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New Method of Corrosion in Isomerization Units

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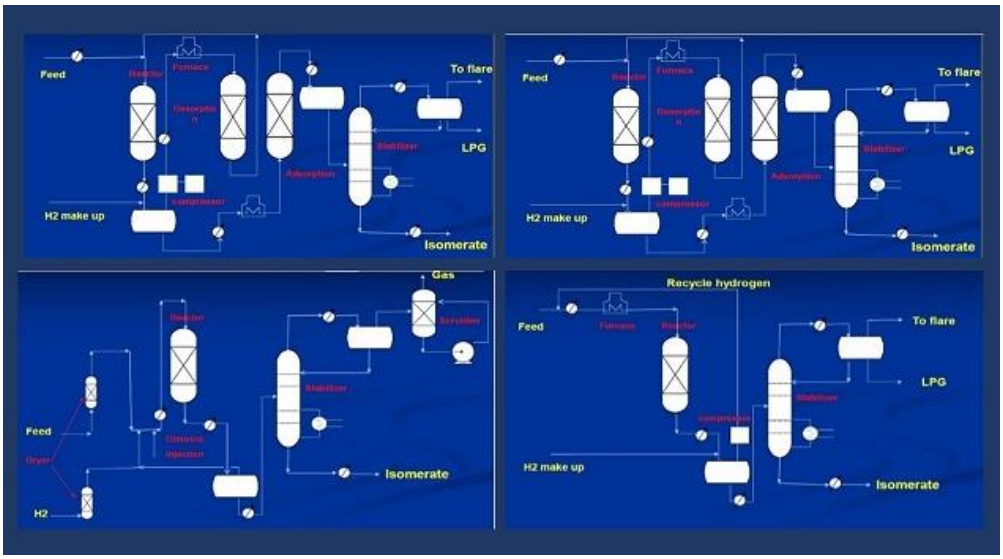
ABSTRACT

Naphtha isomerization is one of the reactions present in catalytic conversion process of heavy naphtha. The catalyst is highly active at 80-100 °C; however, due to corrosion, environmental issues, and the lack of appropriate selectivity, it has not been commonly used. In addition, since naphtha conversion catalysts act at 320-450 °C and at this temperature isomerization is not appropriately done, the catalyst did not show good activity in isomerization of light alkanes. The presence of a known concentration of HCl on the catalyst surface will cause the Bronsted places to have stability and maintain the catalytic activity during the reaction. In this research study, the conditional contract arrangement was utilized to extract the relevant knowledge in isomerization for 3 major factors: H_2/HC, optimum pH and acidic site in catalyst. Results revealed that, the best range of temperature of light Naphtha in feed was less 30 °C, pressure of recycle gas was more than 35 bar, the H_2/HC was less than 0.05, conditions of feed (temperature was less than 35 °C, pressure was more than 19 bar), optimum pH was less than 5.5 and the ratio of metal and acidic site in catalyst was under 6.

GRAPHICAL ABSTRACT



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Introduction

Due to the environmental concerns regarding benzene and aromatic compounds in gasoline structure, environmental organizations in the world demand to eliminate it. Adding tetraethyl led to gasoline with low octane number, which traditionally was used to increase the octane number, has been stopped due to lead hazards. Compounds such as methyl *tert*-butyl ether, which was considered as a substitute for tetraethyl lead, should also be banned because of serious environmental problems it creates. Although many studies have been conducted to find suitable additives, pentane and hexane isomerization process can serve as an appropriate alternative for increasing the octane number of gasolines [1, 2]. The number of isomers of hydrocarbons increases exponentially with the number of carbon atoms. Determining the thermodynamic properties of these compounds is not possible through vitro methods. Smith showed thermodynamic calculations of ideal gases in equilibrium in a group can be done in two stages: According to the Samimi Results in his article (2020) isomers of a group are considered as a matter and then molar ratio of the mixture in equilibrium is calculated [3]. Thermodynamic properties depend on isomer ratio of the group and their sum is considered as thermodynamic property of isomer mixture. For example, for *n*-hexane, isomers mixture can contain 2 MP, 3 MP, 2, 2 DMB 2, 3 DMB. The molar ratio of isomers in the mixture while in equilibrium depends only on the temperature. The values of thermodynamic parameters for three types of olefin isomers of hexane, Pantene and butane were calculated by Alberti while the values for the rest of olefins are estimated by extrapolation. Figure 1 and 2 reveal the isomerization unit (reactor and stabilizer section and compressor section).

Main Chemical Reaction

Chemical Reaction: Paraffin C_5/C_6 isomerization reactions in the unit Penex/DIH. The octanes presented in this section are for pure elements. Feed process includes light naphtha. Therefore, isomerization reaction has three stages:

- Disposal of normal paraffin molecules on the location of the dehydrogenation and hydrogenation which results in normal olefin dehydrogenation
- Disposal of normal paraffin from dehydrogenation sites and releasing it to places with regular structure that changes olefins to iso-olefins.
- Dehydrogenation of iso-elfin molecules to iso-paraffin.

