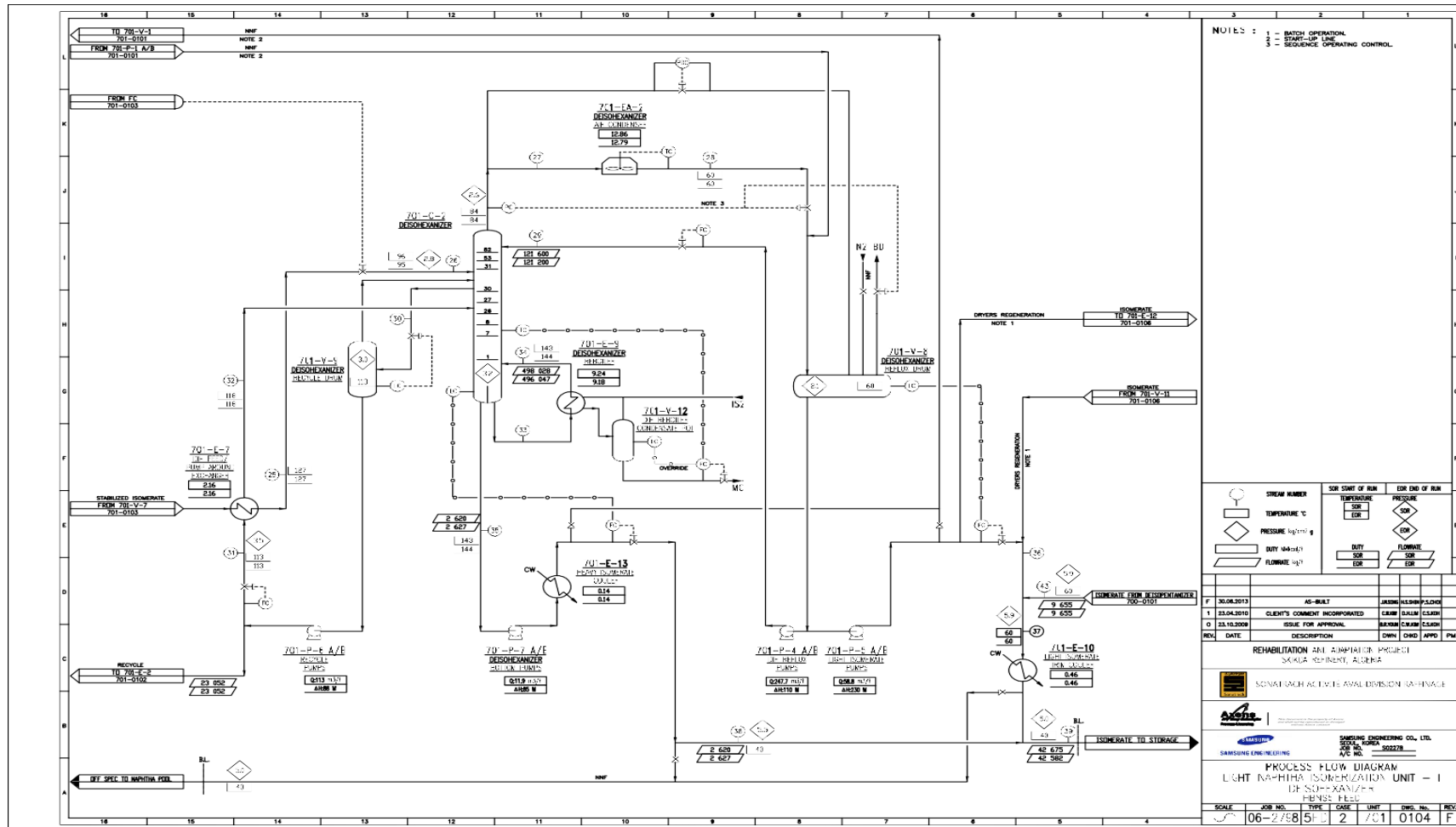


Job Number 06-2798	Unit 701	Type 1HB	Page 9/11
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Client : NAFTEC, Spa	Date	By	Check by	Iss.
Adaptation Project, SKIKDA Refinery, ALGERIA	June 07	LMO	GCI	0
Unit : Light Naphtha Isomerization Unit - I				
Run case : FEED RAIK - CASE SOR				

	DIH reboiler inlet 33	DIH reboiler outlet 34	DIH bottom 35	DIH distillate 36
Temperature °C	143	144	144	60
Pressure kg/cm ² g	3.2	3.2	3.2	5.9
TOTAL STREAM				
Weight rate kg/h	489 744	489 744	1 984	30 400
Molar rate kmol/h	5 413.72	5 413.72	21.74	401.86
Enthalpy Mkcal/h	34.76	43.83	0.14	0.96
Density kg/m ³	651.4	44.04	651.0	590.0
Mol. Weight kg/kmol	90.46	90.46	91.24	75.65
Wt pc vapor %		25.00		
Wt pc free water %	0.00	0.00	0.00	0.00
Vapor Pressure kg/cm ² a	4.2		4.2	2.3
TOTAL VAPOR				
Weight rate kg/h		122 436		
Molar rate kmol/h		1 388.20		
Volumetric rate m ³ /h		10 555.5		
Normal vapor rate Nm ³ /h		31 115.0		
Enthalpy Mkcal/h		17.50		
Spec. Enthalpy kcal/kg		142.9		
Density kg/m ³		11.60		
Mol. Weight kg/kmol		88.20		
Viscosity cP		0.0098		
Thermal Cond. kcal/h.m.°C		0.021		
Specific Heat kcal/kg.°C		0.480		
Cp/Cv		1.078		
Comp. factor		0.903		
TOTAL LIQUID				
Weight rate kg/h	489 744	367 308	1 984	30 400
Molar rate kmol/h	5 413.72	4 025.52	21.74	401.86
Volumetric rate m ³ /h	751.8	564.3	3.0	51.5
Std liquid rate m ³ /h	631.7	473.6	2.6	47.8
Enthalpy Mkcal/h	34.76	26.33	0.14	0.96
Spec. Enthalpy kcal/kg	71.0	71.7	71.7	31.7
Spec. Gravity	0.7760	0.7763	0.7763	0.6366
Density kg/m ³	651.4	651.0	651.0	590.0
Mol. Weight kg/kmol	90.46	91.24	91.24	75.65
Viscosity cP	0.16	0.16	0.16	0.17
Thermal Cond. kcal/h.m.°C	0.083	0.083	0.083	0.098
Specific Heat kcal/kg.°C	0.585	0.586	0.586	0.586
Surf. Tension dyn/cm	11.7	11.7	11.7	11.8
DRY LIQUID				
Weight rate kg/h	489 744	367 308	1 984	30 400
Spec. Gravity	0.7760	0.7763	0.7763	0.6366
Density kg/m ³	651.4	651.0	651.0	590.0
Crit. Pressure kg/cm ² a	38.4	38.1	38.1	34.0

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Process flow diagram for light naphtha isomerization unit 701 (Deisohexanizer 701-C-2)