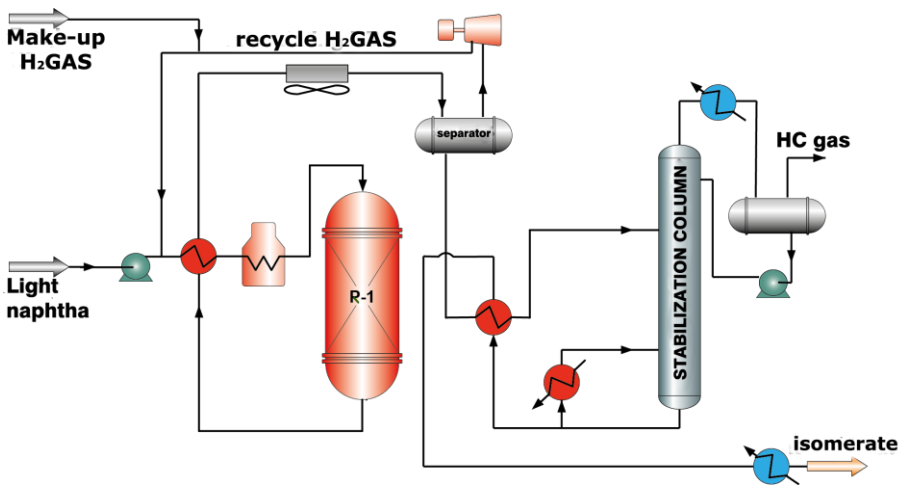

Figure 1. The schematic of isomerization unit (Reactor and stabilizer section)

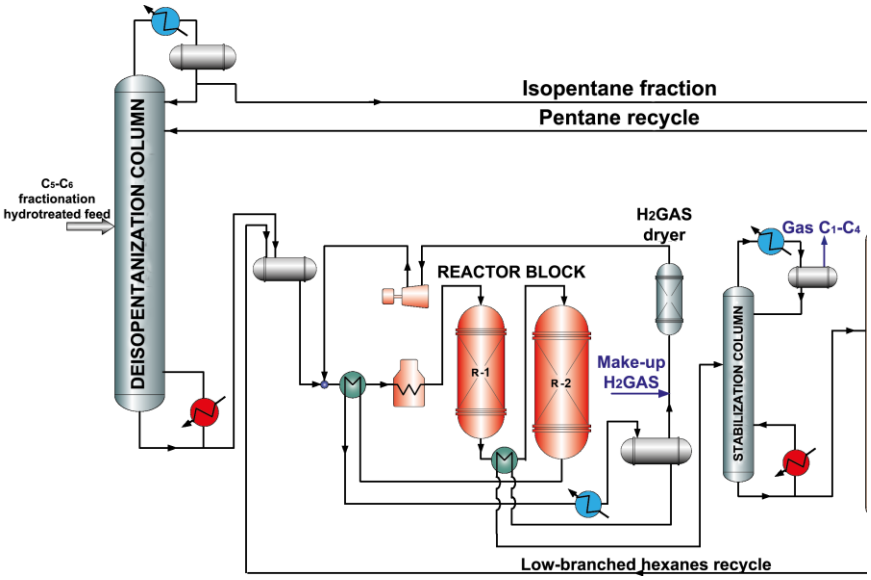

Figure 2. The schematic of isomerization unit (compressor section)

Generally, normal paraffin dehydrogenation can be carried out through the bilateral function below:

N-Paraffin → N-Olefin→ i-Olefin→ i-Paraffin (1)

According to the Samimi Results in his article (2019) light Naphtha isomerization process is a complex chemical reaction networks where some kinds of reactions find acidic and metal-catalyst sites [4]. Therefore, the mathematical model of isomerization process is a very important tool in the oil refining industry. This makes laboratory data change to parameters that are used as the basis for process optimization in commercial reactors. Figure 3 and 4 demonstrate the De-isohexanizer, unconverted hydrogen and *n*-paraffin's in isomerization unit.

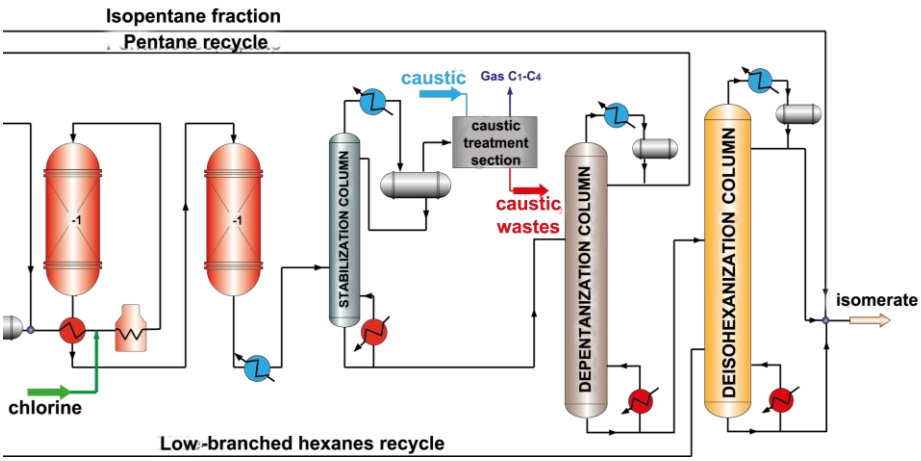

Figure 3. The schematic of isomerization unit (De-isohexanizer Section)

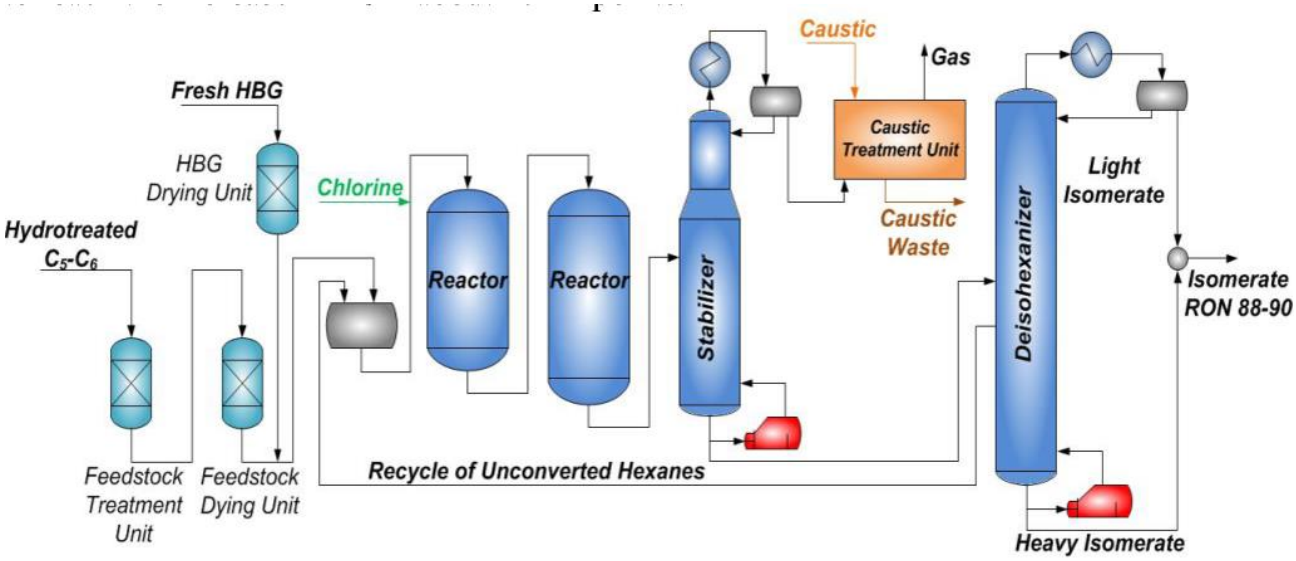

Figure 4. The schematic of isomerization unit (Unconverted hydrogen and N-paraffin's)

Research Background

According to the Samimi Results in his article four factors knowledge in catalytic reforming Units (CRU), density, pH, SFe and H_2S, the obtained results the best range of density (in Feed) is less than 0.515 kg/m^3, pH (water in vessels) is more than 6.7, Iron(II) sulphide (SFe) is less than 1.5 ppm and H_2S in recycle gas is less than 700 ppm.

In 2019 Zarinabadi *et al.* wrote the article about the catalytic conversion of naphtha is a refinery process in which heavy naphtha feeds through the catalytic bed of several reactors at high temperatures and pressures increase the aromatics content of naphtha and ultimately increase its octane number. In this study, operational conditions in octanizer and hydro-treating units in oil refinery company is investigated and optimized the conditions of catalysis was investigated [5-7].

The Effect of Best Operating Conditions on Reaction

Temperature: The easiest and most effective way to increase the octane number is rising temperatures. To maintain octane number of isomerization product, temperature should be regularly raised to compensate for the gradual reduction of catalyst activity [8]. Temperature increase causes an increase in energy consumption. In general, by increasing the operating temperature of the isomerization process:

1. Production efficiency decreases
2. The amount of light gas and LPG emissions increases
3. Coke formation on the catalyst surface occurs faster
4. The useful life of the catalyst decreases

Isomerization reaction is improved by reducing the temperature and in a competitive reaction, speed of adverse reactions such as cracking, Hydrogenolosis, and coke formation decreases. By examining equilibrium constants, it is found out that as the temperature decreases, concentration of isomer mixture increases compared to the concentration of paraffin's and linear olefins, hence the catalysts that work at lower temperatures (such as SO_4Pt/ZrO_2 and Pt/ Cl-AL_2O_3) have more isomer selectivity and less cracking products (C_3 and C_4) compared to the high-temperature catalysts (zeolite-based catalysts). However, with increasing

temperature, the isomerization reaction selectivity decreases and selectivity to cracking reactions increases. However, the speed of reaction increases. This is justifiable because the activation energy is always positive and temperature rise has direct relationship with the increase in reaction rate constant.

$$k = A \exp\left(\frac{-E_a}{RT}\right) \quad (2)$$

For example, in the case of a catalytic the activity of which has decreased, the temperature has decreased from 127 to 111 °C temperature, conversion percentage (X) of linear hexane has decreased from 0.5 to 0.19, and the conversion of normal pentane has decreased from 0.2 to 0.13. Also, molar percentage of produced 2,2 DMB has decreased from 4.68 to 1.9 and molar percentage of linear pentane has decreased from 14 to 4.3. Since the production of 2MP, 3MP is done faster, it has high concentration seven at low temperatures. Considering the fact that feed is in reactor for limited residence time and that the increase in temperature leads to increased reaction rate and decreased Isomeration selectivity, the optimum temperature at which the highest conversion rates occur in the reactor with the mass flow rate (FA) and residence time (τ) should be calculated. On the other hand, the increase in temperature helps dehydrogenation reaction that is required to start the isomerization reaction. Thus, having the minimum necessary temperature is required for the dehydrogenation reaction and it can dramatically increase the speed of reaction. This is desirable as far as thermodynamic limitations of equilibrium constants do not decrease the concentration of isomers. Although temperature increase is useful for the dehydrogenation and increases its rate, it slows hydrogenation of alkenes (olefins) and increase the concentration of alkenes on active catalyst sites. As a result, it increase the rate of polymerization reactions and the formation of coke.

Since isom reaction is a reaction which is carried out without changing the total number of moles, concentrations of products in thermodynamic equilibrium are unaffected by pressure. Although the increase in pressure does not change the equilibrium concentrations, it decreases reaction rate. This can be justified by the reduction of reaction rate of dehydrogenation of alkanes. Increasing the total pressure increases the concentration of hydrogen and according to Le Chatelier's Principle, hydrogenation reaction of alkenes progress while dehydrogenation reaction rate decreases. Increasing the pressure may decease caking and cracking reaction rate which again can be justified by the decrease in the concentration of alkane on catalyst which is caused by the hydrogenation of alkenes. The rate of deceleration of cracking reaction is higher than that of isomerization reaction. Therefore, pressure increase can improve the selectivity of reaction towards isomerization [9-12].

The optimal amount of pressure depends on the type of catalyst, but it is usually between 20 to 30 barg for commercial catalysts. Chao and colleagues also observed and confirmed improved selectivity of n-heptane isomerization reaction. In addition to decreasing dehydration, pressure improves the activity of acidic sited to produce Carboniom ions with 7 carbon atoms. According to the Samimi Results in his article (2019), by increasing the operating pressure from 1 atmosphere to 30.6, isomerization selectivity increases, while the selectivity of cracking reaction and conversion decrease. The increase in pressure increases isomerization selectivity as far as it does not cause the formation of liquid phase of products or feed in catalyst holes [1, 13]. Since the dissolution of hydrogen in the liquid phase is low, the formation of liquid phase decreases hydrogen in contact with the olefin and reduces the selectivity. The pressure at which conversion reactions are done affects the yield and catalyst

life. By raising the operating pressure in the isom units, hydrocracking reactions increase and thus the efficiency for the desired octane number decreases. At a constant octane number, by increasing the operating pressure, the useful lifetime of the catalyst increases too. Relative severity is used to determine the decrease in catalyst activity. As octane number of isomerization increases, deactivation rate of catalyst also increases. As operating pressure increases, the catalyst deactivation also decreases.

Hydrogen to Feed Ratio (H_2/HC)

Higher molar ratio H_2/HC has a positive impact on catalyst performance and increases the stability of the catalyst over time, since it prevents the formation of coke. Chu *et al*. (2018) and Samimi *et al*. (2019) studied the effect of hydrogen on the isomerization of n-hexane and showed that if hydrogen gas is replaced by nitrogen gas in identical operating conditions, the selectivity of isomerization reaction decreases from 90% to 20% while the reactions tend to cracking and cracking selectivity increases from 6 % to 74 %. Since the pressure of isomerization reaction in the reactor is supplied by hydrogen gas, the effect of the ratio of hydrogen to hydrocarbon and the effect of total pressure of the reaction are considered together. Usually, instead of using the total pressure in speed relationships, hydrogen partial pressure is used [14]. As mentioned, the reaction rate decreases with increasing pressure, while isomerization selectivity increases. Therefore, the partial pressure of hydrogen usually has negative power in speed equations. Kinyakin test results showed that in n-hexane isomerization, if the ratio H_2/HC increases to more than 2, weight percent and conversion rates of isomer products decrease. The optimum ratio of H_2/HC for n-hexane isomerization is 2:1.

To protect the catalyst against the coke and chemical interactions in reactors, we need circulating hydrogen gas. The main purpose of circulating hydrogen gas in Naphtha isomerization unit is raising the partial pressure of hydrogen to prevent the formation of multiple-ring aromatic hydrocarbon which is almost similar to the formula n(CH) and is called coke (Figure 6). According to a research study, with decreasing the proportion of hydrogen to hydrocarbon from 8 to 4, the speed of coke formed on the catalyst surface increases 1.75 times while if this ratio is reduced from 4 to 2, the speed of coke formation on the catalyst increases 3.6 times. Similarly, if we reduce the ratio of hydrogen to hydrocarbon from 5 to 4, life time of the catalyst is reduced approximately 20%. Reducing the molar ratio of hydrogen to hydrocarbon has two reasons:

- Saving energy
- Better isomerization interactions.

The conditions of feed: Industrial isomerization unit feed which is called light naphtha is carbonated linear molecules and isomers 4, 5, 6 and 7 with a significant percentage of naphthen and a bit of aromatics mainly benzene and toluene. Since the catalyst Pt/CL-AL_2O_3 is sensitive to water, CO, CO_2, H_2S, mercaptans, pesticides, nitrogen and structural oxygen, naphtha treatment unit should separate Naphtha from these impurities. On the other hand, the feed which consists of 5 and 6-carbon linear molecule is increases the rate of isomerization reaction, while the isomer molecules 5 and 6 carbon on the catalyst only takes part in cracking reaction and decreases isom reaction rate by occupation catalyst's active sites. The presence of linear Heptane and the molecules heavier than it (C_7^+) significantly make cracking reactions proceed.

Since Carboniom ions formed in isomers formed in the cracking of hydrocarbons heavier than heptane (C_7^+) are more stable than the Carboniom ions formed in the isomerization

reaction of these materials, cracking reaction is accelerated while it is the opposite for 5 and 6 carbon hydrocarbons. Aromatics are a serious problem for industrial isomerization units. Aromatics should not be usually over 5 weight percent of feed.

Optimum pH for the reaction of isomerization: Both isomerization and cracking of hydrocarbons are performed on acidic sites and the increase in power and density of acidic sites accelerates both reactions. In the process of isomerization, cracking reaction is an adverse reaction and should be reduced. Samimi *et al.* (2020), studied the effect of amount and strength of acidic sites in cracking and isomerization reactions of normal butane on zeolite, alumina, and halogenated alumina catalysts. They compared acid strength and power distribution of various catalysts through the absorption of ammonia and its absorption heat. Cracking mainly happens for hydrocarbons with more than 6 carbon atoms. Part of the cracking producing hydrocarbons with 3 and 4 carbon atoms is done on acidic sites and is in direct proportion to the number and strength of acidic sites.

The ratio of metal and acidic site in catalyst: The activity of two-factor catalysts strongly depends on the ratio of metal and acidic sites. For instance, in the catalyst Pt/HY which is a zeolite catalyst for isomerization, the optimal ratio of strong acidic sites to metal sites in n-heptane isomerization is determined under 6. This ratio affects selectivity of the catalyst and reactions such as cracking. To determine the optimal ratio of metal, metal compounds can be used to reduce the effect of metal on selectivity of reaction. High levels of platinum increase the cracking reaction called Hydrogenolosis. On the other hand, if the amount of platinum decreases excessively, dehydrogenation rate and catalyst activity decrease. To compensate for the reduction in catalyst activity due to metal platinum poisoning, reaction temperature is increased, leading to an increase in the cracking reactions. The greater the distance between metal and acidic sites, and the less the distribution of metal, the slower the practice of hydrogenation and the more the opportunity for adverse reactions such as oligomerization. Metal accumulation around acidic site could clog it and reduce the adsorption of molecules on acidic sites. Such conditions reduce the acidity of the catalyst. Lee *et al.* showed although the acidity of the catalyst Pt/Hβ is less than that of Pt/HMOR, its activity in normal hexane isomerization is more because of the larger pore size of catalyst and appropriate distribution and the platinum metal [15-18].

Supervised machine learning algorithm (SMLA): Recursive partitioning (RP), is the selected methodology in this work, is one of the most common methods for creating nonparametric classification trees. RP is a systematic process through which a DT is built by splitting the nodes of the dt into two sub-nodes. As an attractive trait of the cart, it repeats a series of hierarchical Boolean questions (is $t_j \geq X_i$? where t_j is a threshold value), hence it is relatively simple to figure out and discuss the results. An uncomplicated example of RP algorithms involving two independent variables X_0 and X_1. Suppose the dt given in Figure 5. The processing methodology of this flowchart are as follows:

Is $X_1 \leq q_t$?

In that case we have been faced with 2 parts:

Yes, it follows the left arm

No, it follows the right arm

Now the answer of question is important. Positive means is $X_0 \leq q_e$?

If yes in terminal node T_1 with corresponding interval $R_a = [X_0 \leq q_e, X_1 \leq q_t]$.

In contrast, if no, in terminal node T_2 with corresponding interval $R_b = [X_0 > q_e, X_1 \leq q_t]$.

Now if the answer of question 1 is "NO" should ask $X_1 \leq q_c$?

But if the answer of question 1 is "Yes" should ask $X_0 \leq q_d$?

Hence if yes, we can write: $R_c = [X_0 \leq q_d, q_a < X_1 \leq q_c\}$ and if no we should write: $R_d = [X_0 > q_d, q_a < X_1 \leq q_c]$.

If the answer of q_c is "NO", we should write: $R_e = [X_1 > q_c]$.

To sum-up, after analyzing this method, the results with these tips: $q_b < q_d$ & $q_a < q_c$. In that case and in this study two different functions of c-tree and r-part was used. Because according to analyzing methods if we use c-tree, it is suitable for statistical computing for scientists and if we use R package, it is good for programming language. But both are suitable for separator and reflux drum in isom units to analyze the results and choose the best performance.

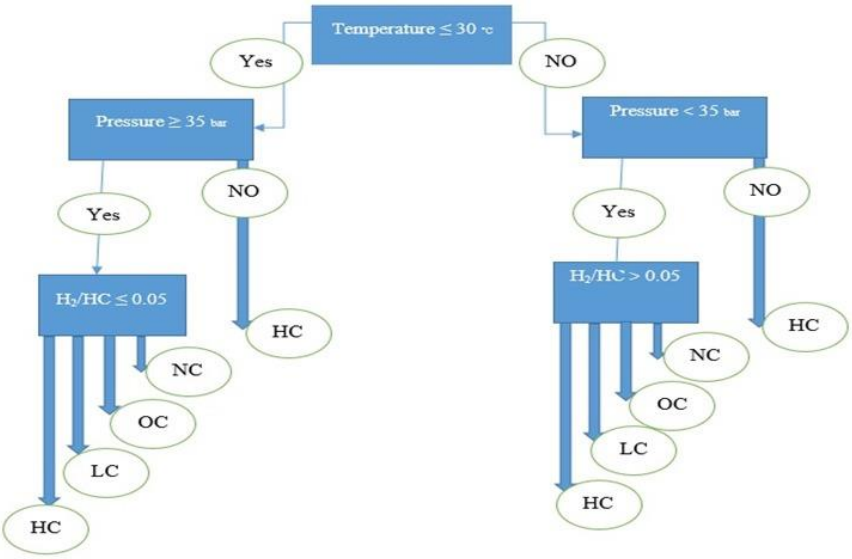

Figure 5. Data analyze for separator drum in ISOM units by r-part function in order to create a decision chart

Data Definition

In ISOM Unit according to the conditional in it the range of temperature of light naphtha is between 100 and 135 °C, the range of pressure of recycle gas (bar) is between 31 to 37 bar, the range of effect of hydrogen to feed ratio (H_2/HC) is between 0.04 to 1, the range of conditions of feed (temperature is between 30 to 45 °C and pressure is between 16 to 22 bar, the range of optimum pH for the reaction of isomerization is between 5.4 to 7 and the range of ratio in metal and acidic site in catalyst is between 6 to 7.1. In addition, in this work for the development of DTs, 3 major factors are more important than others. Temperature of light naphtha, pressure of recycle gas (p bar), the effect of hydrogen to feed ratio (H_2/HC). Because these parameters are vital for corrosion and humidity in isom units. The corrosion level based on Temperature of light naphtha in feed, value is considered as four classes as shown in Table 1. This means that if temperature of light Naphtha, is less than 30 °C, it is appropriate for units. Table 1 shows:

- If 45 > Temperature, the high corrosion (HC) in pipelines would be accrued.
- If 35 ≤ temperature ≤ 45, the low corrosion (LC) in pipelines would be accrued.
- If 34 < Temperature, the optimum corrosion (OC) in pipelines would be accrued.
- If 30 < temperature, the no corrosion (NC) in pipelines would be accrued.

The corrosion level based on pressure of recycle gas (bar), value is considered as four classes as shown in Table 2. This means that if pressure of recycle gas (bar) is more than 35 °C, it is appropriate for units. Table 2 shows:

- If 24 < pressure, the high corrosion (HC) in pipelines would be accrued.

➢ The corrosion level based on the effect of hydrogen to feed ratio (H_2/HC), value is considered as four classes as shown in **Table 3**. This means that if the effect of hydrogen to feed ratio (H_2/HC) is less than 0.05, it is appropriate for units. Table 3 shows:

➢ If 1 > H_2/HC, the high corrosion (HC) in pipelines would be accrued.

➢ If 24≤ pressure ≤ 33, the low corrosion (LC) in pipelines would be accrued.

➢ If 33.1 ≤ pressure ≤ 35, the Optimum Corrosion (OC) in pipelines would be accrued.

➢ If 35 > pressure, the no corrosion (NC) in pipelines would be accrued.

➢ If 0.2 ≤ H_2/HC ≤ 1, the low corrosion (LC) in pipelines would be accrued.

➢ If 0.2 < H_2/HC, the optimum Corrosion (OC) in pipelines would be accrued.

➢ If 0.05 < H_2/HC, the no corrosion (NC) in pipelines would be accrued.

Table 1. Data Definition for Analyzing about temperature of light Naphtha (L.N) in feed

High Corrosion (HC)	Low Corrosion (LC)	Optimum Corrosion (OC)	No Corrosion (NC)
45 ˚C > Temperature	35°≤ Temperature ≤ 45 ˚C	34 ˚C ≤ Temperature	30 ˚C ≤ Temperature

Table 2. Data Definition for Analyzing about pressure of recycle gas (P bar)

High Corrosion (HC)	Low Corrosion (LC)	Optimum Corrosion (OC)	No Corrosion (NC)
pressure < 24 Bar	24 Bar ≤ pressure ≤ 33 Bar	33.1 Bar≤ pressure ≤ 35 Bar	pressure > 35 Bar

Table 3. Data Definition for Analyzing about the effect of hydrogen to feed ratio (H_2/HC)

High Corrosion (HC)	Low Corrosion (LC)	Optimum Corrosion (OC)	No Corrosion (NC)
H_2/HC > 1	0.2 ≤ H_2/HC ≤ 1	0.2 < H_2/HC	0.05 < H_2/HC

About corrosion level in the separator vessel based on the feed parameters according to Table 4 in this study:

For low Corrosion (LC): In this case shows that:

1- According to row 2 when we have low corrosion (LC), this study has been faced with 35 ≤ Temperature ≤ 45, 24 ≤ pressure ≤ 33, 0.2 ≤ H_2/HC ≤ 1, Probability is approximately 53%. Hence temperature shows this fact that less than 35 °C is very suitable for catalyst and corrosion.

2- According to row 6 when we have low corrosion (LC), this study has been faced with 35 ≤ temperature ≤ 40, 24 ≤ pressure ≤ 33, 0.2 ≤ H_2/HC ≤ 1, probability is approximately 55%. Hence temperature shows this fact that less than 40 °C is better than 45 in row 2. It means that if the temperature would be increased, the corrosion will be decreased.

For High Corrosion (HC): In this case shows that:

1- According to row 1 when we have high corrosion (HC), the worst stage in this case, this study has been faced with 45 > temperature, 24 < pressure and 1 > H_2/HC, probability is approximately 75%. Hence temperature shows this fact that more than 45 °C is not appropriate for catalyst and corrosion. In that case we can see high level of corrosion in isom units. This stage is the worst in in this project.

2- According to row 5 when we have high corrosion (HC), this study has been faced with 40 > temperature, 24 < pressure and 1 > H_2/HC, probability is approximately 75%. Thus temperature shows this fact that if we can decrease temperature approximately 5 °C, the probability is approximately will be decreased to 60%. It shows the effect of temperature in isom units.

For Optimum Corrosion (OC): In this case shows that:

1- According to row 3 when we have optimum corrosion (OC), this study has been faced with 30 < temperature, 33.1 ≤ pressure ≤ 35, 0.2 < H_2/HC, probability is approximately 77%. Hence temperature shows between 30 to 33.1 °C is very suitable for corrosion. Also the range of H_2/HC is approximately acceptable (not suitable) according to manual units. Compressor pressure is suitable and acceptable for feed. This means that although we have optimum corrosion in pipeline, rang of ration is is not appropriate and should be decreased to less than 0.05.

2- According to row 7 when we have optimum corrosion (OC), this study has been faced with 25< temperature, 34 ≤ pressure ≤ 35, 0.25 < H_2/HC, probability is approximately 90%. Hence Temperature shows less than 25 °C is very suitable for corrosion and optimum. Also the range of H_2/HC is not suitable according to manual units. Compressor pressure is very suitable and acceptable for feed. This means that although we have optimum corrosion in pipeline, rang of pressure for compressor is appropriate.

For No Corrosion (NC): In this case shows that:

1- According to row 4 when we have no corrosion (NC), we have been faced with 30< temperature, 34 > pressure 0.08 < H_2/HC, probability is approximately 90%. Hence temperature shows less than 30 °C is very suitable for corrosion and optimum. Also the range of H_2/HC is suitable according to manual units. Compressor pressure is very suitable and acceptable for feed. This stage is normal, but not the best.

2- According to row 8 when we have no corrosion (NC), the best stage in this study, we have been faced with 20< temperature, 34 > pressure 0.05<H_2/HC, probability is approximately 100%. Hence temperature shows less than 20 °C is very suitable for corrosion and optimum. Also the range of H_2/HC is suitable according to manual units. Compressor pressure is very suitable and acceptable for feed. This stage is normal and the best stage in this study.

Table 4. Corrosion level in the separator vessel based on the feed parameters

Entry	Corrosion level	Population of the bin	Probability	Rule
1	HC	4%	75%	temperature > 45 °C pressure < 24 Bar, H_2/HC > 1
2	LC	5%	53%	35 °C ≤ temperature ≤ 45 °C 24 Bar ≤ pressure ≤ 33 Bar 0.2 ≤ H_2/HC ≤ 1
3	OC	4%	77%	temperature < 30 °C 33.1 Bar ≤ pressure ≤ 35 Bar H_2/HC < 0.2
4	NC	3%	90%	temperature < 30 °C pressure > 34 Bar, H_2/HC < 0.08
5	HC	4%	60%	40 °C > temperature 24 Bar < pressure, 1 > H_2/HC
6	LC	5%	55%	35 °C ≤ temperature ≤ 40 °C 24 Bar ≤ pressure ≤ 33 Bar 0.2 ≤ H_2/HC ≤ 1
7	OC	4%	90%	temperature < 25 °C 34 Bar ≤ pressure ≤ 35 Bar, H_2/HC < 0.25
8	NC	1%	100%	temperature < 20 °C pressure > 35 Bar, H_2/HC < 0.0

Reflux Drum

In Figure 6 we analyze these data for separator drum in isom units by r-part function in order to create a decision chart.
About corrosion level in the reflux vessel based on the feed parameters according Table 5:

For low Corrosion (LC): In this case shows that:
1- According to row 2 when we have low corrosion (LC), this study has been faced with 40≤ temperature ≤45, 26 ≤ pressure ≤ 33, 0.2 ≤ H_2/HC ≤ 0.9, probability is approximately 80%. Hence temperature shows this fact that less than 40 °C is very suitable for catalyst and corrosion.
2- According to row 6 when we have low corrosion (LC), this study has been faced with 35≤temperature ≤45, 24 ≤ pressure ≤ 33, 0.2 ≤ H_2/HC ≤ 1, Probability is approximately 60%. Hence temperature shows this fact that less than 35 °C is better than 40 in row 2. It means that if the temperature would be increased, the corrosion will be decreased.

For High Corrosion (HC): In this case shows that:

1- According to row 1 when we have high corrosion (HC), the worst stage in this case, this study has been faced with: 45>temperature, 24<pressure and 1>H_2/HC, probability is approximately 100%. Hence temperature shows this fact that more than 45 °C is not appropriate for catalyst and corrosion. In that case we can see high level of corrosion in isom units. Also the range of ration and pressure is not appropriate. This stage is the worst in in this project.
2- According to row 5 when we have high corrosion (HC), this study has been faced with 40 > Temperature, 24<Pressure and 1> H_2/HC, Probability is approximately 90%. Thus Temperature shows this fact that if we can decrease temperature approximately 5 °C, the Probability is approximately will be decreased to 90%. It shows the effect of temperature in isom units.

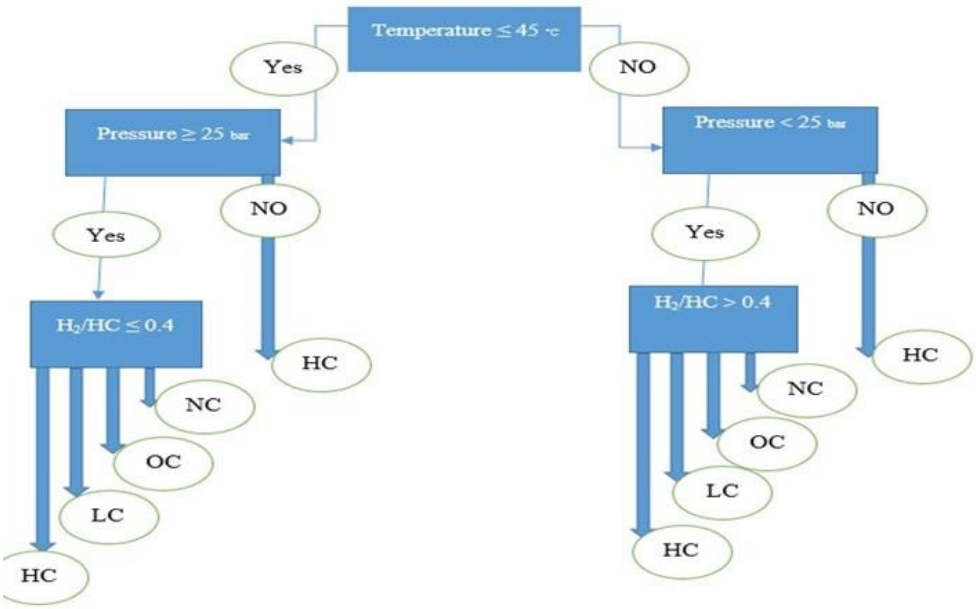

Figure 6. Data analyze for reflux drum in ISOM units by r-part function in order to create a decision chart

Table 5. Corrosion level in the reflux vessel based on the feed parameters

Entry	Corrosion level	Population of the bin	Probability	Rule
1	HC	2%	100%	temperature > 45 °C 24 Bar < pressure, 1 > H_2/HC
2	LC	4%	80%	40 °C ≤ temperature ≤ 45 °C 26 Bar ≤ pressure ≤ 33 Bar 0.2 ≤ H_2/HC ≤ 0.9
3	OC	7%	70%	temperature < 30 °C 33.1 Bar ≤ pressure ≤ 35 Bar 0.2 < H_2/HC
4	NC	4%	90%	temperature < 30 35 Bar > pressure, 0.05 < H_2/HC
5	HC	7%	90%	40 °C > temperature 24 Bar < pressure, 1 > H_2/HC
6	LC	8%	60%	35 °C ≤ temperature ≤ 40 °C 24 Bar ≤ pressure ≤ 33 0.2 ≤ H_2/HC ≤ 1
7	OC	9%	71%	25 °C < temperature 33.1 Bar ≤ pressure ≤ 35, 0.2 < H_2/HC
8	NC	3%	96%	20 °C < temperature Pressure > 35 Bar 0.05 < H_2/HC

For Optimum Corrosion (OC): In this case shows that:

1- According to row 3 when we have optimum corrosion (OC), this study has been faced with 30 < temperature, 33.1 ≤ pressure ≤ 35, and the ratio, 0.2< H_2/HC, probability is approximately 70%. Hence temperature shows between 30 to 33.1 °C is very suitable for corrosion. Also, the range of H_2/HC is approximately acceptable (not suitable) according to manual units. Compressor pressure is suitable and acceptable for feed. This means that although we have optimum corrosion in pipeline, rang of ration is is not appropriate and should be decreased to less than 0.05.

2- According to row 7 when we have optimum corrosion (OC), this study has been faced with 25<temperature, 34≤pressure≤35, and the ratio, 0.25 < H_2/HC, probability is 71%. Hence Temperature shows less than 25 °C is very suitable for corrosion and optimum. Also, the range of H_2/HC is not suitable according to manual units. Compressor pressure is very suitable and acceptable for feed. This means that although we have optimum corrosion in pipeline, rang of pressure for compressor is appropriate.

For No Corrosion (NC): In this case shows that:

1- According to row 4 when we have no corrosion (NC), we have been faced with:

30 < temperature, 34 > pressure and the ratio, 0.08<H_2/HC, probability is approximately 90%. Hence temperature shows less than 30 °C is very suitable for corrosion and optimum. The range of H_2/HC is suitable according to manual units. Compressor pressure is very suitable and acceptable for feed. This stage is normal, but not the best.

According to row 8 when we have no corrosion (NC), the best stage in this study, we have been faced with 20 < temperature, 34>pressure 0.05 < H_2/HC, probability is approximately 96%. Hence temperature shows less than 20 °C is very suitable for corrosion and optimum. Also, the range of H_2/HC is suitable according to manual

units. Compressor pressure is very suitable and acceptable for feed. This stage is normal and the best stage in this study.

Conclusion

In this study, the conditional contract arrangement was used to extract the relevant knowledge in isomerization for 3 major factors for the first one with Amir Samimi Methods: the effect of hydrogen to feed ratio, optimum pH for the reaction of isom and the ratio of metal and acidic site in catalyst. All of these factors are related to corrosion and this paper aims to optimize some conditions. Additives such as CH_3Cl, CCl_4, C_2Cl_4, and C_2Cl_2 will release HCl after their reaction with hydrogen gas.

These main conclusions can be deduced from the current study: Light Naphtha isomerization is carried out in order to give isomer high selectivity. In this regards, after analyzing 4 cases (high corrosion, low corrosion, optimum corrosion and no corrosion) the results show that:

Separator drum: According to row 8 when we have no corrosion (NC), the best stage in this study, we have been faced with 20 < temperature, 34 > pressure 0.05<H_2/HC, probability is approximately 100%. Hence Population of the bin 1%. This stage is very ideal and engineers must try to supply it in units.

Reflux Drum: According to row 8 when we have no corrosion (NC), the best stage in this study, we have been faced with 20 <temperature, 34> pressure 0.05<H_2/HC, probability is approximately 96%. Hence population of the bin 3%. This stage is very ideal and engineers must try to supply it in units. Finally, our results show how this approach can be used to gain insight into some refineries, deliver results in a comprehensible and user-friendly way.

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